United States
Department of
Agriculture

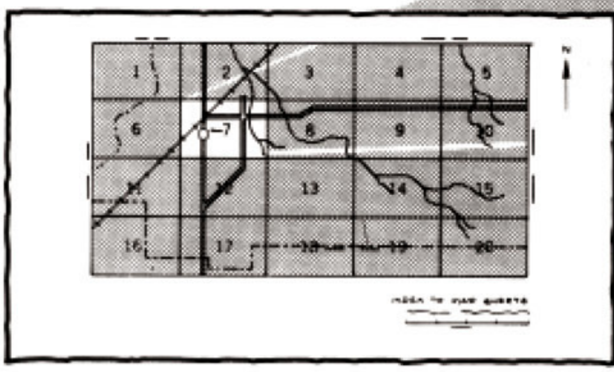
Soil
Conservation
Service

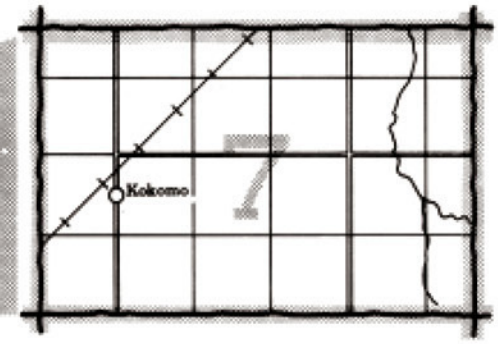
In cooperation with the
Oklahoma Agricultural
Experiment Station
and the Oklahoma
Conservation Commission

Soil Survey of Grant County, Oklahoma

HOW TO USE

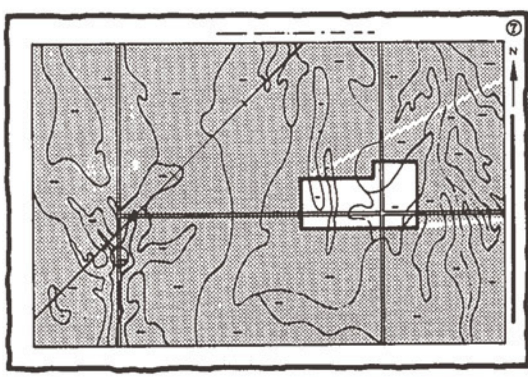
1. Locate your area of interest on the "Index to Map Sheets"

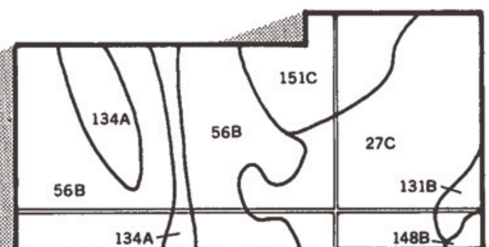




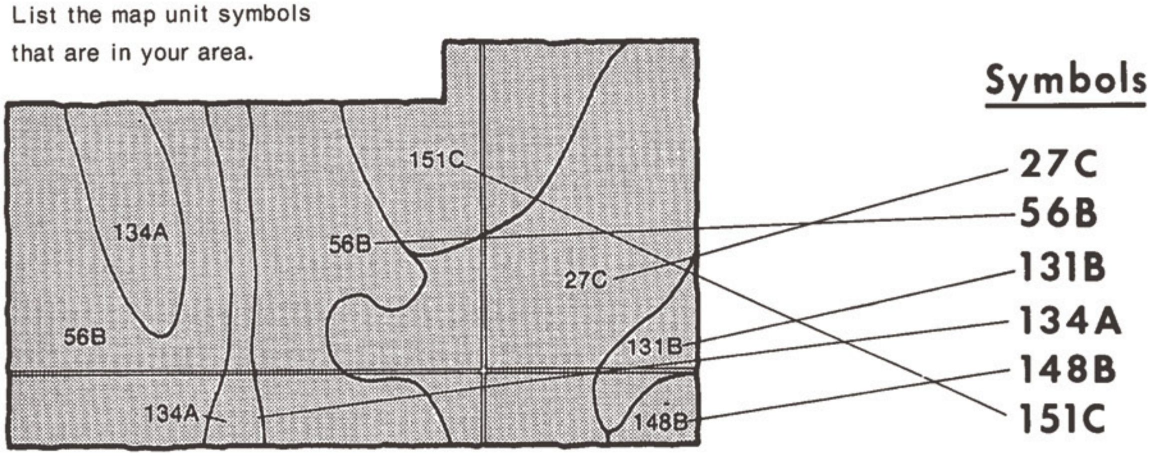
2. Note the number of the map sheet and turn to that sheet.

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



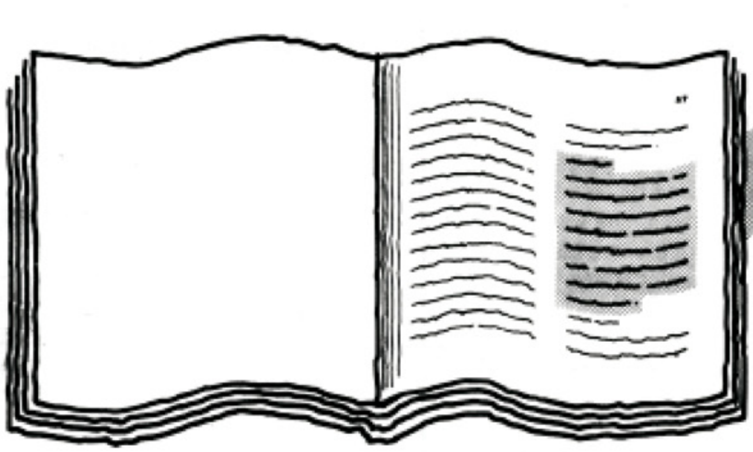
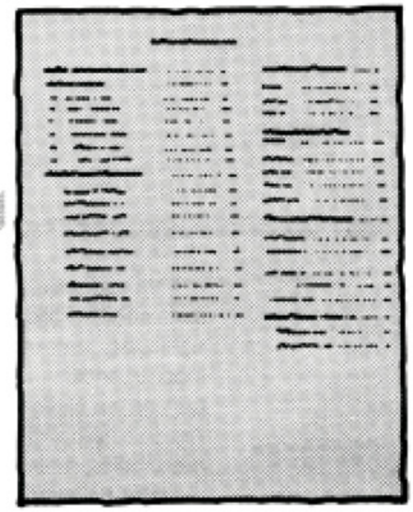


4. List the map unit symbols that are in your area.

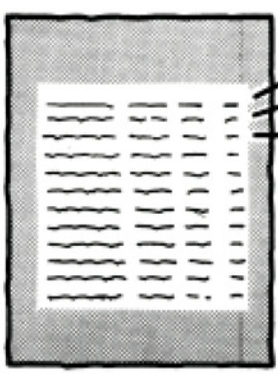
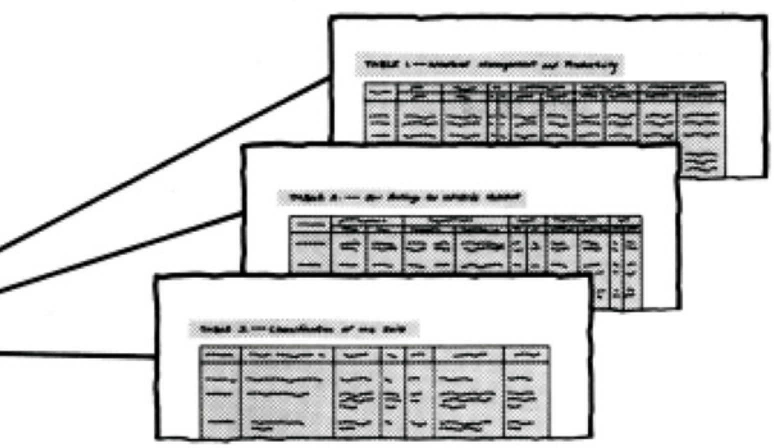


THIS SOIL SURVEY

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

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

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

This 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. In line with Department of Agriculture policies, benefits of this program are available to all, regardless of race, color, national origin, sex, religion, marital status, or age.

Major fieldwork for this soil survey was completed in 1982. Soil names and descriptions were approved in 1982. Unless otherwise indicated, statements in this publication refer to conditions in the survey area in 1982. This soil survey was made cooperatively by the Soil Conservation Service, the Oklahoma Agricultural Experiment Station, and the Oklahoma Conservation Commission. It is part of the technical assistance furnished to the Grant County 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.

Cover: Wheat being harvested on McLain silt loam, rarely flooded.

Contents

Soil Series

Issued December 1985

Index to Map Units

Summary of Tables

Foreword

This soil survey contains information that can be used in land-planning programs in Grant 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.

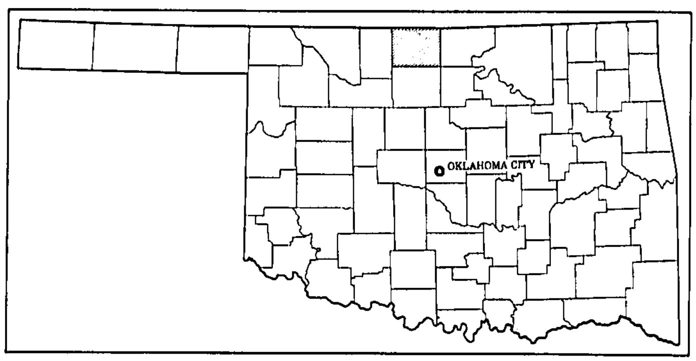
This soil survey is designed for many different users. Farmers, ranchers, foresters, and agronomists can use it to evaluate the potential of the soil and the management needed for maximum food and fiber production. Planners, community officials, engineers, developers, builders, and home buyers can use the survey to plan land use, select sites for construction, and identify special practices needed to insure 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 to 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.

Roland R. Willis

Roland R. Willis
State Conservationist
Soil Conservation Service



Location of Grant County in Oklahoma.

Soil Survey of Grant County, Oklahoma

By Glen E. Williams, Edward E. Horn, and Joe D. White,
Soil Conservation Service

United States Department of Agriculture, Soil Conservation Service
in cooperation with
the Oklahoma Agricultural Experiment Station
and the Oklahoma Conservation Commission

Grant County is in the north-central part of Oklahoma. It is bordered on the north by Harper and Sumner Counties, Kansas. It is bordered on the east by Kay County, on the south by Garfield County, and on the west by Alfalfa County, Oklahoma. Grant County has an area of 1,007 square miles, or 644,480 acres. Medford is the county seat.

General Nature of the County

This section gives general information concerning the county. It discusses the settlement and development; physiography; transportation and industry; natural resources; climate; and landscape resources.

Settlement and Development

Nina Pond, Grant County Historical Society, Medford, Oklahoma, contributed this section.

The land of Grant County was acquired by the United States from France in 1803 as part of the Louisiana Purchase. By treaties, it became Cherokee Indian Territory. Grant County was a part of what was known as the Cherokee Strip.

Grant County was opened for settlement by a land run on September 16, 1893. Eligible men could claim 160 acres of free land from the United States Government. The virgin land had been burned over to drive out 'sooners' who came in earlier. Despite the heat, the scorched earth, and the crowd, each homesteader was inspired by free land and a new home.

In time, the land use gradually changed from all native range to a preponderance of cultivated crops. Alfalfa, corn, cotton, and small grains were among the major crops prior to the 1930's. Today, wheat is the main crop. About 430,000 acres was planted to wheat in 1982.

Physiography

Grant County is in the Central Rolling Red Prairies major land resource area. The Salt Fork of the Arkansas River crosses the county from west to east, and its broad, sandy, windworked terraces cover thousands of acres north of the river. The drainage in most of the county flows to the Salt Fork of the Arkansas River. The Chikaskia River and Bluff Creek drain a small area in the northeastern part of the county.

Sand dunes are along the western border of Grant County and in scattered areas north of the Salt Fork of the Arkansas River. High, broad, smooth clayey terraces are in the central, north-central, and northeastern parts of the county. Younger, loamy terraces that are lower in elevation are associated with the large creeks and the Salt Fork of the Arkansas River. In the northern and southern parts and other scattered areas there are soils that formed in geologic deposits of Permian age. One of the larger areas is the gently rolling hills in the southwestern part of the county.

Elevation ranges from 960 feet where the Salt Fork of the Arkansas River leaves the county on the eastern border to 1,410 feet at the top of some sand dunes in the western part of the county.

Transportation and Industry

Grant County is served by a network of state and federal highways. U.S. Highway 81 and Oklahoma Highway 132 cross the county in a north-south direction.

U.S. Highways 60 and 64 cross the southern part of the county in an east-west direction and meet a few miles west of Pond Creek; from that point the joint highway runs southward out of the county. Oklahoma Highway 11 crosses the county from east to west, and Oklahoma Highway 74, in the eastern part of the county, extends from Highway 11 to the south.

Agriculture is the main industry in the county, and the main products are wheat and cattle. The wheat is marketed mostly in Grant County, but the cattle are marketed out of the county. Oil and gas production is an important industry throughout the county. Oil refineries are located near Medford, Lamond, and Wakita. Small agriculture-related manufacturing plants are in Pond Creek and Wakita.

Natural Resources

Large areas of prime farmland, oil, and natural gas are the most important natural resources in the county. Grant County has about 450,000 acres of prime farmland, which is fertile and productive for winter crops, principally wheat. Grain sorghums, forage sorghums, and alfalfa are important crops on some bottom lands and to a lesser extent on uplands. Summer crop production is severely limited in some years by limited rainfall during the growing season.

Many areas have an inadequate water supply for domestic and livestock use. Rural water systems presently serve much of Grant County. Water for these systems and for limited irrigation is available under some of the bottom land soils. In some areas the water is too high in salts and minerals for domestic use. Farm ponds furnish much of the water for livestock.

The exploration and development of oil and natural gas fields are major economic enterprises in several areas in the county. Most of the wells are less than 7,000 feet deep.

Climate

Prepared by the National Climatic Center, Asheville, North Carolina.

Table 1 gives data on temperature and precipitation for the survey area as recorded at Jefferson, Oklahoma in the period 1951 to 1978. 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 38 degrees F, and the average daily minimum temperature is 26 degrees. The lowest temperature on record, which occurred at Jefferson on January 4, 1959, is -9 degrees. In summer the average temperature is 81 degrees, and the average daily maximum temperature is 95 degrees. The highest recorded temperature, which occurred at Jefferson on July 14, 1954, is 115 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 30 inches. Of this, 21 inches, or 70 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 16 inches. The heaviest 1-day rainfall during the period of record was 10 inches at Jefferson on October 11, 1973. Thunderstorms occur on about 60 days each year, and most occur in summer.

The average seasonal snowfall is 8 inches. The greatest snow depth at any one time during the period of record was 30 inches. On an average of 34 days, at least 1 inch of snow is on the ground. The number of such days varies greatly from year to year.

The average relative humidity in midafternoon is about 60 percent. Humidity is higher at night, and the average at dawn is about 70 percent. The sun shines 70 percent of the time possible in summer and 60 percent in winter. The prevailing wind is from the south. Average windspeed is highest, 14 miles per hour, in spring.

Tornadoes and severe thunderstorms occur occasionally. These storms are of short duration in local areas, and the pattern of drainage is variable and spotty.

Landscape Resources

David G. Thompson, landscape architect, Soil Conservation Service, helped prepare this section.

The appearance and visual qualities of Grant County are important and worthy of inventory, evaluation, and management. The visual landscape resource is the definable appearance of a landscape unit as determined by its landforms, vegetation, water, and manmade structural elements and patterns. As with any resource, landscape resources are finite and should be regarded as worthy of proper management for effective conservation.

Each general soil map unit has a distinct appearance that can be modified by changing the landscape elements or patterns. In some areas, the visual landscape resource is extensively changed by agricultural practices or urban expansion.

In the general soil map units, the visual diversity of the landscape is described and rated. These descriptions are based on a comparison of landscapes within the county and the patterns which are created by the basic landscape elements—landform, vegetation, water, and manmade structures.

Landscape resource elements and patterns are readily visible, and the diversity of a landscape can be rated as high, medium, or low. A landscape which has high visual diversity will have some or all of the following characteristics: varied vegetative patterns, rivers or streams or both with high clarity, lakes or ponds with diverse shorelines, and contrasting manmade structures that are visually compatible with the landscape and other structures.

In areas of low visual diversity, one landscape element may dominate and create an appearance that has little or no contrast in pattern. Low diversity areas may have the following characteristics: landforms with no variety; vegetative cover with no variation in type, height, or color; water bodies with limited visual interest and shorelines with no variety; and manmade structures that have little relation to their surroundings.

When a change in landscape pattern or elements is considered, the potential visual impact on the landscape should be carefully analyzed. Often a single practice may increase or decrease the visual quality. For example, the grading and revegetating of an eroded area can increase resource quality. A loss of visual quality is often experienced when the soil behavior of an area is not taken into consideration. For instance, a sloping area which has soil suitable for woodland may be cleared and planted to row crops. The soil may erode severely during winter months if it is not protected by vegetative cover. The result could be bare and unsightly eroded areas, loss of soil, decrease in water quality caused by silty sediment, and loss of vegetation in other areas because of increased runoff.

A knowledge of each map unit and of the result that land use changes have on the landscape is necessary to plan effectively for proper management of the area. Assistance in planning is available from the Soil Conservation Service field office. Proper consideration of soil characteristics, land use, and the visual resource helps in conserving the optimum quality of the landscape resources.

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 from 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, the landforms, relief, climate, and the 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, acidity, 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 are generally collected for laboratory analyses and for engineering tests. Soil scientists interpreted the data from these analyses and tests as well as the field-observed characteristics and the soil properties in terms of expected behavior of the soils under different uses. Interpretations for all of the soils were field tested through observation of the soils in different uses under different levels of management. Some interpretations are modified to fit local conditions, and new interpretations sometimes are developed to meet local needs. Data were 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 were 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 state with a fairly high degree of probability 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 several 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. In the detailed soil map units, these latter soils are called inclusions or included soils. In the general soil map units, they are called soils of minor extent.

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 soils 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 broad areas that have a distinctive pattern of soils, relief, and drainage. Each map unit on the general soil map is a unique natural landscape. Typically, a map unit consists of one or more major soils and some minor soils. It is named for the major soils. The soils making up one unit can occur in other units but in a different pattern.

The general soil map 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 a building or other structure. The soils in any one map unit differ from place to place in slope, depth, drainage, and other characteristics that affect management.

The soils in the survey area vary widely in their potential for major land uses. Each map unit is rated for *cultivated crops, tame pasture, rangeland,* and *urban uses.* Cultivated crops are those grown extensively in the survey area. Tame pasture refers to areas where introduced grasses are grown. Range refers to areas of native grass. Urban uses include residential, commercial, and industrial developments.

Deep to Shallow, Nearly Level to Strongly Sloping, Nonalkali and Alkali, Loamy Soils; on Uplands

The five map units in this group make up about 68 percent of Grant County. The soils are used mostly for wheat. They are used less extensively as rangeland and for tame pasture.

1. Kirkland-Kingfisher-Pawhuska Association

Deep and moderately deep, nearly level to gently sloping, well drained and moderately well drained, nonalkali and alkali soils that have a loamy surface layer over a clayey or loamy subsoil; on uplands

The soils making up this association are on broad, smooth, nearly level to gently sloping plains that have a few gently sloping, shallow entrenched drainageways. Slopes are dominantly 0 to 3 percent, but they range from 0 to 5 percent.

The uniform topography exhibits little diversity because the range in slope is narrow. Vegetative patterns are limited to cultivated crops and tame pasture. Water elements are uncommon except for narrow drainageways. The structures scattered throughout the association generally are farmstead structures, residences, or commercial buildings. Visual diversity is medium; changes in the landscape pattern will generally be visually insignificant.

This association makes up about 5 percent of the county. It is about 47 percent Kirkland soils, 29 percent Kingfisher soils, 9 percent Pawhuska soils, and 15 percent soils of minor extent.

Kirkland soils are in flat or concave areas on smooth upland plains. These deep, nearly level to very gently sloping soils are well drained. They have a loamy surface layer over a clayey subsoil.

Kingfisher soils are on foot slopes and side slopes of weathered sandstone and siltstone hills. These moderately deep, very gently sloping to gently sloping soils are well drained. They have a loamy surface layer and a loamy subsoil that is underlain by interbedded sandstone, siltstone, and shale of Permian age.

Pawhuska soils are in flat or concave saline areas on smooth upland plains. These deep, nearly level to very gently sloping soils are moderately well drained. They have a loamy surface layer over a clayey subsoil.

The soils of minor extent are the deep Bethany, Pond Creek, and Tabler soils on smooth upland plains; the deep Grant soils on rolling, loamy hills; the deep Norge soils on the lower part of slopes; the deep Oscar soils on flood plains; the deep Renfrow soils on side slopes; and the moderately deep to deep, moderately well drained Wakita soils on foot slopes of hills.

This association has medium potential for crops. Most of the acreage is planted to wheat, and a lesser acreage is planted to other small grains or sorghums or is used as native range or tame pasture. The chief objectives in management are to reduce excess salts, to conserve moisture, and to maintain soil structure and fertility. Good surface and subsurface drainage helps to remove salts from the affected areas. Adding gypsum to salt-affected soil converts the adsorbed sodium to a leachable form. Protecting the soil surface from excessive evaporation by a mulch or a close-growing cover of salt-tolerant plants helps improve permeability and reduce evaporation. Adding nutrients is also beneficial to crops.

The soils in this association have medium potential for native grasses and tame pasture. Establishing tame pasture is difficult, but bermudagrass and tall wheatgrass are salt-tolerant enough to produce on all but the worst salt spots.

These soils have low potential for most urban uses. The saline areas have special problems. Building foundations can crack because of the high shrink-swell potential in the Kirkland and Pawhuska soils. The very slow permeability and moderately well drained conditions make septic tank absorption fields impractical. Lawns and shrubs are difficult to establish and maintain on saline soils.

2. Kirkland-Tabler Association

Deep, nearly level to very gently sloping, well drained and moderately well drained, nonalkali soils that have a loamy surface layer over a clayey subsoil; on uplands

This association consists of nearly level to very gently sloping soils on smooth upland plains. Slopes range from 0 to 3 percent.

The uniform topography exhibits little diversity because the range in slope is narrow. Vegetative patterns are limited to cultivated crops and tame pasture. Water elements are uncommon except for narrow drainageways. The structures scattered throughout the association generally are farmstead structures, residences, or commercial buildings. Visual diversity is medium; changes in the landscape pattern will generally be visually insignificant.

This association makes up about 33 percent of the county. It is about 68 percent Kirkland soils, 18 percent Tabler soils, and 14 percent soils of minor extent.

Kirkland soils are on smooth upland plains. They are deep, nearly level to very gently sloping, and well drained. They have a loamy surface layer and a clayey subsoil that is underlain, in some areas, by reddish, calcareous shale.

Tabler soils are on very flat, smooth upland plains. They are deep, nearly level, and moderately well drained. They have a loamy surface layer and a clayey subsoil that is underlain by clayey sediment.

The soils of minor extent are the deep, well drained Bethany and Pond Creek soils on ridge crests of upland plains and on high terraces; the deep Norge soils on the lower part of slopes; the deep, well drained Port soils on flood plains of upland drainageways; the deep, well drained Renfrow soils on side slopes of upland plains; and the deep, well drained Shellabarger soils on moderately high stream terraces.

The soils in this association have high potential for small grains and medium potential for grain sorghums. If the soils are cultivated, the main objectives in management are to conserve moisture, maintain soil structure and fertility, and keep erosion within allowable limits. Managing crop residue, adding plant nutrients, and terracing the very gently sloping soils are the major conservation practices that can be applied.

The soils in this association have medium potential for tame pasture and native grass. The quality of grass can be improved by proper stocking, controlling grazing, and preventing fires.

These soils have low potential for most urban uses. Sewage lagoons are generally a better choice than septic tank absorption fields because of the very slow permeability of the soils. The high shrink-swell potential in the clayey subsoil necessitates special design for building foundations and roads. The choice of trees and shrubs is limited by the clayey subsoil.

3. Pond Creek-Bethany-Grant Association

Deep, nearly level to strongly sloping, well drained, nonalkali soils that have a loamy surface layer and a predominantly loamy subsoil; on uplands

This association consists of nearly level to gently sloping soils on terraces and sloping to strongly sloping soils on hills. Slopes range from 0 to 12 percent but are dominantly less than 5 percent.

The topography ranges from nearly level to strongly sloping, but most of the terrain is nearly level to gently sloping. There are no prominent landforms or conspicuous geologic formations. Cultivated crops, primarily wheat, are the dominant plant cover. Widely spaced drainageways are the only water elements present. Visual diversity is low; thus, changes in the landscape are likely to be visually significant.

This association makes up about 16 percent of the county. It is about 43 percent Pond Creek soils, 28 percent Bethany soils, 20 percent Grant soils, and 9 percent soils of minor extent.

Pond Creek soils are on stream terrace uplands. They are deep, nearly level to very gently sloping, and well drained. They have a dark loamy surface layer and a loamy subsoil that is underlain by loamy sediment.

Bethany soils are on stream terrace uplands. They are deep, nearly level, and well drained. They have a loamy surface layer and a loamy and clayey subsoil that is underlain by mostly loamy sediment.

Grant soils are on rolling, loamy hills and the associated side slopes and on strongly sloping side slopes of upland drainageways. They are deep, very gently sloping to strongly sloping, and well drained. They have a loamy surface layer and a loamy subsoil that is underlain by Permian shales and sandstones.

The soils of minor extent are the moderately deep Kingfisher soils on upland side slopes; the deep Kirkland soils on upland plains; the deep North soils on the lower part of slopes; the deep Port soils on flood plains; the shallow Quinlan soils and the moderately deep Woodward soils on loamy hills, summits, and steep side slopes; and the deep Renfrow soils on side slopes of upland plains.

The soils in this association have moderately high potential for cultivated crops. Wheat, other small grains on lesser acreages, and sorghums are grown on these soils. The main concerns in management are conserving moisture, maintaining fertility and soil structure, and controlling erosion. Keeping crop residue on the soil surface, fertilizing, and terracing the very gently sloping and sloping soils are the major conservation practices that can be used.

The soils in this association have high potential for tame pasture and native grass. The quality of grass can be improved by proper stocking, planned grazing, and weed control.

These soils have medium potential for most urban uses. Septic tank absorption fields require a moderate amount of lateral lines. Building foundations require more than minimum design. Lawns, trees, and shrubs grow well on these soils but require extra care during dry periods.

4. Quinlan-Grant-Kingfisher Association

Shallow to deep, nearly level to strongly sloping, well drained, nonalkali soils that have a loamy surface layer and a loamy subsoil; on uplands

The soils making up this association are nearly level to strongly sloping and are on smooth, convex uplands that have some geologically eroded areas and small sharp breaks, buttes, and channels. Slopes range from 0 to 12 percent.

The topography ranges from nearly level to strongly sloping. Geologic erosion has produced some variation in landforms. Vegetative patterns are limited in diversity. Water elements are occasional narrow drainageways. Visual diversity is medium, so that changes in the landscape will be visually insignificant in most cases.

This association makes up about 4 percent of the county. It is about 35 percent Quinlan soils, 31 percent Grant soils, 29 percent Kingfisher soils, and 5 percent soils of minor extent.

Quinlan soils are on the summits and side slopes of small isolated hills on the eroded uplands. They are shallow, nearly level to strongly sloping, and well drained. They have a loamy surface layer and a loamy subsoil that is underlain by weakly consolidated, calcareous sandstone.

Grant soils are on rolling, loamy hills and the associated side slopes. Rills, shallow gullies, and a few deep gullies are in some areas. The soils are deep, gently sloping to sloping, and well drained. They have a thin loamy surface layer and a loamy subsoil that is underlain by silty shales and sandstones of Permian age.

Kingfisher soils are on rolling, loamy hills and the associated side slopes. Rills, shallow gullies, and a few deep gullies are in some areas. The soils are moderately deep, gently sloping to sloping, and well drained. They have a thin loamy surface layer and a loamy subsoil that is underlain by silty shales and sandstones of Permian age.

The soils of minor extent are the deep, well drained, loamy Attica soils, the deep, well drained, sandy Pratt soils, and the moderately deep, well drained, loamy Woodward soils. Attica and Pratt soils are undulating to hummocky eolian soils that are in small areas intermingled with areas of the loamy Quinlan and Woodward soils.

The soils in this association have medium potential for wheat and sorghums. The shallow soils are somewhat droughty. Conserving moisture and controlling erosion are the main concerns in management. Fertilizing to increase plant growth and crop residue helps provide shade and conserve moisture. Terracing helps to control erosion.

The potential for native range and tame pasture is medium; however, these uses adequately control erosion. The quality of grass can be improved by proper stocking, controlling grazing, and preventing fires.

The soils have medium potential for most urban uses. Septic tank absorption fields seldom function adequately in the Quinlan and Kingfisher soils because of depth to bedrock. Additional lateral lines are generally needed for proper functioning of septic tank absorption fields in the Grant soils.

5. Renfrow-Grainola Association

Deep and moderately deep, very gently sloping to gently sloping, well drained, nonalkali soils that have a loamy surface layer over a clayey subsoil; on uplands

The soils making up this association are in erosional areas and on smooth uplands. Slopes range from 1 to as much as 5 percent on side slopes of uplands.

The smooth uplands exhibit some variety on drainageway side slopes and occasional moderately steep slopes. The slopes commonly are 5 percent or less. Vegetative patterns are an equal mixture of native rangeland and cultivated cropland. Water elements are limited to narrow drainageways and scattered stock ponds. Visual diversity is medium, so that changes in the landscape will be visually insignificant in most cases.

This association makes up about 10 percent of the county. It is about 40 percent Renfrow soils, 30 percent Grainola soils, and 30 percent soils of minor extent.

Renfrow soils are on the side slopes of smooth uplands and on eroded uplands. They are deep, very gently sloping to gently sloping, and well drained. They have a loamy surface layer and a clayey subsoil that formed in material weathered from shale.

Grainola soils are on side slopes of uplands. They are moderately deep, very gently sloping to gently sloping, and well drained. They have a loamy surface and a clayey subsoil that formed in residuum of shale.

The soils of minor extent are the deep, well drained Bethany soils on ridge crests of uplands on plains of high terraces; the deep Grant soils and moderately deep Kingfisher and Woodward soils on side slopes; the deep, well drained Kirkland soils and moderately well drained Pawhuska soils on smooth upland plains; the shallow Masham soils on drainage breaks of uplands; and the deep, well drained Port soils on the flood plain of upland drainageways.

The soils in this association have medium potential for wheat and low potential for grain sorghums. Wheat is the main crop. In cultivated areas, the main objectives in management are to conserve moisture, maintain soil structure and fertility, and to keep erosion within tolerable limits. Managing crop residue, adding plant nutrients, and terracing are the major conservation practices that can be applied.

The soils have low potential for all grasses. The main objective in managing rangeland is to maintain a mixture of highly palatable perennial decreasers and allowable increasers. Maintaining soil fertility, practicing weed control, using rotation grazing, and protecting the area from uncontrolled burning are the major conservation practices that can be applied to pastureland and rangeland.

The soils have low potential for most urban uses. Septic tank absorption fields require extensive lateral lines to function. Building foundations and local roads and streets require special design because of the high shrink-swell potential of these soils. Droughtiness is a disadvantage for lawns and shrubs.

Deep, Nearly Level to Steep, Nonalkali, Sandy and Loamy Soils; on Uplands

The two map units in this group make up about 10 percent of Grant County. The soils are used mostly as rangelands. A small acreage is in field crops and tame pasture.

6. Attica-Goodnight-Pratt Association

Deep, nearly level to moderately steep, well drained and excessively drained, nonalkali soils that have a sandy or loamy surface layer and a sandy or loamy subsoil; on uplands

The soils making up this association are on undulating and hummocky slopes and stabilized sand dunes. Slopes range from 0 to 20 percent but are dominantly less than 12 percent.

The topography of this map unit is nearly level to moderately steep. Landforms are undulating and hummocky hills and stabilized sand dunes; no prominent geologic formations are visible. Vegetative patterns are somewhat diverse, as land uses are divided among cultivated crops, tame pasture, and native grasses. Drainageways are the only water elements present. Visual diversity is medium; changes in the landscape will be visually insignificant in most cases.

This association makes up about 8 percent of the county. It is about 30 percent Attica soils, 26 percent Goodnight soils, 16 percent Pratt soils, and 28 percent soils of minor extent.

Attica soils are on low, loamy knolls. They are deep, nearly level to gently sloping, and well drained. They have a loamy surface layer and a loamy subsoil that is underlain by sandy or loamy material.

Goodnight soils are on sandy hummocks and dunes near the Salt Fork of the Arkansas River. They are deep, very gently sloping to moderately steep, and excessively drained. They have a sandy surface layer and a sandy subsoil.

Pratt soils are on summits, side slopes, and foot slopes of undulating to slightly hummocky sandy knolls. They are deep, nearly level to sloping, and well drained. They have a sandy surface layer and a sandy subsoil that is underlain by sandy material.

The soils of minor extent are the deep Aline and Goltry soils on very gently undulating parts of the sandy uplands; the Carwile and Shellabarger soils on high river terraces; the Gracemont and Yahola soils on flood plains; and the Tivoli soils on dunes. Goltry soils have a water table that is beneficial to deep-rooted plants. Carwile soils are loamy and somewhat poorly drained. Gracemont, Shellabarger, and Yahola soils are deep and loamy.

The soils in this association have medium potential for cultivated crops. About one-half of the acreage is planted to wheat or sorghums. The soils must be carefully managed to keep wind erosion under control. Residue management, fertilizing, sorghum strips, and windbreaks are needed to control wind erosion. Also, some of the soils need to be limed if they are cultivated.

The soils have medium potential for native grasses and tame pasture. The quality of grasses can be improved by proper stocking, controlled grazing, and weed control.

The soils have medium potential for most urban uses. Special designs are needed for roads and streets because of the looseness of the sandy soils.

7. Tivoli-Goltry Association

Deep, steep to nearly level, excessively drained and moderately well drained, nonalkali soils that have a sandy surface layer and a sandy subsoil; on uplands

This association consists of stabilized sand dunes and undulating, sandy soils on terraces of streams. Slopes range from 0 to 30 percent.

The landforms of this map unit are highly varied, as the slope ranges from steep to nearly level. Vegetative patterns are varied because most of the acreage is native range. Water elements are scattered drainageways. Visual diversity is medium; thus, changes in the landscape will be visually insignificant in most cases.

This association makes up about 2 percent of the county. It is about 55 percent Tivoli soils, 28 percent Goltry soils, and 17 percent soils of minor extent.

Tivoli soils are stabilized sand dunes. They are deep, sloping to steep, and excessively drained. They have a sandy surface layer and a sandy subsoil over sandy, eolian parent material.

Goltry soils are on the low parts of the sand dune landscape. They are deep, nearly level to very gently sloping, and moderately well drained. The water table is high enough to favor adapted plants. The soils have a sandy surface layer and a sandy subsoil that is underlain by more sand.

The soils of minor extent are mainly the deep, sandy Aline and Pratt soils and the deep, loamy Attica soils. They are undulating and hummocky and are intermingled with the Tivoli and Goltry soils. Also included are the deep, sandy Goodnight soils on hummocks and dunes on flood plains.

The soils in this association have low potential for cultivated crops because of the sandy surface layer, the low fertility, and the hazard of wind erosion.

The soils are mainly used as native range. Tivoli soils produce small amounts of forage. Goltry soils, which have a beneficial water table, have high potential for native grass and tame pasture.

The soils have medium potential for most urban uses. In places the steep dunes of loose sand need to be leveled to provide a good building site. The seasonal high water table of Goltry soils can cause problems for many urban uses.

Deep, Nearly Level to Very Gently Sloping, Nonalkali and Alkali, Loamy and Sandy Soils; on Flood Plains and Terraces

The three map units in this group make up about 22 percent of Grant County. The soils are used mostly for wheat. In a few areas they are used as rangeland and for tame pasture.

8. McLain-Dale-Hawley Association

Deep, nearly level, moderately well drained and well drained, nonalkali soils that have a loamy surface layer over a clayey or loamy subsoil; on terraces and flood plains

The soils making up this association are on nearly level flood plains along the Salt Fork of the Arkansas River and some of the major streams within the county. They are subject to rare flooding. Slopes range from 0 to 1 percent.

The topography of this map unit consists of nearly level flood plains. Vegetative patterns present the greatest diversity in the county, as cropland, woodland, and rangeland are interspersed throughout. The water elements are numerous, consisting of major drainageways and their tributaries; shoreline patterns are varied and water clarity is high. Visual diversity is high; changes in the landscape are likely to be visually insignificant.

This association makes up about 16 percent of the county. It is about 28 percent McLain soils, 23 percent Dale soils, 14 percent Hawley soils, and 35 percent soils of minor extent.

McLain soils are on smooth to slightly concave alluvial terraces, well back from the stream channel, on the flood plains of the Salt Fork of the Arkansas River and large creeks. They are deep, nearly level, and moderately well drained. They have a loamy surface layer and a loamy and clayey subsoil.

Dale soils are on alluvial terraces of flood plains near the larger rivers and creeks. They are deep, nearly level, and well drained. They have a loamy surface layer and a loamy subsoil.

Hawley soils are on alluvial terraces of flood plains along the Salt Fork of the Arkansas River and large creeks. They are deep, nearly level, and well drained. They have a loamy surface layer and a loamy subsoil.

The soils of minor extent include the deep, somewhat poorly drained, clayey Lela soils and the deep, well drained Reinach soils on terraces of flood plains; and the deep, well drained Pocasset, Port, and Yahola soils on flood plains. Also included are gently sloping to sloping Dale soils, which are on the slopes between terraces of different elevations.

The soils in this association have high potential for wheat and sorghums. The main management objectives are to conserve moisture and maintain soil structure and fertility. Residue management and fertilizing generally achieve these objectives.

The soils have high potential for tame pasture and native grass. The quality of the grasses can be improved by proper stocking, controlling grazing, and preventing fires. Tame pasture should be fertilized.

The soils have low potential for most urban uses. Flooding is the main hazard for building sites in most areas.

9. McLain-Drummond-Oscar Association

Deep, nearly level to very gently sloping, moderately well drained and somewhat poorly drained, nonalkali and alkali soils that have a loamy surface layer over loamy or clayey sediment; on terraces and flood plains

The soils making up this association are on smooth to concave river terraces that are situated well back from the Salt Fork of the Arkansas River and from large creeks. Slopes range from 0 to 2 percent.

The nearly level to very gently sloping topography offers very little variety in landforms. Vegetative patterns have some diversity, as land uses are divided between rangeland and cultivated crops. Water elements are limited to scattered drainageways. Visual diversity is low; thus, changes in the landscape are likely to be visually significant.

This association makes up 4 percent of the county. It is about 41 percent McLain soils, 29 percent Drummond soils, 8 percent Oscar soils, and 22 percent soils of minor extent.

McLain soils are on smooth to slightly concave alluvial terraces on the flood plains of the river and large creeks. These deep, nearly level soils are moderately well drained. They have a loamy surface layer and a clayey subsoil.

Drummond soils are on smooth to concave alluvial terraces some way back on the flood plain from the Salt Fork of the Arkansas River and large creeks. These deep, nearly level soils are somewhat poorly drained. They have a loamy surface layer and a loamy and clayey subsoil. These soils are severely alkali-affected.

Oscar soils are on flood plains in upland drainageways. These deep, nearly level to very gently sloping soils are moderately well drained. They have a loamy surface layer and a loamy subsoil. They are alkali soils and are severely affected by salts.

The soils of minor extent are the deep Dale, Gracemont, Grant, Lela, Pocasset, and Port soils. Dale, Gracemont, and Port soils are loamy throughout. Dale and Lela soils are rarely flooded, Port soils are occasionally to frequently flooded, and Pocasset soils are frequently flooded. Gracemont soils are somewhat poorly drained and saline and are occasionally flooded. These soils all are on flood plains. Grant soils are on side slopes of upland drainageways; they occur in a complex with Oscar soils.

The soils in this association have medium potential for crops. In most areas they are used for sorghums or tame pasture. The main management objectives are to remove excess salts, to conserve moisture, and to maintain soil structure and fertility. Improving surface and subsurface drainage aids in the removal of salts from the affected area. Adding gypsum to a salt-affected soil converts adsorbed sodium into a leachable form. Protecting the soil surface from excessive evaporation by mulching or by planting salt-tolerant plants improves permeability and reduces evaporation. A temporary reduction of alkali can allow some crops, such as alfalfa, to become established in spite of salt concentrations that may develop later. Adding crop nutrients is also of some benefit on these soils.

The soils in this association have high potential for native grass and tame pasture. Establishment of tame pasture is difficult, but bermudagrass, tall wheatgrass, and alkali sacaton are salt-tolerant enough to produce on all but the worst salt spots.

The soils have low potential for most urban uses. The problems are flooding, poor surface drainage, high salt concentrations, and, in some soils, a high water table.

10. Yahola-Gaddy Association

Deep, nearly level to very gently sloping, well drained and somewhat excessively drained, alkali soils that have a loamy or sandy surface layer over loamy or sandy stratified alluvium; on flood plains

The soils making up this association are on smooth to undulating flood plains and old river channel bars along the Salt Fork of the Arkansas River. Slopes are 0 to 2 percent.

The topography has little variation in landforms or relief. Vegetative patterns are complex and highly diversified. Riverine woodland vegetation is intermixed with small acreages of cultivated crops. The Salt Fork of the River is the major water element; it has varied shoreline patterns and moderate water clarity. Visual diversity is high, so that changes in the landscape will be visually insignificant.

This association makes up about 2 percent of the county. It is about 38 percent Yahola soils, 33 percent Gaddy soils, and 29 percent soils of minor extent.

Yahola soils are in old river channels on flood plains along the river. They are deep, nearly level, and well drained. They have a loamy surface layer that is underlain by stratified loamy alluvium.

Gaddy soils are channel bank and channel bar deposits on flood plains. They are deep, nearly level to very gently sloping, and somewhat excessively drained. They have a sandy surface layer that is underlain by stratified sandy alluvium.

The soils of minor extent in this association are the deep, well drained Dale, Hawley, McLain, and Reinach soils on terraces of flood plains; the deep, excessively drained Goodnight soils on sandy hummocks and dunes along the river; and the deep, well drained Pocasset and Port soils on flood plains.

The soils in this association are used mainly as native rangelands. Small acreages are in alfalfa, small grains, sorghums, and tame pasture. The potential for these uses is medium. The major objective in range management is to maintain highly palatable forage. Controlled grazing, protection from burning, and weed and brush control are beneficial.

The soils naturally support good habitat for wildlife. Planting and maintaining a good stand of deciduous trees, conifers, and shrubs for cover are very beneficial to wildlife. Native grass, legumes, and wild herbaceous plants for wildlife are generally abundant on these soils.

The potential of Yahola and Gaddy soils is low for most urban uses. Flooding is the main hazard.

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 "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 underlying material, 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 underlying material. 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, Grant silt loam, 1 to 3 percent slopes, is one of several phases in the Grant series.

Some map units are made up of two or more major soils. These map units are called soil complexes or undifferentiated groups.

A *soil complex* consists of two or more soils 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. Grant-Kingfisher silt loams, 4 to 8 percent slopes, is an example.

An *undifferentiated group* is made up of two or more soils that could be mapped individually but are mapped as one unit because similar interpretations can be made for use and management. The pattern and proportion of the soils in a mapped area are not uniform. An area can be made up of only one of the major soils, or it can be made up of all of them. Port and Pocasset soils, frequently flooded, is an undifferentiated group in this survey area.

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 small *miscellaneous areas*. Such areas have little or no soil material and support little or no vegetation. Small areas of outcrops of shale or of slickspots are examples. Miscellaneous areas are identified by a special symbol on the soil maps.

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.

1—Aline fine sand, 0 to 3 percent slopes. This is a deep, somewhat excessively drained, nearly level to very gently sloping soil. It is in the sandy deposits on terraces. Slopes are undulating. Most areas are less than 200 acres.

Typically, the surface layer is brown fine sand about 9 inches thick. The subsurface layer is pale brown fine sand that extends to a depth of about 38 inches. The subsoil is alternating layers of light brown fine sand 1/2 inch to 4 inches thick and reddish yellow loamy fine sand 1/4 inch to 2 inches thick. It extends to a depth of about 80 inches.

This soil is low in natural fertility and in organic matter content. The surface layer is medium acid to neutral. Permeability is rapid, and the available water capacity is low. The root zone is deep and easy for plant roots to penetrate.

Included with this soil in mapping are intermingled areas of Goltry soils on the lowest parts of the landscape; Goodnight soils near the river; Pratt soils, which are slightly hummocky but at similar elevations; and Tivoli soils or sand dunes at higher elevations on the landscape. The included soils make up about 15 percent of the map unit, but individual areas generally are less than 5 acres.

This soil has low potential for cultivated crops. Wind erosion is a severe hazard, natural fertility is low, and the available water capacity is low. The hazard of wind erosion can be reduced by planting windbreaks, keeping crop residue in and on the surface layer, and planting sorghum strips.

This soil has medium potential for native range and tame pasture. Weeping lovegrass is a good tame pasture grass for this soil. Forage production can be increased by fertilizing with nitrogen and controlling stocking rates to prevent overgrazing.

This soil has high potential for most urban uses. The loose, sandy surface layer is subject to wind erosion until lawns and shrubs are established. This soil is a poor filter for septic tank absorption fields. Seepage is a limitation for sewage lagoons. There are no limitations for roads and streets, commercial buildings, or dwellings.

This soil is in capability subclass IVs and in the Deep Sand range site.

2—Attica fine sandy loam, 0 to 3 percent slopes. This is a deep, well drained, nearly level to very gently sloping soil on uplands. Slopes are slightly undulating. Most areas are less than 100 acres.

Typically, the surface layer is brown fine sandy loam about 9 inches thick. The upper part of the subsoil is reddish brown loam to a depth of about 24 inches, and the lower part is light reddish brown loamy fine sand to a depth of 45 inches. The underlying material is reddish yellow fine sand to a depth of about 75 inches.

Attica soils are medium in natural fertility and low in organic matter content. Reaction in the plow layer ranges from medium acid to neutral. The available water capacity is medium, and permeability is moderately rapid. The soil is easy for plant roots to penetrate. The surface layer is very friable and is subject to severe wind erosion when dry.

Included with this soil in mapping are a few intermingled areas of Pratt soils. Also included are soils similar to the Attica soil except that the underlying material is silt loam, which is at a depth of 30 to 45 inches in about 5 percent of this map unit and at a depth of 45 to 80 inches in about 15 percent. All of the included soils combined make up about 25 percent of the map unit. The individual areas are less than 5 acres.

This soil has medium potential for wheat, grain sorghums, and forage sorghums. Controlling wind erosion and maintaining adequate fertility are the main concerns in soil management (fig. 1). Leaving plant residue on the soil surface helps control erosion and reduce the soil temperature and evaporation. Applying proper fertilizer or planting nitrogen-fixing plants promotes crop growth, increases residue, and improves fertility. Emergency tillage when soil blowing is severe roughens the surface by bringing clods to the surface.

The potential is medium for native grass and tame pasture. Proper fertilization of tame pasture includes nitrogen fertilizer. All grasses can be improved by preventing wildfires, proper stocking, and controlling weeds.

This soil has high potential for most urban uses. It is particularly well suited to septic tanks, building foundations, roads, streets, trees, and shrubs. Seepage is a limitation for sewage lagoons and sanitary landfills.

This soil is in capability subclass IIe and in the Sandy Prairie range site.

3—Attica fine sandy loam, 3 to 5 percent slopes. This is a deep, well drained, gently sloping soil on uplands. Slopes are short and moderately convex. The mapped areas generally range from 10 to 250 acres.

This soil is medium in natural fertility and low in organic matter content. Reaction ranges from medium acid to neutral in the plow layer and from slightly acid to mildly alkaline in the subsoil. The available water capacity is medium, and permeability is moderately rapid. This soil is easy for plant roots to penetrate. The surface layer is very friable and is subject to severe wind erosion when dry.

Included with this soil in mapping are areas of Pratt and Shellabarger soils, each of which makes up about 10 percent of this map unit. The individual areas generally are 5 acres or less.

This Attica soil has medium potential for wheat and grain sorghums. Wind erosion is a severe hazard if this soil is planted to sorghums or small grains. Proper fertilization is helpful in producing the amount of crop residue needed to control soil blowing. Fewer tillage operations, cover crops, and stripcropping are needed to control soil blowing if this soil is cultivated. Emergency tillage when soil blowing is severe roughens the soil surface by bringing clods to the surface.

The soil has medium potential for tame pasture and native grass. Bermudagrass and weeping lovegrass are well suited to this soil, provided that the pasture is properly fertilized and properly stocked. Controlled grazing, mowing weeds, and preventing wildfire improve the quality of all grasses.

The soil has high potential for most urban uses. The low shrink-swell potential makes it suitable for building foundations. There are no significant limitations for dwellings, septic tank absorption fields, roads, and streets.

This soil is in capability subclass IIIe and in the Sandy Prairie range site.

4—Bethany silt loam, 0 to 1 percent slopes. This is a deep, well drained, nearly level soil on intermediate and high terraces of uplands. Slopes are broad and smooth. The areas range from 10 to 2,000 acres.

Typically, the surface layer is dark grayish brown silt loam about 12 inches thick. The upper part of the

Figure 1.—Sorghum strips protect the soil from wind erosion in an area of Attica fine sandy loam, 0 to 3 percent slopes.

subsoil is brown silty clay loam about 4 inches thick. The middle part, to a depth of about 48 inches, is brown and dark brown silty clay. The lower part of the subsoil is yellowish red silty clay loam to a depth of about 72 inches.

This soil is high in natural fertility and in organic matter content. The surface layer is medium acid to neutral. Permeability is slow, and the available water capacity is high. The root zone is deep, but it is moderately difficult for plant roots to penetrate below a depth of 20 inches.

Included with this soil in mapping are Kirkland soils in slightly depressional areas and Pond Creek soils intermingled on the landscape with the Bethany soil; each of these soils makes up about 5 percent of the map unit. Also included are intermingled soils similar to the Bethany soil except that the lower part of the argillic horizon is brown and does not have coarse mottles; these soils make up about 5 percent of the map unit. Individual areas of the included soils generally are less than 5 acres.

The potential is high for small grains and row crops. Maintaining soil structure and fertility are the main concerns in management. Fertilizing to obtain a large amount of crop residue helps to maintain soil structure and fertility. An adequate cover of residue can hold down the surface temperature and the evaporation of moisture from this soil. Minimum tillage also helps maintain soil structure.

The potential for tame pasture and native grass is medium. The quality of all grasses can be improved by preventing wildfires, proper stocking, and controlling weeds. Fertilizing tame pasture increases the production of forage and improves the quality.

The potential is medium for most urban uses. There are no significant limitations for area sanitary landfills. The slow permeability is a limitation for septic tank absorption fields, and the clay content is a limitation for trench sanitary landfills. The main limitation for dwellings, commercial buildings, roads, and streets is the shrink-swell potential. Most of these limitations can be overcome by proper design or by altering the soil.

This soil is in capability class I and in the Loamy Prairie range site.

5—Carwile-Attica complex, 0 to 2 percent slopes. This complex consists of deep Carwile and Attica soils on terraces of uplands. These soils are so intricately intermingled that mapping them separately was impractical at the scale selected for mapping. The Carwile soil is somewhat poorly drained and is in low swales. The Attica soil is well drained. It is on side slopes and in undulating areas a few feet higher than the Carwile soil.

The Carwile soil makes up 35 percent of the map unit. Typically, the surface layer is very dark gray loam about 14 inches thick. The upper part of the subsoil, to a depth of about 39 inches, is gray clay that has brownish mottles. The underlying material is light gray sandy clay that has brownish and yellowish mottles.

The Carwile soil is high in natural fertility and medium in organic matter content. The surface layer is moderately alkaline and generally is calcareous. Permeability is slow. The available water capacity is high. This soil is ponded for short periods and remains wet for extended periods. The wetness delays tillage and harvesting and reduces crop yields. An apparent water table is at a depth of 0 to 2 feet from fall to spring during wet years. This soil is easy for plant roots to penetrate.

The Attica soil makes up 20 percent of the map unit. Typically, the surface layer is yellowish brown loamy fine sand about 12 inches thick. The upper part of the subsoil is strong brown fine sandy loam to a depth of about 36 inches, and the lower part is brown fine sandy loam to a depth of about 44 inches. The underlying material is grayish brown sandy loam to a depth of 75 inches or more.

The Attica soil is medium in natural fertility and low in organic matter content. Reaction in the plow layer ranges from medium acid to neutral. The available water capacity is high, and permeability is moderately rapid. The root zone is easy for plant roots to penetrate. The surface layer of this soil is very friable and is subject to severe wind erosion when dry.

Included with these soils in mapping and intermingled with them are areas of Goltry and Pratt soils, each of which makes up about 10 percent of the map unit. Also included, and making up about 15 percent of the map unit, are soils similar to the Carwile soil except that they are redder or have a fine-loamy argillic horizon. Also included, and making up about 10 percent, are soils similar to the Attica soil except that they have gray mottles at a depth of 40 inches or less. The individual areas of the included soils are less than 5 acres.

These soils have medium potential for small grains and sorghums. Controlling soil blowing, maintaining fertility, and providing adequate surface drainage are the main concerns in management. Soil blowing can be controlled by adequate crop residue on the surface, field windbreaks, forage trap strips, and strip crops. Emergency tillage, at right angles to the prevailing winds, roughens the surface and helps reduce wind erosion. Applications of commercial fertilizer and legume crops help maintain soil fertility and increase crop residue. Surface drainage can be improved by land smoothing. Drainage ditches are difficult to install because of the complex pattern of the Carwile soil. Applications of lime may be needed in the undulating areas.

The soils have medium potential for native grass and tame pasture plants, such as bermudagrass or weeping lovegrass. Proper fertilization of tame pasture includes use of nitrogen fertilizer. All grasses can be improved by controlling fires, proper stocking, and controlling weeds.

The potential is medium for most urban uses. The Attica soil has no significant limitation for septic tank absorption fields, building foundations, roads, streets, or tree and shrub plantings. The seasonal wetness and high shrink-swell potential of the Carwile soil are limitations for dwellings, small commercial buildings, roads, and streets. The wetness problem is very difficult and expensive to overcome for building sites. Septic tank absorption fields in areas of Carwile soil cease to function during wet periods.

The soils in this complex are in capability subclass IIw. The Carwile soil is in the Loamy Bottomland range site, and the Attica soil is in the Sandy Prairie range site.

6—Dale silt loam, rarely flooded, 0 to 1 percent slopes. This is a well drained, nearly level soil on low stream terraces. Slopes are broad, smooth, and slightly convex. Individual areas generally are parallel to streams and range from 10 to 1,200 acres.

Typically, the surface layer is brown silt loam about 15 inches thick. The subsoil is brown and reddish brown silt loam to a depth of about 48 inches. The underlying material is yellowish red silt loam that extends to a depth of about 72 inches.

This soil is high in natural fertility and organic matter content. The surface layer is slightly acid to mildly alkaline. The available water capacity is high, and permeability is moderate. Ground water below a depth of 80 inches is available to some deep-rooting plants in the spring of most years. This soil has good tilth and can be easily worked throughout a wide range of moisture content. The root zone is deep and is easily penetrated by plant roots.

Included with this soil in mapping are intermingled areas of McLain and Reinach soils and some areas of Dale soils that have slopes of more than 1 percent. McLain soils make up about 10 percent of the map unit, and Reinach soils make up 5 percent. The areas of the included soils generally are less than 5 acres.

This soil has high potential for wheat, grain sorghums, and forage sorghums. It has high potential for alfalfa because underground water is available to the deep roots. Maintaining soil structure and fertility are the main concerns in management. Leaving plant residue on the surface and applying proper fertilizer help maintain soil structure, fertility, and soil moisture.

The potential is high for native grass and tame pasture. Proper fertilization on tame pasture includes nitrogen, which helps improve the quality of grasses. Proper grazing, controlling weeds, and preventing wildfires improve the quality of all grasses.

This soil has low potential for most urban uses. Flooding is the main limitation. Upstream flood control structures and conservation practices can reduce the flood hazard but cannot completely eliminate flooding.

This soil is in capability class I and in the Loamy Bottomland range site.

7—Dale silt loam, rarely flooded, 3 to 8 percent slopes. This is a deep, well drained, gently sloping to sloping soil on short breaking slopes that separate low areas along flood plains from higher areas along terraces. This soil is also on short side slopes of old stream channels that are not at present the major stream in the area. The slopes are uneven and the areas are irregular in shape because of the meandering old stream channels. Most areas range from 10 to 100 acres.

Typically, the surface layer is brown silt loam about 23 inches thick. The subsoil, to a depth of about 52 inches, is also brown silt loam. The underlying material is the surface layer of a buried soil. It is brown, calcareous silt loam that extends to a depth of more than 72 inches.

This soil is high in natural fertility and in organic matter content. The surface layer is slightly acid to mildly alkaline. The available water capacity is high, and permeability is moderate. Ground water is available to deep-rooted plants in the spring of most years. This soil has good tilth and can be easily worked throughout a wide range of moisture content. The root zone is deep and is easily penetrated by plant roots.

Included with this soil in mapping are areas of Hawley, Port, and Reinach soils. Hawley soils generally are in the bends of creeks. Port soils are in lower areas and in channels. Reinach soils are intermingled with the Dale soil. The included soils make up about 10 percent of the map unit, but the individual areas are generally less than 5 acres.

This soil has high potential for wheat, grain sorghums, forage sorghums, and alfalfa. Maintaining soil structure and fertility and controlling erosion are the main concerns in management. Leaving plant residue on the surface and applying fertilizers help to accomplish these goals. Minimum tillage also helps control erosion. Terracing is difficult on the short slopes.

The potential is high for native grasses and tame pasture. Proper fertilizers for tame pasture include nitrogen and, in some areas, phosphate. The quality of all grasses can be improved by preventing fires, proper grazing, and controlling weeds.

This soil has low potential for most urban uses because of the hazard of flooding. Upstream flood control structures and conservation practices can reduce the hazard but cannot completely eliminate flooding.

This soil is in capability subclass IIIe and in the Loamy Bottomland range site.

8—Drummond loam, saline, rarely flooded. This is a deep, somewhat poorly drained, nearly level saline and alkali soil. It is on low terraces of flood plains. Slopes are 0 to 1 percent and are smooth in most areas, but some areas are uneven and have shallow channels. The areas are irregular in shape and range from 10 to 150 acres.

Typically, the surface layer is dark grayish brown loam about 4 inches thick. The subsoil is grayish brown and dark grayish brown clay to a depth of about 44 inches. The underlying material is dark grayish brown clay.

This soil is low in natural fertility and medium in organic matter content. Because of the salts in this soil, the available water capacity is medium or low. Permeability is very slow. Only salt-tolerant plants survive on this saline and alkali soil. The soil is subject to rare flooding. It has an apparent water table at a depth of 2 to 4 feet from fall to spring.

Included with this soil in mapping are areas of soils that are similar to the Drummond soil except that the argillic horizon has an average clay content of less than 35 percent and soils that are similar to the Drummond soil except that the surface layer is fine sand, sandy loam, silt loam, or silty clay loam about 10 to 20 inches thick and has a low content of salts. The included soils make up about 15 percent of the map unit, but individual areas generally are less than 5 acres.

Potential is low for cultivated crops. The high salt and sodium content significantly reduces crop yields.

In most areas, this Drummond soil is used for native grass. It has medium potential for native grass because of the quality of forage produced. The proportion of desirable range plants and plant vigor can be maintained or improved by a timely weed and brush control program. This soil is moderately well suited to bermudagrass or tall wheatgrass. On native rangeland and tame pasture, proper stocking, rotation grazing, and timely deferment of grazing help keep the grass and soil in good condition.

This soil has low potential for most urban uses. Flooding, excess salt and alkali content, extended periods of wetness, and the high shrink-swell potential are the major limitations.

This soil is in capability subclass Vs and in the Saline Subirrigated range site.

9—Gaddy fine sand, frequently flooded. This is a deep, somewhat excessively drained, nearly level and very gently sloping soil. It is in elongated areas on flood plains. Slopes are smooth to undulating and range from 0 to 2 percent. Most areas range from 20 to about 300 acres.

Typically, the surface layer is pale brown fine sand about 7 inches thick. The underlying material is very pale brown fine sand that has thin strata of loam and clay loam. It extends to a depth of about 60 inches. In some areas, the surface layer is fine sandy loam, loam, or silt loam.

This soil is low in natural fertility and in organic matter content. The surface layer is moderately alkaline. Permeability is moderately rapid or rapid, and the available water capacity is low. This soil has a deep root zone. It is subject to frequent flooding.

Included with this soil in mapping are a few intermingled areas of Yahola soils, which make up about 5 percent of the map unit. Also included are saline soils that are similar to the Gaddy soil but have a water table within a depth of 40 inches during the spring; these soils make up about 5 percent of the map unit. The individual areas of included soils are generally less than 3 acres.

The potential for small grains and row crops is very low. Frequent flooding is the main limitation.

The potential for native grass and tame pasture is medium. Protecting the soil from flooding, controlling erosion, increasing the available water capacity, and maintaining fertility are all concerns in management. Fertilizer is needed on tame pasture to increase the density of the grass cover and thus to protect the soil from erosion. Brush control, proper grazing, and protection from fire are good management practices to improve stands of all grasses.

The potential for most urban uses is low. The main limitation is flooding. The potential flood hazard is extremely high for all types of community developments on this soil. Upstream flood control can reduce the hazard but cannot completely eliminate flooding.

This soil is in capability subclass Vw and in the Sandy Bottomland range site.

10—Gaddy loamy fine sand, occasionally flooded. This is a deep, somewhat excessively drained, nearly level and very gently sloping soil on flood plains. Slopes are smooth to undulating and range from 0 to 2 percent. Most areas range from 10 to 400 acres.

Typically, the surface layer is reddish yellow loamy fine sand about 12 inches thick. The underlying material to a depth of about 64 inches is reddish yellow loamy fine sand and is stratified with thin layers of fine sand to clay loam.

This soil is low in natural fertility and in organic matter content. The surface layer is moderately alkaline. Permeability is moderately rapid or rapid, and the available water capacity is low. This soil has a deep root zone. It is subject to occasional flooding.

Included with this soil in mapping are intermingled areas of Yahola soils and soils that are similar to the Gaddy soil except that the underlying material has strata of reddish loam and clay loam about 6 to 15 inches thick. Also included are Goodnight soils on hummocks and dunes. The included soils make up about 10 percent of the map unit, but the individual areas are generally less than 5 acres.

The potential for small grains and row crops is low. Controlling erosion, minimizing damage caused by flooding, and maintaining fertility are the main concerns in management. Soil blowing can be reduced by planting row crops at a right angle to the prevailing wind. Proper fertilization helps growing crops to form a thick cover that protects the soil from erosion by floodwaters. Cover crops and minimum tillage to maintain abundant residue in and on the surface layer help to control wind erosion and to reduce summer soil temperature and loss of soil moisture. Flood control structures reduce the hazard of flooding.

The potential for native grass and tame pasture is medium. Protecting the soil from flooding, controlling erosion, increasing the available water capacity, and maintaining fertility are all concerns in management. Fertilizer is needed on tame pasture to increase the density of the grass cover and thus to protect the soil from erosion. Brush control, proper grazing, and protection from wildfires also help to improve stands of all grasses.

The potential for most urban uses is low. The main limitation is flooding. The potential hazard of flooding is high for all types of community development on this soil. Upstream flood control can reduce the hazard but cannot completely eliminate flooding.

This soil is in capability subclass IIIs and in the Sandy Bottomland range site.

11—Goltry fine sand, 0 to 2 percent slopes. This is a deep, moderately well drained soil on sandy uplands. This soil is on the lowest parts of the landscape. Slopes are nearly level to undulating. The areas are 40 to 200 acres.

Typically, this Goltry soil has a grayish brown, fine sand surface layer about 12 inches thick. The subsurface layer is very pale brown fine sand about 23 inches thick. The upper part of the subsoil consists of bands of reddish yellow loamy fine sand 1/4 inch to 4 inches thick separated by very pale brown fine sand subsurface material in layers 1/2 inch to 4 inches thick. Below a depth of 48 inches the subsoil has bands of reddish yellow loamy fine sand separated by layers of reddish yellow fine sand.

This soil is low in natural fertility and in organic matter content. It is rapidly permeable above the water table. The available water capacity is low. Root penetration is deep and rapid with adequate fertilization. An apparent water table is at a depth of 2.5 to 6 feet in wet winter seasons and at a depth of about 5 to 6.5 feet during dry periods.

Included with this soil in mapping are small areas of Aline and Pratt soils on the higher parts of the landscape. Also included, in depressional areas, are soils that are similar to the Goltry soil except that they have a water table at a depth of less than 30 inches in wet periods. The included soils make up about 15 percent of the map unit, but the individual areas generally are less than 10 acres.

This soil has low potential for small grains and grain sorghums. Wind erosion is a severe hazard if cultivated crops are grown. Crop residue in and on the surface layer reduces wind erosion and helps prevent soil loss. A cover crop is needed to protect the soil during winter.

Goltry soils have medium potential for tame pasture and high potential for native grass. Because of the water table, forage production is high where this soil is properly fertilized. Proper grazing and preventing wildfires increase the quality of all grasses.

This soil has high potential for most urban uses. It is too wet during most seasons for dwellings with basements. The sandy surface layer is a problem until lawns and shrubs are established. Septic tank absorption fields commonly fail in this soil because of the seasonal water table. Improved roads are easy to build, but the shoulders are liable to erode excessively.

This soil is in capability subclass IVs and in the Subirrigated range site.

12—Goodnight fine sand, 5 to 15 percent slopes. This is a deep, excessively drained, sloping to moderately steep soil. It forms hummocks and dunes on flood plains. Slopes are smooth and slightly convex on the top and sides of dunes and slightly concave in the areas between dunes. The areas range from 10 to about 100 acres.

Typically, the surface layer is light yellowish brown fine sand about 6 inches thick. The underlying material is reddish yellow fine sand that extends to a depth of about 60 inches.

This soil is low in natural fertility and in organic matter content. The surface layer is neutral to moderately alkaline. Permeability is rapid, and the available water capacity is low. The root zone is deep and is easily penetrated by plant roots.

Included with this soil in mapping are intermingled areas of Aline and Tivoli soils. Also included are intermingled areas of Yahola soils in low positions between dunes. The included soils make up about 10 percent of the map unit, but the individual areas generally are less than 5 acres.

This soil has low potential for cultivated crops and tame pasture. It is not cultivated or used for tame pasture because of the steep slopes, the very severe hazard of wind erosion, and the low available moisture for plant use.

This soil has medium potential for native grass. It is subject to severe erosion in areas that are overgrazed. Blowouts can occur on high dunes. Proper grazing, controlling brush, and preventing wildfires help to improve the stand of grass.

This soil has low potential for most urban uses. Some leveling is generally needed for building sites. Seepage from sanitary facilities can contaminate the underground water supply in this sandy soil.

This soil is in capability subclass VIe and in the Deep Sand range site.

13—Goodnight loamy fine sand, 2 to 6 percent slopes. This is a deep, excessively drained, very gently sloping to sloping soil. It forms dunes or hummocks on the flood plain of the Salt Fork of the Arkansas River. Slopes are smooth and slightly convex on the top and sides of dunes and slightly concave between hummocks and dunes. The areas range from 10 to 100 acres.

Typically, the surface layer is brown loamy fine sand about 8 inches thick. The underlying material is brown and light brown loamy fine sand and reddish yellow fine sand that extends to a depth of about 80 inches.

This soil is low in natural fertility and in organic matter content. Permeability is rapid, and the available water capacity is low. This soil can be tilled within a wide range of moisture content, but it blows easily when dry. The root zone is deep and is easily penetrated by plant roots.

Included with this soil in mapping are intermingled areas of Attica, Gaddy, Hawley, and Yahola soils. The included soils make up about 15 percent of the map unit, but the individual areas are less than 5 acres.

This soil has low potential for small grains and sorghums. Controlling soil blowing, maintaining fertility, and overcoming droughtiness are the main concerns in management. Soil blowing can be controlled by protecting the surface with an adequate amount of crop residue during the period of fallow and early seedling growth. Field windbreaks, forage trap strips, and stripcropping also help reduce wind erosion. Emergency tillage operations, such as listing, ridging, duckfooting, and chiseling, help to roughen the soil surface and bring stable aggregates to the surface. All of these practices should be done at a right angle to the prevailing wind. Soil fertility can be maintained by using commercial fertilizer and including soil-improving crops in the rotation. Moisture loss can be reduced through a good residue management program. A cover of crop residue acts as an insulator, holds down the summer soil temperature, and reduces air movement over the soil surface, thus reducing evaporation. Adding organic matter to this soil increases its available water capacity and improves its structural stability. Residue management, additions of farm manures, and sod crops provide extra organic matter.

The potential for native grass and tame pasture is medium. Weeping lovegrass, if properly fertilized, grows well and effectively controls wind erosion. The quality of all grasses can be improved by controlled grazing, properly managing livestock, and preventing wildfires.

This soil has low potential for most urban uses. Seepage is the major problem for sanitary facilities. Flooding, soil blowing, and droughtiness are the major problems for building site development. Soil blowing and flooding are the main problems for recreational development.

This soil is in capability class IVe and in the Deep Sand range site.

14—Gracemont loam, saline, occasionally flooded. This is a deep, somewhat poorly drained, nearly level soil on flood plains. Slopes are smooth to slightly undulating and range from 0 to 2 percent. The areas range from 10 to 400 acres.

Typically, the surface layer is brown loam about 9 inches thick. The next layer is reddish brown fine sandy loam to a depth of about 16 inches and yellowish red fine sandy loam to a depth of about 25 inches. The next layer is dark grayish brown fine sandy loam to a depth of about 39 inches. The underlying material to a depth of about 60 inches is brown fine sandy loam stratified with darker loam and sandy clay loam.

This soil is medium in natural fertility and low in organic matter content. The surface layer is moderately alkaline. The permeability is moderately rapid, and the available water capacity is medium to high. The root zone is deep and is easily penetrated by plant roots. Tilth is fair. This soil is occasionally flooded, and it has an apparent water table at a depth of 2 to 3 feet during winter and spring.

Included with this soil in mapping are areas of Attica, Hawley, and Pratt soils in higher positions. Also included are intermingled areas of soils that are similar to the Gracemont soil except that the surface layer is very dark grayish brown and more than 10 inches thick, or mottles of low chroma are in the lower part of the soil, or exchangeable sodium is more than 15 percent. The included soils make up about 30 percent of the map unit, but the areas generally are less than 5 acres.

This soil has low potential for small grains. Salinity, a seasonal high water table, wind erosion, and maintaining fertility are the main concerns in management. Large amounts of crop residue on the surface reduce evaporation and thus reduce the amount of salts accumulating in the surface layer; crop residue also helps protect the soil from wind erosion. Drainage, in some areas, can lower the water table and help reduce the concentration of salts in the root zone.

The potential is medium for native grasses and tame pasture. The main tame pasture grasses are improved bermudagrass, weeping lovegrass, plains bluestem, and tall wheatgrass. Forage production can be increased by fertilizing with nitrogen. The quality of all grasses can be improved by proper stocking and weed control.

The potential for most urban uses is low. Flooding, wetness, and salinity are the main limitations. Upstream flood control can reduce the flood hazard but cannot completely eliminate flooding. The water table causes septic tanks to fail during part of most years.

This soil is in capability subclass IVs and in the Saline Subirrigated range site.

15—Grainola silty clay loam, 1 to 3 percent slopes. This is a moderately deep, well drained, very gently sloping soil on uplands. Slopes are smooth and slightly convex. The areas range from 10 to about 150 acres.

Typically, the surface layer is reddish brown silty clay loam about 6 inches thick. The subsoil, to a depth of about 25 inches, is reddish brown silty clay. The underlying material is reddish brown weathered shale that extends to a depth of 29 inches or more.

This soil is high in natural fertility and low in organic matter content. The surface layer is mildly alkaline or moderately alkaline. Permeability is slow, and the available water capacity is medium. The root zone is moderately deep, but this soil is difficult for roots to penetrate when it is dry.

Included with this soil in mapping are areas of Masham soils on ridge crests or more convex side slopes and Renfrow soils on smooth side slopes. The included soils make up about 15 percent of the map unit, but the individual areas are generally less than 5 acres.

This soil has low potential for small grains and row crops. Winter crops, principally wheat, are the best adapted, but the yield is low on this droughty soil. Terraces are needed to aid in the control of water erosion. Residue management and minimum tillage are needed to control erosion, reduce evaporation, and improve infiltration. Grassed waterways are needed to prevent gullies from forming at terrace outlets. Terraces need to be plowed periodically, and excessive plant growth in the waterways should be controlled; otherwise, the terraces and waterways can become silted up and fail their purpose. Tillage operations on this soil need to be timely to prevent breakdown of soil structure, which causes reduction of pore space, and to prevent cloddiness, which hinders germination and seedling growth.

The potential for native grass is medium. Tame pasture grasses produce low yields on this soil. Grass stands can be improved by proper grazing and preventing wildfires.

The clayey subsoil, high shrink-swell potential, slow permeability, moderate depth, and high corrosivity for steel pipes make this soil low in potential for most urban uses. The soil is muddy and sticky if it is used for lawns. For a septic tank absorption field to function adequately, suitable loamy material can be mounded over the laterals, the filter field can be enlarged, or a second absorption field can be added for wet periods. Sewage lagoons are difficult to build, but they function well on this soil. Building foundations have to be designed to withstand the shrinking and swelling of the soil. Roads and streets are difficult to maintain because of the high shrink-swell potential.

This soil is in capability subclass IIIe and in the Shallow Prairie range site.

16—Grainola silty clay loam, 3 to 5 percent slopes. This is a moderately deep, well drained, gently sloping soil on short side slopes of uplands. Slopes are smooth and slightly convex. The areas generally range from 30 to about 400 acres, but some areas are about 15 acres.

The surface layer is reddish brown silty clay loam about 5 inches thick. The upper part of the subsoil is reddish brown clay loam about 3 inches thick; the middle and lower parts are red silty clay to a depth of about 28 inches. The underlying material to a depth of 32 or more inches is red, weathered shale that has light greenish gray spots.

This soil is high in natural fertility and low in organic matter content. The surface layer is moderately alkaline. Permeability is slow, and the available water capacity is medium. The root zone is moderately deep, but this soil is difficult for roots to penetrate when it is dry.

Included with this soil in mapping are areas of Masham soils on ridge crests or more convex side slopes and Renfrow soils on smooth side slopes. Also included are in a few highly fertilized areas of the Grainola soil where the surface layer is neutral. The included soils make up about 15 percent of the map unit, but the individual areas are generally less than 5 acres.

This soil has low potential for small grains and row crops. Winter crops, principally wheat, are the best adapted, but the yield is low on this droughty soil. Row crops tend to induce excessive erosion and should be avoided. Terraces are needed to help control water erosion. Residue management and minimum tillage are needed to control erosion, reduce evaporation, and improve infiltration. Grassed waterways help prevent the formation of gullies at terrace outlets. Terraces need to be plowed periodically, and excess vegetation in waterways needs to be mowed to prevent it from trapping silt and choking the waterway.

The potential for native grass and tame pasture is low. Tame pasture grasses produce low yields on this soil. Grass stands can be improved by proper grazing and preventing fires.

The clayey subsoil, high shrink-swell potential, slow permeability, moderate depth, and high corrosivity for steel pipes make this soil low in potential for most urban uses. The soil is muddy and sticky if it is used for lawns. For a septic tank absorption field to function adequately, suitable loamy material can be mounded over the laterals, the filter field can be enlarged, or a second absorption field can be added for wet periods. Sewage lagoons are difficult to build, but they function well on this soil. Building foundations have to be designed to withstand the shrinking and swelling of the soil. Roads and streets are difficult to maintain because of the high shrink-swell potential.

This soil is in capability subclass IVe and in the Shallow Prairie range site.

17—Grant silt loam, 1 to 3 percent slopes. This is a deep, well drained, very gently sloping soil on broad uplands. Slopes are smooth and slightly convex. The areas range from 10 to 400 acres.

Typically, the surface layer is brown silt loam about 12 inches thick. The upper part of the subsoil, to a depth of about 17 inches, is brown silt loam. The middle part, to a depth of about 44 inches, is reddish brown silt loam. The lower part of the subsoil is yellowish red silt loam to a depth of about 59 inches. The underlying material to a depth of about 65 inches is reddish yellow, weathered soft sandstone.

This soil is high in natural fertility and in organic matter content. The surface layer is slightly acid to mildly alkaline. Permeability is moderate, and the available water capacity is high. The root zone is deep and is easily penetrated by plant roots. Tilth is good.

Included with this soil in mapping are intermingled areas of Kingfisher soils in similar positions. Small areas of Norge and Pond Creek soils are also included. The included soils make up about 15 percent of this map unit, but the individual areas are less than 5 acres.

This soil has high potential for small grains and medium potential for grain sorghums. The main concerns in management are controlling erosion and maintaining soil structure and fertility. Summer crop yields are limited by inadequate rainfall during the growing season. Residue management is needed to maintain the content of organic matter and protect the soil from water erosion. Terraces are needed to protect the soil. Minimum tillage and stubble mulching help control erosion.

The potential is medium for native grass and high for tame pasture. Forage production of tame pasture can be increased by fertilizing with nitrogen. The quality of all grasses can be improved by proper stocking, preventing wildfires, and controlling weeds.

The potential is medium for most urban uses. There are no significant limitations for dwellings or small commercial buildings. Septic tank absorption fields require large filter fields because the permeability is moderate. Bedrock interferes with the use of this soil for trench sanitary landfills. Seepage of pollutants to underground water can be a problem for area-type sanitary landfills. The low strength of this soil necessitates special design for roads and streets.

This soil is in capability subclass IIe and in the Loamy Prairie range site.

18—Grant silt loam, 3 to 5 percent slopes. This is a deep, well drained, gently sloping soil on broad uplands. Slopes are smooth and slightly convex. The areas are mostly 10 to 50 acres.

Typically, the surface layer is brown silt loam about 11 inches thick. The upper part of the subsoil is brown silt loam to a depth of about 16 inches. The middle part of the subsoil, to a depth of about 38 inches, is reddish brown silty clay loam, and the lower part, to a depth of about 46 inches, is reddish brown silt loam. At a depth of about 46 inches the subsoil rests on soft, yellowish red sandstone.

This soil is high in natural fertility and in organic matter content. The surface layer is slightly acid to mildly alkaline. Permeability is moderate, and the available water capacity is high. The subsoil is loamy and is easy for plant roots to penetrate.

Included with this soil in mapping are intermingled areas of Kingfisher, Norge, and Pond Creek soils and areas of eroded Grant soils. The included soils make up about 15 percent of the map unit, but the individual areas are about 5 acres.

This soil has medium potential for small grains and grain sorghums. It has low potential for alfalfa because of slope and inadequate rainfall during the growing season. Good residue management and terraces are needed to keep erosion to a minimum and maintain the organic matter content. Row crops should be avoided unless cover crops are used in the rotation. Terraces need to be plowed periodically, and vegetation in grassed waterways needs to be mowed to prevent silting up of the waterways.

The potential is medium for native grass and high for tame pasture. Forage production of tame pasture can be increased by fertilizing with nitrogen. The quality of all grasses can be improved by proper stocking, preventing wildfires, and controlling weeds.

The potential for most urban uses is medium. Septic tank absorption fields require large filter fields because the permeability is moderate. Bedrock interferes with trench-type sanitary landfills. Seepage of pollutants to underground water can be a problem for area landfill operations. This soil has no significant limitations for buildings. The low strength of the soil necessitates special designs for roads and streets.

This soil is in capability subclass IIIe and in the Loamy Prairie range site.

19—Grant silt loam, 3 to 5 percent slopes, eroded. This is a deep, well drained, gently sloping soil on eroded, convex side slopes of adjoining terraces and broad uplands. Slopes are smooth; the areas are irregular in shape and range from 10 to 60 acres. Erosion has removed part of the original surface layer on about 75 percent of the acreage of this map unit. On about 25 percent of the acreage, the surface layer has been mixed with the subsoil by tillage. Rills, shallow gullies, and a few deep gullies are present in about 30 to 60 percent of each mapped area.

Typically, the surface layer is brown silt loam about 8 inches thick. The upper part of the subsoil is brown silty clay loam to a depth of about 12 inches, the middle part is reddish brown and yellowish red silty clay loam to a depth of about 42 inches, and the lower part of the subsoil is yellowish red silt loam to a depth of about 54 inches. The underlying material is red, weathered sandstone to a depth of about 60 inches.

This soil is high in natural fertility and in organic matter content. The surface layer is slightly acid to mildly alkaline. Permeability is moderate, and the available water capacity is high. The root zone is deep, and the soil is easily penetrated by roots.

Included with this soil in mapping are intermingled areas of Kingfisher and Norge soils. In eroded areas the surface layer is lighter in color than is typical of the Grant soil. The included soils make up 15 percent of the map unit, but the individual areas are generally less than 5 acres.

This soil has medium potential for small grains and grain sorghums. Residue management, terraces, adequate fertilizer, and contour tillage are needed to keep erosion to a minimum and maintain organic matter content. When this soil has been row-cropped, a cover crop is needed to reduce soil loss.

The potential is medium for native grass and tame pasture. Forage production of tame pasture can be increased by fertilizing with nitrogen. The quality of all grasses can be improved by proper stocking, preventing wildfires, and controlling weeds.

The potential for urban uses is medium. Septic tank absorption fields require large areas because the permeability is moderate. Bedrock interferes with trench-type sanitary landfills. Seepage of pollutants to underground water can be a problem for area landfill operations. This soil has no significant limitations for buildings. The low strength of this soil necessitates special designs for roads and streets.

This soil is in capability subclass IIIe and in the Loamy Prairie range site.

20—Grant-Kingfisher silt loams, 4 to 8 percent slopes. This complex consists of the deep Grant soil and the moderately deep Kingfisher soil. These well drained, gently sloping to sloping soils are on smooth side slopes of uplands. The soils are intermingled in such an intricate pattern that mapping them separately was impractical at the scale selected for mapping. The mapped areas range from 10 to 70 acres. The individual areas of each soil are 3 to 5 acres.

Grant soil makes up 50 percent of the mapped area. Typically, the surface layer is brown silt loam about 10 inches thick. The upper part of the subsoil is brown silt loam about 5 inches thick. The middle part of the subsoil, to a depth of about 34 inches, is reddish brown silty clay loam. The lower part of the subsoil is yellowish red silt loam to a depth of 50 inches. The underlying material is reddish, soft sandstone to a depth of about 61 inches.

Grant soil is high in natural fertility and in organic matter content. The surface layer is slightly acid to mildly alkaline. Permeability is moderate, and the available water capacity is high. This soil is deep and is easy for plant roots to penetrate.

Kingfisher soil makes up 30 percent of the mapped area. Typically, the surface layer is reddish brown silt loam about 8 inches thick. The upper part of the subsoil is reddish brown silt loam to a depth of about 13 inches. The middle part of the subsoil is reddish brown silty clay loam to a depth of about 20 inches, and the lower part is yellowish red silt loam to a depth of about 27 inches. The underlying material is red, soft sandstone to a depth of 34 inches.

The Kingfisher soil is high in natural fertility and in organic matter content. The surface layer is slightly acid to mildly alkaline. Permeability is moderately slow, and the available water capacity is medium because of the moderate depth to rock. This soil is moderately deep and is easy for plant roots to penetrate.

Included in mapping are areas of Pond Creek soils at the bottom of slopes and Quinlan soils on ridge crests. Pond Creek soils make up about 10 percent of the map unit, and Quinlan soils make up about 5 percent. Also included are some small intermingled areas of eroded soils, which make up about 5 percent. The individual areas of each soil are less than 5 acres.

The soils making up this complex have medium potential for small grains and row crops. Adequate moisture at critical periods and the control of erosion are important concerns in soil management. Terraces, residue management, minimum tillage, contouring, and adequate fertilizer are all needed to control erosion on these soils. If the soils are row-cropped, a cover crop is needed after the harvest to reduce soil loss.

The soils have medium potential for native grass and for tame pasture plants, such as bermudagrass or weeping lovegrass. Forage production of tame pasture can be increased by fertilizing with nitrogen. The quality of all grasses can be improved by proper stocking, preventing fires, and controlling weeds.

The potential for most urban uses is medium. The bedrock is relatively soft and can be excavated by using normal construction equipment. Building foundations need extra reinforcement because of the shrinking and swelling of the Kingfisher soil. Septic tank absorption fields require large areas because of the moderately slow and moderate permeability and the soil depth. The depth to bedrock makes trench-type sanitary landfills impractical.

These soils are in capability subclass IVe and in the Loamy Prairie range site.

21—Grant-Kingfisher silt loams, 4 to 8 percent slopes, eroded. This complex consists of the deep Grant soil and the moderately deep Kingfisher soil. The soils are intermingled in such an intricate pattern that mapping them separately was impractical at the scale selected for mapping. These well drained, gently sloping to sloping, eroded soils are on smooth, slightly convex side slopes. The mapped areas range from 10 to 300 acres, but the individual areas of each soil are less than 5 acres. In most areas, 30 to 60 percent of the surface layer has been removed by erosion. The plow layer is dominantly a mixture of the original surface layer and the upper part of the subsoil. There are a few shallow gullies. Rills are common.

Grant soil makes up 40 to 60 percent of the map unit. Typically, the surface layer is brown silt loam about 6 inches thick. The upper part of the subsoil is reddish brown silt loam to a depth of about 46 inches, and the lower part is yellowish red silt loam to a depth of about 56 inches. The underlying material is yellowish red, weathered, soft sandstone to a depth of about 60 inches.

The Grant soil is high in natural fertility and medium in organic matter content. The surface layer is slightly acid to mildly alkaline. Permeability is moderate, and the available water capacity is high. This soil is deep and easy for plant roots to penetrate.

Kingfisher soil makes up 30 to 50 percent of the map unit. Typically, the surface layer is reddish brown silt loam about 7 inches thick. The upper part of the subsoil is reddish brown silt loam to a depth of about 12 inches, the middle part is reddish brown silty clay loam, and the lower part is red silt loam to a depth of about 26 inches. The underlying material is red, soft shale and sandstone to a depth of about 40 inches.

The Kingfisher soil is high in natural fertility and in organic matter content. The surface layer is slightly acid to mildly alkaline. Permeability is moderately slow, and the available water capacity is medium because of the moderate depth. This soil is easy for plant roots to penetrate.

Included with these soils in mapping are Norge and Quinlan soils in intermingled areas on the side slopes and Pond Creek soils near the bottom of slopes. The included soils make up about 15 percent of the map unit, but the individual areas generally are less than 5 acres.

The soils making up this complex have medium potential for small grains. Adequate moisture in critical periods and the control of erosion are important soil management problems. Terraces, residue management, minimum tillage, contouring, and adequate fertilizer are needed to control erosion on the slopes. Row crops should be avoided.

The soils have medium potential for native grass and for tame pasture plants, such as bermudagrass or weeping lovegrass. Forage production of tame pasture can be increased by fertilizing with nitrogen. The quality of all grasses can be improved by proper stocking, preventing wildfires, and controlling weeds.

The potential for most urban uses is medium. The bedrock is relatively soft and can be excavated by using normal construction equipment. Building foundations need extra reinforcement because of the shrinking and swelling of the Kingfisher soil. Septic tank absorption fields require large areas because of the moderately slow and moderate permeability and the soil depth. The depth to bedrock makes trench-type sanitary landfills impractical.

These soils are in capability subclass IVe and in the Loamy Prairie range site.

22—Grant-Port complex, 0 to 20 percent slopes. This complex consists of small areas of Grant and Port soils that are so closely intermingled that they could not be mapped separately at the scale selected for mapping. The soils are in narrow, elongated areas along prairie drainageways. The Grant soil is gently sloping to moderately steep and is on side slopes, and the Port soil is nearly level to very gently sloping and is on valley floors. The Port soil is frequently flooded for brief periods.

Grant soil makes up about 45 percent of the map unit. Typically, the surface layer is brown silt loam about 11 inches thick. The upper part of the subsoil, to a depth of about 16 inches, is brown silt loam; the lower part is reddish brown silty clay loam to a depth of about 55 inches. The underlying material to a depth of about 65 inches is yellowish red, weathered sandstone.

The Grant soil is medium in natural fertility and in organic matter content. The surface layer is slightly acid to mildly alkaline. Permeability is moderate. The available water capacity is high. This deep soil is easy for plant roots to penetrate.

Port soil makes up 25 percent of the map unit. Typically, the surface layer is brown silt loam about 24 inches thick. The subsoil is reddish brown silt loam to a depth of 38 inches. The underlying material to a depth of 80 inches is reddish brown silt loam.

The Port soil is high in natural fertility and in organic matter content. The surface layer is neutral to moderately alkaline. Permeability is moderate. The available water capacity is high. This is a deep, fertile soil that is easy for plant roots to penetrate.

Included with these soils in mapping are areas of Grainola, Kingfisher, Kirkland, Quinlan, Pond Creek, and Renfrow soils. Also included are soils that are similar to the Grant soil except that they have a thin surface layer or a cambic horizon or have calcium carbonate above a depth of 36 inches. The included soils make up about 30 percent of the map unit, but the areas of the individual soils are less than 5 acres.

The soils in this complex have low potential for cultivated crops. Strong and moderately steep slopes and flooding are the main limitations for cultivated crops.

The soils have medium potential for tame pasture and native grass. Bermudagrass is generally used for tame pasture. The quality of tame pasture grasses can be improved and the yield increased by fertilizing with nitrogen or growing nitrogen-storing legumes. The quality of all grasses can be improved by proper stocking, controlling weeds, and preventing wildfires.

The soils have low potential for most urban uses. The moderately steep slopes and flooding are limitations for most urban development.

The soils are in capability subclass VIe; the Grant soil is in the Loamy Prairie range site, and the Port soil is in the Loamy Bottomland range site.

23—Hawley fine sandy loam, rarely flooded. This is a deep, well drained, nearly level soil on terraces above deeply incised stream channels. Slopes are 0 to 1 percent and are smooth or slightly undulating. The areas range from 20 to 500 acres.

Typically, the surface layer is brown fine sandy loam about 18 inches thick. The subsoil, to a depth of 34 inches, is brown fine sandy loam. The underlying material is brown loamy fine sand to a depth of about 50 inches and loam to a depth of about 66 inches. It is stratified with material of finer and coarser texture.

This soil is medium in natural fertility and low in organic matter content. The surface layer ranges from medium acid to mildly alkaline. Permeability is moderate, and the available water capacity is medium. The root zone is deep and is easily penetrated by plant roots. The tilth is good.

Included with this soil in mapping are areas of Dale and Reinach soils and of soils similar to the Hawley soil except that they have a darker surface layer. Also included are small areas of Hawley soils that have short, convex slopes of 1 to 2 percent. The included soils make up about 25 percent of the map unit, and the areas generally are less than 10 acres.

This soil has high potential for small grains and grain sorghums. It has only medium potential for nonirrigated alfalfa because moisture is inadequate during the growing season. The main concerns in management are controlling wind erosion and maintaining soil fertility. Crop residue management helps maintain the content of organic matter, improves tilth and water infiltration, and helps protect the soil from wind and water erosion.

The potential is high for native grass and tame pasture grass. Suitable grasses for tame pasture are improved bermudagrass, weeping lovegrass, and plains bluestem. Forage production can be increased by fertilizing with nitrogen. The quality of all grasses can be improved by proper stocking and weed control.

The potential for most urban uses is low. Flooding is the main limitation. Upstream flood control structures can reduce the hazard but cannot completely eliminate flooding. The potential flood hazard is high for houses built on the flood plain.

This soil is in capability class I and in the Loamy Bottomland range site.

24—Kingfisher silt loam, 1 to 3 percent slopes. This is a moderately deep, well drained, very gently sloping soil on uplands. Slopes are smooth and slightly convex. Most areas range from 50 to 250 acres.

Typically, the surface layer is reddish brown silt loam about 11 inches thick. The subsoil, to a depth of about 29 inches, is reddish brown silt loam and silty clay loam. The underlying material is reddish brown, weathered, soft silty shale to a depth of about 41 inches.

This soil is high in natural fertility and in organic matter content. The surface layer is slightly acid to mildly alkaline. Permeability is moderately slow, and the available water capacity is medium. This soil is easy to till throughout a wide range of moisture content. The root zone is moderately deep, and the roots of most plants easily penetrate the soil.

Included with this soil in mapping are areas of Grant soils on similar landscapes and Pond Creek soils on lower slopes. Grant soils make up about 10 percent of the map unit, and Pond Creek soils make up about 5 percent. Also included are a few small areas of Quinlan soils on steeper slopes. The individual areas of the included soils generally are less than 5 acres.

This soil has high potential for small grains and medium potential for forage and grain sorghums. The potential for alfalfa is low because rainfall during the growing season is inadequate. Good residue management is needed to maintain the content of organic matter and protect the soil from water erosion. Terraces and stubble mulching are needed to control water erosion. Minimum tillage helps to keep crop residue on the surface.

The potential is medium for native grass and tame pasture. Forage production of tame pasture can be increased by fertilizing with nitrogen. The quality of all grasses can be improved by proper stocking, preventing fires, and controlling weeds.

The potential for most urban uses is medium. Septic tank absorption fields can function if adequately designed. The moderate depth to rock is the main limitation for trench-type sanitary landfills. The moderate shrink-swell potential in the subsoil necessitates special design for the foundation of residences and small commercial buildings. Roads and streets require special design because of the low strength of the subsoil.

This soil is in capability subclass IIe and in the Loamy Prairie range site.

25—Kingfisher silt loam, 3 to 5 percent slopes. This is a moderately deep, well drained, gently sloping soil on uplands. Slopes are smooth and slightly convex. The areas of this soil generally are less than 50 acres.

Typically, the surface layer is brown silt loam about 10 inches thick. The upper part of the subsoil, to a depth of about 13 inches, is brown silt loam. The lower part of the subsoil, to a depth of about 26 inches, is reddish brown silty clay loam. The underlying material is reddish brown sandstone to a depth of about 32 inches.

This soil is high in natural fertility and in organic matter content. The surface layer is slightly acid to mildly alkaline. Permeability is moderately slow, and the available water capacity is medium. The root zone is moderately deep and is easy for plant roots to penetrate.

Included with this soil in mapping are areas of Grant soils on similar landscapes, which make up about 15 percent of the map unit, and Quinlan soils on steeper slopes, which make up about 5 percent. The individual areas of these soils generally are less than 5 acres.

This soil has medium potential for small grains and sorghums. Good residue management and terraces are needed to keep erosion to a minimum and maintain organic matter content. Row crops should be rotated with small grains to prevent excessive soil loss. Minimum tillage helps to keep crop residue on the surface. Terraces and waterways need to be maintained.

The potential is medium for native grass and tame pasture. Forage production of tame pasture can be increased by fertilizing with nitrogen. The quality of all grasses can be improved by proper stocking, preventing wildfires, and controlling weeds.

The potential for urban uses is low to medium. Septic tank absorption fields can function if adequately designed. The moderate depth to rock is the main limitation for trench-type sanitary landfills. The moderate shrink-swell potential in the subsoil necessitates special design for the foundation of residences and small commercial buildings. Roads and streets require special design because of the low strength of the subsoil.

This soil is in capability subclass IIIe and in the Loamy Prairie range site.

26—Kingfisher silt loam, 2 to 5 percent slopes, eroded. This is an eroded, moderately deep, well drained, very gently sloping to gently sloping soil on convex side slopes of uplands. Slopes are smooth and slightly convex. The areas are irregular in shape and range from 10 to 200 acres. Erosion has removed part of the original surface layer in about 80 percent of the mapped acreage. Rills, shallow gullies, and a few deeper gullies occur in about 35 to 65 percent of each area.

Typically, the surface layer is brown silt loam about 7 inches thick. The upper part of the subsoil, to a depth of about 12 inches, is brown silt loam; the lower part, to a depth of about 25 inches, is reddish brown silty clay loam. The underlying material is calcareous, red silty shale and sandstone to a depth of about 30 inches.

This soil is high in natural fertility and in organic matter content. The surface layer is slightly acid to moderately alkaline. Permeability is moderately slow, and the available water capacity is medium. The root zone is moderately deep and is easy for plant roots to penetrate.

Included with this soil in mapping are a few small areas of severely eroded soils. Also included are intermingled areas of Grant soils and smaller areas of Renfrow and Quinlan soils. The included soils make up about 20 percent of the map unit. The individual areas generally are less than 5 acres.

This soil has medium potential for small grains and low potential for sorghums. Residue management, terraces, adequate fertilizer, and contour tillage are needed to keep erosion to a minimum and maintain organic matter content. Terraces need to be plowed up periodically, and waterways need to be mowed to prevent siltation. Row crops should be avoided in the crop rotation.

The potential is medium for native grass and tame pastures. Forage production for tame pasture can be increased by fertilizing with nitrogen. The quality of all grasses can be improved by proper grazing, preventing wildfires, and controlling weeds.

The potential for most urban uses is medium. Septic tank absorption fields can function if adequately designed. The moderate depth to rock is the main limitation for trench-type sanitary landfills. This soil is limited for building sites. The moderate shrink-swell potential in the subsoil necessitates special design for the foundation of residences and small commercial buildings. Roads and streets require special design because of the low strength of the subsoil.

This soil is in capability subclass IIIe and in the Loamy Prairie range site.

27—Kingfisher-Wakita silt loams, 1 to 3 percent slopes. This complex is made up of moderately deep Kingfisher soil and moderately deep to deep Wakita soil. These soils are very gently sloping and are on narrow, smooth hillcrests and side slopes of uplands. The areas of Wakita soil are so small and so irregular in shape that it was not practical to map them separately at the scale used in mapping. The Wakita soil is intermingled as saline-alkali spots about 200 feet in diameter or as elongate bands, 20 to 200 feet in width and several hundred feet in length, across the lower part of the slope. The mapped areas of these soils generally range from 40 to 400 acres. The individual areas of each soil are 5 to 10 acres.

The well drained Kingfisher soil makes up about 45 to 65 percent of each mapped area. Typically, the surface layer is brown silt loam about 7 inches thick. The upper part of the subsoil, to a depth of about 12 inches, is brown silty clay loam. The lower part, to a depth of about 25 inches, is reddish brown silty clay loam. The underlying material is yellowish red, weathered silty sandstone to a depth of about 30 inches.

Kingfisher soil is high in natural fertility and in organic matter content. The surface layer is slightly acid to mildly alkaline. Permeability is moderately slow, and the available water capacity is medium. This soil is easy to till throughout a wide range of moisture content. The root zone is moderately deep and is easily penetrated by roots.

The moderately well drained Wakita soil makes up about 15 to 25 percent of each mapped area. Typically, the surface layer is light reddish brown, massive silt loam about 5 inches thick. The upper part of the subsoil, to a depth of about 14 inches, is reddish gray silt loam. The middle part, to a depth of about 22 inches, is reddish brown silty clay loam. The lower part of the subsoil, to a depth of about 32 inches, is light reddish brown silt loam. The underlying material is light reddish brown, weathered, interbedded sandstone and silty shale to a depth of about 37 inches.

This Wakita soil is high in natural fertility, but it is severely affected by a high content of sodium and by a low to high amount of soluble salts. The organic matter content is low. The surface layer is medium acid to strongly alkaline. Permeability is slow, and the available water capacity is low because of the high salt content. Generally, this soil is easily tilled, but tillage is difficult if the soil is too wet or too dry. Roots of most plants are severely affected by the high salt content. There is a perched water table at a depth of 2 to 3 feet in spring.

Included with these soils in mapping are sizable areas of Grant soils and minor areas of Kirkland and Pawhuska soils. Also included are sizable areas of soils that are similar to the Kingfisher and Grant soils except that they have secondary carbonates above a depth of 36 inches and are moderately affected by salts. Also included are soils that are similar to the Wakita soil except that the depth to sandstone is more than 40 inches. The included soils make up about 15 to 30 percent of each mapped area, but the individual areas generally are less than 5 acres.

These soils have medium potential for small grains and grain sorghums. The main management concerns are erosion, maintenance of soil fertility and structure, and injury to crops in areas of the Wakita soil. Saline areas can be improved by drainage, application of gypsum, and fertilizing to produce abundant growth and large amounts of residue. Deep-rooted, salt-tolerant plants improve soil structure and internal drainage and increase the infiltration of water. Large amounts of plant growth in the saline areas protect the soil from evaporation by the sun and thus reduce the movement of water and salts upward to the surface. A cropping system that utilizes crop residue improves soil structure and tillage. Terraces and grassed waterways help control erosion. Minimum tillage needs to be practiced to keep crop residue on the surface.

The soils have medium potential for native grass and tame pasture. Tame pasture should be established during the period when the concentraton of salts is least likely to damage the plants. Salt-tolerant grasses, such as bermudagrass or tall wheatgrass, can be grown in the saline areas. The quantity of all grasses can be improved by protecting from wildfire, proper stocking and grazing, and controlling weeds.

The soils have low potential for most urban uses. Depth to rock is the main limitation for septic tank absorption fields, sewage lagoons, and sanitary landfills. The shrink-swell potential needs to be considered in designing foundations for dwellings and small commercial buildings. These limitations generally can be overcome by proper design or by altering the soil. All urban uses should be avoided in salt-affected areas.

These soils are in capability subclass IIIs. Kingfisher soil is in the Loamy Prairie range site, and Wakita soil is in the Slickspot range site.

28—Kingfisher-Wakita silt loams, 2 to 5 percent slopes, eroded. This complex is made up of moderately deep Kingfisher soil and moderately deep to deep Wakita soil. These soils are very gently sloping to gently sloping and are on side slopes of uplands. The areas of Wakita soil are so small and so irregular in shape that it was not practical to map them separately at the scale used in mapping. The Wakita soil is intermingled as saline-alkali spots about 200 feet in diameter or as elongated bands, 20 to 200 feet in width and several hundred feet in length, across the lower part of the slope. The mapped areas of the soils generally range from 40 to 400 acres. The individual areas of each soil are 5 to 20 acres.

The well drained Kingfisher soil makes up about 45 to 65 percent of each mapped area. Typically, the surface layer is brown silt loam about 6 inches thick. The upper part of the subsoil, to a depth of about 11 inches, is brown silty clay loam. The lower part, to a depth of about 26 inches, is reddish brown silty clay loam that is more clayey than the upper part. The underlying material is yellowish red, weathered silty sandstone to a depth of about 32 inches.

Kingfisher soil is high in natural fertility and in organic matter content. The surface layer is slightly acid to mildly alkaline. Permeability is moderately slow, and the available water capacity is medium. This soil is easy to till throughout a wide range of moisture content. Roots of most plants easily penetrate this soil.

The moderately well drained Wakita soil makes up about 15 to 25 percent of each mapped area. Typically, the surface layer is reddish brown, massive silt loam about 6 inches thick. The upper part of the subsoil, to a depth of about 9 inches, is reddish brown silty clay loam. The middle part, to a depth of about 27 inches, is red clay loam and silty clay loam. The lower part, to a depth of about 34 inches, is light red silty clay loam. The underlying material is light reddish brown, weathered, interbedded sandstone and silty shale to a depth of about 42 inches.

This Wakita soil is medium in natural fertility, but it is severely affected by a high content of sodium and by a low to high amount of soluble salts. The organic matter content is low. The surface layer is neutral to moderately alkaline. Permeability is slow, and the available water capacity is low because of the high salt content. Generally, this soil is easily tilled, but it is difficult to till in dry areas. Roots of most plants are severely affected by the high salt content. There is a perched water table at a depth of 2 to 3 feet in spring.

Included with these soils in mapping are sizable areas of Grant soils and small areas of Kirkland and Pawhuska soils. Also included are sizable areas of soils that are similar to the Kingfisher and Grant soils except that they have secondary carbonates above a depth of 36 inches and are moderately affected by salts. Also included are soils that are similar to the Wakita soil except that the depth to sandstone is more than 40 inches. The included soils make up 15 to 30 percent of each mapped area, but the individual areas generally are less than 5 acres.

These soils have medium potential for small grains and grain sorghums. The main management concerns are a severe hazard of erosion, maintenance of soil fertility and structure, and injury to crops by soluble salts and sodium in areas of the Wakita soils. Saline areas can be improved by drainage, application of gypsum, and fertilizing to produce large amounts of residue. Deep-rooted, salt-tolerant plants improve soil structure and internal drainage, and increase the infiltration of water. Large amounts of plant growth in the saline areas protect the soil from evaporation and thus reduce the movement of water and salts upward to the surface. A cropping system that utilizes crop residue improves soil structure and tillage. Continuous row crops should be avoided. Terraces and grassed waterways help reduce the loss of soil by erosion. Minimum tillage needs to be practiced to keep crop residue on the surface.

The soils have medium potential for native grass and tame pasture. Tame pasture should be established during the period when the concentration of salts is least likely to damage the plants. Salt-tolerant grasses, such as bermudagrass or tall wheatgrass, can be grown in the saline areas. The quantity of all grasses can be improved by protecting from wildfire, proper stocking and grazing, and controlling weeds.

The soils have low potential for most urban uses. Depth to rock is the main limitation for septic tank absorption fields, sewage lagoons, and sanitary landfills. The shrink-swell potential needs to be considered in designing foundations for dwellings and small commercial buildings. These limitations generally can be overcome by proper design or by altering the soil. All urban uses should be avoided in salt-affected areas.

These soils are in capability subclass IVs. Kingfisher soil is in the Loamy Prairie range site, and Wakita soil is in the Slickspot range site.

29—Kirkland silt loam, 0 to 1 percent slopes. This is a deep, well drained, nearly level soil on high upland plains. Slopes are broad and smooth. The areas range from 15 to 2,000 acres.

Typically, the surface layer is brown silt loam about 10 inches thick. The upper and middle parts of the subsoil, to a depth of about 46 inches, are reddish brown clay. The lower part of the subsoil is red clay that extends to a depth of about 72 inches.

This soil is high in natural fertility and medium in organic matter content. The surface layer is medium acid or slightly acid. Permeability is very slow, and the available water capacity is high. This deep soil has a dense, compact subsoil that is difficult for plant roots to penetrate.

Included with this soil in mapping are small areas of Tabler soils in depressional areas and Bethany soils on low ridges. The included soils make up about 10 percent of the total acreage. The individual areas generally are less than 10 acres.

This soil has high potential for small grains. It has medium potential for summer row crops because the clayey subsoil does not readily release moisture to plants and because rainfall is inadequate during the growing season. Droughtiness, improving the rate of water intake, and maintaining desirable soil structure and fertility are the main concerns in management. Crop residue in and on the surface layer increases water infiltration and reduces runoff, soil temperature, and the loss of soil moisture. Large applications of nitrogen fertilizer are needed to maintain fertility if a large amount of crop residue is produced and left on the soil.

The potential is medium for native grass and for tame pasture. Forage production of tame pasture can be increased by fertilizing with nitrogen. The quality of all grasses can be improved by proper stocking, preventing wildfires, and controlling weeds.

The potential for most urban uses is low. This soil has no limitation for sewage lagoons. The very slow permeability is the main limitation for septic tank absorption fields. The soil is too clayey for trench-type sanitary landfills. The high shrink-swell potential is the main limitation for dwellings, commercial buildings, roads, and streets, and low strength is an additional limitation for roads and streets (fig. 2). Most of these limitations can be overcome by proper design or by altering the soil.

This soil is in capability subclass IIs and in the Claypan Prairie range site.

30—Kirkland silt loam, 1 to 3 percent slopes. This is a deep, well drained, very gently sloping soil that is on uplands of reddish Permian shale or on high upland terraces. Slopes are smooth. The areas range from 10 to 1,500 acres.

Typically, the surface layer is dark grayish brown silt loam about 10 inches thick. The upper part of the subsoil, to a depth of about 29 inches, is brown clay. The middle part, to a depth of about 60 inches, is reddish brown clay. The lower part of the subsoil to a depth of about 72 inches is red clay.

This soil is high in natural fertility and medium in organic matter content. The surface layer is medium acid or slightly acid. Permeability is very slow, and the available water capacity is high. This deep soil has a dense, compact subsoil that is difficult for plant roots to penetrate.

Included with this soil in mapping are areas of soils that are similar to this Kirkland soil except that they have a gradual textural change between the surface layer and the subsoil or have a mollic epipedon less than 20 inches thick. Also included are soils that are similar to the Kirkland soil except the plow layer is strongly acid. The included soils make up about 20 percent of the mapped acreage, but individual areas generally are less than 10 acres.

This soil has high potential for small grains. It has medium potential for row crops because the clayey subsoil does not readily release moisture to plant roots and because rainfall is inadequate during the growing season. The main concerns in management are controlling erosion, improving the rate of water intake, and maintaining desirable soil structure and fertility. Crop residue in and on the surface layer increases water infiltration and reduces runoff, erosion, summer soil temperatures, and the loss of soil moisture. Large applications of nitrogen fertilizer are needed to maintain fertility if a large amount of crop residue is left on the soil. Terraces and grassed waterways are needed to control soil loss.

The potential is medium for native grass and tame pasture. Forage production of tame pasture can be increased by fertilizing with nitrogen. The quality of all grasses can be improved by proper stocking, preventing wildfires, and controlling weeds.

The potential for most urban uses is low. The very slow permeability is the main limitation for septic tank absorption fields. The soil is too clayey for trench-type sanitary landfills. The high shrink-swell potential is the main limitation for dwellings, commercial buildings, roads, and streets. Low strength is an additional limitation for roads and streets. Most of these limitations can be overcome by proper design or by altering the soil.

This soil is in capability subclass IIIe and in the Claypan Prairie range site.

31—Kirkland-Pawhuska silt loams, 0 to 2 percent slopes. This complex consists of well drained Kirkland soil intermingled with irregularly shaped spots and streaks of saline-alkali, moderately well drained

Figure 2.—A highway on Kirkland silt loam, 0 to 1 percent slopes, shows damage caused by shrinking and swelling and by the low strength of this soil under heavy traffic.

Pawhuska soil. The areas of Pawhuska soil are too small and too irregular in shape to be mapped separately at the scale selected for mapping. The soils are deep and are nearly level to very gently sloping. They are on upland plains. The mapped areas range from 10 to 400 acres.

Kirkland soil makes up about 55 percent of the map unit. It generally is on slightly higher, convex to very gently sloping parts of the landscape. Typically, the surface layer is brown silt loam about 11 inches thick. The upper part of the subsoil is reddish brown, moderately alkaline clay to a depth of about 47 inches. It contains free calcium carbonates. The lower part is reddish brown clay loam to a depth of more than 75 inches.

The Kirkland soil is high in natural fertility and medium in organic matter content. The surface layer is medium acid to moderately alkaline. Permeability is very slow, and the available water capacity is high. This deep soil has a dense, compact subsoil that is difficult for plant roots to penetrate.

Pawhuska soil makes up about 15 percent of the map unit. It is in concave and depressional parts of the landscape. Typically, the surface layer is brown silt loam about 5 inches thick. The upper part of the subsoil is brown and reddish brown silty clay to a depth of about 26 inches. The middle part is reddish brown clay and silty clay to a depth of about 59 inches. The lower part of the subsoil is reddish brown silty clay loam to a depth of about 65 inches. The underlying material is weathered shale to a depth of about 68 inches.

The Pawhuska soil is low in natural fertility and in organic matter content. Excessive exchangeable sodium and moderately high amounts of soluble salts decrease the availability of water and plant nutrients. The surface layer is slightly acid to moderately alkaline. Permeability is very slow, and the available water capacity is low because of the content of salts and sodium. Although this soil is deep, it has a dense, compact subsoil that is difficult for plant roots to penetrate.

About 15 percent of this map unit consists of areas of sodium-affected and saline soils that are gradational in development between the Kirkland and Pawhuska soils. Nonsaline to moderately affected saline and alkali soils that are otherwise similar to Pond Creek, Bethany, and Grant soils make up about 15 percent of the map unit. The acreage of these soils is locally sizable.

The soils making up this complex have medium potential for small grains and grain sorghums. The Pawhuska soil is mainly cultivated along with large areas of Kirkland, Bethany, Renfrow, or Pond Creek soils, which make up most of the field. Maintaining tilth and fertility, improving surface drainage, and counteracting the high exchangeable sodium and salinity are the main concerns in management. Keeping crop residue on the surface, avoiding tilling the soil when it is wet, and applying fertilizer and gypsum are beneficial management practices.

The soils have medium potential for native grass and tame pasture. Bermudagrass and plains bluestem are commonly used as tame pasture. Fertilizing tame pasture increases the amount of forage produced and improves its quality. The quality of native and tame pasture grasses also can be improved by controlling grazing, proper stocking, and preventing wildfires.

The soils have low potential for most urban uses. There is no significant limitation for sewage lagoons or area sanitary landfills. The high shrink-swell potential is the main limitation for dwellings, small commercial buildings, roads, and streets. The very slow permeability of the soils limits their use as septic tank absorption fields. These limitations can be largely overcome by proper design of building foundations and road bases or by enlarging the absorption field of a septic system.

These soils are in capability subclass IIIs. The Kirkland soil is in the Claypan Prairie range site. The Pawhuska soil is in the Slickspot range site.

32—Lela clay, rarely flooded. This is a deep, somewhat poorly drained, nearly level soil on low terraces of flood plains. Slopes are 0 to 1 percent and are broad and smooth. Most areas of this soil range from 15 to 400 acres, but some are as small as 10 acres.

Typically, the surface layer is brown clay about 20 inches thick. The next layer, to a depth of about 45 inches, is reddish brown clay. The underlying material to a depth of about 72 inches is reddish brown clay.

This soil is high in natural fertility and in organic matter content. The surface layer is slightly acid to moderately alkaline. Permeability is very slow, and the available water capacity is high. Tilth is poor because the surface layer is high in clay content. The root zone is deep but hard for plant roots to penetrate. This soil is subject to rare flooding.

Included with this soil in mapping are areas of McLain soils in similar positions and Port soils on small flood plains. Also included are intermingled areas of soils similar to the Lela soil except that they have nonintersecting slickensides, are red, or are calcareous in the surface layer. The included soils make up about 20 percent of the map unit, but the individual areas are less than 5 acres.

Potential for small grains and alfalfa is medium. The soil is droughty in dry years and is often excessively wet in years of average rainfall. Surface drainage is needed to remove excess water. Good crop residue management helps to maintain the content of organic matter and thus improves water infiltration and tilth.

The potential is medium for native grass and tame pasture. The production of tame pasture can be increased by fertilizing with nitrogen. The quality of all grasses can be improved by proper stocking, preventing wildfires, and controlling weeds.

The potential is low for most urban uses. The high shrink-swell potential and flooding are the main limitations for building site development. Generally, septic tank absorption fields are nearly useless because the effluent is absorbed very slowly. Sewage lagoons work well if they are adequately diked against floodwaters. Roads, streets, and foundations for buildings require special design to withstand the high shrink-swell potential of this soil.

This soil is in capability subclass IIIw and in the Heavy Bottomland range site.

33—Masham-Port complex, 0 to 20 percent slopes. This complex consists of shallow Masham soil on upland side slopes and deep Port soil on flood plains. Masham soil is gently sloping to moderately steep and is on side slopes of drainageways. Port soil has slopes of 0 to 3 percent and is in nearly level to very gently sloping areas along small stream channels. The Port soil is frequently flooded for brief periods. The areas of Port soil are so narrow and irregular in shape that it was impractical to map them separately at the scale selected for mapping. The areas generally range from 200 to 400 acres, but some areas are about 10 acres.

Masham soil makes up about 65 percent of the map unit. Typically, the surface layer is reddish brown silty clay about 4 inches thick. The subsoil, to a depth of about 12 inches, is red silty clay. The underlying material is red, granular shale that extends to a depth of 37 inches or more.

Masham soil is medium in natural fertility and low in organic matter content. The surface layer is moderately alkaline and predominantly calcareous. Permeability is very slow, and the available water capacity is low. Roots penetrate this shallow soil with difficulty.

Port soil makes up about 15 percent of the map unit. Typically, the surface layer is dark brown silty clay loam about 15 inches thick. The upper part of the subsoil, to a depth of about 43 inches, is reddish brown silty clay loam. The lower part, to a depth of about 53 inches, is reddish brown silty clay loam that has strata containing many shale fragments. The underlying material is weathered red shale that contains common hard carbonate concretions. It extends to a depth of about 70 inches.

Port soil is high in natural fertility and in organic matter content. The surface layer is moderately alkaline and calcareous. Permeability is moderate, and the available water capacity is high. This deep, fertile soil is easy for plant roots to penetrate.

Included with these soils in mapping are areas of Grainola soils on side slopes and soils similar to the Masham soil except that they are slightly deeper over shale and slightly better developed. Also included are small areas of soils that are on knolls and sharp breaks and are 10 inches or less deep over bedrock. The included soils make up about 20 percent of the map unit, but the individual areas generally are less than 5 acres.

The soils making up this complex have low potential for cultivated crops. They have low potential for tame pasture and native range. The strong slopes, shallowness to bedrock, and the clayey texture of the dominant Masham soil lower the potential productivity.

The soils have low potential for most urban uses. The clayey nature of the Masham soil and flooding on the Port soil are limitations for most urban development.

These soils are in capability subclass VIe. The Masham soil is in the Red Clay Prairie range site, and the Port soil is in the Loamy Bottomland range site.

34—McLain silt loam, rarely flooded. This is a deep, moderately well drained, nearly level soil on low benches of flood plains. It is in elongated areas away from the stream channel. Slopes are 0 to 1 percent. They are smooth and level or slightly concave. The mapped areas generally are 20 to 300 acres, but they range to 1,500 acres.

Typically, the surface layer is brown silt loam about 14 inches thick. The upper part of the subsoil is brown silty clay loam about 5 inches thick. The lower part of the subsoil is reddish brown silty clay to a depth of about 35 inches and yellowish red silty clay loam to a depth of about 59 inches. The underlying material is yellowish red silty clay loam to a depth of about 75 inches.

This soil is high in natural fertility and in organic matter content. The surface layer is slightly acid to moderately alkaline. Permeability is slow, and the available water capacity is high. The root zone is deep, but it is moderately difficult for plant roots to penetrate because of the high clay content of the subsoil.

Included with this soil in mapping, and making up about 20 percent of the acreage, is a soil similar to the McLain soil except that the argillic horizon has clay content of 30 to 35 percent. Also included are areas of saline soils and of Dale silt loam, which make up about 10 percent of the total acreage. The individual areas of the included soils generally are less than 5 acres.

This soil has high potential for small grains, alfalfa, and sorghums. The yields of all warm-season crops are greatly increased in seasons of abundant rainfall. Maintaining desirable soil structure and fertility are the main concerns in management. Periodically changing the depth of tillage reduces the risk of developing a tillage pan. Crop residue in and on the surface layer increases water infiltration, reduces evaporation, and increases the moisture available for plant use (fig. 3). Additions of nitrogen fertilizer to produce large amounts of crop residue help to protect the soil from erosion during the critical seeding period.

The potential is high for native grass and tame pasture. Forage production of tame pasture can be increased by fertilizing with nitrogen. The quality of all grasses can be improved by proper stocking, preventing wildfires, and controlling weeds.

The potential for most urban uses is low. The high shrink-swell potential and the flood hazard make this soil generally undesirable for building sites.

This soil is in capability class I and in the Loamy Bottomland range site.

35—McLain-Drummond silt loams, rarely flooded. This complex consists of areas of McLain soil and irregularly shaped spots and streaks of the saline-alkali Drummond soil. Most areas of the Drummond soil are so small and so irregular in shape that it was not practical to map them separately at the scale used in mapping. These nearly level soils are on smooth flood plains. Slopes are 0 to 1 percent. The areas range from 10 to 1,500 acres.

McLain soil makes up about 40 percent of the map unit. It is a deep, moderately well drained, nearly level soil. It is on slightly higher, convex or smooth and even parts of the landscape. Typically, the surface layer is dark brown silt loam to a depth of about 12 inches. The upper part of the subsoil is brown silty clay loam to a depth of about 16 inches. The middle part of the subsoil, to a depth of about 38 inches, is dark reddish brown silty clay loam. The lower part, to a depth of about 46 inches, is reddish brown silty clay loam. The underlying material to a depth of about 75 inches is reddish brown and yellowish red silt loam.

McLain soil is high in natural fertility and in organic matter content. The surface layer is slightly acid to moderately alkaline. Permeability is slow, and the available water capacity is high. The root zone is deep, but it is moderately difficult for plant roots to penetrate because of the high clay content of the subsoil.

Drummond soil makes up about 25 percent of the map unit. It is a deep, somewhat poorly drained, saline-alkali

Figure 3.—As wheat is harvested, abundant strawy residue is left to protect the soil in this area of McLain silt loam, rarely flooded.

soil. It is on the slightly lower, concave parts of the landscape. Typically, the surface layer is yellowish brown silt loam about 9 inches thick. The upper part of the subsoil is dark grayish brown and brown silty clay loam to a depth of about 21 inches. The lower part of the subsoil is reddish brown and reddish yellow silty clay loam to a depth of about 38 inches. The underlying material is yellowish red and reddish brown silty clay loam that extends to a depth of about 60 inches.

Drummond soil is medium in natural fertility and in organic matter content. The surface layer is slightly acid to moderately alkaline. Permeability is very slow, and the available water capacity is low because of the high salt content. The root zone is deep, but plant roots do not grow abundantly in this saline-alkali soil. An apparent water table is at a depth of 3 to 6 feet during winter and spring.

About 20 percent of the map unit consists of included areas of sodium- and saline-affected soils that are similar to McLain and Drummond soils except that they are gradational in development between these two soils. Also included and making up about 15 percent of the map unit are areas of Dale and Oscar soils. Areas of Port and Reinach soils make up a small acreage. The individual areas of the included soils generally are 5 acres or less.

These soils have medium potential for grain sorghums and small grains. The small areas of Drummond soil are cultivated along with other soils that are dominant within the fields in which they occur. Maintaining tilth and fertility, improving surface drainage, and overcoming the high exchangeable sodium and salinity in the Drummond soil are the main concerns in management. Leaving crop residue on the surface and in some cases applying additional amounts, avoiding tilling the soil when it is wet, applying fertilizer and gypsum, and in some areas installing a drainage system are desirable practices. The subsoil of the Drummond soil, because of its high salt content, is rapidly eroded if it is exposed in surface drains or waterways. In many cases, it is more desirable to improve drainage in these areas by adding about 6 inches of loamy soil on the surface.

The soils have high potential for native grass and tame pasture. Forage production of tame pasture can be increased by fertilizing with nitrogen. Only salt-tolerant grasses, such as tall wheatgrass or bermudagrass, should be planted on the Drummond soil (fig. 4). The quality of all grasses can be improved by proper stocking, preventing wildfires, and controlling weeds.

These soils have low potential for most urban uses. Flooding is the main limitation that makes the soils undesirable for dwellings.

These soils are in capability subclass IIIs; McLain soil is in the Loamy Bottomland range site, and Drummond soil is in the Saline Subirrigated range site.

36—Norge silt loam, 3 to 5 percent slopes. This is a deep, well drained, gently sloping soil on side slopes of adjoining terraces on broad uplands. Slopes are smooth and slightly convex. The areas are mainly 10 to 50 acres.

Typically, the surface layer is brown silt loam about 12 inches thick. The upper part of the subsoil is brown silt loam to a depth of about 17 inches. The middle part of the subsoil is reddish brown silty clay loam to a depth of about 50 inches. The lower part of the subsoil is yellowish red silty clay loam to a depth of about 66 inches.

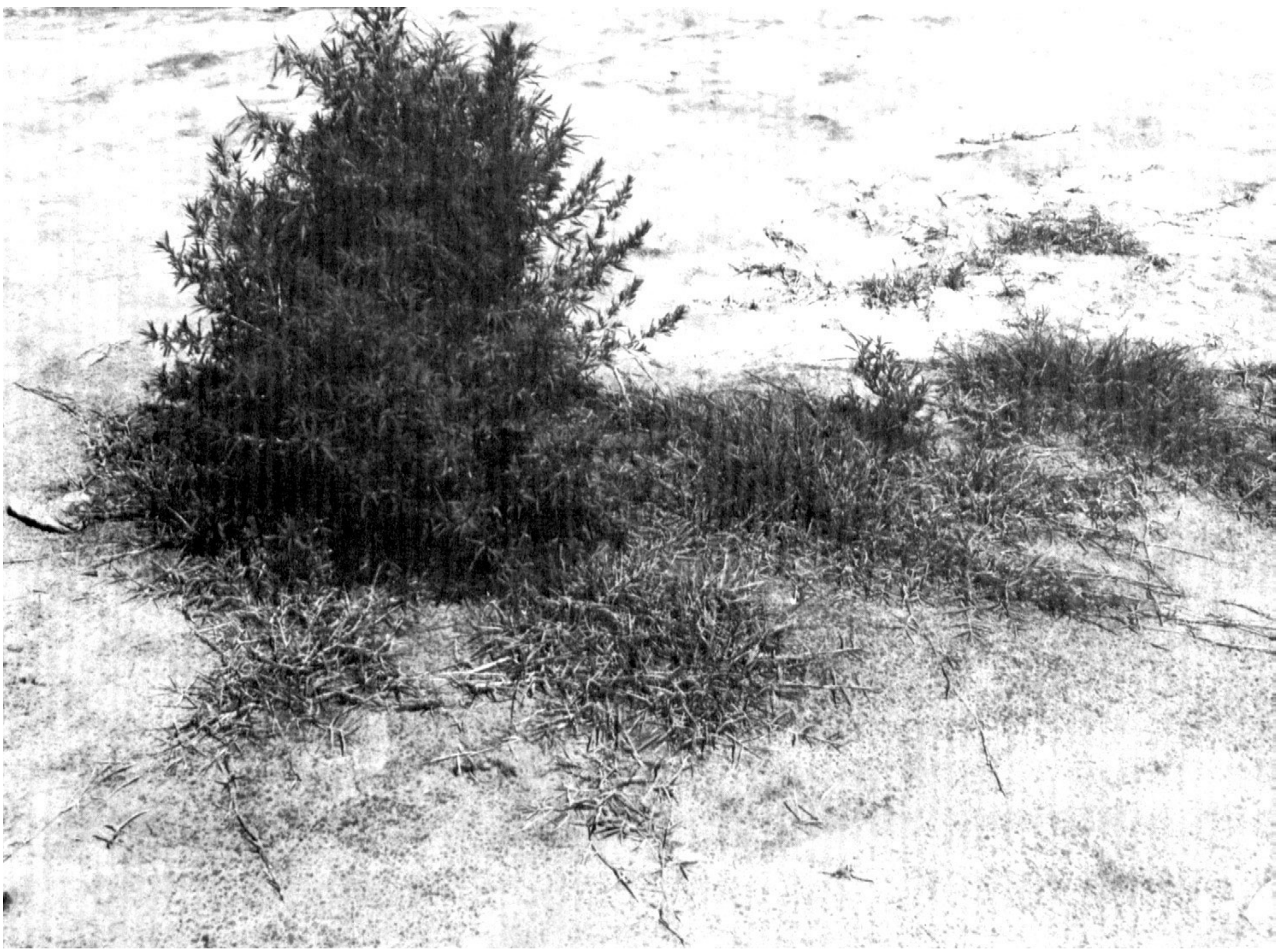


Figure 4.—Kochia and bermudagrass becoming established on Drummond soil in an area of McLain-Drummond silt loams, rarely flooded.

This soil is high in natural fertility and in organic matter content. The surface layer is medium acid to neutral. Permeability is moderately slow, and the available water capacity is high. The subsoil is loamy and is easily penetrated by plant roots.

Included with this soil in mapping are intermingled areas of Kingfisher and Grant soils and a few small areas of eroded Norge soils. The included soils make up about 15 percent of the map unit, but the individual areas are about 5 acres.

This soil has medium potential for small grains and grain sorghums. It has low potential for alfalfa because of slope and inadequate rainfall during the growing season. Good residue management, adequate fertilizer, contour tillage, and terraces are needed to keep erosion to a minimum and maintain organic matter content.

The potential is medium for native grass and high for tame pasture. Forage production of tame pasture can be increased by fertilizing with nitrogen. The quality of all grasses can be improved by proper stocking, preventing wildfires, and controlling weeds.

The potential for most urban uses is medium. A large filter field is needed for a septic tank absorption field because the permeability is moderately slow. Seepage of pollutants to underground water can be a problem for sewage lagoons. This soil has no significant limitations for area sanitary landfills. The shrink-swell potential requires special designs for building foundations and roads and streets.

This soil is in capability subclass IIIe and in the Loamy Prairie range site.

37—Norge silt loam, 3 to 5 percent slopes, eroded. This is a deep, well drained, gently sloping soil on eroded, convex side slopes of adjoining terraces on broad uplands. Slopes are smooth. The areas are irregular in shape and range from 10 to 60 acres. Erosion has removed part of the original surface layer on about 75 percent of the acreage. On about 25 percent of the acreage, the remaining surface layer and the subsoil have been mixed through tillage. Rills, shallow gullies, and a few deep gullies are present in about 30 to 60 percent of each mapped area.

Typically, the surface layer is brown silt loam about 7 inches thick. The upper part of the subsoil is brown and reddish brown silty clay loam to a depth of about 30 inches, and the middle part is yellowish red silty clay loam to a depth of about 56 inches. The lower part of the subsoil is yellowish red silty clay loam to a depth of 72 inches.

This soil is medium in natural fertility and in organic matter content. The surface layer is medium acid to neutral. Permeability is moderately slow, and the available water capacity is high. The root zone is deep, and the soil is easily penetrated by roots.

Included with this soil in mapping are intermingled areas of Grant and Kingfisher soils. The included soils make up 10 percent of the map unit. The individual areas are generally less than 5 acres.

This soil has medium potential for small grains and grain sorghums. Residue management, terraces, adequate fertilizer, and contour tillage are needed to keep erosion to a minimum and maintain the content of organic matter. A cover crop is needed to reduce soil loss after a row crop has been harvested.

The potential is medium for native grass and high for tame pasture. Forage production of tame pasture can be increased by fertilizing with nitrogen. The quality of all grasses can be improved by proper stocking, preventing wildfires, and controlling weeds.

The potential for urban uses is medium. Because the permeability is moderately slow, a septic tank absorption field must take in a considerably larger area than is commonly used. Seepage of pollutants to underground water can be a problem for sewage lagoons. There are no significant limitations for area sanitary landfills. The shrink-swell potential necessitates special designs for building foundations and roads and streets.

This soil is in capability subclass IIIe and in the Loamy Prairie range site.

38—Oscar-Grant complex, frequently flooded, 0 to 12 percent slopes. This complex consists of the nearly level to very gently sloping Oscar soil on flood plains in upland drainageways and the very gently sloping to strongly sloping Grant soil on side slopes of the drainageways. Most areas of Grant soil are too narrow and too irregular in shape to be mapped separately at the scale selected for mapping. The areas of this map unit are 100 to 300 acres.

The Oscar soil makes up about 45 percent of this complex. It is a deep, moderately well drained, nearly level to very gently sloping soil on flood plains. Typically, the surface layer has a light brown silt loam crust about 2 inches thick. Below this crust, to a depth of about 11 inches, is brown silt loam. The upper part of the subsoil is reddish brown silt loam to a depth of about 22 inches. The lower part is reddish brown silt loam that extends to a depth of about 48 inches. The underlying material is reddish brown, massive silty clay loam that extends to a depth of more than 76 inches.

This Oscar soil is low in natural fertility, high in content of toxic salts, and low in organic matter content. The surface layer is neutral to moderately alkaline. Permeability is slow, and the available water capacity is low because the salt content is high. Root development is poor. This soil is subject to frequent flooding.

The Grant soil makes up about 25 percent of this complex. It is a deep, well drained, very gently sloping to strongly sloping soil on side slopes of upland drainageways. Typically, the surface layer is dark brown silt loam about 10 inches thick. The upper part of the subsoil is brown silt loam to a depth of about 28 inches, and the lower part is reddish yellow silty clay loam to a depth of 45 inches. The underlying material to a depth of about 75 inches is yellowish red, weathered sandstone.

This Grant soil is high in natural fertility and in organic matter content. The surface layer is neutral or mildly alkaline. Permeability is moderate, and the available water capacity is high. The subsoil is loamy and is easy for plant roots to penetrate, but the underlying material is difficult to penetrate.

Included with these soils in mapping are areas of Port soils and of soils, similar to the Oscar soil, that have high salt and sodium concentrations but do not have the natric horizon. On the side slopes of the drainageways there are soils that are similar to Renfrow and Pond Creek soils except that they are calcareous in the upper part. The included soils make up about 30 percent of the map unit, but the individual areas generally are less than 10 acres.

The soils making up this complex have low potential for cultivated crops because of the flood hazard, the slope, and the high concentration of sodium in the Oscar soil.

The soils have medium potential for native grass and tame pasture. Bermudagrass and tall wheatgrass are the main grasses for tame pasture. Fertilizing tame pasture grasses increases the amount and improves the quality of forage. The quality of native and tame pasture grasses can be improved by controlled grazing, proper stocking, and controlled burning.

The soils have low potential for most urban uses. Flooding, slope, and the high salt content of the soils on the flood plain are the main limitations. Upstream flood control structures and land treatment can reduce flooding but cannot completely eliminate it. The potential flood hazard is high for houses built on the flood plain.

These soils are in capability subclass Vw. The Oscar soil is in the Alkali Bottomland range site, and the Grant soil is in the Loamy Prairie range site.

39—Pond Creek silt loam, 0 to 1 percent slopes. This is a deep, well drained, nearly level soil on intermediate and high stream terraces. Slopes are smooth or slightly convex. Most areas range from 10 to 2,000 acres.

Typically, the surface layer is brown silt loam about 14 inches thick. The subsoil is brown silt loam to a depth of about 22 inches, brown silty clay loam to a depth of about 50 inches, and yellowish red silt loam to a depth of about 72 inches.

This soil is high in natural fertility and in organic matter content. The surface layer is medium acid to neutral. Permeability is moderately slow, and the available water capacity is high. This soil has good tilth and a deep root zone.

Included with this soil in mapping are a few intermingled areas of Bethany and Kirkland soils. Also included are areas of soils, below adjacent areas of Grant and Kingfisher soils, that are similar to the Pond Creek soil except powdery lime is at a depth of 20 to 40 inches. The included soils make up about 8 percent of the map unit, but the individual areas are generally less than 3 acres.

The potential is high for small grains and row crops. Maintaining soil structure and fertility are the main concerns in management. Fertilizing to obtain a large amount of crop residue helps to maintain desirable soil structure and natural fertility. An adequate cover of residue also reduces the surface temperature and the loss of soil moisture by evaporation. Minimum tillage helps maintain soil structure.

The potential is high for tame pasture and medium for native grass. The quality of all grasses can be improved by preventing wildfires, proper stocking, and controlling weeds. Fertilizing tame pasture increases the production of forage and improves the quality.

The potential is medium for most urban uses. There are no significant limitations for sewage lagoons or area sanitary landfills. The moderately slow permeability is a limitation for septic tank absorption fields, and the content of clay in the soil is a limitation for trench sanitary landfills. The main limitation for dwellings, commercial buildings, roads, and streets is the shrink-swell potential. Most of these limitations can be overcome by proper design or by altering the soil.

This soil is in capability class I and in the Loamy Prairie range site.

40—Pond Creek silt loam, 1 to 3 percent slopes. This is a deep, well drained, very gently sloping soil on intermediate and high terraces. Slopes are smooth or slightly convex. The mapped areas range from 10 to about 1,000 acres.

Typically, the surface layer is brown silt loam about 14 inches thick. The subsoil is brown silt loam to a depth of about 20 inches, brown silty clay loam to a depth of about 40 inches, reddish brown silty clay loam to a depth of about 60 inches, and yellowish red silty clay loam to a depth of about 72 inches.

This soil is high in natural fertility and in organic matter content. The surface layer is medium acid to neutral. Permeability is moderately slow, and the available water capacity is high. This soil has good tilth and can be tilled throughout a wide range of moisture content. The root zone is deep, and plant roots can penetrate with little difficulty.

Included with this soil in mapping are areas of Grant and Kirkland soils. Also included are areas of soils, below adjacent areas of Grant and Kingfisher soils, that are similar to the Pond Creek soil except that soft powdery lime is at a depth of 20 to 40 inches. The included soils make up about 10 percent of the map unit, but the individual areas are less than 5 acres.

This soil has high potential for small grains and medium potential for grain sorghums. The main concerns in management are controlling erosion and maintaining soil structure and fertility. This soil is limited for summer crop production by inadequate moisture during the growing season. Residue management is essential to maintain organic matter content and protect the soil from water erosion. Terraces are needed to protect the soil. Minimum tillage and stubble mulching aid in controlling erosion.

The potential is medium for native grass and high for tame pasture, such as bermudagrass and lovegrass. Fertilizer is needed to maintain high production of tame pasture. The quality of all grasses can be improved by controlling wildfires, proper stocking, and controlling weeds.

The potential is medium for most urban uses. There are no significant limitations for area sanitary landfills. Sewage lagoons are limited by slope. The moderately slow permeability is a limitation for septic tank absorption fields, and the content of clay in the soil is a limitation for trench sanitary landfills. The main limitation for dwellings, commercial buildings, roads, and streets is the high shrink-swell potential. Most of these limitations can be overcome by proper design or by altering the soil.

This soil is in capability subclass IIe and in the Loamy Prairie range site.

41—Port silt loam, occasionally flooded. This is a deep, well drained, nearly level soil on broad, smooth areas on flood plains. Slopes are 0 to 1 percent. The mapped areas are irregular in shape and range from 10 to 600 acres.

Typically, the surface layer is reddish brown silt loam about 27 inches thick. The subsoil is also reddish brown silt loam and extends to a depth of about 48 inches. The underlying material to a depth of about 72 inches is reddish brown silt loam that has strata of darker material.

This soil is high in natural fertility and in organic matter content. The surface layer is slightly acid to mildly alkaline or, in the lower part, moderately alkaline. Permeability is moderate, and the available water capacity is high. The root zone is deep and is easily penetrated by plant roots. This soil is occasionally flooded.

Included with this soil in mapping are intermingled areas of Dale, McLain, and Yahola soils, which make up about 10 percent of the total acreage. Also included are intermingled areas of soils similar to this Port soil that have a surface layer of clay loam or silty clay loam. The included soils make up about 30 percent of the map unit, but the areas generally are less than 5 acres.

This soil has high potential for small grains, sorghums, and alfalfa. In some years, flooding can damage some crops or prevent harvest. Maintaining desirable soil structure and fertility and protecting this soil from flooding are the main concerns in management. Residue management helps conserve moisture. Periodically changing the depth of tillage and tilling only when the soil is not wet help to prevent the formation of a tillage pan. Upstream flood control or channel improvement reduces flooding on this soil along some streams.

The potential is high for native grass and for tame pasture, such as bermudagrass, lovegrass, small grains, and tall wheatgrass. Nitrogen fertilizer is needed for excellent yields of tame pasture.

The potential is low for most urban uses because of flooding. Upstream flood control structures can reduce the hazard but cannot completely eliminate flooding.

This soil is in capability subclass IIw and in the Loamy Bottomland range site.

42—Port and Pocasset soils, frequently flooded. The soils in this map unit are on smooth, nearly level flood plains of large creeks and the adjacent side slopes of the drainageways. Port silt loam is the dominant soil along some creeks in Grant County, and Pocasset soil is dominant along others. Along some creeks the areas are made up of both soils. These soils were mapped together because they are similar in use and management. Slopes are dominantly 0 to 1 percent. The mapped areas along the major creeks range to as much as 500 acres.

The Port soil makes up about 45 percent of this map unit. Typically, the surface layer is brown silt loam about 22 inches thick. The subsoil is brown silty clay loam to a depth of about 32 inches. The underlying material to a depth of about 72 inches is brown silt loam stratified with thin layers of loam.

The Port soil is high in natural fertility and in organic matter content. The surface layer is slightly acid to mildly alkaline and ranges to moderately alkaline in the lower part. The permeability is moderate, and the available water capacity is high. The root zone is deep and is easily penetrated by plant roots. This soil is subject to frequent flooding.

The Pocasset soil makes up about 25 per cent of this map unit. Typically, the surface layer is brown silt loam about 14 inches thick. The next layer, to a depth of about 40 inches, is brown fine sandy loam. The underlying material is brown very fine sandy loam to a depth of about 72 inches.

The Pocasset soil is high in natural fertility and in organic matter content. The surface layer is mildly alkaline or moderately alkaline. The permeability is moderate, and the available water capaciaty is high. This soil has good tilth and a deep root zone that is easily penetrated by plant roots. The soil is subject to frequent flooding.

Included with these soils in mapping are areas of soils similar to the Port soil except that they have a lighter colored or thin surface layer, Reinach soils, and soils similar to the Pocasset soil except that the profile is clay loam. Also included are soils, on the steep side slopes, that have a profile similar to the Port and Pocasset soils; these soils are on slopes of 15 to 45 percent. The included soils make up about 30 percent of this map unit, but the individual areas are generally less than 5 acres.

The Port and Pocasset soils have low potential for field crops. They are not cultivated because of the frequent flooding and steep slopes.

The soils have high potential for native grass and tame pasture. The main concerns in management are flooding and controlling brush. Spraying brush reduces shade and increases the production of native grass. The less sloping soils in this map unit can be planted to bermudagrass or lovegrass.

These soils have low potential for most urban uses. Flooding is the main limitation. Flood control structures can reduce the hazard but cannot completely eliminate flooding. The hazard of flooding is high for houses on the flood plain.

These soils are in capability subclass Vw and in the Loamy Bottomland range site.

43—Pratt loamy fine sand, 2 to 6 percent slopes. This is a deep, well drained, very gently sloping to sloping soil on uplands. Slopes are smooth and undulating to slightly hummocky. The areas range from 10 to 100 acres.

Typically, the surface layer is pale brown loamy fine sand about 11 inches thick. The subsoil, to a depth of about 40 inches, is yellowish red loamy fine sand. The underlying material is reddish yellow loamy fine sand that extends to a depth of about 66 inches.

This soil is medium in natural fertility and low in organic matter content. Permeability is rapid, and the available water capacity is low. This soil has good tilth and can be worked throughout a wide range of moisture content. The root zone is deep and is easily penetrated by roots.

Included with this soil in mapping are intermingled areas of Attica and Tivoli soils and areas of Carwile soils in low places. Also included are soils similar to the Pratt soil except that the underlying material is reddish fine sandy loam or loam. The included soils make up about 20 percent of this map unit, but the individual areas are less than 5 acres.

This soil has low potential for small grains and grain sorghums. Controlling soil blowing and maintaining soil fertility are the main concerns in management. Soil blowing can be controlled by using a deep-furrow drill for planting crops, planting the crops at a right angle to the direction of prevailing winds, and keeping the soil protected by an adequate cover of crop residue at seeding time. Fertilizer generally is needed, and crops respond well to applications of a complete fertilizer. Proper fertilization helps growing crops form ample cover to protect the soil from erosion. It also helps to produce abundant residue that can be left on the surface to reduce soil temperature and evaporation.

The potential for native grass and tame pasture is medium. If properly fertilized, weeping lovegrass grows well and effectively controls erosion. The quantity of all grasses can be increased by controlling grazing, proper stocking, and controlling wildfires.

This soil has medium potential for most urban uses. There are no significant limitations for dwellings, small commercial buildings, roads, or streets. Seepage is the main limitation for sanitary landfills and sewage lagoons. This soil is a poor filter for septic tank absorption fields.

This soil is in capability subclass IVe and in the Deep Sand range site.

44—Quinlan loam, 1 to 3 percent slopes. This is a shallow, well drained, very gently sloping soil on uplands in the northwestern part of Grant County. Slopes are smooth and slightly undulating. Most areas of this soil range from 50 to 500 acres, but some are less than 15 acres.

Typically, the surface layer is brown loam about 6 inches thick. The subsoil is yellowish red loam to a depth of about 17 inches. The underlying material is soft, red sandstone that extends below a depth of 30 inches.

This soil is low in natural fertility and in organic matter content. Permeability is moderate, and the available water capacity is low. The root zone is shallow, but the soil is easily penetrated by roots.

Included with this soil in mapping are intermingled areas of soils that are similar to the Quinlan soil except that the depth to sandstone is 10 inches or less. Also included are intermingled areas of Kingfisher and Woodward soils. The included soils make up about 8 percent of the map unit, but the individual areas generally are less than 5 acres.

The potential is low for small grains and row crops. Small grains generally produce better yields than summer crops, such as grain sorghums, because this shallow soil is droughty in summer. Crop residue management and terraces are needed to control erosion.

One of the best uses of this soil is for native grass production, although the potential is low. Bermudagrass and plains bluestem have low potential; they are, however, the most commonly grown tame pasture grasses. Adding fertilizer substantially increases yields of bermudagrass. Proper grazing, controlling weeds, and preventing wildfires improve the quality of all grasses.

The potential is low for most urban uses. Shallowness to bedrock is the main limitation. The shallow depth over sandstone interferes with foundation installation and restricts the root development of trees and shrubs. It also interferes with the functioning of septic tank absorption fields. Ripping the sandstone and adding suitable soil to the building site commonly is very beneficial.

This soil is in capability subclass IIIe and in the Shallow Prairie range site.

45—Quinlan loam, 2 to 5 percent slopes, eroded. This is a shallow, well drained, very gently sloping to gently sloping soil on uplands in the northwestern part of Grant County. The surface layer has been thinned by erosion. On about 50 percent of the acreage, the surface layer and subsoil have been mixed by plowing. In some areas, there are shallow gullies and rills between the gullies. Slopes are smooth and slightly convex. The areas generally range from 20 to 100 acres, but some areas are about 10 acres.

Typically, the surface layer is yellowish red loam about 5 inches thick. The subsoil is also yellowish red loam to a depth of about 14 inches. It rests on reddish yellow, firm sandstone, which extends below a depth of 30 inches.

This soil is low in natural fertility and in organic matter content. The surface layer is moderately alkaline. Permeability is moderate, and the available water capability is low. The shallowness of this soil restricts the growth of plants.

Included with this soil in mapping are intermingled areas of soils that are similar to this Quinlan soil except that the depth to sandstone is 10 inches or less. Also included are intermingled areas of Kingfisher and Woodward soils. The included soils make up about 20 percent of the map unit, but the individual areas generally are less than 5 acres.

The potential is low for small grains and row crops. Small grains generally produce better yields than summer crops, such as grain sorghums. This shallow soil is too droughty for most summer crops. Terraces and crop residue management are needed to control erosion. Row crops should be avoided.

One of the best uses of this soil is for native grass production, although the potential production is low. Bermudagrass and plains bluestem have low potential and are the commonly grown tame pasture grasses. Adding fertilizer substantially increases yields of bermudagrass. Preventing wildfires, proper grazing, and controlling weeds improve the amount and quality of all grasses.

This Quinlan soil has medium potential for most urban uses. The sandstone bedrock interferes with foundation installation and restricts the root development of trees and shrubs. The shallowness to sandstone also interferes with the functioning of septic tank absorption fields. Ripping the sandstone and adding suitable soil help to overcome this limitation.

This soil is in capability subclass IVe and in the Shallow Prairie range site.

46—Quinlan-Woodward loams, 3 to 12 percent slopes. This complex consists of shallow Quinlan soil and moderately deep Woodward soil. The areas of these soils are so intricately mixed or so small that it was not practical to separate them in mapping. Quinlan soil is on the crest of ridges, and Woodward soil is on side slopes. Both of these soils are on dominantly convex slopes in the northwestern part of Grant County. Most mapped areas range from 15 to 600 acres, but the individual areas of each soil are about 5 acres.

Quinlan loam makes up about 50 percent of the map unit. Typically, the surface layer is yellowish red loam about 4 inches thick. The subsoil is yellowish red loam to a depth of about 14 inches. The underlying material is weakly cemented, red, calcareous sandstone to a depth of about 28 inches.

This Quinlan soil is low in natural fertility and in organic matter content. The surface layer is moderately alkaline. Permeability is moderate, and the available water capacity is low. The root zone is shallow and is easily penetrated by roots.

Woodward loam makes up about 30 percent of the map unit. Typically, the surface layer is brown loam about 17 inches thick. The subsoil is yellowish red very fine sandy loam that extends to a depth of about 35 inches. The underlying material is weathered, yellowish red, calcareous sandstone to a depth of 40 inches or more.

This Woodward soil is medium in natural fertility and low in organic matter content. The surface layer is neutral to moderately alkaline. Permeability is moderate, and the available water capacity is medium. This soil has a moderately deep root zone and is penetrated easily by roots.

Included with these soils in mapping are small areas of soils similar to the Quinlan soil except that the depth to sandstone is 10 inches or less. Also included are small areas of Grant, Kingfisher, and Port soils and outcrops of sandstone and shale. The included soils make up about 20 percent of the map unit, but the individual areas generally are less than 5 acres.

The soils have low potential for cultivated crops because of the rough, irregular slopes. They have low potential for tame pasture and medium potential for native grass. The depth to bedrock, low yields, and rough terrain make tame pasture generally too expensive for the return in forage produced. In areas of native grassland, preventing overgrazing, controlling weeds, and protecting the areas from wildfires improve the quality of forage.

The potential for most urban uses is low. The depth to bedrock is a limitation for building sites and sanitary facilities.

The soils in this complex are in capability subclass VIe. The Quinlan soil is in the Shallow Prairie range site and the Woodward soil is in the Loamy Prairie range site.

47—Reinach very fine sandy loam, rarely flooded. This is a deep, well drained, nearly level soil on low benches of flood plains. Slopes are broad and smooth and range from 0 to 1 percent. Most areas of this soil range from 100 to 500 acres, but some areas are about 15 acres.

Typically, the surface layer is brown very fine sandy loam about 26 inches thick. The subsoil, to a depth of about 60 inches, is brown very fine sandy loam. The underlying material is reddish yellow very fine sandy loam that extends to a depth of about 75 inches.

This soil is high in natural fertility and in organic matter content. The surface layer is slightly acid to moderately alkaline. Permeability is moderate, and the available water capacity is high. The root zone is deep and is easily penetrated by roots.

Included with this soil in mapping are intermingled areas of Hawley soils, which make up about 5 percent of the map unit, and Dale soils, which make up about 10 percent. The individual areas of these soils generally are less than 5 acres.

This soil has high potential for all crops. Wind erosion can be controlled by keeping adequate residue on the surface until planting time. Minimum tillage is needed.

This soil has high potential for native grasses and tame pasture. Tame pasture production is excellent if the pasture is properly fertilized with nitrogen and phosphate. The quality of all grasses can be improved by controlling grazing, practicing proper stocking, and preventing wildfires.

This soil has low potential for most urban uses. Flooding is the main limitation for septic tank absorption fields, sanitary landfills, dwellings, small commercial buildings, roads, and streets. Flooding can be reduced by upstream flood control structures and land treatment, but it cannot be completely eliminated. The hazard of flooding is high for houses built on the flood plain.

This soil is in capability class I and in the Loamy Bottomland range site.

48—Renfrow silt loam, 3 to 5 percent slopes. This is a deep, well drained, gently sloping soil on side slopes of uplands. Slopes are smooth or slightly convex. The areas generally range from 20 to about 100 acres, but some areas are about 10 acres.

Typically, the surface layer is brown silt loam about 9 inches thick. The upper 3 inches of the subsoil is brown silty clay loam. The middle part of the subsoil, to a depth of about 45 inches, is reddish brown clay, and the lower part, to a depth of about 68 inches, is red clay. The underlying material is red, weathered shale that extends to a depth of about 75 inches.

This soil is high in natural fertility and medium in organic matter content. The surface layer is slightly acid or neutral. Permeability is very slow, and the available water capacity is high. The root zone is deep, but the clayey part of the subsoil is difficult for roots to penetrate.

Included in mapping are intermingled areas of soils that are similar to the Renfrow soil except that they have secondary carbonates at a depth of 28 inches or less and shale at a depth of 40 to 60 inches. Also included are a few small intermingled areas of Grainola and Kirkland soils. The included soils make up about 20 percent of the map unit, but the individual areas generally are less than 15 acres.

This soil has medium potential for small grains and low potential for row crops. It is inherently droughty in summer because the clayey subsoil does not readily release moisture to plants and because water moves slowly into and through the soil. Improving the intake of water, maintaining desirable soil structure and fertility, and controlling water erosion are the main concerns in management. Crop residue in and on the surface layer increases water infiltration and reduces runoff, erosion, evaporation, and summer soil temperatures. Terraces help to control water erosion. Large applications of nitrogen fertilizer are needed if a large amount of crop residue is returned to the soil.

The potential is medium for native grass and low for tame pasture. Forage production of tame pasture can be increased by fertilizing with nitrogen. The quality of all grasses can be improved by proper stocking, preventing wildfires, and controlling weeds.

The potential for most urban uses is low. The very slow permeability is the main limitation for septic tank absorption fields. An onsite test is needed to determine if large filter fields can function in this soil. This soil has no limitations for area sanitary landfills. Slope is the main restriction for sewage lagoons. The high shrink-swell potential is the main limitation for dwellings, commercial buildings, roads, and streets. Most of these limitations can be overcome by proper design or by altering the soil.

This soil is in capability subclass IVe and in the Claypan Prairie range site.

49—Renfrow silty clay loam, 2 to 5 percent slopes, eroded. This is a deep, well drained, very gently sloping to gently sloping, eroded soil on uplands. The surface layer has been thinned by erosion. In about 50 percent of the acreage, the surface layer and subsoil have been mixed by plowing. In some areas, there are a few crossable gullies about 400 feet apart, and rills are common between the gullies. A thin layer of soil has accumulated at the lower end of slopes. Slopes are smooth and slightly convex between the gullies. Most areas of this soil range from 10 to 80 acres, but some areas are as small as 5 acres.

Typically, the surface layer is brown silty clay loam about 6 inches thick. The upper part of the subsoil, to a depth of about 12 inches, is reddish brown clay; the middle part, to a depth of about 43 inches, is yellowish red clay. The lower part of the subsoil, to a depth of about 62 inches, is red clay. The underlying material is red weathered shale to a depth of about 70 inches.

This soil is medium in fertility and low in organic matter content. The surface layer is slightly acid to mildly alkaline. Permeability is very slow, and the available water capacity is high. The rooting zone is deep, but it is very difficult for most plant roots to penetrate.

Included with this soil in mapping are intermingled areas of Grainola soils. Also included are intermingled areas of soils that are similar to the Renfrow soil except that they have secondary carbonates at a depth of 28 inches or less and shale at a depth of 40 to 60 inches. The included soils make up about 20 percent of this map unit, but the individual areas are less than 5 acres.

This soil has medium potential for small grains and low potential for row crops. It is droughty in summer because the clayey subsoil does not readily release moisture to plants and because water moves slowly into and through the soil. Improving the intake of water, attaining a desirable soil structure, improving fertility, controlling water erosion, and the high clay content of the soil are the main concerns in management. Nitrogen fertilizer can be used to produce adequate crop yields and sufficient crop residue to control erosion. Terraces and minimum tillage help to control erosion.

The potential is medium for native grass and low for tame pasture. Forage production of tame pasture can be increased by fertilizing with nitrogen. The quality of all grasses can be improved by proper stocking, preventing wildfires, and controlling weeds.

The potential for most urban uses is low. The very slow permeability is the main limitation for septic tank absorption fields. An onsite test should be evaluated to determine if large filter fields can function. Lawns, trees, and shrubs require extra care because of past erosion. This soil has no limitations for area sanitary landfills. Slope is the main restriction for sewage lagoons. The high shrink-swell potential is the main limitation for dwellings, commercial buildings, roads, and streets. These limitations can be overcome by proper design or by altering the soil.

This soil is in capability subclass IVe and in the Claypan Prairie range site.

50—Renfrow-Pawhuska complex, 2 to 5 percent slopes, eroded. This complex consists of deep, well drained Renfrow soil and deep, moderately well drained Pawhuska soil. The Pawhuska soil is moderately affected to severely affected by salts. The areas of the soils are so intricately intermingled or so small that it was impractical to map them separately. These eroded soils are very gently sloping to gently sloping and are on side slopes of uplands. Part of the original surface layer has been removed by erosion on about 60 percent of the acreage. On about 25 percent of the acreage, the surface layer and the upper part of the subsoil have been mixed by tillage. The plow layer is a complex of silt loam and silty clay loam. Rills caused by water erosion are common throughout. A few shallow gullies are present. The areas of this complex are mainly in the southern part of Grant County. They range from 10 to 90 acres. The individual areas of each soil are 2 to 5 acres.

Renfrow silt loam makes up about 50 percent of each mapped area. Typically, the surface layer is brown silt loam about 7 inches thick. The upper part of the subsoil, to a depth of about 39 inches, is reddish brown silty clay loam. The lower part of the subsoil is also reddish brown silty clay loam; it extends to a depth of about 42 inches. The underlying material to a depth of 66 inches is mixed silty clay loam and weakly weathered, reddish brown shale.

The Renfrow soil is high in natural fertility and in organic matter content. Permeability is very slow, and the available water capacity is medium. This soil has a deep root zone, but the subsoil is hard for plant roots to penetrate when it is dry.

Pawhuska silty clay loam makes up about 30 percent of each mapped area. Typically, the surface layer has a hard crust 1/4 inch thick that is underlain by brown silt loam about 6 inches thick. The upper part of the subsoil is silty clay loam and clay to a depth of about 26 inches. The lower part is yellowish red silty clay loam to a depth of about 42 inches. The underlying material is massive red silty clay loam to a depth of 65 inches or more.

The Pawhuska soil is low in natural fertility and medium in organic matter content. Permeability is very slow, and the available water capacity is low. The root zone is deep, but the subsoil is hard for plant roots to penetrate when it is dry.

Included with these soils in mapping are areas of soils similar to the Renfrow soil except that the profile has a fine-silty control section. The included soils make up about 20 percent of the map unit, but the individual areas generally are less than 5 acres.

The soils making up this complex have low potential for cultivated crops. The main limitations are the high salt concentrations, moderate erosion, and slope. Applying fertilizer, terracing, contour farming, and keeping an adequate cover of residue on the surface are beneficial. Minimum tillage is needed.

The soils have low potential for tame pasture and medium potential for native grass. Bermudagrass and plains bluestem are tame pasture grasses that are grown on these soils. These grasses respond to fertilizing by increased production. The quality of all grasses can be improved by proper stocking, controlling weeds and brush, preventing wildfires, and rotation grazing.

The potential for most urban uses is low. The very slow permeability is the main limitation for septic tank absorption fields. Slope is a limitation for sewage lagoons. The high shrink-swell potential is the main limitation for dwellings, commercial buildings, roads, and streets. Lawns, trees, and shrubs are adversely affected by high salt concentrations, past erosion, and the high clay content of the soil. All of these limitations can be overcome by proper design or by altering the soil.

The soils in this complex are in capability subclass IVe. Renfrow soil is in the Claypan Prairie range site, and Pawhuska soil is in the Slickspot range site.

51—Shellabarger fine sandy loam, 1 to 3 percent slopes. This is a deep, well drained, very gently sloping soil on upland terraces. Slopes are smooth and slightly convex. The areas generally range from 30 to 200 acres, but some areas are as small as 10 acres.

Typically, the surface layer is brown fine sandy loam about 7 inches thick. The upper part of the subsoil is reddish brown loam to a depth of about 11 inches. The middle part of the subsoil is reddish brown sandy clay loam to a depth of about 33 inches. The lower part of the subsoil is light red sandy loam to a depth of about 42 inches. The underlying material to a depth of about 72 inches is reddish yellow loam and loamy sand.

This soil is medium in natural fertility and in organic matter content. The surface layer ranges from strongly acid to slightly acid. Permeability is moderate, and the available water capacity for plants is high. This soil has a loamy subsoil that is easy for roots to penetrate.

Included with this soil in mapping are areas of Attica soils and of soils similar to the Shellabarger soil except that they are moderately alkaline at a depth of about 30 inches. The included soils make up about 15 percent of this map unit, but the individual areas generally are 5 acres or less.

This soil has high potential for small grains and row crops. The yields of summer crops are reduced somewhat in most years by inadequate rainfall during the growing season. Wind erosion is a moderate hazard. Residue management, adequate fertilizer, stripcropping, and planting the rows with a deep-furrow drill and at a right angle to the prevailing wind generally adequately control wind erosion.

The potential is medium for native grass and tame pasture. Nitrogen fertilizer increases the forage production of tame pasture. The quality of all grasses can be improved by proper stocking, preventing wildfires, and controlling weeds.

The potential for most urban uses is high. This soil is particularly desirable for septic tank absorption fields, sanitary landfills, lawns, and shrubs. It is also desirable for commercial building sites, roads, streets, and dwellings.

This soil is in capability subclass IIe and in the Sandy Prairie range site.

52—Tabler silt loam, 0 to 1 percent slopes. This is a deep, moderately well drained, nearly level soil on high terraces of upland plains. Slopes are smooth. The areas generally are broad and range from 500 to 4,000 acres, but some areas are about 100 acres.

Typically, the surface layer is dark gray silt loam about 10 inches thick. The upper part of the subsoil is dark gray clay to a depth of about 30 inches. The lower part is dark grayish brown clay to a depth of about 44 inches. The underlying material to a depth of 60 inches is grayish brown clay.

This soil is high in natural fertility and medium in organic matter content. The surface layer is medium acid or slightly acid. Permeability is very slow, and the available water capacity is high. This deep soil has a dense, compact subsoil that is difficult for plant roots to penetrate. It has a perched water table at a depth of 2 1/2 to 3 1/2 feet from fall to spring in wet years.

Included with this soil in mapping, and making up 5 percent of the map unit, are areas of Kirkland soils and a few small areas of Bethany soils. Also included are soils that are similar to the Tabler soil except that the surface layer is silty clay loam; these soils make up about 15 percent of the map unit. All of the included soils are closely intermingled with the Tabler soil on the landscape. The areas generally are less than 5 acres.

This soil has high potential for small grains. It has medium potential for row crops because the dense clay does not readily release moisture to plants and because rainfall is inadequate during the growing season for summer crops. Improving the intake of water, maintaining desirable soil structure and fertility, and providing adequate surface drainage are the main concerns in soil management (fig. 5). Crop residue in and on the surface layer increases water infiltration and reduces runoff, soil temperature, and loss of soil moisture by evaporation. Extra nitrogen fertilizer is needed if a large amount of crop residue is returned to the soil. Land smoothing can be used to improve surface drainage.

The potential is medium for native grass and tame pasture. Forage production of tame pasture can be increased by fertilizing with nitrogen. The quality of all grasses can be improved by proper stocking, preventing wildfires, and controlling weeds.

The potential for most urban uses is low. The very slow permeability is the main limitation for septic tank absorption fields. The main limitation for sewage lagoons and area sanitary landfills is wetness. The high shrink-swell potential is the main limitation for dwellings, commercial buildings, roads, and streets. Most of these limitations can be overcome by proper design or by altering the soil.

This soil is in capability subclass IIs and in the Claypan Prairie range site.

53—Tivoli fine sand, 5 to 10 percent slopes. This is a deep, excessively drained, sloping to strongly sloping soil on dunes and hummocks, mainly north of the Salt Fork of the Arkansas River. Slopes are smooth. The mapped areas are mainly 20 to 80 acres, but the range is from 10 to 600 acres.

Typically, the surface layer is brown fine sand about 9 inches thick. The underlying material to a depth of about 80 inches is reddish yellow fine sand.

This soil is low in natural fertility and in organic matter content. The available water capacity is low, and

Figure 5.—Wetness delays farming operations in this area of Tabler silt loam, 0 to 1 percent slopes.

permeability is rapid. The root zone is deep and is easily penetrated by the roots of the native grasses.

Included with this soil in mapping are small areas of Aline and Goltry soils. Aline soils make up about 12 percent of the map unit, and Goltry soils make up 4 percent. The areas of these soils generally are less than 5 acres.

Tivoli soils are not suitable for dryland cultivation, because wind erosion is an extreme hazard and the soil is naturally droughty. The best agricultural use of this soil is native range.

This soil has low potential for native grass and tame pasture. Weeping lovegrass stands are difficult to establish and commonly last only a few years. This soil is subject to severe erosion in areas that are overgrazed. Blowouts can occur on the higher dunes. Proper grazing and controlling wildfires help increase the quantity of grasses.

This soil has low potential for most urban uses. Some leveling is generally desirable for most urban uses. The soil is a poor filter, and septic systems can contaminate the underground water supply because of the extremely sandy texture. Lawns and shrubs on this soil require frequent watering and fertilizing.

This soil is in capability subclass VIIe and in the Dune range site.

54—Tivoli fine sand, 10 to 30 percent slopes. This is a deep, excessively drained, strongly sloping to steep soil on dunes near the western border of the county. Slopes are smooth and convex. Most areas range from 500 to 1,500 acres, but some areas are 100 to 300 acres.

Typically, the surface layer is pale brown fine sand about 7 inches thick. The underlying material to a depth of about 72 inches is reddish yellow fine sand that has a few thin bands of loamy fine sand.

This soil is low in natural fertility and in organic matter content because it is largely composed of clean sand grains. Permeability is rapid, and the available water capacity is low. This soil is slightly acid to mildly alkaline throughout. Roots easily penetrate the soil for many feet.

Included with this soil in mapping are areas of Goltry and Aline soils in low areas between the sand dunes. The included soils make up about 10 percent of the map unit, but the individual areas generally are less than 5 acres.

This soil is not used for cultivated crops or tame pasture because of its loose sandy texture, low productivity, and steepness of slope.

The soil has low potential for native range. It is imperative that grazing be carefully managed to control soil blowing. Blowouts have occurred in a few small areas. Proper grazing and controlling wildfires help maintain the grass cover.

The soil has low potential for most urban uses. It is a poor filter, and septic systems can contaminate the underground water supply. Extensive leveling is generally desirable before houses are built. Improved roads are badly needed on the loose sandy soil. The soil is good base material for improved streets and roads.

This soil is in capability subclass VIIe and in the Dune range site.

55—Yahola fine sandy loam, occasionally flooded. This is a deep, well drained, nearly level soil on flood plains. Slopes are smooth and slightly undulating and range from 0 to 1 percent. Most areas of this soil range from 50 to 400 acres, but some areas are about 10 acres.

Typically, the surface layer is brown fine sandy loam about 12 inches thick. The next layer is brown very fine sandy loam to a depth of about 24 inches and reddish yellow fine sandy loam to a depth of about 42 inches. The underlying material to a depth of about 72 inches is brown fine sandy loam stratified with coarser and finer textured material.

This soil is high in natural fertility and low in organic matter content. The surface layer is mildly alkaline or moderately alkaline. The available water capacity is high, and permeability is moderately rapid. Ground water is available to deep-rooted plants in the spring of most years. This soil has good tilth and can be easily worked throughout a wide range of moisture content. The root zone is deep and is easily penetrated by roots. This soil is subject to occasional flooding.

Included with this soil in mapping are areas of Gaddy soils in lower positions than the Yahola soil. Also included are areas of Hawley and Reinach soils on low terraces of flood plains. The included soils make up about 15 percent of the map unit, but the individual areas generally are less than 5 acres.

This Yahola soil has high potential for row crops and small grains. The main concerns in management are occasional flooding, soil blowing, and maintaining tilth and fertility. Crops that make their growth late in fall, throughout winter, and during spring prevent excessive soil loss. Spring planting is often delayed until after the usual flood period. Most crops that produce a large amount of residue can be grown continuously if fertilizer is added to obtain the maximum residue. Minimum tillage and maintenance of the organic matter content of this soil help maintain good tilth, reduce wind erosion, and increase the intake of water. Using this soil for tame pasture reduces soil loss during the flood period.

The soil has high potential for native grasses and tame pasture. Bermudagrass, weeping lovegrass, and tall wheatgrass are commonly used for tame pasture. Fertilizing tame pasture increases the amount and improves the quality of forage; the additional plant growth protects the soil from erosion. The quality of native and tame pasture grasses also can be improved by controlling grazing, proper stocking, and preventing wildfires.

The soil has low potential for most urban uses. Flooding is the main limitation for septic tank absorption fields, sewage lagoons, sanitary landfills, dwellings, small commercial buildings, roads, and streets. Upstream flood control structures and land treatment can reduce flooding but cannot completely eliminate it on this soil. The potential flood hazard is high for houses built on the flood plain.

This Yahola soil is in capability subclass IIw and in the Loamy Bottomland range site.

Prime Farmland

In this section, prime farmland is defined and discussed, and the prime farmland soils in Grant County are listed.

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. The acreage of high-quality farmland is limited, and the U.S. Department of Agriculture recognizes that government at local, state, and federal levels, as well as individuals, must encourage and facilitate the wise use of our nation's prime farmland.

Prime farmland soils, as defined by the U.S. Department of Agriculture, are soils that are best suited to producing food, feed, forage, fiber, and oilseed crops. Such soils have properties that are favorable for the economic production of sustained high yields of crops. The soils need only to be treated and managed using acceptable farming methods. The moisture supply, of course, must be adequate, and the growing season has to be sufficiently long. Prime farmland soils produce the highest yields with minimal inputs of energy and economic resources. Farming these soils results in the least damage to the environment.

Prime farmland soils may presently be in use as cropland, pasture, or woodland, or they may be in other uses. They either are used for producing food or fiber or are available for these uses. Urban or built-up land and water areas cannot be considered prime farmland. Urban or built-up land is any contiguous unit of land 10 acres or more in size that is used for such purposes as housing, industrial, and commercial sites, sites for institutions or public buildings, small parks, golf courses, cemeteries, railroad yards, airports, sanitary landfills, sewage treatment plants, and water control structures.

Prime farmland soils usually get an adequate and dependable supply of moisture from precipitation or irrigation. The temperature and growing season are favorable. The acidity or alkalinity level of the soils is acceptable. The soils have few or no rocks and are permeable to water and air. They are not excessively erodible or saturated with water for long periods and are not subject to frequent flooding during the growing season. The slope ranges mainly from 0 to 5 percent.

In this county about 457,301 acres, or 71.0 percent, is prime farmland. Areas are scattered throughout the county, but most are in the central and northwestern parts, mainly in map units 1, 5, 7, and 8 of the general soil map. Approximately 81 percent of this prime farmland is field crops, 13 percent is rangeland, 4 percent is tame pasture, and 2 percent is woodland. Crops grown on this land are mainly wheat, grain sorghums, and alfalfa.

A recent trend in land use in some parts of the county has been the loss of some prime farmlands to urban uses. The loss of prime farmland to other uses puts pressure on marginal lands, which generally are more erodible, droughty, and difficult to cultivate, and usually less productive.

The following map units, or soils, make up prime farmland in Grant County. The location of each map unit is shown on the detailed soil maps at the back of this publication. The extent of each unit is given in table 4. The soil qualities that affect use and management are described in the section "Detailed Soil Map Units." This list does not constitute a recommendation for a particular land use.

2 Attica fine sandy loam, 0 to 3 percent slopes
3 Attica fine sandy loam, 3 to 5 percent slopes
4 Bethany silt loam, 0 to 1 percent slopes
6 Dale silt loam, rarely flooded, 0 to 1 percent slopes
15 Grainola silty clay loam, 1 to 3 percent slopes
16 Grainola silty clay loam, 3 to 5 percent slopes
17 Grant silt loam, 1 to 3 percent slopes
18 Grant silt loam, 3 to 5 percent slopes
23 Hawley fine sandy loam, rarely flooded
24 Kingfisher silt loam, 1 to 3 percent slopes
25 Kingfisher silt loam, 3 to 5 percent slopes
29 Kirkland silt loam, 0 to 1 percent slopes
30 Kirkland silt loam, 1 to 3 percent slopes
32 Lela clay, rarely flooded
34 McLain silt loam, rarely flooded
36 Norge silt loam, 3 to 5 percent slopes
39 Pond Creek silt loam, 0 to 1 percent slopes
40 Pond Creek silt loam, 1 to 3 percent slopes
41 Port silt loam, occasionally flooded
47 Reinach very fine sandy loam, rarely flooded
48 Renfrow silt loam, 3 to 5 percent slopes
51 Shellabarger fine sandy loam, 1 to 3 percent slopes
52 Tabler silt loam, 0 to 1 percent slopes
55 Yahola fine sandy loam, occasionally flooded

Use and Management of the Soils

Bobby J. Smith, district conservationist, Soil Conservation Service, helped prepare this section.

This soil survey is an inventory and evaluation of the soils in the survey area. It can be used as a technical reference to assist in adjusting land uses to the limitations and potentials of natural resources and the environment. Also, it can help avoid soil-related failures associated with improper land uses.

In preparing a soil survey, soil scientists, conservationists, engineers, and others collect extensive field data about the nature and behavior 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 for predicting soil behavior.

Information in this section can be used to plan the use and management of soils for crops and pasture; as rangeland and woodland; as sites for buildings, sanitary facilities, highways and other transportation systems, and parks and other recreation 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 that is in harmony with nature.

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

Keith Vaughan, conservation agronomist, and David D. Ankle, range 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 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 "Detailed Soil Map Units." Specific information can be obtained from the local office of the Soil Conservation Service or the Cooperative Extension Service.

Crops

More than 475,200 acres in Grant County was used for crops and pasture in 1967 *(3)*. Of this total, 3,700 acres was used as permanent pasture; 14,600 acres for row crops, mainly sorghum; 360,400 acres for close-growing crops, mainly wheat and other small grains; and 28,400 acres for rotation hay and pasture. The rest was idle cropland.

The soils in Grant County have medium potential for increased production of food. About 80,000 acres that has medium potential for crops is used as rangeland, and about 3,700 acres is used as pasture. In addition to the reserve productive capacity represented by this land, food production could also be increased considerably by extending the latest crop production technology to all cropland in the county.

The acreage in crops and pasture has been gradually decreasing as more and more land is used for urban development. In 1978 there was about 2,700 acres of urban and built-up land in the county, and this figure has been growing.

Soil erosion is the major concern on about 90 percent of the cropland, rangeland, and pasture in Grant County. Erosion is a hazard where the slope is more than 2 percent. Grainola, Grant, Kingfisher, Norge, and Quinlan soils, for example, have slope of 2 to 5 percent.

Loss of the surface layer through erosion is damaging for two reasons. First, 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 Bethany, Grainola, Kirkland, Pawhuska, Renfrow, and Tabler soils, and on soils that have a layer in or below the subsoil that limits the depth of the root zone and the available water capacity. Such a layer can be bedrock, as in Kingfisher, Quinlan, and Woodward soils. Erosion also reduces productivity on soils that tend to be droughty, such as Renfrow soils. Second, soil erosion on farmland results in sedimentation of streams. Controlling erosion minimizes the pollution of streams by sediment and improves the quality of water for municipal use, for recreation, and for fish and wildlife.

On many sloping fields, tilling or preparing a good seedbed is difficult because the original friable surface soil has been eroded away and the less friable subsoil is exposed. Such spots are common in areas of moderately eroded Grant, Kingfisher, Norge, Quinlan, and Renfrow soils.

Erosion control practices provide protective surface cover, reduce runoff, and increase infiltration. A cropping system that keeps plant cover on the soil for extended periods can hold soil losses to an amount that will not reduce the productive capacity of the soils. On livestock farms, which require pasture and hay, the legume and grass forage crops in the cropping system reduce erosion on sloping land, provide nitrogen, and improve tilth for the following crop.

Minimizing tillage and leaving crop residue on the surface help to increase infiltration and to reduce runoff and erosion. These practices can be adapted to most soils in the county, but they are more difficult to use successfully on the eroded soils and on the soils that have a clayey surface layer, such as Lela soils. No-tillage for wheat is effective in reducing erosion on sloping land and can be adapted to most soils in the county, but it is difficult to practice successfully on the soils that have a clayey surface layer. At present, moreover, it is not economically feasible because of the marginal production on most soils in the county.

Terraces and diversions reduce the length of slope and reduce runoff and erosion. They are practical on deep, well drained soils that have regular slopes. Bethany, Grainola, Grant, Kingfisher, Kirkland, Norge, Pond Creek, Woodward, and some Shellabarger soils are suitable for terraces. Most other soils are less suitable for terraces and diversions because of irregular slopes, a clayey subsoil which would be exposed in terrace channels, or bedrock at a depth of less than 20 inches. Goltry and Pratt soils are so sandy that terracing is not practical. On these soils, a cropping system that provides ample and lasting plant cover is required to control erosion unless conservation tillage is practiced.

Contouring and contour stripcropping are effective in controlling erosion. They are best adapted to soils that have smooth, uniform slopes, for example, most areas of Grainola, Grant, Kingfisher, Kirkland, Norge, Pond Creek, Quinlan, Renfrow, and Woodward soils.

Soil blowing is a hazard on the sandy Attica, Goltry, and Pratt soils. If the soils are dry and bare of vegetation or surface mulch, soil blowing can damage these soils in a few hours when winds are strong. Maintaining a plant cover, surface mulch, or a rough surface produced by proper tillage minimizes soil blowing on these soils. Windbreaks of adapted trees, such as Austrian pine, red mulberry, or autumn-olive, are effective in reducing soil blowing.

Information for the design of erosion control practices for each kind of soil is available from the local office of the Soil Conservation Service.

Soil drainage is the major management need on about 1 percent of the acreage used for crops and pasture in Grant County. The somewhat poorly drained Drummond and Gracemont soils are so wet that the production of crops commonly grown in the county is generally not possible, or the yield is greatly reduced. These soils also have a high content of salts and sodium; consequently, surface drainage commonly is not practical (fig. 6).

The design of surface and subsurface drainage systems varies with the kind of soil. Subsurface drainage can be used successfully in most areas. Drains have to be more closely spaced in slowly permeable soils than in more permeable soils. Finding an adequate outlet for a subsurface drainage system is difficult in some areas of Drummond and Gracemont soils, especially along the Salt Fork of the Arkansas River. Information on drainage design for each kind of soil is available from the local office of the Soil Conservation Service.

Soil fertility is naturally low in most sandy soils in the county. Alluvial soils on flood plains, such as Dale, Hawley, Lela, McLain, Port, Reinach, and Yahola soils, are naturally higher in plant nutrients than most soils on uplands. The level of available phosphorus is naturally low in many of the soils. On all soils, additions of fertilizer should be based on the results of soil tests, on the need of the crop, and on the expected level of yields. The Cooperative Extension Service can help in determining the kind and amount of fertilizer to apply.

Tilth is an important factor in the germination of seeds and in the infiltration of water into the soil. Soils that have good tilth are granular and porous and do not have a compacted pan.

Some of the soils used for crops in Grant County have a surface layer of silt loam or fine sandy loam that is light in color and low to medium in content of organic matter. Generally, the structure of such soils is weak, and intense rainfall causes a crust to form on the surface. The crust is hard when dry and is nearly impervious to water. Once the crust forms, it reduces infiltration and increases runoff. Regular additions of crop residue, manure, and other organic material can help improve soil structure and reduce crusting.

Fall plowing is generally not a good practice on the light colored soils that have a surface layer of loamy fine sand or fine sandy loam because it increases the hazard of soil blowing in winter and spring. Also, some of the cropland consists of sloping soils that are subject to damaging erosion if they are plowed in the fall.

Tilth is a concern for the dark colored Kirkland, McLain, Renfrow, and Tabler soils. If these soils are wet

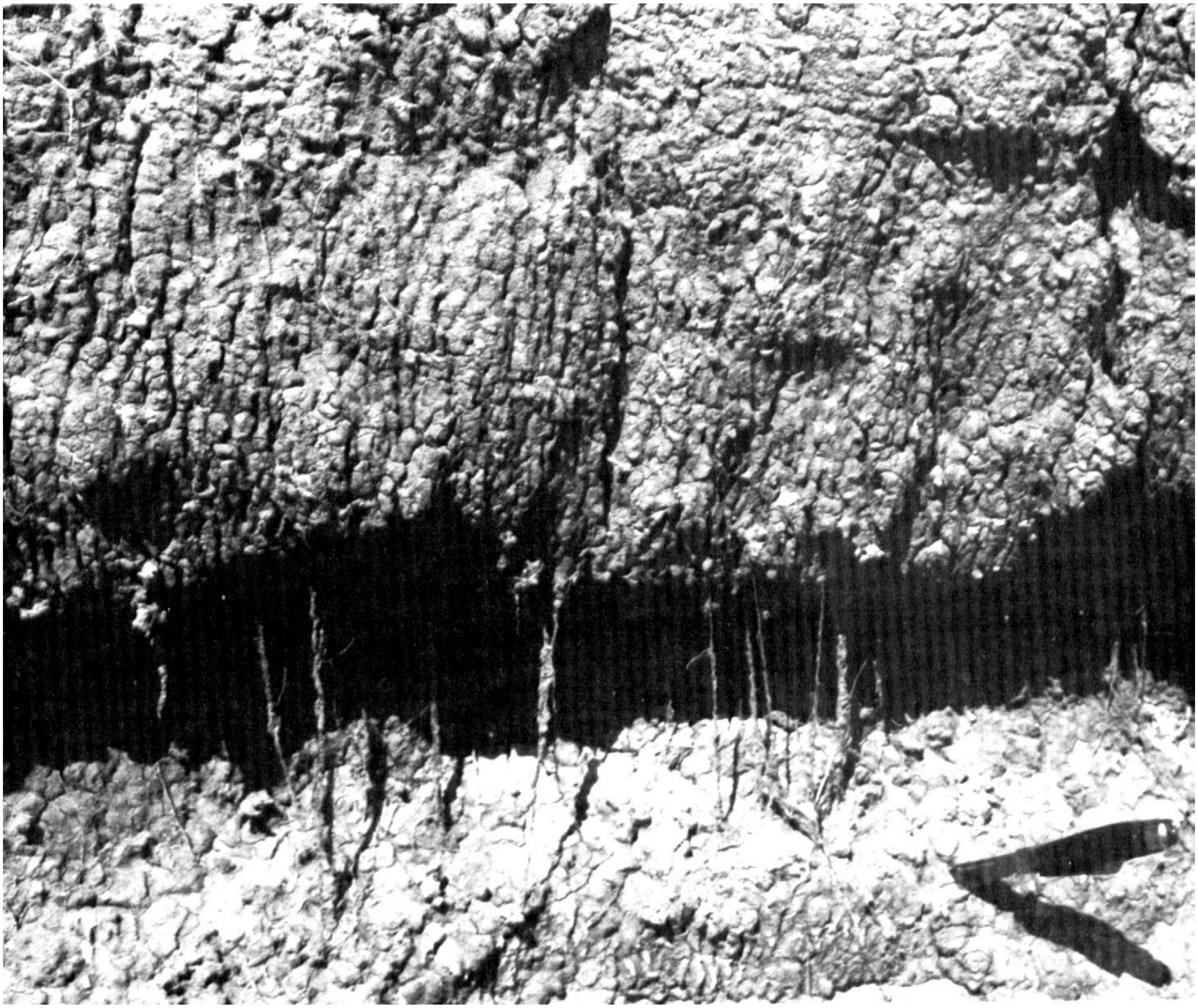


Figure 6.—Compound blocky and columnar structure, coated by salts, in the subsoil of the Drummond soil in an area of McLain-Drummond silt loams, rarely flooded. This structure is high in sodium and is easily eroded in spillways, terraces, and waterways.

when plowed, they tend to become very cloddy when dry, and a good seedbed is difficult to prepare. Fall plowing generally results in better tilth than plowing in the spring.

Field crops suited to the soils and climate of Grant County include many that are not now commonly grown. Cotton and grain sorghum are the common row crops. Guar, corn, sunflowers, mung beans, soybeans, peanuts, potatoes, and similar crops can be grown.

Wheat, barley, and oats are the common close-growing crops. Rye, millet, and flax could be grown, and seed could be produced from rye, vetch, fescue, alfalfa, and lovegrass.

Specialty crops grown in Grant County are vegetables, small fruits, tree fruits, and nursery plants. A small acreage throughout the sandy part of the county could be used for melons, sweet corn, tomatoes, and small fruits. Apples and peaches are the most important tree fruits grown in the county. Attica, Goltry, Hawley, Pratt, Reinach, and Shellabarger soils are especially well suited to many vegetables and small fruits because they are deep soils that have good natural drainage and that warm up early in spring. Irrigation is essential for good production in most years.

Some of the well drained soils in the county are suitable for orchards and nursery plants. Pecan trees have a deep root system and require ample moisture. They grow best on flood plain soils, such as Dale, Hawley, Lela, McLain, Port, Reinach, and Yahola soils.

The latest information and suggestions for growing specialty crops can be obtained from the local office of the Cooperative Extension Service or of the Soil Conservation Service.

Farming and other land uses are competing for large areas of the county. About 2,700 acres, or nearly 0.4 percent of Grant County, was urban or built-up land in 1978. Much of this acreage was well suited to crops. Each year additional land is being developed for urban uses.

In general, the soils in the county that are well suited to crops are also well suited to urban development. The data about specific soils in this soil survey can be used in planning future land use patterns. Potential productive capacity in farming should be weighed against soil limitations and potential for nonfarm development.

In some areas, however, the soils are well suited to farming but are poorly suited to nonfarm development. The areas correspond to map units 8, 9, and 10 on the general soil map. In these areas the dominant soils are Dale, Drummond, Gaddy, Hawley, McLain, Oscar, and Yahola soils, all of which are on flood plains and are subject to overflow, so that there are serious hazards for nonfarm development.

In other areas, the soils are only fairly well suited to farming but are generally well suited to nonfarm development. The areas correspond to map units 6 and 7, which are dominated by Goltry, Goodnight, Pratt, and Tivoli soils. These soils are sandy, droughty, and subject to soil blowing; however, the rolling landscape, good soil drainage, and other soil qualities are favorable for residential development and other urban uses.

Tame Pasture

About 3 percent of the acreage in the county is in tame pasture plants. The present trend is to convert marginal cropland to pasture. To a lesser degree, rangeland is also being converted to pasture, especially some areas of depleted rangeland that are scattered among large areas of cropland.

The principal pasture grass is improved bermudagrass. Some of the better pastures of bermudagrass are overseeded with small grains. This practice increases the yield of forage and lengthens the grazing period.

Tall wheatgrass is an important grass in the county, especially on saline soils. It provides sufficient forage for grazing on soils that have abundant available moisture. It is used in the pasture program with other forages to furnish grazing and additional protein late in fall and during the spring. To maintain a vigorous stand, it needs to be fertilized early in spring and early in fall, and it should not be grazed during summer.

Weeping lovegrass, a warm-season perennial bunchgrass, is grown on a few acres in the county. It is suited to well drained loamy and sandy soils. It begins growth earlier in spring than bermudagrass and remains green later in fall. It responds well to fertilizer, especially nitrogen. It becomes less palatable to cattle as it matures.

Some areas of cropland are used for forage plants that supplement the permanent grasses. Small grains in the pasture program provide grazing and additional protein for livestock late in fall and during spring. Small grains need to be seeded and fertilized late in summer or early in fall to help obtain the maximum amount of forage. Small grains can be grazed until maturity, or livestock can be removed in spring to allow the plants to bear a seed crop for harvest. Wheat, oats, barley, and rye are the small grains mainly used for grazing.

Forage sorghum, an annual grass, is also used on some cropland to supplement permanent grasses. Forage sorghum can be used in the pasture program to provide grazing during summer, or it can be harvested for hay. In some areas, forage sorghum is allowed to grow until frost and is grazed in the winter. Fertilizer should be used to help obtain maximum growth.

Plains bluestem, a warm-season perennial tall grass, is grown on a few acres in the county. It is suited to well drained loamy and clayey soils. It begins growth earlier in spring than bermudagrass, and as it matures it remains palatable to cattle much longer than lovegrass. It also responds very well to fertilization. Plains bluestem is capable of producing two seed crops a year in normal years.

Pasture management

The kind of soil and the plants that are best suited to it must be considered in tame pasture management. Good pasture can be achieved by managing to maintain the desired kinds of plants in the stand. Plants must have vigor to keep a proper balance in the stand. Grazing needs to be compatible with the growth cycle of the plants.

Proper grazing and rotation grazing help lengthen the life of most tame pasture plants. Deferred grazing when tame pasture plants are under the most stress is beneficial. It allows the plants to regain vigor by helping to maintain a large root system where food can be stored for the next growing season; thus, the total production of forage will increase.

Fertilizer that contains the proper elements contributes to the vigor of pasture plants and thus helps increase the amount of forage produced and lengthen the lifespan of the plants. Plant food can be added by using commercial fertilizers or legumes, or both, to furnish

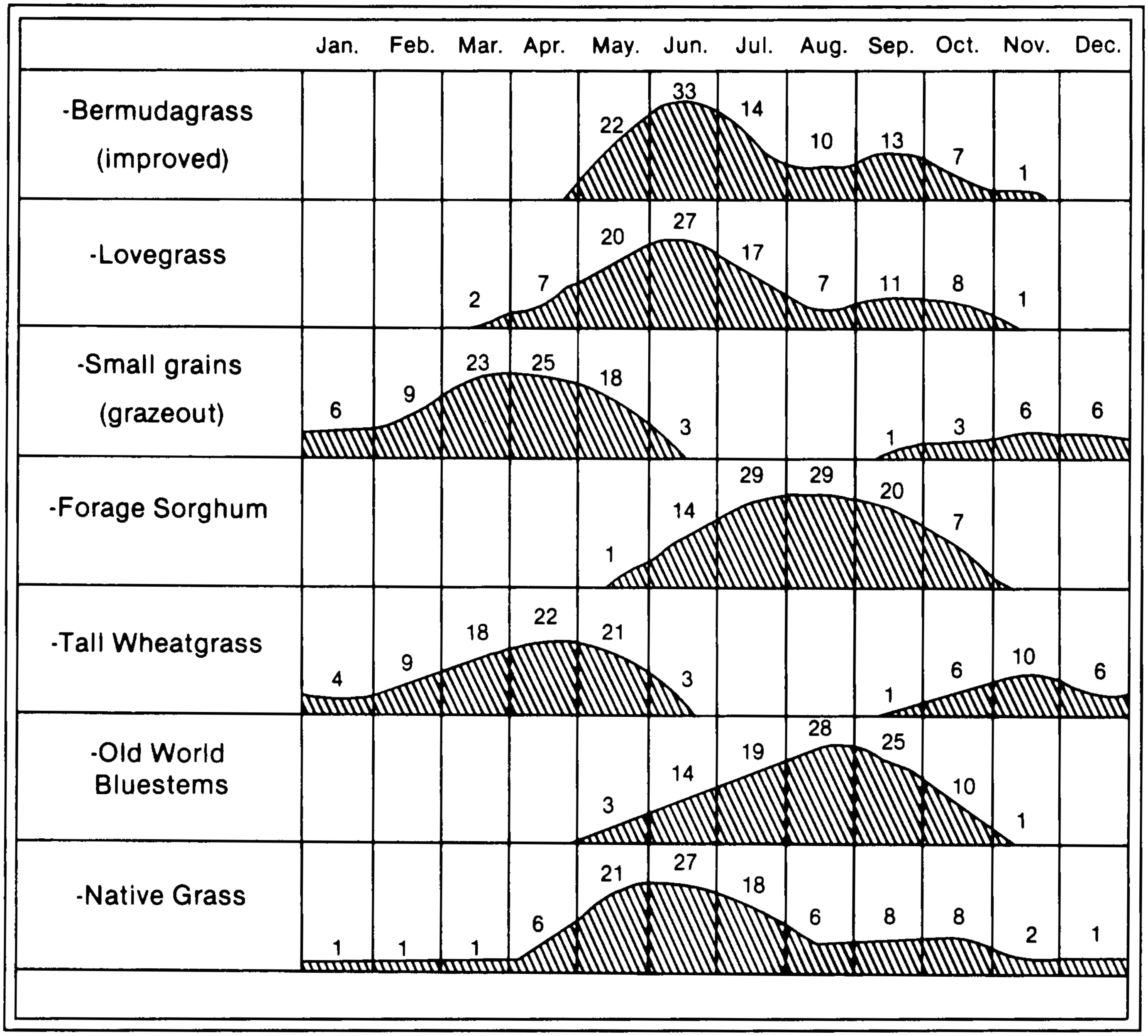


Figure 7.—Forage calendar showing monthly growth as a percentage of forage produced annually.

nitrogen. The acidity of the soil needs to be adjusted to the kinds of plants desired in the stand. Large amounts of plant food, especially nitrogen, are needed unless legumes are grown with the grass.

Desirable pasture plants can be maintained in the stand only by controlling the invasion of undesirable plants. Weeds need to be controlled. Brush control is essential in areas where trees grow. Mowing or spraying, or both, properly used, help control weeds and brush.

Planning a Pasture Program

A pasture program can be planned so that adequate forage is available during every month of the year. A study of the growth habits of the different plants is necessary. The seasons in which various kinds of forage plants make their growth and the monthly percentage of annual growth for each kind of plant are shown in the accompanying graph (fig. 7). For example, bermudagrass makes 33 percent of its yearly growth during the month of June.

Soils vary in their capacity to produce forage for grazing. Pond Creek soils produce more forage than Renfrow soils, primarily because they furnish more available moisture to plants. The total yearly production of common pasture plants for each soil is given in animal unit months (AUM) in table 5. For example, bermudagrass on 1 acre of Pond Creek silt loam, 1 to 3 percent slopes, will furnish grazing for one animal unit for 7 months per year.

In planning a pasture program, one must consider the total yearly production of the pasture plant in AUM and the normal growth made by the plant in a particular month. For example, bermudagrass makes 33 percent of its annual growth during June; the yearly production on Pond Creek silt loam, 1 to 3 percent slopes, is 7 AUM. Since 33 percent of 7 AUM is 2.3 AUM, 1 acre of this soil provided grazing for 2.3 animals in June. Therefore, a 50-acre bermudagrass pasture would furnish grazing for 115 animals during June. Soil Conservation Service or County Extension Office personnel can help plan a pasture program.

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 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 use as cropland. 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 rangeland, for woodland, and for engineering purposes.

In the capability system, soils are generally grouped at three levels: capability class, subclass, and unit. Only class and subclass are used in this survey. These levels are defined in the following paragraphs.

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

Capability subclasses are soil groups within one class. They are designated by adding a small letter, *e, w, s,* or *c,* to the class numeral, for example, IIe. The letter *e* shows that the main limitation is risk of erosion unless a 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 affected by salinity and alkalinity; 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.

There are no subclasses in class I because the soils of this class have few limitations. The soils in class V are subject to little or no erosion, but they have other limitations that restrict their use to pasture, rangeland, woodland, wildlife habitat, or recreation. Class V contains only the subclasses indicated by *w, s,* or *c*.

The capability class and subclass of each soil is shown in table 6. The capability classification of each map unit is also given in the section "Detailed Soil Map Units."

Rangeland

David D. Ankle and Ernest C. Snook, range conservationists, Soil Conservation Service, assisted in the preparation of this section.

Rangeland is land on which the native vegetation consists of a wide variety of grasses, grasslike plants, forbs, shrubs, and trees. The plant species are generally suitable for grazing and are sufficiently abundant to be used for grazing. Rangeland or native grassland receives no regular or frequent cultural treatment. The composition and production of the plant community are determined by soil, climate, topography, overstory canopy, and use or grazing management.

According to records of the local office of the Soil Conservation Service, 20 percent of Grant County is used as rangeland. The original range vegetation was a wide variety of tall and mid grasses interspersed with an abundance of forbs.

Three distinct types of rangeland exist in Grant County. In the eastern part of the county, most of the soils are loamy and deep to shallow over shale or clayey sediments. These soils support tall and mid grasses, and productivity is high.

In the southern and western parts of the county, along the Salt Fork of the Arkansas River and adjacent to Sand Creek, the soils are sandy and deep over sandy sediment. Some areas are hummocky. Soil blowing is a hazard. The soils support tall grasses, and productivity is moderate to high.

In the northwestern part of the county, the soils are shallow to moderately deep over shale or sandstone. Some large areas are characterized by steep slopes and escarpments. The soils support tall, mid, and short grasses, and potential productivity is low because the rooting depth is shallow and there is little available water.

The plant community has changed in the past few years, especially in the small areas of rangeland that are interspersed with cropland. Heavy grazing in these areas has caused the grasslands to deteriorate, and much of the high-quality vegetation has been grazed out. Now tall grasses flourish in only a few places and have been replaced in most most areas by a mixture of short to mid grasses and poor-quality grasses and forbs. The amount of forage presently produced may be less than half of that originally produced.

Although there are some cow-calf operations in the county, mainly on large rangeland units, most operations are stocker-feeder enterprises. Many ranches supplement their herds with stockers, thus achieving greater flexibility in adjusting the number of livestock to be cared for during a drought.

Livestock operations generally supplement the grazing of native grassland with the grazing of improved pastureland and cropland. Improved bermudagrass and weeping lovegrass are commonly grown for improved pasture. Protein supplement, hay, and grazing of small grains are used to supplement livestock feeding throughout the winter.

Approximately 75 percent of the annual growth of forage vegetation takes place in April, May, and June when spring rains and moderate temperatures are favorable for the growth of warm-season plants. A secondary growth period generally occurs in September and October, when fall rains and gradually cooling temperatures prevail.

Droughts of varying length are frequent in this area. Short midsummer droughts are normal. Longer periods of drought frequently last for several months.

Range Sites and Condition Classes

A range site is a distinctive kind of rangeland that produces a characteristic natural plant community that differs from natural plant communities on other range sites in kind, amount, and proportion of range plants. The relationship between soils and vegetation was established during this survey; thus, range sites generally can be determined directly from the soil map. The soil properties that affect moisture supply and plant nutrients have the greatest influence on the productivity of range plants. Soil reaction, salt content, and a seasonal high water table are also important.

Climax vegetation on the range site is the stabilized plant community that consists of the plants that were growing there when the region was first settled. This plant community reproduces itself and changes very little as long as the environment remains unchanged. If cultivated crops are not grown, the most productive combination of forage plants on a range site is generally the climax vegetation.

Decreasers, or preferred plants, are those constituents of the climax vegetation that tend to decrease in relative amount under close grazing. They generally are the tallest and most productive perennial grasses and forbs, and they are the most palatable to livestock.

Increasers, or desirable plants, are those that increase in relative amount as the more desirable decreaser plants are reduced by close grazing. They are commonly shorter and less productive than decreasers and are generally less palatable to livestock.

Invaders, or undesirable plants, are those that cannot compete with plants in the climax plant community for moisture, nutrients, and light. The seeds of many invaders germinate in bare, open soil. However, invaders grow along with increasers after the climax vegetation has been reduced by grazing. Some invaders have fair value for grazing.

The range condition in a particular area is judged according to the present kind and amount of vegetation in relation to the climax plant community for that range site. Four range condition classes are used to indicate the degree of departure from the potential, or climax, vegetation. Range is in excellent condition if 76 to 100 percent of the vegetation is of the same kind as that in the climax stand; in good condition if the percentage is 51 to 75; in fair condition if the percentage is 26 to 50; and in poor condition if the percentage is 25 or less.

Potential forage production depends on the range site. Current forage production depends on the range condition and the moisture available to plants during the growing season. Potential annual production is the amount of vegetation that can be expected to grow annually on well managed rangeland that is supporting the potential natural plant community. It includes all vegetation, whether or not it is palatable to grazing animals. It includes the current year's growth of leaves, twigs, and fruits of woody plants. It does not include the increase in stem diameter of trees and shrubs. It is expressed in pounds per acre of air-dry vegetation for favorable, average, and unfavorable years. In a favorable year, the amount and distribution of precipitation and the temperatures make growing conditions substantially better than average. In an average year, growing conditions are about normal. In an unfavorable year, growing conditions are well below average, generally because of low available soil moisture.

Table 7 shows, for each soil, the range site and the potential annual production as dry weight of vegetation in favorable, average, and unfavorable years. Dry weight is the total annual yield per acre reduced to a common percent of air-dry moisture content. Only those soils that are used as rangeland or are suited to this use are listed.

The primary objective of good range management is to keep the range in excellent or good condition. If the range is well managed, water is conserved, yields increase, and the soils are protected. The main concern in management is recognizing important changes in the plant cover on a range site. These changes take place gradually and can be misinterpreted or overlooked. Growth encouraged by heavy rainfall may give the impression that the range is in good condition, whereas in reality the cover is weedy and the long-term trend is toward lower production. On the other hand, some rangeland that has been closely grazed for short periods under the supervision of a careful manager may have a degraded appearance that temporarily conceals its quality and ability to recover. After years of prolonged overuse of rangeland, seed sources of the desirable vegetation will have been eliminated. At this point, the vegetation must be reestablished before management can be effective.

Range management practices suitable for Grant County are proper grazing use, deferred grazing, and a planned grazing system. Auxiliary practices that assist in management are stock water development, fencing, and the placement of salting and feeding locations. When regression has taken hold and undesirable plants dominate, such regenerative practices as range seeding, brush management, weed management, and prescribed burning should be considered singly or as part of a range management system. Such a system, properly applied and maintained, generally results in the optimum production of vegetation, reduction of undesirable species, conservation of water, and control of erosion. Sometimes, however, a range condition somewhat below the potential meets grazing needs, provides habitat for wildlife, and protects soil and water resources.

The following information contains guidelines for potential annual utilization on a broad scale. If more detail is needed for a particular area or situation, it is available from the local office of the Soil Conservation Service.

The amount of annual growth that can be removed, while at the same time the quality and quantity of native vegetation is maintained or improved, depends on the potential productivity and condition of the site. As a rule, approximately 50 percent of the annual season's growth should be left on the soil surface. For tall and mid grasses, one-third of the plant's height at maturity equals 50 percent of the annual production. If 50 percent of the annual season's growth remains on the site, the natural equilibrium of soil, plants, animals, and environment is sustained. The surplus 50 percent of annual growth may or may not be removed from the site. The removal may be accomplished in a number of ways, as by micro-organisms, rodents, insects, grazing mammals, and deterioration caused by climatic variations. Generally, cattle or other large grazing animals remove approximately 50 percent of the growth of forage plants from the site, or 25 percent, by weight, of the total annual season's growth. For example, the annual season's growth in an area of the Loamy Prairie range site in excellent condition, for an average growing season, would be 3,500 pounds per acre of air-dry vegetative material. Approximately 25 percent, or 875 pounds per acre of the average productivity of grasses and forbs, is available for livestock forage. The total of 3,500 pounds includes the production of all plants: grasses, forbs, and woody species. Generally, however, woody species are not considered livestock forage.

A 1,000-pound cow is equivalent to one animal unit (AU), which is the standard of consumption used in measuring production of feed and forage and in determining the carrying capacity of rangeland or pasture. The cow consumes 2.5 to 3 percent of its body weight in forage each day; thus, the requirement for one animal unit is 25 to 30 pounds of air-dry forage per day. An animal-unit-month (AUM) is calculated on a 30-day base. In 30 days (or 1 month), an animal will consume 750 to 900 pounds of native vegetation, mainly grass; the amount varies depending on the quality, condition, and stage of growth of the forage plants.

If the average amount (875 pounds) of available forage that is produced annually on 1 acre of Loamy Prairie range site in excellent condition is divided by 25 to 30 pounds (AU requirement per day), it is shown that 1 acre can maintain 1 animal unit for 29 to 35 days per year. If the 875 pounds of available forage is divided by the monthly requirement of 750 to 900 pounds, the result works out to 1.17 to .97 AUM per acre. Thus, it would require from 10.0 to 12.3 acres of the Loamy Prairie range site in excellent condition to run one range cow for 12 months, or year-round.

There are 14 range sites in Grant County: Alkali Bottomland, Claypan Prairie, Deep Sand, Dune, Heavy Bottomland, Loamy Bottomland, Loamy Prairie, Red Clay Prairie, Saline Subirrigated, Sandy Prairie, Sandy Bottomland, Shallow Prairie, Slickspot, and Subirrigated.

Alkali Bottomland

The Oscar soils in map unit 38 are in this site.

The potential plant community is dominated by short and mid grasses. Its composition by weight is 75 percent grasses and 25 percent forbs. Switchgrass, little bluestem, sideoats grama, western wheatgrass, Pitcher sage, and perennial lespedezas are preferred plants and make up 65 percent of livestock forage production when the range is in excellent condition. Under continuous or heavy grazing, the preferred plants disappear and are replaced by desirable plants such as alkali sacaton, Texas dropseed, blue grama, buffalograss, tall dropseed, goldenrods, and prairie coneflower.

Continued overgrazing and extreme climatic conditions cause a decline in the desirable plants. If the plant community deteriorates further, undesirable plants such as threeawns, ragweeds, wax goldenweed, pricklypear, and annual grasses and forbs dominate the site. As undesirable plants become dominant, the potential for forage production is greatly reduced.

Claypan Prairie

The Kirkland, Renfrow, and Tabler soils in map units 29, 30, 31, 48, 49, 50, and 52 are in this site.

The potential plant community is dominated by mid and tall grasses. Its species composition, by weight, is 80 percent grasses, 15 percent forbs, and 5 percent woody plants. Big bluestem, little bluestem, and switchgrass are the main forage grasses; along with indiangrass, leadplant, and catclaw sensitivebrier, they are preferred plants that make up 70 percent of livestock forage production when the range is in excellent condition. Under continuous or heavy grazing, the preferred plants disappear and are replaced by desirable plants such as sideoats grama, blue grama, buffalograss, tall dropseed, goldenrods, heath aster, prairie coneflower, and dotted gayfeather.

Continued overgrazing and extreme climatic conditions cause a decline in the desirable plants. If the plant community deteriorates further, undesirable plants such as little barley, silver bluestem, annual bromes, prairie threeawn, common broomweed, western ragweed, and ironweed dominate the site. As undesirable plants become dominant, the potential for forage production is greatly reduced.

Coralberry and pricklypear cactus commonly are present in minor amounts and increase if range is overused.

Deep Sand

The Aline, Goodnight, and Pratt soils in map units 1, 12, 13, and 43 are in this site.

The potential plant community is dominantly tall grasses. The species composition, by weight, is 80 percent grasses, 15 percent forbs, and 5 percent woody plants. Big bluestem, sand bluestem, indiangrass, little bluestem, switchgrass, perennial lespedeza, and tickclover are preferred plants that make up 80 percent of livestock forage production when the range is in excellent condition. Under continuous or heavy grazing, the preferred plants disappear and are replaced by desirable plants such as purpletop, tall dropseed, Scribner panicum, sand lovegrass, wild alfalfa, heath aster, goldenrods, and sumac.

Continued overgrazing and extreme climatic conditions cause a decline in the desirable plants. If the plant community deteriorates further, undesirable plants such as showy partridge pea, ragweeds, annual threeawn, silver bluestem, witchgrass, plum, and annual grasses and forbs dominate the site. As undesirable plants become dominant, the potential for forage production is greatly reduced.

Dune

The Tivoli soils in map units 53 and 54 are in this site.

The potential plant community is dominantly mid and tall grasses. The species composition, by weight, is 75 percent grasses, 20 percent forbs, and 5 percent woody plants. Little bluestem, sand bluestem, sand lovegrass, indiangrass, big sandreed, and wildryes are preferred plants that make up 60 percent of livestock forage production when the range is in excellent condition. Under continuous or heavy grazing, the preferred plants disappear and are replaced by desirable plants such as sand paspalum, fall witchgrass, Texas bluegrass, hairy grama, sand dropseed, Scribner panicum, bigtop dalea, sagewort, queensdelight, small soapweed, sand plum, and skunkbush.

Continued overgrazing and extreme climatic conditions cause a decline in the desirable plants. If the plant community deteriorates further, undesirable plants such as sandbur, purple sandgrass, gummy lovegrass, red lovegrass, camphorweed, annual sunflower, western ragweed, nightshades, common broomweed, and other annual grasses and forbs dominate the site. As undesirable plants become dominant and woody species increase, the potential for forage production is greatly reduced.

Heavy Bottomland

The Lela soils in map unit 32 are in this site.

The potential plant community is dominantly mid and tall grasses. The species composition, by weight, is 70 percent grasses, 20 percent forbs, and 10 percent woody plants. Big bluestem, indiangrass, switchgrass, little bluestem, wildryes, perennial lespedezas, and Maximilian sunflower are preferred plants that make up 65 percent of livestock forage production when the range is in excellent condition. Under continuous or heavy grazing, the preferred plants disappear and are replaced by desirable plants such as tall dropseed, sideoats grama, Scribner panicum, western wheatgrass, vine-mesquite, goldenrods, sedges, purpletop, heath aster, and sageworts.

Continued overgrazing and extreme climate conditions cause a decline in the desirable plants. If the plant community deteriorates further, undesirable plants such as windmillgrass, silver bluestem, inland saltgrass, buffalograss, barnyard grass, ragweeds, ironweed, and cocklebur dominate the site. As undesirable plants become dominant and woody species increase, the potential for forage production is greatly reduced.

Loamy Bottomland

The Carwile, Dale, Hawley, McLain, Pocasset, Port, Reinach, and Yahola soils in map units 5, 6, 7, 22, 23, 33, 34, 35, 41, 42, 47, and 55 are in this site.

The potential plant community is tall grasses. The species composition, by weight, is 80 percent grasses, 15 percent forbs, and 5 percent woody plants. Big bluestem, indiangrass, switchgrass, eastern gamagrass, wildryes, leadplant, compassplant, and Maximilian sunflower are preferred plants that make up 75 percent of livestock forage production in excellent condition. Under continuous or heavy grazing, the preferred plants disappear and are replaced by desirable plants such as little bluestem, tall dropseed, sideoats grama, Scribner panicum, wild alfalfa, heath aster, goldenrods, and sageworts.

Continued overgrazing and extreme climatic conditions cause a decline in the desirable plants. If the plant community deteriorates further, undesirable plants such as silver bluestem, fall witchgrass, threeawns, partridge pea, ragweeds, ironweed, coralberry, and annual grasses and forbs dominate the site. As undesirable plants become dominant and woody species increase, the potential for forage production is greatly reduced.

Loamy Prairie

The Bethany, Grant, Kingfisher, Norge, Pond Creek, and Woodward soils in map units 4, 17, 18, 19, 20, 21, 22, 24, 25, 26, 27, 28, 36, 37, 38, 39, 40, and 46 are in this site.

The potential plant community is mainly mid and tall grasses. The species composition, by weight, is 75 percent grasses, 20 percent forbs, and 5 percent woody plants. Big bluestem, little bluestem, indiangrass, switchgrass, leadplant, compassplant, Pitcher sage, and perennial sunflowers are preferred plants that make up 75 percent of livestock forage production when the range is in excellent condition. Under continuous or heavy grazing, the preferred plants disappear and are replaced by desirable plants such as sideoats grama, blue grama, tall and meadow dropseed, Scribner panicum, wild alfalfa, wild indigos, dotted gayfeather, and heath aster.

Continued overgrazing and extreme climatic conditions cause a decline in the desirable plants. If the plant community deteriorates further, undesirable plants such as silver bluestem, fall witchgrass, tumblegrass, annual threeawn, common broomweed, western ragweed, plum, and annual grasses and forbs dominate the site. As undesirable plants become dominant, the potential for forage production is greatly reduced.

Red Clay Prairie

The Masham soils in map unit 33 are in this site.

The potential plant community is mainly mid and short grasses. The species composition, by weight, is 75 percent grasses, 20 percent forbs, and 5 percent woody plants. Little bluestem, big bluestem, and sideoats grama primarily along with buffalograss, halfshrub sundrop, prairie clover, and catclaw sensitivebrier are preferred plants that make up 60 percent of livestock forage production when the range is in excellent condition. Under continuous or heavy grazing, the preferred plants disappear and are replaced by desirable plants such as vine mesquite, hairy grama, blue grama, buffalograss, tall dropseed, dotted gayfeather, and blacksamson.

Continued overgrazing and extreme climatic conditions cause a decline in the desirable plants. If the plant community deteriorates further, undesirable plants such as silver bluestem, western ragweed, threeawn, Japanese brome, windmillgrass, common broomweed, and pricklypear cactus dominate the site. As undesirable plants become dominant, the potential for forage production is greatly reduced.

Woody species such as coralberry, plum, and sumac commonly are present in minor amounts and increase if the range is overused.

Saline Subirrigated

The Drummond and Gracemont soils in map units 8, 14, and 35 are in this site.

The potential plant community is dominated by tall grasses. The species composition, by weight, is 80 percent grasses, 15 percent forbs, and 5 percent woody plants. Switchgrass, sand bluestem, little bluestem, indiangrass, prairie cordgrass, wildryes, bundleflower, and perennial sunflowers are preferred plants that make up 75 percent of livestock forage production when the range is in excellent condition. Under continuous or heavy grazing, the preferred plants disappear and are replaced by desirable plants such as western wheatgrass, alkali sacaton, tall dropseed, Scribner panicum, knotroot bristlegrass, willow baccharis, buttonbush, seacoast sumpweed, and smartweed.

Continued overgrazing and extreme climatic conditions cause a decline in the desirable plants. If the plant community deteriorates further, undesirable plants such as inland saltgrass, silver bluestem, threeawn, ragweed, kochia, ironweed, tamarisk, cottonwood, and annual grasses and forbs dominate the site. As undesirable plants become dominant and woody species increase, the potential for forage production is greatly reduced.

Sandy Bottomland

The Gaddy soils in map units 9 and 10 are in this site.

The potential plant community is dominated by tall grasses. The species composition, by weight, is 75 percent grass, 20 percent forbs, and 5 percent woody plants. Switchgrass, sand bluestem, indiangrass, little bluestem, big sandreed, Illinois bundleflower, and Maximilian sunflower are preferred plants that make up 60 percent of livestock forage production when the range is in excellent condition. Under continuous or heavy grazing, the preferred plants disappear and are replaced by desirable plants such as sand paspalum, tall dropseed, sideoats grama, wild senna, queensdelight, sand plum, and skunkbush.

Continued overgrazing and extreme climatic conditions cause a decline in the desirable plants. If the plant community deteriorates further, undesirable plants such as sand dropseed, silver bluestem, fall witchgrass, red lovegrass, windmillgrass, sandbur, ragweeds, ironweeds, tamarisk, and annual grasses and forbs dominate the site. As undesirable plants become dominant, the potential for forage production is greatly reduced.

Sandy Prairie

The Attica and Shellabarger soils in map units 2, 3, 5, and 51 are in this site.

The potential plant community is dominated by tall grasses. The species composition, by weight, is 80 percent grasses, 15 percent forbs, and 5 percent woody plants. Little bluestem, sand bluestem, switchgrass, indiangrass, wildrye, sessile tickclover, slender lespedeza, Pitcher sage, and halfshrub sundrop are preferred plants that make up 70 percent of livestock forage production when the range is in excellent condition. Under continuous or heavy grazing, the preferred plants disappear and are replaced by desirable plants such as sideoats grama, blue grama, hairy grama, Scribner panicum, sand paspalum, tall dropseed, wild indigo, wild alfalfa, sand plum, sumac, and skunkbush.

Continued overgrazing and extreme climatic conditions cause a decline in the desirable plants. If the plant community deteriorates further, undesirable plants such as silver bluestem, windmillgrass, tumblegrass, red lovegrass, little barley, threeawns, witchgrass, sand dropseed, sandbur, partridge pea, western ragweed, nightshades, and annual grasses and forbs dominate the site. As undesirable plants become dominant, the potential for forage production is greatly reduced.

Shallow Prairie

The Grainola and Quinlan soils in map units 15, 16, 44, 45, and 46 are in this site.

The potential plant community is dominated by mid and tall grasses. The species composition, by weight, is 75 percent grasses, 20 percent forbs, and 5 percent woody plants. Little bluestem, big bluestem, indiangrass, switchgrass, tephrosia, catclaw sensitivebrier, leadplant, perennial sunflower, and compassplant are preferred plants that make up 65 percent of livestock forage production when the range is in excellent condition. Under continuous or heavy grazing, the preferred plants disappear and are replaced by desirable plants such as sideoats grama, blue grama, hairy grama, tall dropseed, wildindigos, scurfpea, prairie coneflower, and sumacs.

Continued overgrazing and extreme climatic conditions cause a decline in the desirable plants. If the plant community deteriorates further, undesirable plants such as silver bluestem, annual threeawn, little barley windmillgrass, ragweeds, yarrow, ironweeds, and annual forbs and grasses dominate the site. As undesirable plants become dominant, the potential for forage production is greatly reduced.

Slickspot

The Pawhuska and Wakita soils in map units 27, 28, 31, and 50 are in this site.

The potential plant community is dominated by mid and tall grasses. The species composition, by weight, is 80 percent grasses and 20 percent forbs. Little bluestem, switchgrass, western wheatgrass, big bluestem, leadplant, fringeleaf ruellia, catclaw sensitivebrier, and dotted gayfeather are preferred plants that make up 60 percent of livestock forage production when the range is in excellent condition. Under

Figure 8.—Well managed native grass in an area of Goltry fine sand, 0 to 2 percent slopes, furnishes good forage for cattle.

continuous or heavy grazing, the preferred plants disappear and are replaced by desirable plants such as blue grama, silver bluestem, sedges, meadow dropseed, fall witchgrass, groundplum milkvetch, yellow neptunia, antelopehorn, and heath aster.

Continued overgrazing and extreme climatic conditions cause a decline in the desirable plants. If the plant community deteriorates further, undesirable plants such as common witchgrass, windmillgrass, threeawns, little barley, inland saltgrass, croton, ironweed, common yarrow, mesquite, and annual grasses and forbs dominate the site. As undesirable plants become dominant, the potential for forage production is greatly reduced.

Subirrigated

The Goltry soil in map unit 11 is in this site (fig. 8).

The potential plant community is dominated by tall grasses. Its composition, by weight, is 75 percent grasses, 20 percent forbs, and 5 percent woody plants. Sand bluestem, little bluestem, switchgrass, indiangrass, eastern gama, Illinois bundleflower, roundhead lespedeza, Maximilian sunflower, and Pitcher sage are preferred plants and make up 70 percent of forage production when the range is in excellent condition. Under continuous or heavy grazing, the preferred plants disappear and are replaced by desirable plants such as western wheatgrass, sedges and rushes, knotroot bristlegrass, tall dropseed, alkali sacaton, wild senna, milkweeds, goldenrods, willow, and willow baccharis.

Continued overgrazing and extreme climatic conditions cause a decline in the desirable plants. If the plant community deteriorates further, undesirable plants such as inland saltgrass, silver bluestem, fall witchgrass, showy partridge pea, western ragweed, horseweed fleabane, dogbane, and curlycup gumweed proliferate and eventually become dominant; woody species increase and the potential for forage production is greatly reduced.

Windbreaks and Environmental Plantings

Norman E. Smola, forester, Soil Conservation Service, helped prepare this section.

Native trees and shrubs grow on only about 4,000 acres in Grant County, primarily along the Salt Fork of the Arkansas River and its tributaries. American elm, blackjack oak, black willow, cottonwood, green ash, hackberry, and red mulberry are the common species. Among the more common introduced trees are black locust, chinaberry, osageorange, and saltcedar.

Most of the farmsteads in Grant County have trees around them that have been planted at various times. A number of farmstead windbreaks and some field windbreaks have also been planted. Eastern redcedar, Austrian pine, arborvitae, Russian-olive, common hackberry, and mulberry are commonly used in the windbreaks (fig. 9).

Figure 9.—Drip irrigation helps to establish young trees in a farmstead windbreak on Bethany silt loam, 0 to 2 percent slopes. The tree rows are staggered for better protection against strong winds.

In order for windbreaks to fulfill their purpose, the species of trees and shrubs selected must be adapted to the soils. Matching the proper trees with the soil is the first step towards ensuring survival. It also helps to ensure a maximum rate of growth. Soil depth and texture are characteristics that greatly affect the rate of growth of trees and shrubs in windbreaks.

Moisture is very limiting for tree survival in Grant County. Therefore, proper site preparation prior to planting and controlling weeds or other competing plants after planting are major concerns in establishing and managing a windbreak. Supplemental watering significantly improves the survival rate and vigor of seedlings during the 3-year establishment period. Drip irrigation has been shown to be effective in watering windbreaks in Grant County.

Windbreaks protect livestock, buildings, and yards from wind and snow. They also protect fruit trees and gardens, and they furnish habitat for wildlife. Several rows of low- and high-growing broadleaf and coniferous trees and shrubs provide the most protection.

Field windbreaks are narrow plantings made at right angles to the prevailing wind and at specific intervals across the field. The interval depends on the erodibility of the soil. Field windbreaks protect cropland and crops from wind, help to keep snow on the fields, and provide food and cover for wildlife.

Environmental plantings help to beautify and screen houses and other buildings and to abate noise. The plants, mostly evergreen shrubs and trees, are closely spaced. To insure plant survival, a healthy planting stock of suitable species should be planted properly on a well prepared site and maintained in good condition.

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 on 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 nursery.

Recreation

In table 9, the soils of the survey area are rated according to the 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 sewerlines. The capacity of the soil to absorb septic tank effluent and the ability of the soil to support vegetation are also important. Soils subject to flooding are limited for recreational use by the duration and intensity of flooding and the season when flooding occurs. In planning recreation 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, 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

Billy M. Teel, biologist, Soil Conservation Service, helped prepare this section.

Grant County soils provide habitat for good populations of the characteristic wildlife of north-central Oklahoma. The mixture of crops, range, forest, and pasture offers the habitat diversity that is important to game such as dove, quail, deer, squirrel, and turkey and to furbearers such as raccoon, fox, opossum, and beaver. Farm ponds provide good habitat for wintering waterfowl. Most farm ponds have been stocked with bass, catfish, and bluegill sunfish.

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 (fig. 10). Wildlife habitat can be created or improved by planting appropriate vegetation, by maintaining the existing plant

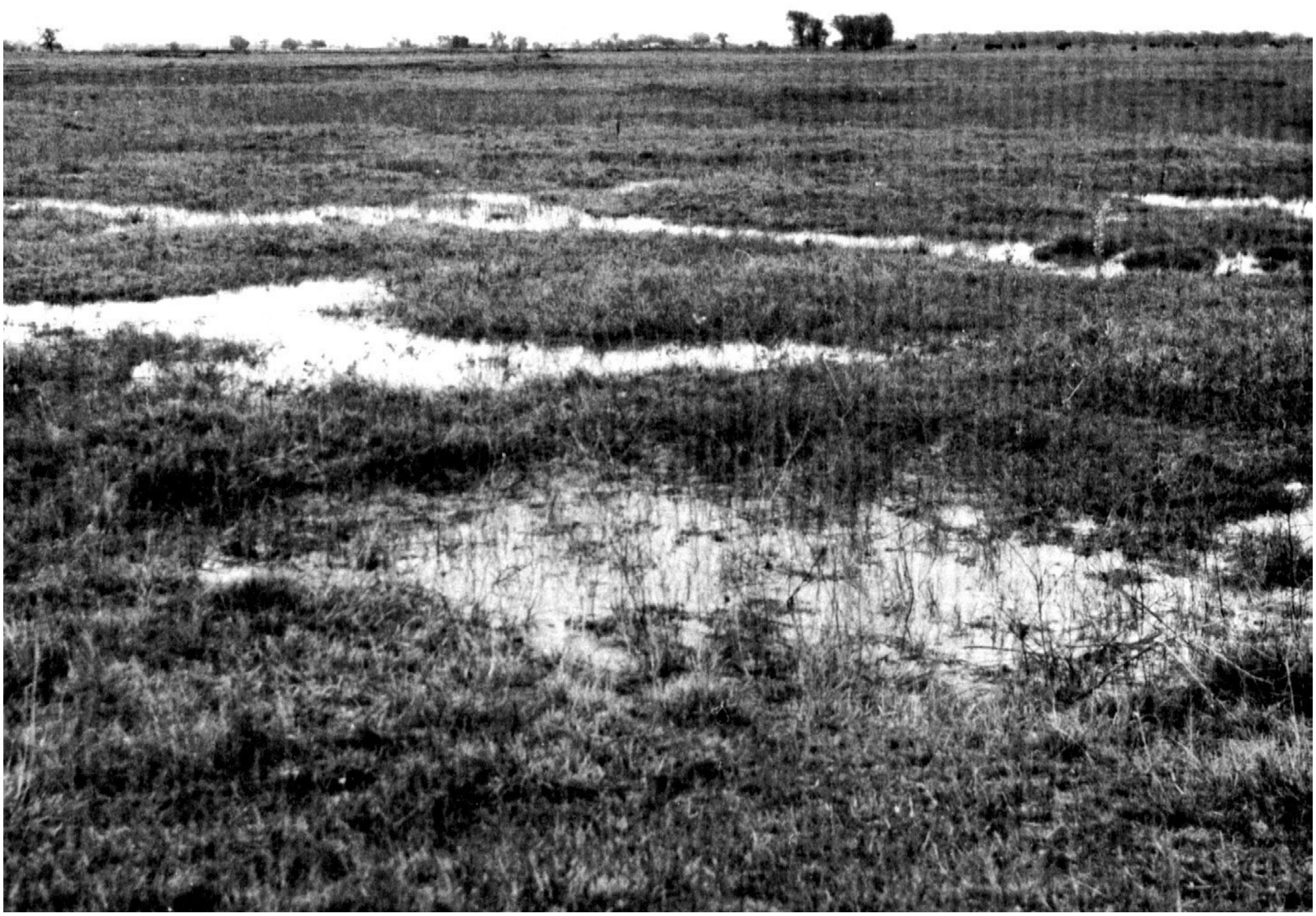


Figure 10.—Water in potholes provides habitat for wildlife in this area of Drummond loam, saline, rarely flooded.

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 flood hazard. Soil temperature and soil moisture are also considerations. Examples of grain and seed crops are grain sorghum, wheat, oats, barley, millet, cowpeas, and sunflowers.

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, flood hazard, and slope. Soil temperature and soil moisture are also considerations. Examples of grasses and legumes are plains bluestem, lovegrass, bermudagrass, 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 flood hazard. Soil temperature and soil moisture are also considerations. Examples of wild herbaceous plants are bluestem, indiangrass, switchgrass, goldenrod, beggarweed, wheatgrass, croton, and grama.

Shrubs are bushy woody plants that produce fruit, buds, twigs, bark, and foliage. Soil properties and features that affect the growth of shrubs are depth of the root zone, available water capacity, salinity, and soil moisture. Examples of shrubs are roughleaf dogwood, sumac, Chickasaw plum, and buckbrush. Examples of fruit-producing shrubs that are suitable for planting on soils rated *good* are Russian-olive, autumn-olive, and crabapple.

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, saltgrass, cordgrass, rushes, sedges, cattail, 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. The wildlife attracted to these areas include bobwhite quail, pheasant, meadowlark, field sparrow, cottontail, and dove.

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.

Habitat for rangeland wildlife consists of areas of shrubs and wild herbaceous plants. Wildlife attracted to rangeland include deer, bobwhite quail, coyote, dove, meadowlark, and prairie dog.

Engineering

Charles E. Bollinger, assistant state conservation engineer, and Thomas J. Lamirand, civil engineer, Soil Conservation Service, helped prepare this section.

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 in the following tables: 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 must 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 to 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 kind 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 the 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, shrink-swell potential, and organic layers can cause the movement of footings. A high water table, depth to bedrock or to a cemented pan, large stones, and flooding affect the ease of excavation and construction. Landscaping and grading that require cuts and fills of more than 5 to 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 the 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 landfills. A rating of *good* indicates that soil properties and site features are favorable for the use and that 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 due to rapid permeability of 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 needs to 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 type 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 type 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 soil blowing.

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 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, 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 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 the depth to the water table is 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. Sand and gravel 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 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; embankments, dikes, and levees; and aquifer-fed ponds. 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 the restrictive features that affect each soil for drainage, 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 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.

Aquifer-fed excavated ponds are pits or dugouts that extend to a ground-water aquifer or to a depth below a permanent water table. Excluded are ponds that are fed only by surface runoff and embankment ponds that impound water 3 feet or more above the original surface. Excavated ponds are affected by depth to a permanent water table, permeability of the aquifer, and the salinity of the soil. Depth to bedrock and the content of large stones affect the ease of excavation.

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 potential 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.

Terraces and diversions are embankments or a combination of channels and ridges constructed across a slope to reduce 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 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 or 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. These results are reported in table 20.

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 characterize key soils.

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

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 "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. "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 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, SP-SM.

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. The AASHTO classification for soils tested, with group index numbers in parentheses, is given in table 20.

Rock fragments larger than 3 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 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, or component, 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 1/3 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, septic tank absorption fields, and construction where the rate of water movement under saturated conditions affects behavior.

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 in each major soil layer is stated in inches of water per inch of soil. 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.

Salinity is a measure of soluble salts in the soil at saturation. It is expressed as the electrical conductivity of the saturation extract, in millimhos per centimeter at 25 degrees C. Estimates are based on field and laboratory measurements at representative sites of nonirrigated soils. The salinity of irrigated soils is affected by the quality of the irrigation water and by the frequency of water application. Hence, the salinity of soils in individual fields can differ greatly from the value given in the table. Salinity affects the suitability of a soil for crop production, the stability of soil if used as construction material, and the potential of the soil to corrode metal and concrete.

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.

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 change is based on the soil fraction less than 2 millimeters in diameter. 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. Losses are expressed in tons per acre per year. These 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 over a sustained period without affecting crop productivity. The rate is expressed 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 and the amount of soil lost. Soils are grouped according to the following distinctions:

1. Sands, coarse 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 sands, loamy fine sands, and loamy very fine sands. These soils are very highly erodible. Crops can be grown if intensive measures to control wind erosion are used.

3. Sandy loams, coarse 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 loamy soils that are less than 35 percent clay and more than 5 percent finely divided calcium carbonate. These soils are erodible. Crops can be grown if intensive measures to control wind erosion are used.

4. Clays, silty clays, 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. Loamy soils that are less than 18 percent clay and less than 5 percent finely divided calcium carbonate and sandy clay loams and sandy clays that are less than 5 percent finely divided calcium carbonate. These soils are slightly erodible. Crops can be grown if measures to control wind erosion are used.

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

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

8. Stony or gravelly soils and other soils not subject to wind erosion.

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 of a soil can be maintained or increased by returning crop residue to the surface of 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 are assigned to one of four groups. They are grouped according to the intake 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 or by runoff from adjacent slopes. Water standing for short periods after rainfall or snowmelt is not considered flooding, nor is water in sloughs and potholes.

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

Frequency, duration, and probable dates of occurrence are estimated. Frequency is expressed as none, rare, common, occasional, and frequent. *None* means that flooding is not probable; *rare* that it is unlikely but possible under unusual weather conditions; *common* that it is likely under normal conditions; *occasional* that it occurs, on the average, no more than once in 2 years; and *frequent* that it occurs, on the average, more than once in 2 years. Duration is expressed as *very brief* if less than 2 days, *brief* if 2 to 7 days, and *long* if more than 7 days. Probable dates are expressed in months; March-August, for example, means that flooding can occur during the period March through August.

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 absence of distinctive horizons that form in soils that are not subject to flooding.

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 depth to a seasonal high water table applies to undrained soils. 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 the depth to the seasonal high water table; the kind of water table—that is, perched, artesian, or apparent; and the months of the year that the water table commonly is high. A water table that is seasonally high for less than 1 month is not indicated in table 17.

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

Only saturated zones within a depth of about 6 feet are indicated. A plus sign preceding the range in depth indicates that the water table is above the surface of the soil. The first numeral in the range indicates how high the water rises above the surface. The second numeral indicates the depth below the surface.

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 specified as 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 generally 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 creates a severely corrosive environment. 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 is also expressed as *low*, *moderate*, or *high*. It is based on soil texture, acidity, and the amount of sulfates in the saturation extract.

Physical and Chemical Analyses of Selected Soils

The results of physical analysis of several typical pedons in the survey area are given in table 18 and the results of chemical analysis in table 19. The data are for soils sampled at carefully selected sites. The pedons are typical of the series and are described in the section "Soil Series and Their Morphology." Soil samples were analyzed by the Soil Morphology Genesis and Classification Laboratory, Department of Agronomy, Oklahoma State University, and the National Soil Survey Laboratory, Lincoln, Nebraska.

Most determinations, except those for grain-size analysis and bulk density, were made on soil material smaller than 2 millimeters in diameter. Measurements reported as percent or quantity of unit weight were calculated on an oven-dry basis. The methods used in obtaining the data are indicated in the list that follows. The codes in parentheses refer to published methods *(5)*.

Sand—(0.05-2.0 mm fraction) weight percentages of materials less than 2 mm (3A1).

Silt—(0.002-0.05 mm fraction) pipette extraction, weight percentages of all materials less than 2 mm (3A1).

Clay—(fraction less than 0.002 mm) pipette extraction, weight percentages of materials less than 2 mm (3A1).

Organic matter—peroxide digestion (6A3).

Extractable cations—ammonium acetate pH 7.0, uncorrected; calcium (6N2), magnesium (602), sodium (6P2), potassium (6Q2).

Cation-exchange capacity—sum of cations (5A3a).
Base saturation—sum of cations, TEA, pH 8.2 (5C3).
Reaction (pH)—1:1 water dilution (8C1a).
Electrical conductivity—saturation extract (8A1a).
Sodium-adsorption ratio (5E).

Engineering Index Test Data

Table 20 shows laboratory test data for pedons sampled at carefully selected sites in the survey area. The pedons are typical of the series and are described in the section "Soil Series and Their Morphology." The soil samples were tested by the Oklahoma Department of Transportation, Materials Division.

The testing methods generally are those of the American Association of State Highway and Transportation Officials (AASHTO) or the American Society for Testing and Materials (ASTM).

The tests and methods are: AASHTO classification—M 145 (AASHTO), D 3282 (ASTM); Unified classification—D 2487 (ASTM); Mechanical analysis—T 88 (AASHTO), D 2217 (ASTM); Liquid limit—T 89 (AASHTO), D 423 (ASTM); Plasticity index—T 90 (AASHTO), D 424 (ASTM).

Classification of the Soils

The system of soil classification used by the National Cooperative Soil Survey has six categories *(6)*. 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 on laboratory measurements. Table 21 shows the classification of the soils in the survey area. The categories are defined in the following paragraphs.

ORDER. Ten 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 Ustoll (*Ust*, meaning dry, 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 Argiustoll (*Argi*, meaning argillic horizon, plus *ustoll*, the suborder of the Mollisols that have an ustic 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. The adjective *Udic* (*Ud* meaning moist) identifies an intergrade to Udolls. An example is Udic Argiustolls.

FAMILY. Families are established within a subgroup on the basis of physical and chemical properties and other characteristics that affect management. Mostly 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 Udic Argiustolls.

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. There can be some variation in the texture of the surface layer or of the substratum 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. The soil is compared with similar soils and with nearby soils of other 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 (4)*. Many of the technical terms used in the descriptions are defined in *Soil Taxonomy (6)*. Unless otherwise stated, colors in the descriptions are for dry 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."

Aline Series

The Aline series consists of deep, somewhat excessively drained, rapidly permeable soils. The soils formed in material weathered from sandy eolian deposits on terraces of uplands. The largest areas are north of the Salt Fork of the Arkansas River in the western part of the county. Slopes are 0 to 3 percent. Soils of the Aline series are sandy, mixed, thermic Psammentic Paleustalfs.

Aline soils are associated with Goltry, Goodnight, Pratt, and Tivoli soils. Goltry soils are in lower areas of sand dune hills and have wetness mottles at a depth of 30 to 60 inches. Goodnight soils are closer to the river than Aline soils, are calcareous in the lower part, and do not have an argillic horizon. Pratt soils are at higher elevations on the landscape and are more hummocky. They have an argillic horizon that decreases in clay content within a depth of 60 inches. Tivoli soils are on high sand dunes closer to the river and do not have an argillic horizon.

Typical pedon of Aline fine sand, 0 to 3 percent slopes, in native range, 1,190 feet east and 200 feet north of the southwest corner of sec. 3, T. 26 N., R. 8 W.

A1—0 to 9 inches; brown (10YR 5/3) fine sand, dark brown (10YR 3/3) moist; weak fine granular structure; soft, very friable; slightly acid; gradual smooth boundary.

A21—9 to 38 inches; pale brown (10YR 6/3) fine sand, brown (10YR 4/3) moist; weak fine granular structure; soft, very friable; neutral; gradual smooth boundary.

A22&B2t—38 to 80 inches; alternating layers of light brown (7.5YR 6/4) fine sand, 1/2 inch to 4 inches thick (A22), and reddish yellow (7.5YR 6/8) loamy fine sand, 1/4 inch to 2 inches thick (B2t); fine sand has weak coarse prismatic structure; loose; mildly alkaline; many uncoated sand grains; loamy fine sand, in abrupt, discontinuous, wavy bands, has weak coarse prismatic structure; soft, very friable; moderately alkaline; bridged and coated sand grains.

The solum is more than 60 inches thick. The A horizon is 20 to 50 inches thick.

The A horizon is brown (10YR 5/3), yellowish brown (10YR 5/4), pale brown (10YR 6/3), light yellowish brown (10YR 6/4), pink (7.5YR 7/4), or light brown (7.5YR 6/4). It is fine sand or sand and is medium acid to neutral.

The A2 horizon is pale brown (10YR 6/3), very pale brown (10YR 7/3, 7/4, 8/3, 8/4), reddish yellow (7.5YR 7/6, 6/6), or light brown (7.5YR 6/4). It is fine sand or sand and is medium acid to neutral.

The B2t horizon is reddish yellow (7.5YR 7/6, 6/6, 6/8; 5YR 6/6), pink (5YR 7/4), yellowish red (5YR 5/6), or red (2.5YR 5/6). It commonly is loamy fine sand, but the range includes fine sandy loam. This horizon is medium acid to moderately alkaline.

Attica Series

The Attica series consists of deep, well drained, moderately rapidly permeable soils on uplands (fig.11). The soils formed in material weathered from predominantly eolian loams that have been reworked by wind. Slopes are mostly 0 to 5 percent. Soils of the Attica series are coarse-loamy, mixed, thermic Udic Haplustalfs.

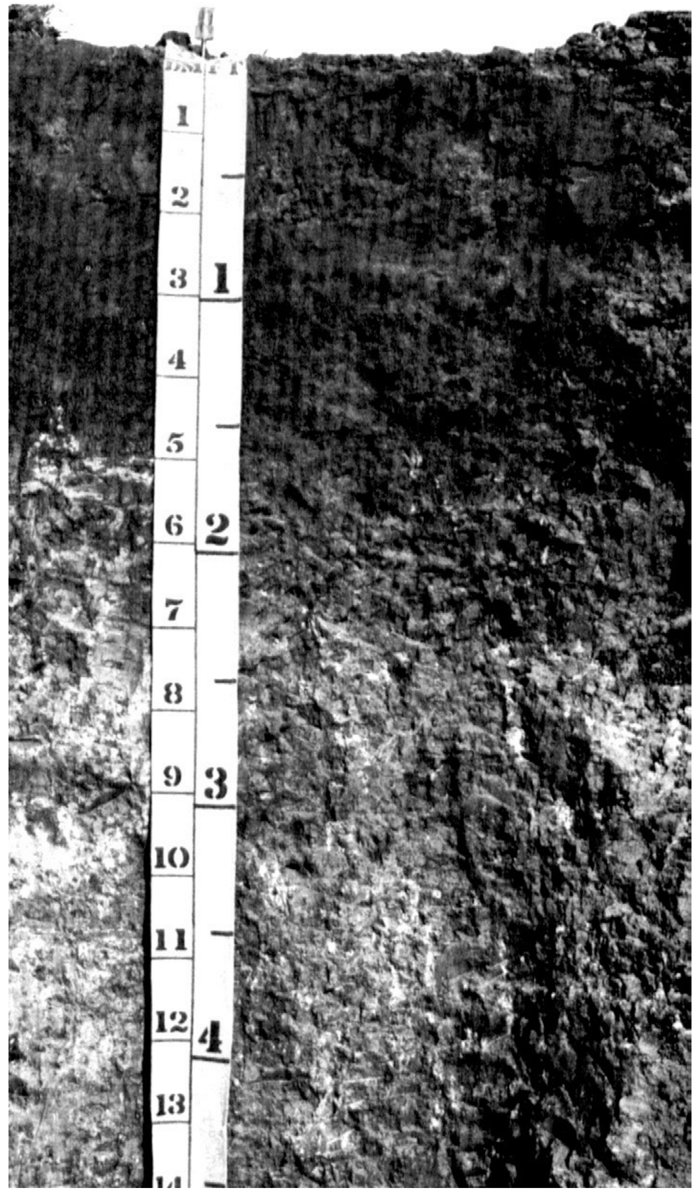


Figure 11.—Profile of Attica fine sandy loam, 0 to 3 percent slopes, showing the B2t horizon, which extends from a depth of about 9 to 24 inches. The scale is in decimeters (left) and feet.

Attica soils are associated with Carwile, Gracemont, Pratt, and Shellabarger soils. Carwile soils are in flat or depressional areas. They have a darker A horizon and a more clayey argillic horizon than those of Attica soils. Gracemont soils are on flood plains. They do not have an argillic horizon and are stratified in the control section. Pratt soils are on similar landscapes, but they have a sandy argillic horizon. Shellabarger soils and Attica soils are at similar elevations, but Shellabarger soils are on more uniform, less undulating slopes, and they have a mollic epipedon and a fine-loamy argillic horizon.

Typical pedon of Attica fine sandy loam, 0 to 3 percent slopes, in a cultivated field, 700 feet north and 350 feet west of the southeast corner of sec. 3, T. 27 N., R. 8 W.

A1—0 to 9 inches; brown (10YR 5/3) fine sandy loam, dark brown (10YR 3/3) moist; moderate fine granular structure; slightly hard, very friable; medium acid; gradual smooth boundary.

B2t—9 to 24 inches; reddish brown (5YR 5/4) loam, reddish brown (5YR 4/4) moist; weak medium subangular blocky structure; hard, friable; clay bridges between sand grains; slightly acid; gradual smooth boundary.

B3—24 to 45 inches; light reddish brown (5YR 6/4) loamy fine sand, reddish brown (5YR 4/4) moist; weak coarse subangular blocky structure; slightly hard, very friable; clay bridges between many sand grains; slightly acid; clear smooth boundary.

C—45 to 75 inches; reddish yellow (5YR 6/6) fine sand, yellowish red (5YR 5/6) moist; single grained; loose, very friable; strata of medium sand and fine sandy loam; slightly acid.

The solum is 40 to 50 inches thick.

The A horizon is light brown (7.5YR 6/4), brown (7.5YR 5/4; 10YR 5/3), pale brown (10YR 6/3), yellowish brown (10YR 5/4), or light yellowish brown (10YR 6/4). It is fine sandy loam or loamy fine sand and ranges from medium acid to neutral.

The B2t horizon is reddish brown (5YR 5/4), reddish yellow (7.5YR 6/6), yellowish red (5YR 5/6), brown (7.5YR 5/4), strong brown (7.5YR 5/6), or light brown (7.5YR 6/4). It is fine sandy loam or loam. It is medium acid to neutral.

The B3 horizon is reddish yellow (5YR 6/6; 7.5YR 6/6), yellowish red (5YR 5/6), light reddish brown (5YR 6/4), brown (7.5YR 5/4; 10YR 5/3), or grayish brown (10YR 5/2). It is fine sandy loam or loamy fine sand and ranges from slightly acid to mildly alkaline.

The C horizon has the same colors as the B3 horizon. It is fine sandy loam or loamy fine sand, and below a depth of 40 inches it includes coarser or more clayey strata. It ranges from slightly acid to mildly alkaline.

Soils that are closely similar to Attica soils (but that differ in having reddish hue, higher chroma, less acid reaction, or less increase in clay between the A horizon and B horizon) were considered as Attica soils in mapping and naming map units. Their use, behavior, and management are the same as those of the Attica series.

Bethany Series

The Bethany series consists of deep, nearly level, well drained, slowly permeable soils on uplands. These soils formed in material weathered from loamy and clayey alluvium and loess. In some areas, Bethany soils are a major component of the landscape. In other areas, Bethany soils are on small, low ridges in the landscape. The slope is 0 to 1 percent. Soils of the Bethany series are fine, mixed, thermic Pachic Paleustolls.

Bethany soils are closely associated with Kirkland, Pond Creek, and Tabler soils. Kirkland and Tabler soils are on the same landscape as Bethany soils. Kirkland soils have an abrupt textural change between the A horizon and B horizon. Tabler soils have higher COLE values and montmorillonitic mineralogy. Pond Creek soils are in lower positions than Bethany soils and have a fine-silty control section.

Typical pedon of Bethany silt loam, 0 to 1 percent slopes, in a cultivated field, 300 feet south and 110 feet east of the northwest corner of sec. 7, T. 28 N., R. 4 W.

Ap—0 to 9 inches; dark grayish brown (10 YR 4/2) silt loam, very dark grayish brown (10YR 3/2) moist; weak fine granular structure; hard, friable; medium acid; clear smooth boundary.

A12—9 to 12 inches; dark grayish brown (10YR 4/2) silt loam, very dark grayish brown (10YR 3/2) moist; moderate fine granular structure; hard, friable; neutral; gradual smooth boundary.

B1—12 to 16 inches; brown (10YR 5/3) silty clay loam, dark brown (10YR 3/3) moist; weak fine subangular blocky structure; hard, firm; neutral; gradual smooth boundary.

B21t—16 to 36 inches; brown (10YR 5/3) silty clay, dark brown (10YR 3/3) moist; moderate medium subangular blocky structure; very hard, very firm; clay films on faces of peds; neutral; gradual smooth boundary.

B22t—36 to 48 inches; brown (7.5YR 5/4) silty clay, dark brown (7.5YR 4/4) moist; moderate coarse subangular blocky structure; very hard, very firm; clay films on faces of peds; few medium calcium carbonate concretions and few fine spots of carbonates; few fine iron and manganese spots; calcareous, moderately alkaline; diffuse smooth boundary.

B23t—48 to 57 inches; yellowish red (5YR 5/6) silty clay loam, yellowish red (5YR 4/6) moist; common fine and medium light brownish gray mottles; weak coarse blocky structure; very hard, very firm; patchy clay films on faces of peds; common fine iron and manganese soft spots and streaks; few fine concretions of calcium carbonate; calcareous, moderately alkaline; gradual smooth boundary.

B3—57 to 72 inches; yellowish red (5YR 5/6) silty clay loam, yellowish red (5YR 4/6) moist; weak coarse blocky structure; very hard, very firm; common fine soft masses of calcium carbonate; moderately alkaline.

The solum is more than 60 inches thick. Thickness of the mollic epipedon is 20 inches or more.

The A horizon is dark grayish brown (10YR 4/2), brown (10YR 4/3, 5/3), or grayish brown (10YR 5/2). It is medium acid to neutral, but in heavily fertilized areas the plow layer ranges to very strongly acid.

The B1 horizon is similar to the A horizon in color. It is silty clay loam and is slightly acid or neutral.

The B21t horizon is brown (7.5YR 4/2; 10YR 4/3, 5/3), dark grayish brown (10YR 4/2), or grayish brown (10YR 5/2). It is clay, clay loam, silty clay loam, or silty clay and is neutral or mildly alkaline.

The B22t horizon has the same color range as the B21t horizon, but also includes brown (7.5YR 4/4, 5/4), dark yellowish brown (10YR 4/4), or yellowish brown (10YR 5/4, 5/6). It is clay or silty clay and is mildly alkaline or moderately alkaline.

The B23t horizon is yellowish red (5YR 5/6), strong brown (7.5YR 5/6), or brown (7.5YR 4/4) with common coarse mottles of strong brown or yellowish red. It is clay, silty clay, or silty clay loam and is mildly alkaline or moderately alkaline. Some pedons have a B3 horizon that is similar in color and texture to the B23t horizon.

Carwile Series

The Carwile series consists of deep, somewhat poorly drained, slowly permeable soils on terraces of the uplands. The soils formed in loamy and clayey alluvium or eolian sediments of Pleistocene age. The largest areas are southwest of Hawley. An apparent water table is at a depth of 0 to 2 feet from fall to spring. Slopes range from 0 to 1 percent. Soils of the Carwile series are fine, mixed, thermic, Typic Argiaquolls.

Carwile soils are associated with Attica, Drummond, Pratt, and Shellabarger soils. Attica, Pratt, and Shellabarger soils have less than 35 percent clay in the control section and are in slightly higher areas. In addition, Attica and Pratt soils do not have a mollic epipedon. Drummond soils are on the same landscape but have a natric horizon.

Typical pedon of Carwile loam, in an area of Carwile-Attica complex, 0 to 3 percent slopes, in a cultivated field, 1,800 feet east and 2,150 feet south of the northwest corner of sec. 14, T. 26 N., R. 8 W.

Ap—0 to 7 inches; very dark gray (10YR 3/1) loam, black (10YR 2/1) moist; moderate medium granular structure; hard, friable; calcareous, moderately alkaline; abrupt smooth boundary.

A12—7 to 14 inches; very dark gray (10YR 3/1) loam, black (10YR 2/1) moist; moderate medium granular structure; hard, friable; calcareous, moderately alkaline; gradual smooth boundary.

B21t—14 to 39 inches; gray (10YR 5/1) clay, very dark gray (10YR 3/1) moist; common coarse distinct yellowish brown mottles; moderate coarse blocky structure; extremely hard, very firm; continuous clay films on faces of peds; common fine threads of calcium carbonate and gypsum; calcareous, moderately alkaline; gradual smooth boundary.

B22t—39 to 59 inches; light brownish gray (10YR 6/2) clay, grayish brown (10YR 5/2) moist; few fine and medium brownish yellow mottles; weak coarse blocky structure; extremely hard, very firm; clay films on faces of peds; common fine masses and threads of calcium carbonate and gypsum; calcareous, moderately alkaline; gradual smooth boundary.

C—59 to 72 inches; light gray (10YR 7/2) sandy clay, light brownish gray (10YR 6/2) moist; common fine distinct brownish yellow and few fine distinct brown mottles; massive; very hard, firm; common medium masses of calcium carbonate; calcareous, moderately alkaline.

The solum ranges from 40 to 60 inches in thickness.

The A horizon is grayish brown (10YR 5/2), very dark gray (10YR 3/1), or brown (7.5YR 5/2). It is clay loam, loam, or fine sandy loam and is moderately alkaline.

The B2t horizon is gray (10YR 5/1), dark grayish brown (10YR 4/2), light brownish gray (10YR 6/2), or brown (7.5YR 4/2). It has mottles in shades of yellow, brown, red, or gray. This horizon is clay loam, clay, or sandy clay and is calcareous and moderately alkaline.

The C horizon is grayish brown (10YR 5/2), gray (10YR 6/1), or light gray (10YR 7/2) and has mottles in shades of yellow, red, brown, or gray. It is sandy clay loam, clay, or sandy clay. It is calcareous and moderately alkaline.

These soils are a taxadjunct to the Carwile series because the A horizon is moderately alkaline. They are similar to the Carwile soils in use, behavior, and management.

Dale Series

The Dale series consists of deep, well drained, moderately permeable soils on low terraces. The soils formed in loamy alluvial deposits. The largest areas are along the Salt Fork of the Arkansas River and the larger creeks. Dale soils most commonly have slopes of 0 to 1 percent, but slopes of 3 to 8 percent are along some streams. These soils, under abnormal conditions, can be flooded for very brief periods. Soils of the Dale series are fine-silty, mixed, thermic Pachic Haplustolls.

Dale soils are associated with Drummond, Hawley, McLain, Port, and Reinach soils. All of these soils are at similar elevations except the Port soils, which are in lower positions. Drummond soils have a natric horizon. Hawley soils do not have a mollic epipedon and have a coarse-loamy control section. McLain soils have a fine textured argillic horizon. Port soils are occasionally or frequently flooded and are stratified above a depth of 40 inches. Reinach soils have a coarse-silty control section.

Typical pedon of Dale silt loam, rarely flooded, 0 to 1 percent slopes, in a cultivated field, 975 feet north and

60 feet west of the southeast corner of sec. 29, T. 26 N., R. 5 W.

A1—0 to 15 inches; brown (7.5YR 5/3) silt loam, dark brown (7.5YR 3/3) moist; weak and moderate fine granular structure; hard, friable; neutral gradual smooth boundary.

B21—15 to 36 inches; brown (7.5YR 5/3) silt loam, dark brown (7.5YR 3/3) moist; weak coarse prismatic structure; hard, friable; moderately alkaline; gradual smooth boundary.

B22—36 to 48 inches; reddish brown (5YR 5/4) silt loam, dark reddish brown (5YR 3/4) moist; weak coarse prismatic structure; hard, friable; few fine and medium soft calcium carbonate bodies and concretions in lower part; calcareous, moderately alkaline; gradual smooth boundary.

C—48 to 72 inches; yellowish red (5YR 5/6) silt loam, yellowish red (5YR 4/6) moist; very weak coarse prismatic structure; hard, friable; few fine soft calcium carbonate bodies and concretions; calcareous, moderately alkaline.

The solum ranges from 30 to 50 inches in thickness. The depth to soft powdery secondary lime and the thickness of the mollic epipedon range from 20 to 50 inches.

The A horizon is brown (7.5YR 5/2, 5/3, 4/2, 4/3). It is slightly acid to mildly alkaline.

The B2 horizon is reddish brown (5YR 5/3, 4/3, 5/4, 4/4) or brown (7.5YR 5/2, 4/2, 5/4, 4/4). It is mainly silt loam, but the range includes silty clay loam and loam. This horizon becomes more alkaline as depth increases; it ranges from slightly acid to moderately alkaline.

The C horizon is reddish brown (5YR 5/4, 4/4), yellowish red (5YR 5/6, 4/6), brown (7.5YR 5/2, 4/2, 5/4, 4/4), or strong brown (7.5YR 5/6). It is similar in texture to the control section, but some pedons are stratified with fine sandy loam below a depth of 50 inches.

Drummond Series

The Drummond series consists of deep, somewhat poorly drained, very slowly permeable soils on old stream terraces. These soils formed in material weathered from loamy and clayey alluvium. Drummond soils have moderate to high salinity and a natric horizon. An apparent water table is at a depth of 2 to 6 feet during the winter and spring. Slopes are 0 to 1 percent. Soils of the Drummond series are fine, mixed, thermic Mollic Natrustalfs.

Drummond soils are associated with Carwile, Dale, and McLain soils. Carwile, Dale, and McLain soils are on the same landscape, but they have a mollic epipedon and do not have a natric horizon.

Typical pedon of Drummond silt loam, in an area of McLain-Drummond silt loams, rarely flooded, 2,300 feet east and 95 feet south of the northwest corner of sec. 18, T. 26 N., R. 4 W.

A1p&A2p—0 to 9 inches; brown (10YR 4/3) silt loam, dark brown (10YR 3/3) moist (A1p); weak fine granular structure; very hard, friable; 40 percent, by volume, very pale brown (10YR 7/3) silt loam, brown (10YR 5/3) moist (A2p), dominated by almost clean sand grains; massive; hard, very friable; surface 1/2 inch is a vesicular crust that has very weak thin platy structure; slightly acid; abrupt smooth boundary.

B21t—9 to 15 inches; dark grayish brown (10YR 4/2) silty clay loam, very dark grayish brown (10YR 3/2) moist; weak coarse columnar structure that breaks to weak medium subangular blocky; very hard, friable; clay films on faces of peds; common fine roots and pores; moderately alkaline; clear smooth boundary.

B22t—15 to 21 inches; brown (7.5YR 5/4) silty clay loam, brown (7.5YR 4/3) moist; moderate medium subangular blocky structure; very hard, firm; common fine roots; few fine pores; nearly continuous clay films on faces of peds; common very fine gypsum threads and masses; moderately alkaline; clear smooth boundary.

B23t—21 to 29 inches; reddish brown (5YR 5/4) silty clay loam, reddish brown (5YR 4/4) moist; weak coarse blocky structure; very hard, firm; few fine gypsum threads; few fine pores; moderately alkaline; gradual smooth boundary.

B3—29 to 38 inches; reddish yellow (5YR 6/6) silty clay loam, reddish brown (5YR 4/4) moist; weak coarse blocky structure; very hard, firm; few fine iron and manganese concretions; calcareous in spots, moderately alkaline; gradual smooth boundary.

C—38 to 60 inches; yellowish red (5YR 5/6) silty clay loam, reddish brown (5YR 4/4) moist; massive; very hard, firm; common fine to 1/2-inch diameter calcium carbonate concretions; reddish brown silt loam below a depth of 49 inches; calcareous, moderately alkaline.

The solum is 38 to 60 inches thick. The effects of the sodium content range from slight to a strongly affected condition. The exchangeable sodium ranges from 15 percent to 100 percent in the natric horizon. Many pedons are calcareous.

The A horizon is brown (7.5YR 4/2, 5/2, 5/3; 10YR 4/3, 5/3), light gray (10YR 6/1), light brownish gray (10YR 6/2), dark grayish brown (10YR 4/2), or grayish brown (10YR 5/2). It is loam or silt loam. This horizon is slightly acid to moderately alkaline. The A2 horizon, where present, is very pale brown (10YR 7/3) or brown (10YR 5/3). The texture and reaction are similar to those of the A1 horizon.

The B2t horizon is grayish brown (10YR 5/2), dark grayish brown (10YR 4/2), brown (7.5YR 5/2, 5/4, 4/2, 4/4; 10YR 4/3), light yellowish brown (10YR 6/4), light brownish gray (10YR 6/2), gray (10YR 5/1), grayish brown (10YR 5/2), or reddish brown (5YR 5/3, 5/4, 4/3, 4/4). It is clay loam, silty clay loam, clay, silty clay, or sandy clay. Reaction is mildly alkaline to strongly alkaline.

The B3 horizon is similar in color, texture, and reaction to the B2t horizon, but the color range also includes yellowish red (5YR 4/6, 5/6) or reddish yellow (5YR 6/6). Mottles of gray, brown, and red are in many pedons. Reaction is mildly alkaline or moderately alkaline.

The C horizon is similar in color and reaction to the B3 horizon. It is variable in texture and has layers of coarser and finer texture than the mass.

Gaddy Series

The Gaddy series consists of deep, somewhat excessively drained, moderately rapidly permeable or rapidly permeable soils on flood plains, mainly along the Salt Fork of the Arkansas River. The soils formed in predominantly sandy, calcareous alluvium. Slopes range from 0 to 2 percent. Soils of the Gaddy series are sandy, mixed, thermic Typic Ustifluvents.

Gaddy soils are associated with Goodnight, Gracemont, and Yahola soils. Goodnight soils are in higher positions on the landscape and are not stratified. Gracemont soils are slightly higher in elevation, are somewhat poorly drained, and have a coarse-loamy control section. Yahola soils are in similar or higher positions and are coarse-loamy in the control section.

Typical pedon of Gaddy fine sand, frequently flooded, in native range, 2,600 feet south and 2,300 feet east of the northwest corner of sec. 27, T. 26 N., R. 8 W.

A1—0 to 7 inches; pale brown (10YR 6/3) fine sand, brown (10YR 5/3) moist; weak fine granular structure; soft, very friable; calcareous, moderately alkaline; clear smooth boundary.

C—7 to 60 inches; very pale brown (10YR 7/4) fine sand, light yellowish brown (10YR 6/4) moist; single grained; loose, very friable; few thin to 1/2-inch thick strata of loam and clay loam; calcareous, moderately alkaline.

The depth of the soil is more than 60 inches. The soil is moderately alkaline and calcareous throughout.

The A horizon is 7 to 15 inches thick. It is reddish yellow (7.5YR 6/6), strong brown (7.5YR 5/6), brown (7.5YR 4/2, 5/2, 4/4, 5/4), pale brown (10YR 6/3), or yellowish brown (10YR 5/4, 5/6). It is dominantly fine sand but ranges to loamy fine sand.

The C horizon is light brown (7.5YR 6/4), reddish yellow (7.5YR 6/6, 7/6, 8/6), light yellowish brown (10YR 6/4), brownish yellow (10YR 6/6), yellow (10YR 7/6), or very pale brown (10YR 7/4, 8/4) loamy fine sand or fine sand. It contains a few thin strata of fine sandy loam to clay loam. The strata are darker in color and are 1 inch or less in thickness.

Goltry Series

The Goltry series consists of deep, moderately well drained, rapidly permeable soils on undulating, sandy terraces of uplands. The soils formed in sandy eolian and alluvial deposits in the western part of the county. Slopes range from 0 to 2 percent. An apparent water table is at a depth of 2-1/2 to 6 feet during winter and spring. Soils of the Goltry series are sandy, mixed, thermic Psammentic Paleustalfs.

Goltry soils are associated with intermingled areas of Aline and Tivoli soils. Aline soils are slightly higher in elevation than Goltry soils, and they do not have wetness mottles and a seasonal water table within 60 inches of the surface. Tivoli soils do not have an argillic horizon and are on sand dunes at higher elevations.

Typical pedon of Goltry fine sand, 0 to 2 percent slopes, in native range, 375 feet east and 240 feet north of the southwest corner of sec. 17, T. 27 N., R. 8 W.

A1—0 to 12 inches; grayish brown (10YR 5/2) fine sand, dark grayish brown (10YR 4/2) moist; weak fine granular structure; soft, very friable; many fine roots; neutral; gradual smooth boundary.

A21—12 to 35 inches; very pale brown (10YR 8/3) fine sand, very pale brown (10YR 7/3) moist; single grained; loose; many fine roots; slightly acid; clear smooth boundary.

A22&B21t—35 to 48 inches; very pale brown (10YR 8/3) fine sand, very pale brown (10YR 7/3) moist; single grained; loose (A22 part); lamellae of reddish yellow (7.5YR 6/6) loamy fine sand, strong brown (7.5YR 5/6) moist (B21t part); few fine dark grayish brown and gray mottles; weak coarse prismatic structure that parts to weak medium subangular blocky; slightly hard, friable; lamellae are 1/4 inch to 4 inches thick and 1/2 inch to 4 inches apart; coatings and films of clay bridge the sand grains; slightly acid; clear smooth boundary.

A23&B22t—48 to 80 inches; reddish yellow (7.5YR 8/6) fine sand, reddish yellow (7.5YR 7/8) moist; single grained; loose (A23 part); lamellae of reddish yellow (7.5YR 7/6) loamy fine sand, reddish yellow (7.5YR 6/6) moist (B22t part); weak coarse prismatic structure that parts to weak coarse subangular blocky; slightly hard, friable; lamellae are 1/4 inch to 3 inches thick and 1 inch to 3 inches apart; coatings and films of clay bridge the sand grains; water table at a depth of 52 inches; slightly acid.

The solum is more than 60 inches thick. Mottles with chroma of 1 or 2 are at a depth of 30 to 60 inches.

Reaction is slightly acid to mildly alkaline throughout. The depth to the water table ranges from 60 to 80 inches in dry periods and from 30 to 72 inches in wet periods.

The A1 horizon is grayish brown (10YR 5/2), brown (10YR 5/3), or pale brown (10YR 6/3). The fine sand (A2) part of the lower two horizons is light yellowish brown (10YR 6/4), brownish yellow (10YR 6/6), very pale brown (10YR 7/3, 7/4, 8/3), reddish yellow (7.5YR 7/6, 8/6), or strong brown (7.5YR 5/6).

The B2t part of the lower two horizons is reddish yellow (7.5YR 6/6, 6/8, 7/6), strong brown (7.5YR 5/6), brown (10YR 5/3), yellowish brown (10YR 5/4, 5/6), light yellowish brown (10YR 6/4), pale brown (10YR 6/3), or very pale brown (10YR 7/3). The B2t part is loamy fine sand mainly in bands or lenses 1/4 inch to 5 inches thick and 1/2 inch to 4 inches apart, but in some pedons it is continuous both horizontally and vertically.

Goodnight Series

The Goodnight series consists of deep, excessively drained, rapidly permeable soils. The soils formed in sandy eolian deposits on the flood plain of the Salt Fork of the Arkansas River. These soils are on hummocks and dunes and have slopes of 2 to 15 percent. Soils of the Goodnight series are mixed, thermic Typic Ustipsamments.

Goodnight soils are associated with Aline, Gaddy, Pratt, Tivoli, and Yahola soils. Aline, Pratt, and Tivoli soils generally are further from the river and in higher positions, and the Gaddy and Yahola soils are at lower elevations on the flood plain. Aline and Pratt soils have an argillic horizon. Gaddy and Yahola soils have strata of loamy texture. Tivoli soils are not calcareous and have discontinuous lamellae in the lower part of the pedon.

Typical pedon of Goodnight fine sand, 5 to 15 percent slopes, in native grass, 750 feet south and 1,330 feet west of the northeast corner of sec. 27, T. 26 N., R. 8 W.

A1—0 to 6 inches; light yellowish brown (10YR 6/4) fine sand, yellowish brown (10YR 5/4) moist; weak fine granular structure; loose dry or moist; moderately alkaline; gradual smooth boundary.

AC—6 to 40 inches; reddish yellow (7.5YR 6/6) fine sand, strong brown (7.5YR 5/6) moist; single grained; loose dry or moist; calcareous, moderately alkaline; gradual smooth boundary.

C—40 to 60 inches; reddish yellow (7.5YR 5/6) fine sand, reddish yellow (7.5YR 6/6) moist; single grained; loose, dry or moist; calcareous, moderately alkaline.

The depth to bedding planes is 30 to 60 inches, and the depth to bedrock is more than 80 inches. The soil is calcareous within a depth of 20 inches.

The A horizon is light brown (7.5YR 6/4), strong brown (7.5YR 5/6), brown (7.5YR 4/4, 5/4; 10YR 4/3, 5/3), light yellowish brown (10YR 6/4), yellowish brown (10YR 5/4, 5/6), very pale brown (10YR 7/3) or pale brown (10YR 6/3). It is neutral to moderately alkaline. The AC horizon is similar to the A horizon, but it generally has higher value and chroma.

The C horizon is brown (7.5YR 5/4), strong brown (7.5YR 5/6, 5/8), light brown (7.5YR 6/4), pink (7.5YR 7/4), or reddish yellow (7.5YR 6/6, 7/6, 8/6, 6/8, 7/8). It is loamy fine sand or fine sand and is moderately alkaline.

Gracemont Series

The Gracemont series consists of deep, somewhat poorly drained, moderately permeable or moderately rapidly permeable soils on flood plains. The soils formed in predominantly loamy alluvial sediments of Recent age. They have an apparent water table at a depth of 2 to 3 feet during the winter and spring. Slopes are 0 to 1 percent. Soils of the Gracemont series are coarse-loamy, mixed (calcareous), thermic Aquic Udifluvents.

Gracemont soils are associated with Attica, Gaddy, and Pratt soils. Attica and Pratt soils are on uplands, and they have an argillic horizon. In addition, Pratt soils have a sandy control section. Gaddy soils are in lower positions on the flood plain, and they have a sandy control section.

Typical pedon of Gracemont loam, saline, occasionally flooded, in native range, 960 feet east and 1,720 feet north of the southwest corner of sec. 2, T. 26 N., R. 8 W.

A1—0 to 9 inches; brown (7.5YR 4/2) loam, very dark grayish brown (7.5YR 3/2) moist; weak fine granular structure; friable; calcareous, moderately alkaline; clear smooth boundary.

C1—9 to 16 inches; reddish brown (5YR 4/4) fine sandy loam, dark reddish brown (5YR 3/4) moist; weak coarse prismatic structure parting to weak fine granular; friable; calcareous, moderately alkaline; clear smooth boundary.

C2—16 to 25 inches; yellowish red (5YR 5/6) fine sandy loam, yellowish red (5YR 4/6) moist; massive; very friable; thin strata of loamy sand and loam; calcareous, moderately alkaline; abrupt smooth boundary.

Ab—25 to 39 inches; dark grayish brown (10YR 4/2) fine sandy loam, very dark grayish brown (10YR 3/2) moist; massive; friable; calcareous, moderately alkaline; clear smooth boundary.

C—39 to 60 inches; brown (7.5YR 5/4) fine sandy loam, brown (7.5YR 4/4) moist; massive; friable; few thin darker strata of loam and sandy clay loam; calcareous, moderately alkaline.

The depth of the soil is 60 inches or more. The soils are calcareous and moderately alkaline, but in some pedons the uppermost 10 inches is noncalcareous and neutral to moderately alkaline. The soils have an electrical conductivity of 4 to 16 millimhos per centimeter.

The A horizon is brown (7.5YR 4/2, 5/2, 4/4, 5/4), grayish brown (10YR 5/2), dark grayish brown (10YR 4/2), or reddish brown (5YR 4/4). It is less than 10 inches thick where the moist value and chroma are 3.5 or less.

The C horizon is reddish brown (5YR 4/4, 5/4), yellowish red (5YR 4/6, 5/6), brown (7.5YR 5/4), strong brown (7.5YR 5/6), or light brown (7.5YR 6/4). It is fine sandy loam or loam and has thin strata of loamy fine sand to sandy clay loam.

The Ab horizon is gray (10YR 5/1), dark grayish brown (10YR 4/2), or brown (7.5YR 4/2; 10YR 4/3). It is fine sandy loam or loam and has thin strata of finer material below a depth of 40 inches. Some pedons do not have an Ab horizon.

Grainola Series

The Grainola series consists of moderately deep, well drained, slowly permeable soils on uplands in the north-central and south-central parts of Grant County. The soils formed in material weathered from shales of the Garber Formation. Slopes range from 1 to 5 percent. Soils of the Grainola series are fine, mixed, thermic, Vertic Haplustalfs.

Grainola soils are associated with Kirkland, Masham, and Renfrow soils. Kirkland soils are on the tops of flat interstream divides. They have a mollic epipedon more than 20 inches thick and are 60 inches or more in depth. Masham soils are at similar elevations and are 10 to 20 inches deep over shale. Renfrow soils are at similar elevations, have a mollic epipedon, and are more than 60 inches deep.

Typical pedon of Grainola silty clay loam, 1 to 3 percent slopes, in cultivation, 530 feet north and 170 feet west of the southeast corner of sec. 6, T. 28 N., R. 6 W.

Ap—0 to 6 inches; reddish brown (5YR 4/4) silty clay loam, dark reddish brown (5YR 3/3) moist; moderate fine granular structure; hard, firm; few fine fragments of shale; calcareous, moderately alkaline; clear smooth boundary.

B2t—6 to 21 inches; reddish brown (5YR 4/4) silty clay, dark reddish brown (5YR 3/4) moist; weak coarse blocky structure; extremely hard, very firm; thin patchy clay films on faces of peds; common spots and streaks of soft powdery lime as much as 1/2 inch across; calcareous, moderately alkaline; clear smooth boundary.

B3—21 to 25 inches; reddish brown (5YR 5/4) silty clay, reddish brown (5YR 4/3) moist; weak coarse blocky structure; extremely hard, very firm; coarse fragments of shale less than 3 inches in diameter make up 10 percent by volume; calcareous, moderately alkaline; abrupt smooth boundary.

Cr—25 to 29 inches; reddish brown (5YR 5/4) weathered shale; 40 percent spots, streaks, and layers of light greenish gray; calcareous.

The thickness of the solum and the depth to shale range from 20 to 40 inches. The soils have cracks in dry periods. The cracks are 1/2 to 1 inch wide and generally are more than 20 inches deep.

The A horizon is reddish brown (5YR 5/3, 4/3, 5/4, 4/4) or brown (7.5YR 4/4). Fragments up to 3 inches in diameter make up 2 to 15 percent by volume. The reaction is mildly alkaline or moderately alkaline. Some pedons are noncalcareous.

The B1 horizon, where present, is reddish brown (5YR 4/3, 4/4, 5/3, 5/4) or brown (7.5YR 4/2, 4/4). It is silty clay loam, clay loam, or clay. Coarse fragments less than 3 inches in diameter make up 5 to 15 percent by volume.

The B2t horizon is reddish brown (5YR 4/3, 4/4, 5/3, 5/4; 2.5YR 4/4, 5/4), yellowish red (5YR 4/6, 5/6, 4/8, 5/8), or red (2.5YR 4/6, 4/8, 5/6, 5/8). It is clay or silty clay. Coarse fragments less than 3 inches in diameter make up 0 to 15 percent by volume.

The B3 horizon is similar in color to the B2t horizon. It is clay, silty clay, shaly clay, or shaly silty clay. Coarse fragments less than 3 inches in diameter make up 5 to 50 percent by volume.

The Cr horizon is brownish or reddish shale and has spots, streaks or layers of grayish, yellowish, or olive colors.

Grant Series

The Grant series consists of deep, well drained, moderately permeable soils on broad uplands. The soils formed in material weathered from silty sandstone of the Permian red beds. Slopes are 1 to 20 percent. Soils of the Grant series are fine-silty, mixed, thermic Udic Argiustolls.

Grant soils are associated with Kingfisher, Oscar, Pond Creek, Quinlan, Wakita, and Woodward soils. Kingfisher soils are intermingled with Grant soils and have a similar profile, but they are 20 to 40 inches deep over shale and sandstone. Oscar soils are on flood plains and have a natric horizon. Pond Creek soils are on high terraces, and they have a thick mollic epipedon and a depth of 60 inches or more. Quinlan and Woodward soils are similar in elevation but do not have a mollic epipedon. In addition, Quinlan soils are shallow, and Woodward soils are coarse-silty. Wakita soils are in intermingled areas, and they have a natric horizon.

Typical pedon of Grant silt loam, 1 to 3 percent slopes, in a cultivated field, 1,700 feet west and 1,240 feet north of the southeast corner of sec. 9, T. 25 N., R. 8 W.

Ap—0 to 12 inches; brown (7.5YR 4/3) silt loam, dark brown (7.5YR 3/3) moist and crushed; weak fine granular structure; hard, friable; upper 8 inches plowed; neutral; gradual smooth boundary.

B1—12 to 17 inches; brown (7.5YR 4/3) silt loam, dark brown (7.5YR 3/3) moist; moderate medium granular structure; slightly hard, friable; neutral; gradual smooth boundary.

B2t—17 to 44 inches; reddish brown (5YR 4/4) silt loam, dark reddish brown (5YR 3/4) moist; weak coarse prismatic structure that parts to weak coarse blocky; hard, friable; weak patchy clay films on faces of peds; neutral; gradual smooth boundary.

B3—44 to 59 inches; yellowish red (5YR 5/6) silt loam, yellowish red (5YR 4/6) moist; weak coarse prismatic structure; hard, friable; soft powdery lime on faces of peds; calcareous, moderately alkaline; gradual irregular boundary.

Cr—59 to 65 inches; reddish yellow (5YR 6/6) weathered soft sandstone, yellowish red (5YR 5/6) moist; calcareous, moderately alkaline.

The thickness of the solum and the depth to bedrock are 40 to 60 inches. The depth to soft secondary carbonates is more than 36 inches. The Grant soils in the Grant-Port complex, 0 to 20 percent slopes, are calcareous and moderately alkaline throughout.

The A horizon is grayish brown (10YR 5/2), brown (7.5YR 5/3, 4/3; 10YR 4/3, 5/3), or reddish brown (5YR 5/3, 4/3). It ranges from slightly acid to mildly alkaline, but the plow layer ranges to strongly acid where it has been heavily fertilized with nitrogen.

The B1 horizon is brown (7.5YR 4/2, 4/4, 5/2, 5/4), dark reddish gray (5YR 4/2), or reddish brown (5YR 4/3, 5/3, 4/4, 5/4). It is silt loam or silty clay loam and is slightly acid to mildly alkaline.

The B2t horizon is red (2.5YR 4/6, 4/8), reddish brown (2.5YR 4/4, 5/4; 5YR 4/4, 5/3, 5/4), or yellowish red (5YR 4/6, 5/6). It is silt loam or silty clay loam and is neutral to moderately alkaline.

The B3 horizon is reddish brown (2.5YR 4/4, 5/4; 5YR 4/4, 5/4), red (2.5YR 4/6, 5/6), light red (2.5YR 6/6), yellowish red (5YR 4/6, 5/6), or reddish yellow (5YR 6/6). In some pedons there is a C horizon, which has the same color range as the B3 horizon. The B3 horizon is silt loam or silty clay loam, and the C horizon is loam or silt loam. Reaction is mildly alkaline or moderately alkaline. The Cr layer is soft, reddish or yellowish silty sandstone or silty shale.

The Grant soils in map unit 22, Grant-Port complex, 0 to 20 percent slopes, are taxadjuncts to the Grant series because the A horizon is calcareous and moderately alkaline. Use, behavior, and management are similar to soils of the Grant series.

Hawley Series

The Hawley series consists of deep, well drained, moderately permeable soils. The soils formed in loamy alluvium on terraces of flood plains. They are subject to rare flooding. The largest areas are located north of the Salt Fork of the Arkansas River and along the major creeks in the western part of the county. Slopes are 0 to 1 percent. Soils of the Hawley series are coarse-loamy, mixed, thermic Fluventic Ustochrepts.

Hawley soils are associated with Dale, McLain, and Reinach soils on terraces of flood plains at similar elevations and with Port and Yahola soils on flood plains at lower elevations. Unlike Hawley soils, the Dale, McLain, Port, and Reinach soils have a mollic surface layer. In addition, Dale and Port soils are fine-silty, McLain soils have a fine control section, and Reinach soils are coarse-silty. Yahola soils do not have a cambic horizon and are calcareous throughout the control section.

Typical pedon of Hawley fine sandy loam, rarely flooded, in a cultivated field, 1,900 feet west and 140 feet south of the northeast corner of sec. 7, T. 26 N., R. 7 W.

Ap—0 to 9 inches; brown (7.5YR 5/4) fine sandy loam, dark brown (7.5YR 3/4) moist; weak fine granular structure; soft, very friable; medium acid; clear smooth boundary.

A12—9 to 18 inches; brown (7.5YR 4/4) fine sandy loam, dark brown (7.5YR 3/4) moist; weak coarse prismatic structure parting to weak fine granular; slightly hard, friable; neutral; gradual smooth boundary.

B2—18 to 34 inches; brown (7.5YR 5/4) fine sandy loam, brown (7.5YR 4/4) moist; weak coarse prismatic structure; soft, very friable; mildly alkaline; gradual smooth boundary.

C1—34 to 50 inches; brown (7.5YR 5/4) fine sandy loam, brown (7.5YR 4/4) moist; massive; soft, very friable; strata 1/4 inch to 4 inches thick of loamy fine sand and very fine sandy loam; moderately alkaline; gradual smooth boundary.

C2—50 to 66 inches; brown (7.5YR 4/4) loam, dark brown (7.5YR 3/2) moist; massive; slightly hard, friable; strata 1/4 inch to 4 inches thick of very fine sandy loam, silt loam, and silty clay loam; few soft powdery masses and threads of calcium carbonate; calcareous, moderately alkaline.

The solum is 20 to 50 inches thick. The organic matter content of the A horizon is less than 1 percent.

The Ap horizon is brown (7.5YR 4/4, 5/4; 10YR 4/3, 5/3), light brown (7.5YR 6/4), pale brown (10YR 6/3), dark yellowish brown (10YR 4/4), or light yellowish brown (10YR 6/4). It is loam, fine sandy loam, or loamy fine sand, and it is medium acid to mildly alkaline.

The A12 horizon is dark brown (7.5YR 3/4; 10YR 3/3, 4/3), brown (7.5YR 4/4, 5/4; 10YR 5/3), dark yellowish brown (10YR 3/4, 4/4), or yellowish brown (10YR 5/4). It is fine sandy loam and is slightly acid to mildly alkaline.

The B2 horizon is dark brown (7.5YR 4/4), brown (7.5YR 5/4), strong brown (7.5YR 4/6, 5/6), reddish brown (5YR 4/4, 5/4), or yellowish red (5YR 4/6, 5/6). It is fine sandy loam or loam and is slightly acid to moderately alkaline. In some pedons the B2 horizon is calcareous. Other pedons have a B3 horizon that is similar to the B2 horizon in color and texture.

The C horizon is brown (7.5YR 4/4, 5/4), strong brown, (7.5YR 4/6, 5/6), light brown (7.5YR 6/4), reddish yellow (7.5YR 6/6; 5YR 6/6), reddish brown (5YR 4/4, 5/4), light reddish brown (5YR 6/4), or yellowish red (5YR 4/6, 5/6). It is fine sandy loam or loam. Below a depth of 36 inches, it is loamy fine sand and has thin strata of silt loam, silty clay loam, sandy clay loam, very fine sandy loam, loamy very fine sand, or fine sand. This horizon is neutral to moderately alkaline.

Some pedons have a buried A horizon below a depth of 25 inches. This horizon is dark brown (7.5YR 3/2, 3/4, 4/2, 4/4; 10YR 3/3, 4/3), brown (7.5YR 5/2, 5/4; 10YR 5/3), very dark grayish brown (10YR 3/2), or yellowish brown (10YR 5/4). In other pedons there are horizons of contrasting texture below a depth of 36 inches.

Kingfisher Series

The Kingfisher series consists of moderately deep, well drained, moderately slowly permeable soils on uplands. The soils formed in loamy material weathered from soft, silty shale red beds of Permian age. Slopes are 1 to 8 percent. Soils of the Kingfisher series are fine-silty, mixed, thermic Udic Argiustolls.

Kingfisher soils are associated with Grant, Quinlan, Wakita, and Woodward soils. Grant and Wakita soils are on the same landscape. Grant soils have sandstone at a depth of 40 to 60 inches, and Wakita soils have a natric horizon. Quinlan and Woodward soils are on ridges and side slopes, and they do not have a mollic epipedon or an argillic horizon.

Typical pedon of Kingfisher silt loam, 1 to 3 percent slopes, in a cultivated field, 700 feet west and 150 feet north of southeast corner of sec. 36, T. 26 N., R. 7 W.

A1—0 to 11 inches; reddish brown (5YR 4/3) silt loam, dark reddish brown (5YR 3/3) moist; moderate fine and medium granular structure; slightly hard, friable; upper 7 inches plowed; slightly acid; clear boundary.

B1—11 to 17 inches; reddish brown (5YR 5/3) silt loam, reddish brown (5YR 4/3) moist; weak coarse subangular blocky structure; hard, firm; mildly alkaline; clear smooth boundary.

B22t—17 to 29 inches; reddish brown (2.5YR 5/4) silty clay loam, reddish brown (2.5YR 4/4) moist; weak coarse subangular blocky structure; hard, friable; calcareous, moderately alkaline; clear smooth boundary.

Cr—29 to 41 inches; reddish brown (2.5YR 4/4) and about 20 percent gray (5YR 6/1) weathered soft silty shale red beds.

The thickness of the solum and the depth to bedrock range from 20 to 40 inches. The A horizon is brown (7.5YR 4/2, 4/3, 5/2, 5/3) or reddish brown (5YR 4/3, 5/3). It is slightly acid to mildly alkaline.

The B1 horizon has colors similar to those of the A horizon. It is silt loam, clay loam, or silty clay loam. The B1 horizon is slightly acid to mildly alkaline.

The B2t horizon is reddish brown (2.5YR 4/4, 5/4; 5YR 4/3, 4/4, 5/3, 5/4), red (2.5YR 4/6, 5/6), or yellowish red (5YR 4/6, 5/6). It is clay loam or silty clay loam. It is mildly alkaline or moderately alkaline and is calcareous in most pedons.

In some pedons there is a B3 horizon. It is similar in color to the B2t horizon. It is silt loam, clay loam, or silty clay loam. It is mildly alkaline or moderately alkaline and is calcareous in most pedons.

The Cr horizon is reddish brown, red, or yellowish red silty shale and sandstone. It has thin greenish and grayish interbedded layers in many pedons.

The Kingfisher soils in this survey area are taxadjuncts to the Kingfisher series, because the depth to calcareous material is less than in the soils of the Kingfisher series. Use, behavior, and management requirements are similar to those of the Kingfisher series.

Kirkland Series

The Kirkland series consists of deep, well drained, very slowly permeable soils (fig. 12). The soils formed in clay and shale of the Wellington Formation, in clayey material of old alluvial plains, or in a combination of these two materials. Slopes are 0 to 3 percent. Soils of the Kirkland series are fine, mixed, thermic Udertic Paleustolls.

Kirkland soils are associated with Bethany, Grainola, Pawhuska, Renfrow, and Tabler soils. Bethany soils generally are at slightly higher elevations than Kirkland soils. Grainola and Renfrow soils are on side slopes on lower parts of the landscape. Bethany and Renfrow soils do not have an abrupt textural change from the mollic epipedon to the argillic horizon. In addition, Bethany soils have COLE values less than 0.07. Grainola soils do not have a mollic epipedon. Pawhuska and Tabler soils are on the same landscape as Kirkland soils, but Tabler soils are in slightly lower positions. Pawhuska soils have a natric horizon. Tabler soils have montmorillonitic mineralogy and are moderately well drained.

Typical pedon of Kirkland silt loam, 1 to 3 percent slopes, in a cultivated field, 2,400 feet west and 1,050 feet north of the southeast corner of sec. 2, T. 28 N., R. 5 W.

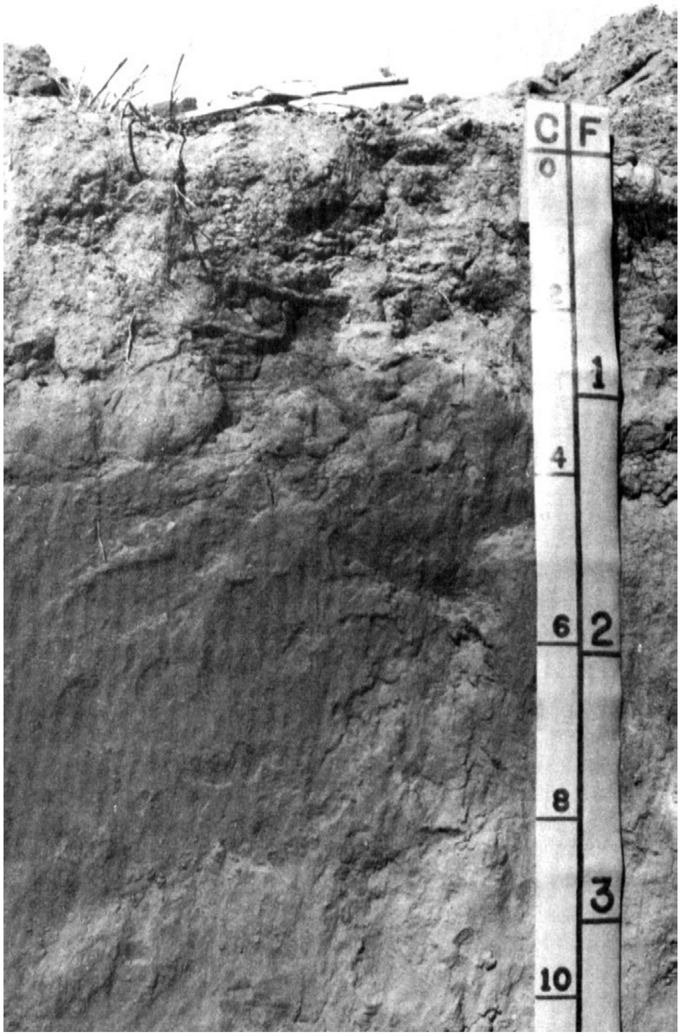


Figure 12.—Profile of Kirkland silt loam, 0 to 1 percent slopes, showing the clayey, blocky argillic horizon below a depth of 14 inches. The scale is in decimeters (left) and feet.

A1—0 to 10 inches; dark grayish brown (10YR 4/2) silt loam, very dark grayish brown (10YR 3/2) moist; moderate medium granular structure; slightly hard, friable; many fine roots; neutral; abrupt smooth boundary.

B21t—10 to 29 inches; brown (7.5YR 4/2) clay, dark brown (7.5YR 3/2) moist; moderate medium subangular blocky structure; extremely hard, very firm; many fine roots; clay films on faces of peds; neutral; diffuse smooth boundary.

B22t—29 to 38 inches; reddish brown (5YR 5/3) clay, dark reddish brown (5YR 3/3) moist; weak medium blocky structure; extremely hard, very firm; clay films on faces of peds; common fine calcium carbonate concretions; coatings of silt on some peds; moderately alkaline; gradual smooth boundary.

B23tca—38 to 60 inches; reddish brown (5YR 5/4) clay, dark reddish brown (5YR 3/4) moist; weak coarse blocky structure; extremely hard, very firm; clay films on faces of peds; common fine and medium calcium carbonate concretions; soft powdery lime on some ped faces; few gypsum grains; calcareous, moderately alkaline; gradual smooth boundary.

B3—60 to 72 inches; red (2.5YR 5/6) clay, dark red (2.5YR 3/6) moist; weak coarse blocky structure; extremely hard, very firm; few medium hard and soft masses of carbonates; calcareous, moderately alkaline.

The solum is more than 60 inches thick. The mollic epipedon is more than 20 inches thick, and the depth to secondary carbonates ranges from 30 to 45 inches. Wide cracks are common in dry periods.

The A horizon is brown or dark brown (7.5YR 5/2, 4/2, 3/2; 10YR 5/3, 4/3), grayish brown (10YR 5/2), very dark grayish brown (10YR 3/2), or dark grayish brown (10YR 4/2). It is medium acid to neutral.

The B21t horizon has the same color range as the A horizon but includes reddish brown (5YR 4/3, 5/3). It is clay or silty clay and is neutral or mildly alkaline.

The B22t horizon is reddish brown (5YR 4/3, 5/3, 4/4, 5/4), yellowish red (5YR 5/6), dark brown (7.5YR 3/2, 4/2, 4/4), or dark grayish brown (10YR 4/2). It is clay or silty clay and is neutral to moderately alkaline.

The B23tca horizon and B3 horizons are red (2.5YR 4/6, 5/6), reddish brown (2.5YR 4/4, 5/4; 5YR 4/4, 5/3, 5/4), yellowish red (5YR 4/6, 5/6), or brown (7.5YR 4/4, 5/4). These horizons are clay or silty clay, calcareous, and moderately alkaline.

In some pedons there is a Cr horizon of reddish, calcareous shale at a depth of 65 inches or more.

The Kirkland soil in map unit 31, Kirkland-Pawhuska silt loams, 0 to 2 percent slopes, is a taxadjunct to the Kirkland series because it has free lime below the A horizon and is moderately alkaline and because the Btca and B3 horizons have a significant decrease in clay content. Use, behavior, and management requirements are similar to those of the Kirkland series.

Lela Series

The Lela series consists of deep, somewhat poorly drained, very slowly permeable soils on low terraces of flood plains. The soils formed in material weathered predominantly from clayey alluvium. Slopes range from 0 to 1 percent. Soils of the Lela series are fine, mixed, thermic Udic Chromusterts.

Lela soils are associated with McLain soils. McLain soils are in similar positions, but they have an argillic horizon.

Typical pedon of Lela clay, rarely flooded, in a cultivated field, 1,550 feet west and 370 feet south of the northeast corner of sec. 24, T. 25 N., R. 3 W.

Ap—0 to 4 inches; brown (7.5YR 4/2) clay, dark brown (7.5YR 3/2) moist; moderate fine granular structure; very hard, very firm; neutral; abrupt smooth boundary.

A12—4 to 20 inches; brown (7.5YR 4/2) clay, dark brown (7.5YR 3/2) moist; moderate medium blocky structure; extremely hard, very firm; neutral; gradual wavy boundary.

AC—20 to 45 inches; reddish brown (5YR 4/3) clay, dark reddish brown (5YR 3/3) moist; moderate medium blocky structure; extremely hard, very firm; few intersecting slickensides; calcareous, moderately alkaline; gradual wavy boundary.

C—45 to 72 inches; reddish brown (5YR 4/3) clay, dark reddish brown (5YR 3/3) moist; massive; extremely hard, very firm; calcareous, moderately alkaline.

The thickness of the solum ranges from 20 to 80 inches. Wide cracks are common in dry periods. The thickness of the A horizon is 10 to 32 inches.

The A horizon is dark reddish gray (5YR 4/2), reddish brown (5YR 4/3), dark reddish brown (5YR 3/2), dark brown (7.5YR 4/2), very dark grayish brown (10YR 3/2), or dark grayish brown (10YR 4/2). It is slightly acid to moderately alkaline.

The AC horizon is dark reddish gray (5YR 4/2), reddish brown (5YR 4/3, 5/3, 4/4, 5/4), or brown (7.5YR 4/2, 5/2). It is clay or silty clay and is moderately alkaline and calcareous. The C horizon is similar in color, texture, and reaction to the AC horizon.

Masham Series

The Masham series consists of shallow, well drained, very slowly permeable soils that formed in residuum weathered from shales of Permian age. These soils are on breaks along drainageways. The largest areas are in the north-central part of the county. Slopes are dominantly 10 to 20 percent, but the range is from 3 to 20 percent. Soils of the Masham series are clayey, mixed, thermic, shallow Typic Ustochrepts.

Masham soils are associated with Grainola soils. The moderately deep Grainola soils have an argillic horizon and are in higher positions on side slopes of uplands.

Typical pedon of Masham silty clay, in an area of Masham-Port complex, 0 to 20 percent slopes, in rangeland, 1,700 feet east and 2,475 feet south of the northwest corner of sec. 5, T. 28 N., R. 6 W.

A1—0 to 4 inches; reddish brown (2.5YR 4/4) silty clay, dark reddish brown (2.5YR 3/4) moist; moderate fine granular structure; very hard, firm; common fine roots; calcareous, moderately alkaline; gradual smooth boundary.

B2—4 to 12 inches; red (2.5YR 5/6) silty clay, dark red (2.5YR 3/6) moist; weak medium blocky structure; extremely hard, very firm; few fine roots; calcareous, moderately alkaline; clear wavy boundary.

Cr—12 to 37 inches; red (2.5YR 4/6) weathered granular shale, dark red (2.5YR 3/6) moist; calcareous, moderately alkaline.

The solum is 10 to 20 inches thick. The soils are moderately alkaline throughout and typically are calcareous, but the A horizon can be noncalcareous.

The A or AB horizon is reddish brown (2.5YR 4/4, 5/4; 5YR 4/4, 5/4) or yellowish red (5YR 4/6).

The B2 horizon is reddish brown (5YR 4/3, 5/3, 4/4, 5/4; 2.5YR 4/4, 5/4), red (2.5YR 4/6, 5/6), or yellowish red (5YR 4/6, 5/6). It is silty clay or clay.

The Cr horizon is reddish or brownish shale. In some pedons it has spots, streaks, or layers of light greenish gray or olive shale.

McLain Series

The McLain series consists of deep, moderately well drained, slowly permeable soils on low terraces of flood plains. The soils formed in material weathered from loamy and clayey alluvium that was washed predominantly from red beds of Permian age. The slopes are 1 percent or less. Soils of the McLain series are fine, mixed, thermic Pachic Argiustolls.

McLain soils are associated with Dale, Drummond, Hawley, Lela, and Reinach soils. Dale, Hawley, Lela, and Reinach soils are at similar elevations, and they do not have an argillic horizon; all of them except Lela soils are closer to the stream than McLain soils. Also, Hawley soils do not have a mollic epipedon, and Lela soils have intersecting slickensides. Drummond soils are intermingled with McLain soils and have a natric horizon.

Typical pedon of McLain silt loam, rarely flooded, in a cultivated field, 600 feet south and 300 feet east of the northwest corner of sec. 29, T. 25 N., R. 6 W.

A1—0 to 14 inches; brown (7.5YR 4/2) silt loam, dark brown (7.5YR 3/2) moist; weak medium granular structure; hard, friable; neutral; gradual smooth boundary.

B1—14 to 19 inches; brown (7.5YR 4/2) silty clay loam, dark brown (7.5YR 3/2) moist; weak fine blocky structure; hard, friable; thin clay films on faces of peds; neutral; gradual smooth boundary.

B2t—19 to 35 inches; reddish brown (5YR 4/3) silty clay, dark reddish brown (5YR 3/3) moist; moderate medium blocky structure; very hard, very firm; thin clay films on faces of peds; mildly alkaline; clear smooth boundary.

B3—35 to 59 inches; yellowish red (5YR 5/6) silty clay loam, yellowish red (5YR 4/6) moist; weak coarse blocky structure; very hard, firm; thin clay films on faces of peds; traces of soft carbonates on faces of peds; calcareous, moderately alkaline; diffuse smooth boundary.

C—59 to 75 inches; yellowish red (5YR 5/6) silty clay loam, yellowish red (5YR 4/6) moist; massive; hard, friable; many streaks and masses of soft carbonates; calcareous, moderately alkaline.

The solum is 45 to more than 60 inches thick. The depth to soft powdery secondary lime is 30 to 45 inches.

The A horizon is very dark grayish brown (10YR 3/2), reddish brown (5YR 4/3, 5/3), dark reddish brown (5YR 3/2), or brown (7.5YR 4/2, 5/2). It is slightly acid to moderately alkaline.

The B1 horizon is similar to the A horizon in color and reaction. It is silty clay loam or silt loam. In some pedons there is no B1 horizon.

The B2t horizon is dusky red (2.5YR 3/2), weak red (2.5YR 4/2), dark reddish gray (5YR 4/2), dark reddish brown (5YR 3/2), reddish brown (5YR 4/3, 4/4, 5/3, 5/4), or yellowish red (5YR 5/6) in the lower part. It is silty clay loam, clay, or silty clay. It is neutral to moderately alkaline and calcareous in the lower part.

The B3 horizon and C horizon are reddish brown (2.5YR 5/4, 4/4; 5YR 5/4, 4/4), yellowish red (5YR 4/6, 5/6), or reddish yellow (5YR 6/6) in the lower part. These horizons are silty clay loam, moderately alkaline, and calcareous. The C horizon can also be silt loam. In some pedons, it has strata of coarser textures below a depth of 50 inches.

Norge Series

The Norge series consists of deep, well drained, moderately slowly permeable soils on terraces of broad uplands. The soils formed in material weathered from loamy loess and underlying alluvium. Slopes are 3 to 5 percent. Soils of the Norge series are fine-silty, mixed, thermic Udic Paleustolls.

Norge soils are associated with Pond Creek soils. The Pond Creek soils are higher in elevation and have a mollic epipedon 20 inches or more in thickness.

Typical pedon of Norge silt loam, 3 to 5 percent slopes, in native range, 1,030 feet west and 130 feet south of the northeast corner of sec. 27, T. 27 N., R. 3 W.

A1—0 to 12 inches; brown (7.5YR 4/3) silt loam, dark brown (7.5YR 3/3) moist; weak fine granular structure; hard, friable; slightly acid; gradual smooth boundary.

B1—12 to 17 inches; brown (7.5YR 4/3) silt loam, dark brown (7.5YR 3/3) moist; weak medium granular structure; slightly hard, friable; slightly acid; gradual smooth boundary.

B21t—17 to 32 inches; reddish brown (5YR 4/4) silty clay loam, dark reddish brown (5YR 3/4) moist; weak medium prismatic structure; hard, firm; thin clay films on faces of peds; slightly acid; diffuse smooth boundary.

B22t—32 to 50 inches; reddish brown (5YR 5/4) silty clay loam, reddish brown (5YR 4/4) moist; weak coarse prismatic structure that parts to weak medium blocky; hard, firm; neutral; diffuse smooth boundary.

B3—50 to 66 inches; yellowish red (5YR 5/6) silty clay loam, yellowish red (5YR 4/6) moist; weak coarse prismatic structure; hard, firm; mildly alkaline.

The solum is 60 to more than 72 inches thick.

The A horizon is brown (7.5YR 4/3, 5/3) or reddish brown (5YR 4/3, 5/3). It ranges from medium acid to neutral.

The B1 horizon is brown (7.5YR 4/2, 4/4, 5/2, 5/4). It is silt loam or silty clay loam and is slightly acid or neutral.

The B2t horizon is reddish brown (5YR 4/4, 5/4) or yellowish red (5YR 4/6, 5/6). It is silt loam or silty clay loam and ranges from slightly acid to mildly alkaline.

The B3 horizon is reddish brown (5YR 4/4, 5/4) or yellowish red (5YR 4/6, 5/6). It is silt loam or silty clay loam and is mildly alkaline or moderately alkaline.

Oscar Series

The Oscar series consists of deep, moderately well drained, slowly permeable, saline-alkali soils on flood plains. These soils formed in weathered, loamy alluvium infused with salt and sodium from saline-alkali springs. Slopes range from 0 to 2 percent. The soils are frequently flooded. Soils of the Oscar series are fine-silty, mixed, thermic Typic Natrustalfs.

Oscar soils are associated with Grant soils on uplands and Port soils on flood plains. Grant and Port soils do not have a natric horizon.

Typical pedon of Oscar silt loam, in an area of Oscar-Grant complex, 0 to 12 percent slopes, in native range, 900 feet east and 340 feet north of the southwest corner of sec. 33, T. 28 N., R. 5 W.

A11—0 to 2 inches; light brown (7.5YR 6/4) silt loam, dark brown (7.5YR 3/3) moist; massive; hard, firm; calcareous, mildly alkaline; clear smooth boundary.

A12—2 to 11 inches; brown (7.5YR 5/4) silt loam, brown (7.5YR 4/4) moist; weak fine granular structure; hard, friable; very thin strata of very fine sandy loam; very thin coatings of soft powdery lime in root channels; calcareous, moderately alkaline; clear smooth boundary.

B21t—11 to 22 inches; reddish brown (5YR 5/4) silt loam, reddish brown (5YR 4/4) moist; weak medium blocky structure; hard, friable; numerous fine root channels; thin clay films on faces of peds; thin light gray coatings on vertical faces; calcareous, moderately alkaline; gradual smooth boundary.

B22t—22 to 34 inches; reddish brown (5YR 5/4) silt loam; reddish brown (5YR 4/4) moist; weak coarse blocky structure; hard, firm; some vertical faces coated with light gray very fine sandy loam; thin clay films on faces of peds; calcareous, moderately alkaline; clear smooth boundary.

B3—34 to 48 inches; reddish brown (5YR 5/4) silt loam, reddish brown (5YR 4/4) moist; weak coarse blocky structure; hard, firm; few jagged brown concretions; few faces coated with light gray very fine sandy loam; calcareous, moderately alkaline; diffuse smooth boundary.

C—48 to 76 inches; reddish brown (5YR 5/4) silty clay loam, reddish brown (5YR 4/4) moist; massive; extremely hard, very firm; calcareous, moderately alkaline.

The solum is 35 to 80 inches thick. Soft, powdery secondary lime is within a depth of 40 inches. The hard surface crust is massive.

The A horizon is brown (7.5YR 4/2, 5/2, 4/4, 5/4; 10YR 4/3, 5/3), dark grayish brown (10YR 4/2), light brown (7.5YR 6/4), or pale brown (10YR 6/3). It is predominantly silt loam and is neutral to moderately alkaline. In some pedons it is noncalcareous. Exchangeable sodium ranges from 0 to 75 percent, and the electrical conductivity ranges from 0 to 16 millimhos per centimeter.

The B2t horizon is reddish brown (2.5YR 5/4; 5YR 4/3, 5/3, 4/4, 5/4) or weak red (2.5YR 4/2). It is silt loam or silty clay loam and is moderately alkaline or strongly alkaline. Exchangeable sodium ranges from 15 to 80 percent, and the electrical conductivity ranges from 4 to 16 millimhos per centimeter.

The B3 horizon and the C horizon are reddish brown (5YR 4/3, 5/4; 2.5YR 4/4) or red (2.5YR 4/6). These horizons are silt loam or silty clay loam and are moderately alkaline to very strongly alkaline. The exchangeable sodium ranges from 15 to 80 percent, and the electrical conductivity ranges from 4 to 12 millimhos per centimeter.

Pawhuska Series

The Pawhuska series consists of deep, moderately well drained, very slowly permeable soils on upland plains or old stream terraces. Pawhuska soils formed in predominantly clayey material that derived from thin alluvium and from the underlying Permian shales. Pawhuska soils have low to high salinity and a natric horizon. Slopes are 0 to 2 percent. Soils of the Pawhuska series are fine, mixed, thermic Mollic Natrustalfs.

Pawhuska soils are associated with intermingled areas of Kirkland and Renfrow soils. Kirkland and Renfrow soils have a mollic epipedon and do not have a natric horizon.

Typical pedon of Pawhuska silt loam, in an area of Kirkland-Pawhuska silt loams, 0 to 2 percent slopes, 600 feet north and 95 feet east of the southwest corner of sec. 5, T. 27 N., R. 6 W.

A1p&A2p—0 to 5 inches; brown (10YR 5/3) silt loam, dark brown (10YR 3/3) moist; weak fine granular structure; hard, friable; 1/4-inch vesicular crust that has weak thin platy structure, massive when dry; 5 percent (A2) very pale brown (10YR 7/3) uncoated, very fine sand grains; few fine roots; mildly alkaline; clear wavy boundary.

B21t—5 to 15 inches; brown (7.5YR 4/2) silty clay, dark brown (7.5YR 3/2) moist; moderate medium columnar structure breaking to moderate medium subangular blocky; extremely hard, firm; nearly continuous clay films on faces of peds; common fine and medium gypsum crystals; few fine black concretions; moderately alkaline; clear smooth boundary.

B22t—15 to 26 inches; reddish brown (5YR 4/4) silty clay, dark reddish brown (5YR 3/4) moist; moderate medium subangular blocky structure; extremely hard, very firm; nearly continuous clay films on faces of peds; moderately alkaline; gradual smooth boundary.

B23t—26 to 44 inches; reddish brown (5YR 5/4) clay, reddish brown (5YR 4/4) moist; moderate medium blocky structure; extremely hard, very firm; nearly continuous clay films on faces of peds; few fine black bodies in lower part; moderately alkaline; clear smooth boundary.

B24t—44 to 59 inches; reddish brown (5YR 5/4) silty clay, reddish brown (5YR 4/4) moist; weak medium blocky structure; extremely hard, very firm; patchy clay films on faces of peds; common prominent coarse light reddish mottles; few fine and medium bodies of gypsum; calcareous, moderately alkaline; clear smooth boundary.

B3—59 to 65 inches; reddish brown (5YR 5/4) silty clay loam, reddish brown (5YR 4/4) moist; weak coarse blocky structure; very hard, very firm; few fine black bodies; calcareous, moderately alkaline; clear smooth boundary.

Cr—65 to 68 inches; reddish brown weathered shale.

The thickness of the solum and the depth to sandstone and shale is 40 to more than 60 inches. The depth to soft powdery lime ranges from 10 to 34 inches.

The A1 horizon is light brownish gray (10YR 6/2), pale brown (10YR 6/3), grayish brown (10YR 5/2), dark grayish brown (10YR 4/2), or brown (7.5YR 4/2, 4/4; 10YR 5/3, 4/3). It is predominantly silt loam but ranges to silty clay loam. It is slightly acid to moderately alkaline. The A2 horizon, where present, is similar to the A1 horizon in texture and reaction, but it is slightly lighter in color and has many clean sand grains. The A horizon has an electrical conductivity of 2 to 16 millimhos per centimeter and an exchangeable sodium percentage of 0 to 25.

The B2t horizon is dark reddish gray (5YR 4/2), reddish brown (2.5YR 4/4, 5/4; 5YR 4/3, 5/3, 4/4, 5/4), brown (7.5YR 4/2; 10YR 4/3, 5/3), grayish brown (10YR 5/2), or dark grayish brown (10YR 4/2). It can also be red (2.5YR 4/6, 5/6) in the lower part. Grayish or reddish mottles are below a depth of 40 inches in some pedons. This horizon is silty clay loam, silty clay, or clay and is calcareous in some pedons. The B2t horizon and B3 horizon have an electrical conductivity of 2 to 16 millimhos per centimeter and an exchangeable sodium percentage of 15 to 45.

The B3 horizon is red (2.5YR 4/6, 5/6), reddish brown (5YR 4/4, 5/4), light reddish brown (5YR 6/4), or yellowish red (5YR 4/6, 5/6). It is silty clay loam, clay loam, silty clay, or clay.

Pocasset Series

The Pocasset series consists of deep, well drained, moderately permeable soils on flood plains. The soils formed in material weathered from predominantly loamy alluvium. The largest areas are along Sand Creek southeast of Nash. Slopes are 0 to 1 percent. Soils of the Pocasset series are coarse-loamy, mixed, thermic Fluventic Haplustolls.

Pocasset soils are associated with Port and Reinach soils. Port soils are on flood plains at about the same elevation. They have a fine-silty control section and a mollic epipedon more than 20 inches thick. Reinach soils are on terraces at higher elevations. They have a coarse-silty control section and a mollic epipedon more than 20 inches thick.

Typical pedon of Pocasset silt loam, in an area of Port and Pocasset soils, frequently flooded, in bermudagrass, 2,050 feet east and 400 feet north of the southwest corner of sec. 30, T. 25 N., R. 7 W.

A1—0 to 14 inches; brown (7.5YR 4/3) silt loam, dark brown (7.5YR 3/3) moist; moderate medium granular structure; hard, friable; calcareous, moderately alkaline; clear smooth boundary.

C1—14 to 40 inches; brown (7.5YR 4/4) fine sandy loam, dark brown (7.5YR 3/4) moist; massive; slightly hard, very friable; strata 1/2 inch to 2 inches thick of brown silt loam and loam; calcareous, moderately alkaline; clear smooth boundary.

C2—40 to 72 inches; brown (7.5YR 5/4) very fine sandy loam, brown (7.4YR 4/4) moist; massive; slightly hard, very friable; thin strata of fine sandy loam and loamy fine sand; common streaks and spots of soft powdery lime; calcareous, moderately alkaline.

The depth of the soil is 60 inches or more. Some pedons have buried dark layers below a depth of 30 inches.

The A horizon is reddish brown (5YR 4/3, 5/3) or brown (7.5YR 4/3, 5/3). It is very fine sandy loam, silt loam, or fine sandy loam. This horizon is mildly alkaline or moderately alkaline. It is noncalcareous in some pedons.

The C horizon is reddish brown (5YR 4/4, 5/4), yellowish red (5YR 4/6, 5/6), or brown (7.5YR 5/4, 4/4, 5/3, 4/3). It is predominantly fine sandy loam, but it has strata 1/4 inch to 4 inches thick of very fine sandy loam, loamy fine sand, loam, or silt loam.

The Pocasset soils in this survey area are taxadjuncts to the Pocasset series because they have brown (7.5YR 4/3, 4/4, 5/3, 5/4) layers below the A horizon. Use, behavior, and management requirements are the same as those of the Pocasset series.

Pond Creek Series

The Pond Creek series consists of deep, well drained, moderately slowly permeable soils on intermediate and high terraces. The soils formed in material weathered from loamy alluvial sediment. The largest areas are near Pond Creek, Nash, and Lamont. Slopes are 0 to 3 percent. Soils of the Pond Creek series are fine-silty, mixed, thermic Pachic Argiustolls.

Pond Creek soils are associated with Bethany, Grant, and Norge soils. Bethany soils are in slightly higher positions and have a clay content of more than 35 percent in the uppermost 20 inches of the argillic horizon. Grant and Norge soils are on side slopes, and they have a mollic epipedon less than 20 inches thick.

Typical pedon of Pond Creek silt loam, 0 to 1 percent slopes, in a cultivated field, 1,800 feet west and 1,700 feet south of the northeast corner of sec. 28, T. 25 N., R. 8 W.

Ap—0 to 10 inches; brown (7.5YR 5/3) silt loam, dark brown (7.5YR 3/3) moist; weak medium granular structure; slightly hard, friable; slightly acid; abrupt smooth boundary.

A1—10 to 14 inches; brown (7.5YR 4/3) silt loam, dark brown (7.5YR 3/3) moist; weak medium granular structure; slightly hard, friable; slightly acid; gradual smooth boundary.

B1—14 to 22 inches; brown (7.5YR 4/3) silt loam, dark brown (7.5YR 3/3) moist; weak coarse blocky structure; hard, friable; neutral; gradual smooth boundary.

B2t—22 to 50 inches; brown (7.5YR 4/3) silty clay loam, dark brown (7.5YR 3/3) moist; moderate coarse subangular blocky structure; hard, firm; clay films on faces of peds; mildly alkaline; gradual smooth boundary.

B3—50 to 72 inches; yellowish red (5YR 5/6) silt loam, yellowish red (5YR 4/6) moist; weak coarse blocky structure; hard, firm; few fine films and spots of soft lime; few fine and medium calcium carbonate concretions; calcareous, moderately alkaline.

The solum is more than 60 inches thick. The depth to soft powdery secondary lime is more than 40 inches.

The A horizon is dark grayish brown (10YR 4/2) or brown (7.5YR 4/2, 4/3, 5/3; 10YR 4/3, 5/3). It is medium acid to neutral.

The B1 horizon is reddish brown (5YR 4/3, 5/3), dark grayish brown (10YR 4/2), or brown (7.5YR 4/2, 4/3, 5/3; 10YR 4/3). It is silt loam, clay loam, or silty clay loam and is slightly acid to mildly alkaline.

The B2t horizon is dark grayish brown (10YR 4/2), brown (7.5YR 4/2, 5/2, 5/4; 10YR 4/3, 5/3), dark yellowish brown (10YR 4/4), yellowish brown (10YR 5/4), or reddish brown (5YR 4/3, 4/4, 5/3, 5/4). It is silt loam or silty clay loam. It is neutral to moderately alkaline, and it can be calcareous below a depth of 40 inches.

The B3 horizon is reddish brown (2.5YR 5/4), yellowish red (5YR 4/6, 5/6), or red (2.5YR 5/6). It is silt loam or silty clay loam. It is moderately alkaline and calcareous.

Soils similar to the Pond Creek soils except that they are moderately alkaline and have lime in the B1 horizon were considered as Pond Creek soils in mapping.

Port Series

The Port series consists of deep, well drained, moderately permeable soils on flood plains. The soils formed in material weathered from loamy alluvium washed from Permian red beds. Slopes are 0 to 3 percent. Soils of the Port series are fine-silty, mixed, thermic Cumulic Haplustolls.

Port soils are associated with Dale, Hawley, McLain, Oscar, and Pocasset soils. Dale, Hawley, and McLain soils are higher in elevation, and Oscar and Pocasset soils are in similar positions on the flood plain. Dale soils do not have strata of darker material within the control section. Hawley soils do not have a mollic epipedon and are coarse-loamy. McLain soils have a fine textured control section. Oscar soils have a natric horizon. Pocasset soils are coarse-loamy and do not have a thick mollic epipedon.

Typical pedon of Port silt loam, occasionally flooded, in bermudagrass pasture, 620 feet west and 300 feet south of the northeast corner of sec. 19, T. 25 N., R. 8 W.

A11—0 to 14 inches; reddish brown (5YR 4/3) silt loam, dark reddish brown (5YR 3/3) moist; moderate fine granular structure; slightly hard, friable; many fine roots; mildly alkaline; clear smooth boundary.

A12—14 to 27 inches; reddish brown (5YR 4/3) silt loam, dark reddish brown (5YR 3/3) moist; moderate medium granular structure; slightly hard, friable; calcareous, moderately alkaline; diffuse smooth boundary.

B2—27 to 48 inches; reddish brown (5YR 4/3) silt loam, dark reddish brown (5YR 3/3) moist; weak coarse prismatic structure that parts to moderate coarse granular; hard, friable; weakly stratified with lighter colored material; calcareous, moderately alkaline; diffuse smooth boundary.

C—48 to 72 inches; reddish brown (5YR 5/3) silt loam, dark reddish brown (5YR 3/3) moist; massive; hard, friable; few thin strata of darker material; trace of soft bodies of secondary lime in peds; calcareous, moderately alkaline.

The depth to carbonates is 10 to 60 inches. The A horizon is 20 to 35 inches thick.

The A horizon is dark reddish gray (5YR 4/2), reddish brown (5YR 4/3, 5/3), or brown (7.5YR 4/2, 5/2). It is predominantly silt loam, but in places it is silty clay loam. It is slightly acid to mildly alkaline and ranges to moderately alkaline in the lower part.

The B2 horizon is reddish brown (2.5YR 4/4, 5/4; 5YR 4/3, 5/3, 4/4, 5/4) or brown (7.5YR 4/2, 5/2, 4/4, 5/4). It is silt loam, clay loam, or silty clay loam and is mildly alkaline or moderately alkaline.

The C horizon is brown (7.5YR 4/4, 5/4) or reddish brown (2.5YR 4/4, 5/4; 5YR 5/3, 5/4, 4/3, 4/4). It is silt loam but has thin strata of sandy loam, loam, clay loam, and silty clay loam. It is moderately alkaline and calcareous.

Port soils in this survey area have calcareous layers higher in the profile than is typical for the Port series. Soils mapped as Port soils in map unit 33, Masham-Port complex, 0 to 20 percent slopes, are similar to the Port series except that they have shale at a depth of 40 to 60 inches. These soils are taxadjuncts to the Port series. Their behavior, use, and management requirements are similar to those of the Port series.

Pratt series

The Pratt series consists of deep, well drained, rapidly permeable soils on uplands. The soils formed in material weathered from sandy eolian deposits. The largest areas are northeast of Nash and east along the Salt Fork of the Arkansas River. Slopes are 2 to 6 percent. Soils of the Pratt series are sandy, mixed, thermic Psammentic Haplustalfs.

Pratt soils are associated with Aline, Attica, Carwile, Goodnight, Gracemont, and Tivoli soils. Aline soils are on terraces of uplands and have an A horizon 20 to 50 inches thick. Attica soils are on similar landscapes, but they have a loamy argillic horizon. Carwile soils are in nearly level, concave areas at lower elevations, and they have a more clayey argillic horizon. Goodnight soils are on low dunes near the river, and they do not have an argillic horizon and are calcareous within a depth of 20 inches. Gracemont soils are on flood plains and are coarse-loamy. Tivoli soils are on high dunes and do not have an argillic horizon.

Typical pedon of Pratt loamy fine sand, 2 to 6 percent slopes, in native range, 2,500 feet east and 500 feet south of the northwest corner of sec. 10, T. 27 N., R. 8 W.

A1—0 to 11 inches; pale brown (10YR 6/3) loamy fine sand, brown (10YR 5/3) moist; weak fine granular structure; soft, very friable; slightly acid; clear smooth boundary.

B2t—11 to 40 inches; yellowish red (5YR 5/6) loamy fine sand, yellowish red (5YR 4/6) moist; weak coarse prismatic structure; slightly hard, friable; clay bridges between sand grains; slightly acid; gradual smooth boundary.

C—40 to 66 inches; reddish yellow (5YR 6/6) loamy fine sand; yellowish red (5YR 5/6) moist; single grained; soft, very friable; slightly acid.

The solum is 35 to 50 inches thick. The A horizon is 7 to 20 inches thick. Free carbonates are below a depth of 50 inches.

The A horizon is pale brown (10YR 6/3), brown (7.5YR 5/2, 5/4; 10YR 5/3), yellowish brown (10YR 5/4), light brownish gray (10YR 6/2), grayish brown (10YR 5/2), light yellowish brown (10YR 6/4), or pinkish gray (7.5YR 6/2). It is slightly acid or neutral.

The B2 horizon is reddish yellow (5YR 6/6; 7.5YR 6/6), strong brown (7.5YR 5/6), brown (7.5YR 5/4), light brown (7.5YR 6/4), light yellowish brown (10YR 6/4), yellowish red (5YR 5/6), or light reddish brown (5YR 6/4). It is loamy fine sand or loamy sand and has a clay content 3 to 9 percent higher than that of the A horizon. In some pedons, this horizon consists of lamellae. This horizon is slightly acid or neutral.

The C horizon is reddish yellow (5YR 6/6; 7.5YR 6/6), light reddish brown (5YR 6/4), strong brown (7.5YR 5/6), brown (7.5YR 5/4), or light brown (7.5YR 6/4). It is loamy fine sand or fine sand and is slightly acid or neutral.

Quinlan Series

The Quinlan series consists of shallow, well drained, moderately permeable soils on uplands. The soils formed in loamy material weathered from residuum of Permian red beds. Quinlan soils are in areas of moderate size in the northwestern part of the county and on the rougher terrain in the southwestern part. Slopes are 0 to 12 percent. Soils of the Quinlan series are loamy, mixed, thermic, shallow Typic Ustochrepts.

Quinlan soils are associated with Grant, Kingfisher, and Woodward soils. Grant and Kingfisher soils are in lower positions and are deeper than Quinlan soils, and they have a mollic epipedon and a fine-silty argillic horizon. Woodward soils are intermingled with Quinlan soils and are moderately deep over sandstone.

Typical pedon of Quinlan loam, 2 to 5 percent slopes, eroded, in a cultivated field, 1,850 feet north and 180 feet east of the southwest corner of sec. 17, T. 29 N., R. 8 W.

Ap—0 to 5 inches; yellowish red (5YR 5/6) loam, yellowish red (5YR 4/6) moist; weak fine granular structure; slightly hard, friable; calcareous, moderately alkaline; clear smooth boundary.

B2—5 to 14 inches; yellowish red (5YR 5/6) loam, yellowish red (5YR 4/6) moist; weak coarse prismatic structure; slightly hard, friable; calcareous, moderately alkaline; gradual wavy boundary.

Cr—14 to 30 inches; reddish yellow (5YR 6/6) firm calcareous sandstone, yellowish red (5YR 5/6) moist.

The solum is 10 to 20 inches thick. Typically, the soil is calcareous and moderately alkaline, but in some pedons the A horizon is noncalcareous and mildly alkaline. Some profiles have a few sandstone fragments coated with soft carbonates.

The A horizon or Ap horizon is reddish brown (5YR 4/4, 5/4), brown (7.5YR 4/4, 5/4), red (2.5YR 4/6, 5/6), or yellowish red (5YR 4/6, 5/6). The B2 horizon has the same color range, but it generally is slightly less brown and more red than the A horizon. It is loam or silt loam. The Cr horizon is sandstone and has light greenish gray layers, spots, or streaks.

The Quinlan soils in this survey area are moist for longer periods than is typical for the Quinlan series. They reflect the use and behavior characteristics of the more moist part of the series range.

Reinach Series

The Reinach series consists of deep, well drained, moderately permeable soils on low terraces of flood plains. The soils formed in loamy alluvial deposits. Slopes are 0 to 1 percent. Soils of the Reinach series are coarse-silty, mixed, thermic Pachic Haplustolls.

Reinach soils are associated with Dale, Hawley, McLain, and Pocasset soils. Dale, Hawley, and McLain soils are in close proximity to Reinach soils and at similar elevations on the landscape. Pocasset soils are on lower flood plains. Dale and McLain soils have more clay in the control section. Hawley and Pocasset soils are coarse-loamy. Also, Hawley soils do not have a mollic epipedon.

Typical pedon of Reinach very fine sandy loam, rarely flooded, in a cultivated field, 2,400 feet south and 1,200 feet west of the northeast corner of sec. 35, T. 26 N., R. 6 W.

A1—0 to 26 inches; brown (7.5YR 4/3) very fine sandy loam, dark brown (7.5YR 3/3) moist; weak medium granular structure; hard, very friable; upper 8 inches plowed; neutral; gradual smooth boundary.

B21—26 to 48 inches; brown (7.5YR 4/3) very fine sandy loam, dark brown (7.5YR 3/3) moist; weak coarse prismatic structure that parts to weak medium granular; hard, very friable; traces of calcium carbonate powder in the mass below a depth of 42 inches; calcareous, moderately alkaline; gradual smooth boundary.

B22—48 to 60 inches; brown (7.5YR 5/4) very fine sandy loam, dark brown (7.5YR 3/4) moist; weak coarse prismatic structure; hard, very friable; few films and spots of calcium carbonates; calcareous, moderately alkaline; clear smooth boundary.

C—60 to 75 inches; reddish yellow (7.5YR 6/6) very fine sandy loam, strong brown (7.5YR 5/6) moist; massive; hard, very friable; traces of powdery calcium carbonates; calcareous, moderately alkaline.

The solum is 30 to 60 inches thick. The depth to secondary lime is 20 to 50 inches. The A horizon is 20 to 30 inches thick. In some pedons, there is a dark buried soil below a depth of 40 inches.

The A horizon is brown (7.5YR 4/2, 4/3, 5/2, 5/3; 10YR 5/3). It is slightly acid to moderately alkaline.

The B2 horizon is reddish brown (5YR 5/3), brown (7.5YR 4/2, 5/2, 4/4, 5/4), or strong brown (7.5YR 5/6). It is silt loam or very fine sandy loam and is neutral to moderately alkaline.

The C horizon is light reddish brown (5YR 6/4), light brown (7.5YR 6/4), or reddish yellow (5YR 6/6; 7.5YR 6/6). It is very fine sandy loam or silt loam. It is calcareous and moderately alkaline.

Renfrow Series

The Renfrow series consists of deep, well drained, very slowly permeable soils on uplands. The soils formed in material weathered from shale of the Permian red beds. Slopes are 2 to 5 percent. Soils of the Renfrow series are fine, mixed, thermic Udertic Paleustolls.

Renfrow soils are associated with Grainola, Kirkland, and Pawhuska soils. Grainola soils are on side slopes in similar positions and are 20 to 40 inches deep to shale. Kirkland soils are on slopes in higher positions than Renfrow soils, and they have an abrupt change in texture from the A horizon to the argillic horizon.

Typical pedon of Renfrow silt loam, 3 to 5 percent slopes, in a cultivated field, 2,400 feet south and 150 feet east of the northwest corner of sec. 4, T. 27 N., R. 4 W.

Ap—0 to 9 inches; brown (7.5YR 4/2) silt loam, dark brown (7.5YR 3/2) moist; weak fine granular structure; hard, friable; slightly acid; gradual smooth boundary.

B1—9 to 12 inches; brown (7.5YR 4/3) silty clay loam, dark brown (7.5YR 3/3) moist; moderate medium blocky structure; hard, firm; neutral; clear smooth boundary.

B21t—12 to 28 inches; reddish brown (2.5YR 4/4) clay, dark reddish brown (2.5YR 3/4) moist; moderate medium and coarse subangular blocky structure; extremely hard, very firm; continuous clay films on faces of peds; mildly alkaline; gradual smooth boundary.

B22t—28 to 45 inches; reddish brown (2.5YR 5/4) clay, reddish brown (2.5YR 4/4) moist; moderate coarse subangular blocky structure; extremely hard, very firm; continuous clay films on faces of peds; common fine calcium carbonate concretions and few soft bodies as much as 1/2 inch in diameter; calcareous, moderately alkaline; gradual smooth boundary.

B3—45 to 68 inches; red (2.5YR 5/6) clay, red (2.5YR 4/6) moist; weak coarse blocky structure; extremely hard, very firm; common fine calcium carbonate concretions; calcareous, moderately alkaline; clear smooth boundary.

Cr—68 to 75 inches; red (2.5YR 5/6) weathered shale, red (2.5YR 4/6) moist; fine, medium, and coarse light greenish gray (5G 7/1) spots and layers that make up about 30 percent; calcareous, moderately alkaline.

The solum is more than 60 inches thick. The mollic epipedon is 10 to 20 inches thick, and the depth to secondary carbonates ranges from 28 to 50 inches. Wide cracks are common in dry periods.

The A horizon is reddish brown (5YR 4/3, 5/3) and brown or dark brown (7.5YR 4/2, 5/2, 5/3, 4/3; 10YR 4/3, 5/3). It is silt loam or silty clay loam and is slightly acid to mildly alkaline.

The B1 horizon is reddish brown (5YR 4/3, 5/3) or brown (7.5YR 4/2, 5/2, 4/4, 5/4). It is dominantly silty clay loam, but the range includes clay loam. This horizon is slightly acid to mildly alkaline.

The B2t horizon is reddish brown (2.5YR 4/4, 5/4; 5YR 4/3, 5/3, 4/4, 5/4), red (2.5YR 4/6, 5/6), or yellowish red (5YR 4/6, 5/6). It is clay or silty clay and is neutral to moderately alkaline.

The B3 horizon is red (2.5YR 4/6, 5/6) or yellowish red (5YR 4/6, 5/6). It is clay or silty clay. It is calcareous and moderately alkaline.

The Cr horizon or C horizon is dominantly red (2.5YR 4/6, 5/6) or yellowish red (5YR 4/6, 5/6).

The Renfrow soils in map unit 50, Renfrow-Pawhuska complex, 2 to 5 percent slopes, eroded, are taxadjunts to the Renfrow series because they are calcareous higher in the profile and have a thinner solum than allowed in the Renfrow series. Use, behavior, and management requirements are similar to those of the Renfrow series.

Shellabarger Series

The Shellabarger series consists of deep, well drained, moderately permeable soils on moderately high terraces. The soils formed in sandy and loamy old alluvium. The largest areas are about 6 to 10 miles southwest of Medford. Slopes are 1 to 3 percent. Soils of the Shellabarger series are fine-loamy, mixed, thermic Udic Argiustolls.

Shellabarger soils are associated with Attica and Carwile soils. Shellabarger soils have a darker A horizon and more clay in the B horizon than Attica soils. In most areas, Attica soils are on slightly higher undulations. In other areas, Shellabarger soils cover large areas and Attica soils are closer to the river to the south. Carwile soils are in concave areas, and they have a fine control section.

Typical pedon of Shellabarger fine sandy loam, 1 to 3 percent slopes, in a cultivated field, 1,200 feet east and 100 feet north of the southwest corner of sec. 6, T. 26 N., R. 6 W.

Ap—0 to 7 inches; brown (7.5YR 5/3) fine sandy loam, dark brown (7.5YR 3/3) moist; weak fine granular structure; slightly hard, friable; strongly acid; clear smooth boundary.

B1—7 to 11 inches; reddish brown (5YR 5/3) loam, dark reddish brown (5YR 3/3) moist; weak coarse prismatic structure; hard, friable; slightly acid; clear smooth boundary.

B2t—11 to 33 inches; reddish brown (5YR 5/4) sandy clay loam, reddish brown (5YR 4/4) moist; moderate coarse prismatic structure; hard, firm; nearly continuous clay films on faces of peds; mildly alkaline; gradual smooth boundary.

B3—33 to 42 inches; light red (2.5YR 6/6) sandy loam, red (2.5YR 5/6) moist; weak coarse prismatic structure; slightly hard, friable; moderately alkaline; gradual smooth boundary.

C1—42 to 52 inches; reddish yellow (5YR 6/6) loam, yellowish red (5YR 5/6) moist; massive; slightly hard, friable; moderately alkaline; abrupt smooth boundary.

C2—52 to 72 inches; reddish yellow (5YR 6/6) loamy sand, yellowish red (5YR 5/6) moist; massive; slightly hard, friable; moderately alkaline.

The solum is 35 to 55 inches thick. The depth to free carbonates is 36 to more than 72 inches. The mollic epipedon is 10 to 20 inches thick.

The A horizon is reddish brown (5YR 4/3) or brown (7.5YR 5/3, 4/3; 10YR 4/3). It is strongly acid to slightly acid.

The B2t horizon is reddish brown (2.5YR 4/4; 5YR 5/4), yellowish red (5YR 5/6), or brown (7.5YR 5/4). It is sandy clay loam or sandy loam. This horizon is neutral or mildly alkaline. Some pedons have a few mottles of brown or yellow in the B2t or B3 horizon.

The C horizon is red (2.5YR 5/6), yellowish red (5YR 5/6), or reddish yellow (5YR 6/6). It is sandy loam, loam, or loamy sand below a depth of 40 inches. It is neutral to moderately alkaline.

Tabler Series

The Tabler series consists of deep, moderately well drained, very slowly permeable soils on high upland plains mostly in the northern half of the county. The soils formed in material weathered from predominantly clayey, old alluvium. There is a perched water table at a depth of 2.5 to 3.5 feet from fall to spring in wet years. Slopes are 0 to 1 percent. Soils of the Tabler series are fine, montmorillonitic, thermic Vertic Argiustolls.

Tabler soils are associated with Bethany and Kirkland soils. Bethany soils have mixed mineralogy; they are in slightly higher positions and are less clayey in the upper part of the argillic horizon than Tabler soils. Kirkland soils are on nearby landscapes and have mixed mineralogy and an abrupt textural change between the A horizon and the argillic horizon.

Typical pedon of Tabler silt loam, 0 to 1 percent slopes, in a cultivated field, 315 feet north and 195 feet east of the southwest corner of sec. 7, T. 27 N., R. 3 W.

Ap—0 to 10 inches; dark gray (10YR 4/1) silt loam, black (10YR 2/1) moist; moderate medium granular structure; slightly hard, friable; slightly acid; clear smooth boundary.

B2t—10 to 30 inches; dark gray (10YR 4/1) clay, black (10YR 2/1) moist; weak medium blocky structure; extremely hard, very firm; thick nearly continuous clay films on faces of peds; neutral; gradual smooth boundary.

B3—30 to 44 inches; dark grayish brown (10YR 4/2) clay, very dark grayish brown (10YR 3/2) moist; common fine faint mottles of gray and yellowish brown; weak medium blocky structure; extremely hard, very firm; few fine calcium carbonate concretions; calcareous, mildly alkaline; diffuse smooth boundary.

C—44 to 60 inches; grayish brown (10YR 5/2) clay, dark grayish brown (10YR 4/2) moist; few fine faint gray mottles and few fine distinct reddish brown (5YR 5/4) mottles; massive; extremely hard, very firm; few medium soft spots and few fine concretions of calcium carbonate; calcareous, moderately alkaline.

The solum is 40 to more than 60 inches thick. The mollic epipedon is more than 20 inches thick, and the depth to secondary carbonates is 20 to 60 inches.

The A horizon is dark gray (10YR 4/1), dark grayish brown (10YR 4/2), or very dark grayish brown (10YR 3/2). It is medium acid or slightly acid.

The B2t horizon is very dark grayish brown (10YR 3/2), dark gray (10YR 4/1), dark grayish brown (10YR

4/2), or gray (10YR 5/1). Mottles are in shades of brown, red, or gray. This horizon is clay or silty clay. It is slightly acid to mildly alkaline in the upper part and slightly acid to moderately alkaline in the lower part.

The B3 horizon is dark grayish brown (10YR 4/2) or grayish brown (10YR 5/2) and is mottled in shades of brown, gray, or red. It is clay or silty clay. It is calcareous and mildly alkaline or moderately alkaline.

The C horizon is grayish brown (10YR 5/2) or brown (10YR 5/3) and is mottled in shades of gray, red, or brown. It is clay or silty clay. It is calcareous and moderately alkaline.

Tivoli Series

The Tivoli series consists of deep, excessively drained, rapidly permeable soils on sand dunes. The soils formed in Quaternary or Recent deposits reworked by wind. In Grant County they are mainly north of the Salt Fork of the Arkansas River. Slopes are 5 to 30 percent. Soils of the Tivoli series are mixed, thermic Typic Ustipsamments.

Tivoli soils are associated with Aline, Goltry, Goodnight, and Pratt soils. Unlike Tivoli soils, the Aline, Goltry, and Pratt soils are on flatter slopes and are in lower positions on the landscape. These soils have an argillic horizon. Goodnight soils are in a lower position on the landscape than the Tivoli soils and are closer to the river. They are calcareous in the lower part. Goltry soils have an apparent water table in wet seasons.

Typical pedon of Tivoli fine sand, 10 to 30 percent slopes, in native range, 1,320 feet north and 360 feet west of the southeast corner of sec. 31, T. 27 N., R. 8 W.

A1—0 to 7 inches; pale brown (10YR 6/3) fine sand, brown (10YR 4/3) moist; single grained; loose, very friable; slightly acid; gradual smooth boundary.

C1—7 to 18 inches; reddish yellow (7.5YR 7/6) fine sand, reddish yellow (7.5YR 6/6) moist; single grained; loose dry or moist; few pale brown krotovinas 2 to 3 inches in diameter; slightly acid; clear wavy boundary.

C2—18 to 72 inches; reddish yellow (7.5YR 7/6) fine sand, reddish yellow (7.5YR 6/6) moist; single grained; loose dry or moist; discontinuous loamy fine sand lamellae less than 1/8 inch wide and 1/4 inch to 2 inches apart above a depth of 52 inches and 1/6 to 1/4 inch wide and 1 inch to 6 inches apart below that depth; single grained; loose, very friable; slightly acid.

The soil depth is more than 6 feet. The A horizon is brown (7.5YR 5/4), pale brown (10YR 6/3), or light yellowish brown (10YR 6/4). The A horizon is slightly acid to mildly alkaline.

The C1 horizon is fine sand and has the same color and reaction range as the C2 horizon. The C2 horizon is reddish yellow (7.5YR 6/6, 7/6), brownish yellow (10YR 6/6), or yellow (10YR 7/6). It is fine sand, and in most pedons it has thin bands of loamy fine sand. It is slightly acid to mildly alkaline.

The Tivoli soils in this survey area are taxadjuncts to the Tivoli series. They are moist for longer periods and have discontinuous thin bands in the lower part of the pedon, which are not typical for the Tivoli series. Use, behavior, and management requirements are similar to those of the Tivoli series.

Wakita Series

The Wakita series consists of moderately deep, moderately well drained, slowly permeable soils on uplands. The soils formed in material weathered from residuum of interbedded sandstone and shale or from loamy deposits over interbedded sandstone and shale. The larger areas are located south of the Salt Fork of the Arkansas River in the central and western parts of the county. Slopes are 1 to 5 percent. These soils have a perched water table at a depth of 2 to 3 feet during the spring. Soils of the Wakita series are fine-silty, mixed, thermic Mollic Natrustalfs.

Wakita soils are associated with Grant and Kingfisher soils. These soils are on the same landscape but do not have a natric horizon.

Typical pedon of Wakita silt loam, in an area of Kingfisher-Wakita silt loams, 1 to 3 percent slopes, in cultivation, 1,834 feet south and 444 feet east of the northwest corner of sec. 12, T. 25 N., R. 7 W.

Ap—0 to 5 inches; light reddish brown (5YR 6/4) silt loam, dark reddish brown (5YR 3/4) moist; moderate medium platy structure, massive when dry; hard, friable; many fine pores; medium acid; abrupt smooth boundary.

B21t—5 to 14 inches; reddish gray (5YR 5/2) silt loam, dark reddish brown (5YR 3/2) moist; moderate coarse columnar structure breaking to subangular blocky; hard, friable; many fine pores; clay films on faces of peds; mildly alkaline; gradual smooth boundary.

B22t—14 to 22 inches; reddish brown (5YR 5/3) silty clay loam, dark reddish brown (5YR 3/3) moist; moderate medium subangular blocky structure; very hard, firm; eluvial material with uncoated sand and silt grains on faces of structure; common fine pores; clay films on faces of peds; few fine threads of gypsum; mildly alkaline; gradual smooth boundary.

B3—22 to 32 inches; light reddish brown (5YR 6/4) silt loam, reddish brown (5YR 4/4) moist; moderate coarse prismatic structure breaking to subangular blocky; hard, firm; few fine pores; clay films on faces of peds; few fine threads of gypsum; moderately alkaline; clear smooth boundary.

Cr—32 to 37 inches; light reddish brown (5YR 6/4) weathered interbedded sandstone and silty shale, reddish brown (5YR 4/4) moist; calcareous, moderately alkaline.

The solum is 24 to 40 inches thick and is calcareous or noncalcareous. After mixing, the upper part of the solum to a depth of 7 inches has moist value of 3 or less.

The Ap or A1 horizon is reddish gray (5YR 5/2), reddish brown (5YR 5/4), pinkish gray (5YR 6/2; 7.5YR 6/2), light reddish brown (5YR 6/3, 6/4), brown (7.5YR 5/2, 5/4), or light brown (7.5YR 6/5). It is medium acid or strongly alkaline. This horizon has an exchangeable sodium percentage of 10 to 30 and an electrical conductivity of 0 to 15 millimhos per centimeter.

The B21t horizon is red (2.5YR 4/6, 5/6), dark reddish gray (5YR 4/2), reddish brown, (5YR 4/3, 4/4, 5/3, 5/4), reddish gray (5YR 5/2), pinkish gray (5YR 6/2; 7.5YR 6/2), light reddish brown (5YR 6/3, 6/4), brown (7.5YR 4/2, 4/4, 5/2, 5/4), or light brown (7.5YR 6/4). It is silt loam, clay loam, or silty clay loam and has a clay content of 25 to 35 percent. It is neutral to strongly alkaline.

The B22t horizon and B3 horizon are reddish brown (2.5YR 4/4, 5/4; 5YR 4/4, 5/4), red (2.5YR 4/6, 5/6), light reddish brown (2.5YR 6/4; 5YR 6/3, 6/4), light red (2.5YR 6/6), yellowish red (5YR 4/6, 5/6), or reddish yellow (5YR 6/6). They are silt loam, clay loam, or silty clay loam. In some pedons, fragments of sandstone and shale, from 2 mm to 76 mm in diameter, make up 0 to 15 percent of the volume. These horizons are mildly alkaline to strongly alkaline.

The Cr horizon is red (2.5YR 4/6, 4/8, 5/6, 5/8), yellowish red (5YR 4/6, 4/8, 5/6, 5/8), reddish brown (5YR 4/4, 5/4), or light reddish brown (2.5YR 6/4; 5YR 6/4). It is weathered interbedded sandstone and silty shale. It can be cut with a spade but is a barrier to roots.

The B horizon and Cr horizon have a sodium adsorption ratio (SAR) of 13 to 100 and an electrical conductivity of 0 to 12 millimhos per centimeter.

Woodward Series

The Woodward series consists of moderately deep, well drained, moderately permeable soils that formed in residuum of calcareous sandstone on uplands. Slopes are 3 to 12 percent. Woodward soils are coarse-silty, mixed, thermic Typic Ustochrepts.

Woodward soils are associated with Grant, Kingfisher, and Quinlan soils. All of these soils and the Woodward soils are in similar positions on the landscape. Grant soils have a mollic epipedon and an argillic horizon and are more than 40 inches deep to bedrock. Kingfisher soils have a mollic epipedon and an argillic horizon. Quinlan soils are shallow over sandstone.

Typical pedon of Woodward loam, in an area of Quinlan-Woodward loams, 3 to 12 percent slopes, in native range, 1,300 feet north and 50 feet east of the southwest corner of sec. 18, T. 29 N., R. 8 W.

A1—0 to 7 inches; brown (7.5YR 5/4) loam, dark brown (7.5YR 4/4) moist; weak fine granular structure; slightly hard, friable; many fine roots; calcareous, moderately alkaline; clear smooth boundary.

B2—7 to 27 inches; yellowish red (5YR 5/6) very fine sandy loam, yellowish red (5YR 4/6) moist; weak coarse prismatic structure; slightly hard, friable; calcareous, moderately alkaline; gradual smooth boundary.

B3—27 to 35 inches; yellowish red (5YR 5/6) very fine sandy loam, yellowish red (5YR 4/6) moist; weak coarse prismatic structure; slightly hard, friable; few streaks of soft powdery lime on faces of peds below a depth of 27 inches; calcareous, moderately alkaline; clear wavy boundary.

Cr—35 to 40 inches; yellowish red (5YR 5/6) weathered sandstone; strata are 1/8 to 1/4 inch thick; calcareous, moderately alkaline.

The solum is 20 to 40 inches thick. The depth to soft powdery lime ranges from 14 to 36 inches.

The A horizon is reddish brown (5YR 4/4), yellowish red (5YR 5/6), or brown (7.5YR 4/4, 5/4). It commonly is calcareous and typically is moderately alkaline, but it ranges to neutral.

The B horizon is yellowish red (5YR 4/6, 5/6), reddish brown (5YR 5/4), brown (7.5YR 5/4), or strong brown (7.5YR 5/6). It is loam, silt loam, or very fine sandy loam. It is calcareous and moderately alkaline.

The Woodward soils in this survey area are taxadjuncts to the Woodward series because they are moist for longer periods than is typical for the Woodward series. Use, behavior, and management requirements are similar to those of the Woodward series.

Yahola Series

The Yahola series consists of deep, well drained, moderately rapidly permeable soils on flood plains. The soils formed in predominantly loamy alluvial sediments of Permian and Pleistocene age. Slopes are 0 to 1 percent. Soils of the Yahola series are coarse-loamy, mixed (calcareous), thermic Typic Ustifluvents.

Yahola soils are associated with Gaddy, Goodnight, and Hawley soils. Gaddy soils are in lower positions than the Yahola soils and have a sandy control section. Goodnight soils are in undulating and hummocky areas, and they are sandy throughout. Hawley soils are on higher terraces of flood plains.

Typical pedon of Yahola fine sandy loam, occasionally flooded, in a cultivated field, 600 feet north and 250 feet east of the southwest corner of sec. 2, T. 25 N., R. 3 W.

Al—0 to 12 inches; brown (7.5YR 4/4) fine sandy loam, dark brown (7.5YR 3/4) moist; weak fine granular structure; soft, friable; upper 7 inches plowed; calcareous, moderately alkaline; gradual smooth boundary.

C1—12 to 24 inches; brown (7.5YR 5/4) very fine sandy loam, dark brown (7.5YR 3/4) moist; massive; slightly hard, friable; calcareous, moderately alkaline; clear smooth boundary.

C2—24 to 42 inches; reddish yellow (7.5YR 6/6) fine sandy loam, strong brown (7.5YR 5/6) moist; single grained; loose, very friable; few thin strata of loam and silt loam; calcareous, moderately alkaline; clear smooth boundary.

C3—42 to 72 inches; brown (7.5YR 5/4) fine sandy loam, brown (7.5YR 4/4) moist; massive; slightly hard, friable; many thin strata of loamy very fine sand and silt loam; calcareous, moderately alkaline.

The depth of the soil is more than 60 inches. In some areas there is a buried soil below a depth of 30 inches. The depth to lime ranges from 0 to 10 inches.

The A horizon is brown (7.5YR 4/2, 5/2, 4/4, 5/4). It is mildly alkaline or moderately alkaline.

The C horizon is brown (7.5YR 5/4), light brown (7.5YR 6/4), strong brown (7.5YR 5/6), or reddish yellow (7.5YR 6/6). It is fine sandy loam, very fine sandy loam, or loam and has strata of finer or coarser texture material.

Formation of the Soils

Factors of Soil Formation

The characteristics of the soil at any given point are determined by five factors: the physical properties and mineralogical composition of the parent material; the climate under which the parent material has existed since it accumulated; the plant and animal life in and on the soil; the relief, or lay of the land; and the length of time that the last three factors of soil development have acted on the parent material. Few generalizations can be made regarding the effects of any one factor because the effects of each are modified by the other four.

Parent Material

Parent material is weathered, unconsolidated rock or mineral material from which the soil forms. Parent material strongly influences the chemical and mineralogical composition of the soil. In the formation of soils, parent material affects color, texture, structure, natural fertility, and other characteristics.

Residuum, alluvium, and eolian material are three kinds of parent material in the survey area. The soils that formed in residuum were derived, at least in part, from shales and sandstone of the Permian period. Renfrow and Grainola soils formed in residuum of shale. Grant and Kingfisher soils formed in residuum of sandstone. Bethany, Tabler, and most of the Kirkland soils formed in old alluvium. McLain, Dale, and Reinach soils formed in younger alluvial deposits. Gaddy and Yahola soils formed in very young alluvial deposits. Goodnight and Tivoli soils formed from alluvial deposits reworked by wind.

Calcium carbonates are added to such soils as Gaddy and Yahola soils by periodic flooding. Goodnight soils are more alkaline than Tivoli soils, which are farther from the river, because calcium carbonates are deposited on the Goodnight soils by the prevailing southerly winds blowing carbonates from the Salt Fork of the Arkansas River.

Drummond, Wakita, and Pawhuska soils are affected by saline-alkali salts carried upward into the soil by underground springs from several hundred feet deep in the earth. The salts become part of the parent material.

Climate

The subhumid continental climate of Grant County is characterized by rains of high intensity. Sufficient moisture and warm temperatures have promoted the formation of distinct horizons in many of the soils. However, differences in soil cannot be attributed to climate, because the climate is uniform throughout the county. Heavy rains have caused rapid runoff that has eroded many of the soils on gently sloping and steeper slopes. Leaching of calcium carbonates and bases is moderate in the soils of Grant County because of moderate precipitation.

Plants and Animals

Plants, burrowing animals, insects, and soil micro-organisms have a direct influence on the formation of soil. Native vegetation, such as trees, grasses, or a combination of both, has a bearing on the amount of organic matter, the amount and kind of plant nutrients, and the type of soil structure and consistence. The Grant and Renfrow soils formed under native grasses. The fibrous roots of these native grasses promote a good granular structure and a high content of organic matter. This type of vegetation reduces loss of soil nutrients by the recycling and feeding ability of the deep grass roots. Consequently, the soils that formed under grass in Grant County tend to have more bases and to contain more organic matter than the soils that formed under trees.

During the past century, man has altered this soil-forming process by removing the native vegetation in much of the county. Lack of adequate conservation measures has resulted in much soil loss through sheet and gully erosion. Where some of the surface layer has been removed and rills have formed, the soils were mapped as an eroded phase. An example is Grant silt loam, 3 to 5 percent slopes, eroded.

Relief

Relief affects soil formation through its influence on moisture, drainage, erosion, and temperature. The relief of Grant County is determined largely by the resistance of the underlying parent material to weathering and geologic erosion.

The effects of relief on soil formation are illustrated by Masham and Renfrow soils. Masham soils generally are in more sloping areas. Surface runoff is more rapid, and less water percolates through the soils to influence the loss, gain, or transfer of soil constituents. Renfrow soils typically are less sloping, and they are deeper and have a more clearly defined profile than Masham soils. On the more sloping soils, much rainfall runs off, carrying soil particles from the surface layer, instead of moving through the soil to help form a deeper solum.

Time

As a factor in soil formation, time is difficult to measure strictly in years. The length of time needed for development of genetic horizons depends on the intensity and the interactions of soil-forming factors in promoting the losses, gains, transfer, or transformations of the constituents necessary in forming soil horizons. Soils that have no definite genetic horizons are young or immature. Mature, or older, soils have approached equilibrium with their environment and tend to have well-defined horizons.

The soils in Grant County range from young to old. Tabler and Kirkland soils are examples of old soils on uplands. Grant and Kingfisher soils are younger, but they have well-expressed horizons. Quinlan and Woodward soils are considered young. They have had sufficient time to develop well-expressed horizons, but because they are sloping, geological erosion takes away soil material almost as fast as it forms. Gaddy and Yahola soils are young. They formed in recent sediment on flood plains and show little horizon development.

Processes of Soil Formation

Active processes that have influenced the formation of horizons in the soils of Grant County are accumulation of organic matter, leaching of calcium carbonates and bases, and translocation of silicate clay minerals. In most soils more than one of these processes have been active in the development of horizons.

The addition of organic matter to the surface layer by native grasses has contributed to the granular structure. In Bethany soils, for example, the surface layer is high in organic matter and is called a mollic epipedon in the soil classification system *(6)*. Aline soils are sandier and consequently have less accumulation of organic matter. The surface layer of Aline soils is called an ochric epipedon in the classification system.

Leaching of carbonates and bases is active in the formation of soils. The accumulation of calcium carbonates and bases in the lower part of the B horizon of the Bethany soils indicates the depth to which water has percolated. Aline soils, which are rapidly permeable, have been leached to such an extent that calcium carbonates have been removed from the soil profile.

Soils on flood plains, such as Yahola and Gracemont soils, are recharged with bases when flooding occurs. Grainola soils formed over weathered shale beds and clayey sediment and are high in carbonates. Calcium carbonates in Grainola soils are related to the nature of the parent material.

The translocation of silicate clay minerals is very important in establishing the properties and classification of soils. The argillic horizon is diagnostic for classification. Clay films on ped surfaces, clay bridges between sand grains, and an increase in total clay are evidences of an argillic horizon. Grant, Kirkland, and Renfrow soils, for example, have an argillic horizon. The varying degrees of translocation of silicate clay minerals and differences in parent material have resulted in wide variation in the texture and other properties of the argillic horizon. Deep rooted grasses on prairie soils bring bases to the surface, and this activity retards leaching.

Geologic erosion on such soils as Masham soils hinders horizon development through soil loss. In Gracemont and Yahola soils on flood plains, the sediment was recently deposited, and there has not been enough time for horizons to form.

Geology

Kenneth S. Johnson, Oklahoma Geological Survey and the University of Oklahoma, Norman, Oklahoma, contributed this section.

The geology of Grant County is fairly simple. A geologic map of the county accompanies the general soil map at the back of this publication. Outcropping rocks consist of Permian sandstones and shales that were

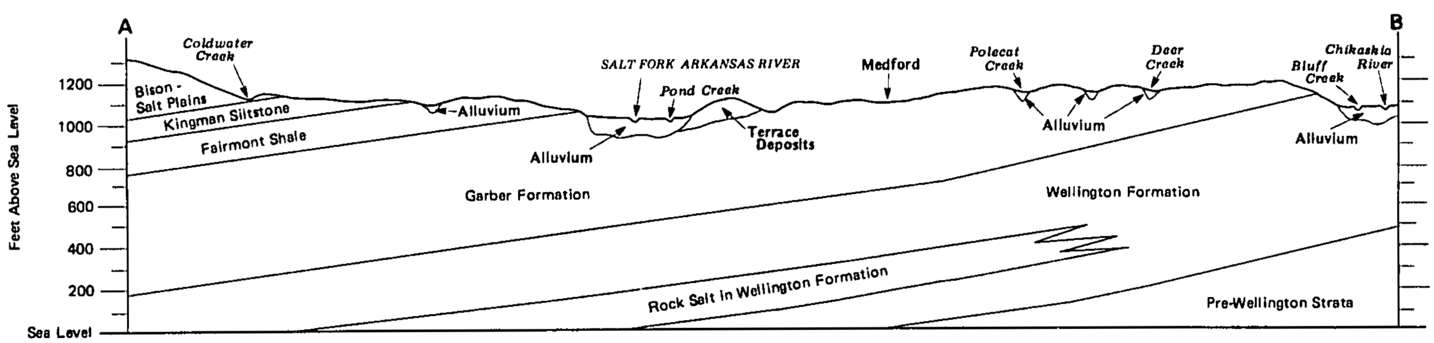


Figure 13.—Geologic cross section between points A and B on the general geology map of Grant County, showing the sequence and dip of the formations. (The geology map is at the back of this survey following the tables.)

deposited near the shoreline of shallow seas that once covered much of western Oklahoma. In many parts of the county these rocks are mantled by unconsolidated alluvium laid down by modern rivers and streams. The outcropping strata overlie older sedimentary rocks that are important sources of petroleum and other mineral resources of the county.

Subsurface rock units of sedimentary origin in Grant County are about 6,500 feet thick in the northeastern part of the county and about 8,500 feet thick in the southwest. These strata rest upon a "basement of granite" that extends some 20 to 25 miles down into the earth's crust. These subsurface sedimentary rocks were deposited in great, shallow seas that covered the Anadarko Basin area of west-central Oklahoma intermittently from the Cambrian period, about 525 million years ago, until the middle of the Permian period, about 250 million years ago. Grant County is on the northern shelf, or platform, of the Anadarko Basin. The various underlying rock formations in the county dip down to the southwest, towards the axis and deep part of that great basin.

It was during the early and middle parts of the Permian period of geologic time, 260 to 250 million years ago, that the outcropping rocks of Grant County were laid down. Sands, silts, and clays were eroded from lowland areas of northeastern Oklahoma and eastern Kansas, and these materials were transported by streams and rivers flowing to the west and southwest into a large inland sea that covered most of western Oklahoma and adjacent states. Grant County was close to the shoreline of this Permian sea, and thus it was the site for deposition of interbedded sandstone, siltstones, and shales laid down as the environment shifted back and forth between river, delta, and shallow sea. Southwest of Grant County the seawater was from time to time evaporated so much that layers of rock salt, gypsum, and other evaporite rocks were precipitated on the sea floor and became part of the sedimentary rock sequence. One of these major evaporite sequences extends across the western two-thirds of Grant County; it consists of thick layers of rock salt in the Wellington Formation at a depth ranging from about 500 feet in the north-central part of the county to more than 1,500 feet in the southwest.

The oldest exposed rocks in Grant County crop out along the eastern border, and they are overlain by successively younger Permian strata to the west and southwest. Outcropping strata dip gently to the southwest across the county at an angle of less than 1 degree (fig. 13).

Because the soils in most areas result from the weathering and disaggregation of outcropping rock units, there is a close relationship between the character of these rock formations and the soils that develop on them. Thus, a description of the outcropping rock units in the county helps explain the character and distribution of soils in the county.

The oldest rock units exposed in Grant County are the Wellington Formation and the Garber Formation, which overlies the Wellington Formation. Both formations consist chiefly of red-brown shale, but they also contain some interbeds of red-brown siltstone and sandstone. Only the uppermost 100 feet of the Wellington Formation is exposed along the eastern border of Grant County, but the full 600 feet of the Garber Formation is exposed across most of the eastern half of the county. Because of the similarities of these two formations, the soils that have formed upon them are also similar. The dominant soils that have formed in a mantle over these rock units are soils of the Kirkland-Tabler association. The only other soils present along drainageways of these rock units are soils of the Renfrow-Grainola association. Both these associations consist of deep, nearly level, well drained loamy soils that have a clayey subsoil and are on broad upland plains.

Overlying the Garber Formation is the Fairmont Shale, which consists of about 150 feet of red-brown shale with many thin layers of siltstone in the uppermost 60 feet. Most Fairmont Shale outcrops are mantled by soils of the Kirkland-Tabler association (chiefly in the lower part of the formation) and soils of the Pond Creek-Grant-Bethany association. Also, soils of the Quinlan-Grant-Kingfisher, Renfrow-Grainola, and Kirkland-Kingfisher-Pawhuska associations have formed on outcrops of this formation. All the various soils are typically deep, level to gently sloping, well drained, and loamy in character; those soils overlying the lower part of the Fairmont Shale have a clayey subsoil, whereas those overlying the upper part have a loamy subsoil.

Overlying the Fairmont Shale are the Kingman Siltstone, the Salt Plains Formation, and the Bison Formation or Bison Banded Member (fig. 14). The Kingman Siltstone is mainly red-brown siltstone and has thin beds of sandstone and shale; the Salt Plains and Bison units are mainly red-brown shale and have thin beds of siltstone and sandstone. The major soils above all three formations are the Pond Creek-Bethany-Grant association and, in some areas, the Quinlan-Grant-Kingfisher association. These two soil associations typically are deep, level to strongly sloping, well drained, loamy soils that are on uplands and are characterized by a loamy subsoil. In some areas where the soils are strongly sloping, erosion has exposed the bedrock.

Quaternary alluvial and terrace deposits in Grant County generally are 10 to 100 feet thick and consist mainly of sand, silt, clay, and some gravel. These sediments were eroded from Permian strata within and to the west of the county and from the Tertiary Ogallala Formation that blankets the High Plains areas 50 to 100 miles to the northwest and west. Quaternary sediments, all deposited within about the past million years, were laid down mainly as flood plain or alluvial deposits along

Figure 14.—Part of the Bison Formation (or Bison Banded Member) of Permian age in western Grant County. The reddish shale strata generally are more resistant to weathering than the light-colored, calcareous sandstones. The overlying soils that are visible on the rim of the cliff are Quinlan and Woodward soils. Note that the strata dip gently from left to right.

major rivers and streams flowing predominantly to the east and south across the county.

Terrace deposits, which consist of older alluvium left behind after a river shifts its course or cuts more deeply into underlying material, occur mainly as broad, level expanses topographically higher than the present flood plain and adjacent to it. These terraces typically are mantled by soils of the McLain-Dale-Hawley association; some areas, however, are covered by soils of the Pond Creek-Bethany-Grant and McLain-Drummond-Oscar associations. Some of the terrace deposits in the county have been modified by wind action, and the sands have been blown into sand dunes in some rather large dune fields on the north side of the Salt Fork of the Arkansas River and the town of Pond Creek. These dune sands typically are covered by soils of the Attica-Goodnight-Pratt and Tivoli-Goltry associations, which are deep, excessively drained and well drained, sandy soils that have a sandy or loamy subsoil.

Alluvial deposits along stream channels or on the flood plain of present-day rivers and streams are mantled by the soils of the Yahola-Gaddy association along the Salt Fork of the Arkansas River and by soils of the McLain-Dale-Hawley and McLain-Drummond-Oscar associations along other rivers and streams.

The mineral and water resources of Grant County are important to the overall development and progress of the county. Petroleum production is by far the most important mineral activity; production in the county in 1981 amounted to about 800,000 barrels of crude oil and about 6.8 billion cubic feet of natural gas, thus ranking Grant County near the midpoint among the petroleum-producing counties in the state. Sand and gravel have been taken from a number of sites in the alluvium and terrace deposits of the county, and thick deposits of rock salt are present in the western two-thirds of the county at depths ranging from about 500 to more than 1,500 feet. Abundant quantities of good-quality ground water are present in some of the major Quaternary alluvial and terrace deposits, and small quantities of good-quality ground water are locally available from some of the thin sandstone and siltstones in the Permian bedrock.

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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.

Alkali (sodic) soil. Soil having so high a degree of alkalinity (pH 8.5 or higher), or so high a percentage of exchangeable sodium (15 percent or more of the total exchangeable bases), or both, that plant growth is restricted.

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—

	Inches
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.

Bedding planes. Fine stratifications, less than 5 millimeters thick, in unconsolidated alluvial, eolian, lacustrine, or marine sediments.

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.

Calcareous soil. A soil containing enough calcium carbonate (commonly combined with magnesium carbonate) to effervesce visibly when treated with cold, dilute hydrochloric acid.

California bearing ratio (CBR). The load-supporting capacity of a soil as compared to that of a standard crushed limestone, expressed as a ratio. First standardized in California. A soil having a CBR of 16 supports 16 percent of the load that would be supported by standard crushed limestone, per unit area, with the same degree of distortion.

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.

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.

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

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.

COLE. Coefficient of linear extensibility; the ratio of the difference between the moist and dry lengths of a clod to the dry length. It is calculated by subtracting *Ld*, the length of the clod when dry, from *Lm*, the length when moist (at 1/3-bar tension), and dividing the result by *Ld*. The measurement correlates with the change in volume of a soil upon wetting and drying.

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.

Compressible (in tables). The volume of soft soil decreases excessively under load.

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

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

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

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

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

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

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

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

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

Cemented.—Hard; little affected by moistening.

Contour stripcropping. 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.

Corrosive. High risk of corrosion to uncoated steel or deterioration of concrete.

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.

Cutbanks cave (in tables). The walls of excavations tend to cave in or slough.

Decreasers. The most heavily grazed climax range plants. Because they are the most palatable, they are the first to be destroyed by overgrazing.

Deferred grazing. Postponing grazing or resting grazingland for a prescribed period.

Dense layer (in tables). A very firm, massive layer that has a bulk density of more than 1.8 grams per cubic centimeter. Such a layer affects the ease of digging and can affect filling and compacting.

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.

Electrical conductivity (EC). The reciprocal of the electrical resistivity. The resistivity is the resistance in ohms of a conductor, metallic or electrolytic, which is 1 centimeter long and has a cross-sectional area of 1 centimeter. Hence, electrical conductivity is expressed in mhos (reciprocal ohms) per centimeter.

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.

Eolian soil material. Earthy parent material accumulated through wind action; commonly refers to sandy material in dunes or to loess in blankets on the surface.

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 the activities of man or other animals or of a catastrophe in nature, such as fire, that exposes the surface.

Excess alkali (in tables). Excess exchangeable sodium is in the soil. The resulting poor physical properties restrict the growth of plants.

Excess fines (in tables). Excess silt and clay are in the soil. The soil is not a source of gravel or sand for construction purposes.

Excess lime (in tables). Excess carbonates in the soil restrict the growth of some plants.

Excess salts (in tables). Excess water-soluble salts in the soil restrict the growth of most plants.

Exchangeable sodium percentage. The degree of saturation with sodium of the soil-exchange complex. It can be determined by dividing the exchangeable sodium by the cation-exchange capacity (both are measured in milliequivalents per 100 grams of soil) and then multiplying the result by 100.

Fallow. Cropland left idle in order to restore productivity through accumulation of moisture. Summer fallow is common in regions of limited rainfall where cereal grains are grown. The soil is tilled for at least one growing season for weed control and decomposition of plant residue.

Fast intake (in tables). The movement of water into the soil is rapid.

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, and clay.

First bottom. The normal flood plain of a stream, subject to frequent or occasional flooding.

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

Forb. Any herbaceous plant that is 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.

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 7.5 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 (7.5 centimeters) in diameter.

Ground water (geology). Water filling all the unblocked pores of underlying 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 upper case letter represents the major horizons. Numbers or lower case letters that follow represent subdivisions of the major horizons. An explanation of the subdivisions is given in the *Soil Survey Manual*. The major horizons of mineral soil are as follows:

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

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, a plowed surface horizon, most of which was originally part of a B horizon.

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 accumulation of clay, sesquioxides, humus, or a combination of these; prismatic or blocky structure; redder or browner colors than those in the A horizon; or a combination of these. The combined A and B horizons are generally called the solum, or true soil. If a soil does not have a B horizon, the A horizon alone is the solum.

C horizon.—The mineral horizon or layer, excluding indurated bedrock, that is little affected by soil-forming processes and does not have the properties typical of the A or B horizon. The material of a C horizon may be either like or unlike that in which the solum formed. If the material is known to differ from that in the solum, the Arabic numeral 2 precedes the letter C.

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

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

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

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.

Increasers. Species in the climax vegetation that increase in amount as the more desirable plants are reduced by close grazing. Increasers commonly are the shorter plants and the plants that are the less palatable to livestock.

Infiltration. The downward entry of water into the immediate surface of soil or other material. This contrasts with percolation, which is movement of water through soil layers or material.

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.

Invaders. On range, plants that encroach into an area and grow after the climax vegetation has been reduced by grazing. Generally, invader plants follow disturbance of the surface.

Irrigation. Application of water to soils to assist in production of crops. Methods of irrigation are—

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.

Basin.—Water is applied rapidly to nearly level plains surrounded by levees or dikes.

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.

Large stones (in tables). Rock fragments that are 3 inches (7.5 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.

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.

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 fine textured soil. Clay loam, sandy clay loam, and silty clay loam.

Montmorillonite. An aluminosilicate clay mineral that has a 2:1 expanding crystal lattice, in which two silica tetrahedral layers enclose an alumina octahedral layer. The crystal units are loosely held together by oxygen linkage of the silica outer layers, so that water can enter and move freely in the space between the units as the lattice expands. Consequently, a soil that is high in montmorillonite changes greatly in volume as it takes up moisture or dries out.

Montmorillonitic. Clay mineralogy class used to define soil groupings in the soil classification system.

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 the three simple variables—hue, value, and chroma. For example, a notation of 10YR 6/4 is a color of 10YR hue, value of 6, and chroma of 4.

Natric horizon. A mineral soil horizon that satisfies the requirements of an argillic horizon but that also has prismatic, columnar, or blocky structure and, in some subhorizon within 40 centimeters of the upper boundary, has a sodium adsorption ration (SAR) of 13 or more or an exchangeable sodium percentage (ESP) of 15 or more.

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.

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 affects 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. For example, slope, stoniness, and thickness.

pH value. A numerical designation of acidity and alkalinity in soil. (See Reaction, soil.)

Piping (in tables). Subsurface tunnels or pipelike cavities are formed 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.

Pleistocene. The first epoch of the Quaternary period of geologic time, following the Tertiary Pliocene epoch and preceding the Holocene epoch. It lasted approximately from 2 million to 10 thousand years ago.

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.

Poor filter (in tables). Because of rapid permeability, the soil may not adequately filter effluent from a waste disposal system.

Poor outlets (in tables). In these areas, surface or subsurface drainage outlets are difficult or expensive to install.

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

Rangeland. Land on which the potential natural vegetation is predominantly grasses, grasslike plants, forbs, or shrubs suitable for grazing or browsing. It includes natural grasslands, savannas, many wetlands, some deserts, tundras, and areas that support certain forb and shrub communities.

Range condition. The present composition of the plant community on a range site in relation to the potential natural plant community for that site. Range condition is expressed as excellent, good, fair, or poor, on the basis of how much the present plant community has departed from the potential.

Range site. An area of rangeland where climate, soil, and relief are sufficiently uniform to produce a distinct natural plant community. A range site is the product of all the environmental factors responsible for its development. It is typified by an association of species that differ from those on other range sites in kind or proportion of species or total production.

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

	pH
Extremely acid	below 4.5
Very strongly acid	4.5 to 5.0
Strongly acid	5.1 to 5.5
Medium acid	5.6 to 6.0
Slightly acid	6.1 to 6.5
Neutral	6.6 to 7.3
Mildly alkaline	7.4 to 7.8
Moderately alkaline	7.9 to 8.4
Strongly alkaline	8.5 to 9.0
Very strongly alkaline	9.1 and higher

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. Rippable bedrock or hardpan can be excavated using a single-tooth ripping attachment mounted on a tractor with a 200-300 draw bar 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). There is a 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.

Saline soil. A soil containing soluble salts in an amount that impairs the growth of plants. A saline soil does not contain excess exchangeable sodium.

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-size particles.

Saprolite (soil science). Unconsolidated, residual material underlying the soil and grading to hard bedrock below.

Seepage (in tables). The movement of water through the soil 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 underlying material. 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.

Silica. A combination of silicon and oxygen. The mineral form is called quartz.

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.

Siltstone. Sedimentary rock made up of dominantly silt-sized particles.

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.

Slick spot. A small area of soil having a puddled, crusted, or smooth surface and an excess of exchangeable sodium. The soil is generally silty or clayey, is slippery when wet, and is low in productivity.

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.

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 (7.5 centimeters) in diameter. Small stones adversely affect the specified use of the soil.

Sodicity. The degree to which a soil is affected by exchangeable sodium. Sodicity is expressed as a sodium absorption ratio (SAR) of a saturation extract, or the ratio of Na^{+} to $Ca^{++} + Mg^{++}$. The degrees of sodicity are—

	SAR
Slight	less than 13:1
Moderate	13-30:1
Strong	more than 30:1

Sodium adsorption ratio (SAR). The standard measure of the relative activity of sodium ions in exchange reactions in a soil. It is calculated by dividing the concentration of sodium (Na^{+}) ions by the square root of 1/2 of the combined total of calcium (Ca^{++}) and magnesium (Mg^{++}) ions. The ionic concentrations are expressed in milliequivalents per liter of soil saturation extract or of irrigation water.

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.

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 underlying material. The living roots and plant and animal activities are largely confined to the solum.

Stones. Rock fragments 10 to 24 inches (25 to 60 centimeters) in diameter.

Stripcropping. Growing crops in a systematic arrangement of strips or bands that provide vegetative barriers to wind 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 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. Technically, the A2 horizon. Generally refers to a leached horizon lighter in color and lower in organic matter content than the overlying surface layer.

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

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.

Terrace. An embankment, or ridge, constructed on the contour or at a slight angle to the contour across sloping soils. 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 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.
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.
Trace elements. Chemical elements, such as zinc, cobalt, manganese, copper, and iron, are in soils in extremely small amounts. They are essential to plant growth.
Trafficability. The ability of a soil to support foot and vehicular traffic.
Unstable fill (in tables). There is a risk of caving or sloughing on banks of fill material.
Upland (geology). Land at a higher elevation, in general, than the alluvial plain or stream terrace; land above the lowlands along streams.
Upstream flood control. Generally, a system administered by the Soil Conservation Service to trap flood waters and release them at a controlled rate.
Variant, soil. A soil having properties sufficiently different from those of other known soils to justify a new series name, but occurring in such a limited geographic area that creation of a new series is not justified.
Weathering. All physical and chemical changes produced by atmospheric agents in rocks or other deposits at or near the earth's surface. These changes result in disintegration and decomposition of the material.
Well graded. Refers to soil material consisting of course 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. This 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 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 1951-78 at Jefferson, Oklahoma]

Month	Temperature						Precipitation				
	Average daily maximum	Average daily minimum	Average daily	2 years in 10 will have-- Maximum temperature higher than--	2 years in 10 will have-- Minimum temperature lower than--	Average number of growing degree days*	Average	2 years in 10 will have-- Less than--	2 years in 10 will have-- More than--	Average number of days with 0.10 inch or more	Average snowfall
	°F	°F	°F	°F	°F	Units	In	In	In		In
January----	46.9	22.6	34.8	72	-3	13	0.64	0.20	1.00	2	1.7
February---	53.0	27.4	40.2	79	3	37	.99	.26	1.56	3	2.6
March------	61.6	34.8	48.2	89	9	122	1.81	.39	2.91	4	.9
April------	73.0	46.5	59.8	93	24	306	2.72	1.23	3.98	5	.2
May--------	81.6	56.0	68.9	98	35	586	3.86	1.24	6.00	6	.0
June-------	91.6	65.6	78.7	105	49	861	3.99	1.93	5.76	6	.0
July-------	96.5	70.3	83.5	108	54	1,039	3.89	1.37	6.00	5	.0
August-----	95.2	68.6	82.0	109	53	992	3.34	1.34	5.02	5	.0
September--	86.4	60.6	73.5	103	39	705	3.22	1.18	4.91	5	.0
October----	75.9	48.7	62.3	96	27	387	2.67	.72	4.25	4	.0
November---	59.9	35.7	47.9	81	14	69	1.88	.04	3.24	3	.9
December---	49.7	26.4	38.1	74	0	10	.98	.27	1.55	2	1.6
Yearly:											
Average--	72.6	46.9	59.8	---	---	---	---	---	---	---	---
Extreme--	---	---	---	112	-4	---	---	---	---	---	---
Total----	---	---	---	---	---	5,127	29.99	22.27	37.18	50	7.9

*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° F).

TABLE 2.--FREEZE DATES IN SPRING AND FALL

[Recorded in the period 1951-78 at Jefferson, Oklahoma]

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--	April 7	April 15	April 27
2 years in 10 later than--	April 2	April 11	April 23
5 years in 10 later than--	March 22	April 2	April 15
First freezing temperature in fall:			
1 year in 10 earlier than--	October 26	October 22	October 12
2 years in 10 earlier than--	November 2	October 27	October 16
5 years in 10 earlier than--	November 16	November 7	October 24

TABLE 3.--GROWING SEASON

[Recorded in the period 1951-78 at Jefferson, Oklahoma]

Probability	Length of growing season if Daily minimum temperature is ---		
	Higher than 24° F	Higher than 28° F	Higher than 32° F
	Days	Days	Days
9 years in 10	211	195	177
8 years in 10	220	203	182
5 years in 10	238	218	192
2 years in 10	255	233	202
1 year in 10	265	241	207

TABLE 4.--ACREAGE AND PROPORTIONATE EXTENT OF THE SOILS

Map symbol	Soil name	Acres	Percent
1	Aline fine sand, 0 to 3 percent slopes	4,380	0.7
2	Attica fine sandy loam, 0 to 3 percent slopes	13,241	2.1
3	Attica fine sandy loam, 3 to 5 percent slopes	2,933	0.5
4	Bethany silt loam, 0 to 1 percent slopes	29,571	4.6
5	Carwile-Attica complex, 0 to 2 percent slopes	5,748	0.9
6	Dale silt loam, rarely flooded, 0 to 1 percent slopes	21,253	3.3
7	Dale silt loam, rarely flooded, 3 to 8 percent slopes	2,655	0.4
8	Drummond loam, saline, rarely flooded	2,026	0.3
9	Gaddy fine sand, frequently flooded	2,415	0.4
10	Gaddy loamy fine sand, occasionally flooded	2,610	0.4
11	Goltry fine sand, 0 to 2 percent slopes	3,984	0.6
12	Goodnight fine sand, 5 to 15 percent slopes	6,832	1.1
13	Goodnight loamy fine sand, 2 to 6 percent slopes	10,003	1.6
14	Gracemont loam, saline, occasionally flooded	1,895	0.3
15	Grainola silty clay loam, 1 to 3 percent slopes	5,709	0.9
16	Grainola silty clay loam, 3 to 5 percent slopes	15,189	2.4
17	Grant silt loam, 1 to 3 percent slopes	12,110	1.9
18	Grant silt loam, 3 to 5 percent slopes	3,978	0.6
19	Grant silt loam, 3 to 5 percent slopes, eroded	3,862	0.6
20	Grant-Kingfisher silt loams, 4 to 8 percent slopes	1,819	0.3
21	Grant-Kingfisher silt loams, 4 to 8 percent slopes, eroded	3,611	0.6
22	Grant-Port complex, 0 to 20 percent slopes	9,209	1.4
23	Hawley fine sandy loam, rarely flooded	14,964	2.3
24	Kingfisher silt loam, 1 to 3 percent slopes	7,756	1.2
25	Kingfisher silt loam, 3 to 5 percent slopes	1,340	0.2
26	Kingfisher silt loam, 2 to 5 percent slopes, eroded	3,336	0.5
27	Kingfisher-Wakita silt loams, 1 to 3 percent slopes	4,914	0.8
28	Kingfisher-Wakita silt loams, 2 to 5 percent slopes, eroded	2,234	0.3
29	Kirkland silt loam, 0 to 1 percent slopes	58,890	9.1
30	Kirkland silt loam, 1 to 3 percent slopes	100,533	15.4
31	Kirkland-Pawhuska silt loams, 0 to 2 percent slopes	13,346	2.1
32	Lela clay, rarely flooded	2,879	0.4
33	Masham-Port complex, 0 to 20 percent slopes	11,009	1.7
34	McLain silt loam, rarely flooded	30,722	4.8
35	McLain-Drummond silt loams, rarely flooded	23,986	3.7
36	Norge silt loam, 3 to 5 percent slopes	2,820	0.4
37	Norge silt loam, 3 to 5 percent slopes, eroded	1,160	0.2
38	Oscar-Grant complex, frequently flooded, 0 to 12 percent slopes	5,188	0.8
39	Pond Creek silt loam, 0 to 1 percent slopes	25,745	4.0
40	Pond Creek silt loam, 1 to 3 percent slopes	22,503	3.5
41	Port silt loam, occasionally flooded	10,856	1.7
42	Port and Pocasset soils, frequently flooded	6,308	1.0
43	Pratt loamy fine sand, 2 to 6 percent slopes	11,746	1.8
44	Quinlan loam, 1 to 3 percent slopes	3,606	0.6
45	Quinlan loam, 2 to 5 percent slopes, eroded	3,202	0.5
46	Quinlan-Woodward loams, 3 to 12 percent slopes	5,100	0.8
47	Reinach very fine sandy loam, rarely flooded	11,574	1.8
48	Renfrow silt loam, 3 to 5 percent slopes	9,176	1.4
49	Renfrow silty clay loam, 2 to 5 percent slopes, eroded	17,481	2.7
50	Renfrow-Pawhuska complex, 2 to 5 percent slopes, eroded	3,713	0.6
51	Shellabarger fine sandy loam, 1 to 3 percent slopes	7,961	1.2
52	Tabler silt loam, 0 to 1 percent slopes	39,600	6.1
53	Tivoli fine sand, 5 to 10 percent slopes	4,409	0.7
54	Tivoli fine sand, 10 to 30 percent slopes	3,069	0.5
55	Yahola fine sandy loam, occasionally flooded	5,998	0.9
	Water	2,323	0.4
	Total	644,480	100.0

TABLE 5.--GRAZING YIELDS PER ACRE OF PASTURE AND FORAGE CROPS

[Yields are those that can be expected under a high level of management. Absence of a yield indicates that the grass or crop is seldom grown or is not suited to the soil]

Map symbol and soil name	Improved bermudagrass	Weeping lovegrass	Tall wheatgrass	Plains bluestem	Small grains (graze out)	Forage sorghum
	AUM*	AUM*	AUM*	AUM*	AUM*	AUM*
1. Aline	4.0	6.0	---	---	2.6	1.8
2. Attica	6.0	7.0	---	4.3	3.9	2.5
3. Attica	5.5	6.5	---	4.0	3.4	2.1
4. Bethany	6.0	---	---	5.8	5.1	3.2
5. Carwile-Attica	5.5	5.5	5.0	---	4.0	2.8
6. Dale	8.5	7.0	7.0	6.8	5.8	4.4
7. Dale	7.5	6.0	5.7	6.5	4.9	3.9
8. Drummond	6.0	---	6.0	---	---	---
9. Gaddy	5.5	6.0	---	---	---	---
10. Gaddy	5.5	6.0	---	---	2.6	2.1
11. Goltry	6.0	5.5	6.0	---	3.0	2.1
12. Goodnight	3.0	4.3	---	---	---	---
13. Goodnight	3.5	4.7	---	---	2.7	2.0
14. Gracemont	6.0	---	6.0	---	3.8	2.5
15. Grainola	2.0	---	---	3.0	2.6	1.4
16. Grainola	1.8	---	---	2.8	2.3	1.2
17. Grant	7.0	6.5	---	6.1	4.8	3.2
18. Grant	6.5	6.0	---	6.0	4.4	2.8
19. Grant	5.0	5.0	---	5.4	4.2	2.6

See footnote at end of table.

TABLE 5.--GRAZING YIELDS PER ACRE OF PASTURE AND FORAGE CROPS--Continued

Map symbol and soil name	Improved bermudagrass	Weeping lovegrass	Tall wheatgrass	Plains bluestem	Small grains (graze out)	Forage sorghum
	AUM*	AUM*	AUM*	AUM*	AUM*	AUM*
20--------------------- Grant-Kingfisher	5.0	5.0	5.0	5.5	3.6	2.4
21--------------------- Grant-Kingfisher	4.0	4.0	4.5	5.0	3.5	2.1
22--------------------- Grant-Port	5.5	---	---	5.7	---	---
23--------------------- Hawley	7.5	8.0	---	6.0	4.6	3.9
24--------------------- Kingfisher	5.5	5.5	5.0	5.5	4.4	2.9
25--------------------- Kingfisher	5.0	5.0	4.5	5.0	4.2	2.6
26--------------------- Kingfisher	4.5	4.0	4.2	4.0	3.5	2.3
27--------------------- Kingfisher-Wakita	4.2	4.7	4.2	4.7	3.9	2.5
28--------------------- Kingfisher-Wakita	3.7	4.2	4.0	4.2	3.8	2.2
29--------------------- Kirkland	5.0	---	---	5.0	4.9	2.5
30--------------------- Kirkland	4.9	---	---	4.7	4.7	2.4
31--------------------- Kirkland-Pawhuska	4.5	---	5.0	4.3	3.3	2.3
32--------------------- Lela	5.5	---	5.5	6.0	4.4	3.2
33--------------------- Masham-Port	2.0	---	---	2.0	---	---
34--------------------- McLain	7.0	---	7.0	6.5	5.5	3.9
35--------------------- McLain-Drummond	6.0	---	6.0	---	4.4	3.1
36--------------------- Norge	7.3	7.1	6.8	6.0	5.2	2.8
37--------------------- Norge	6.8	6.6	6.3	5.5	4.8	2.5
38--------------------- Oscar-Grant	5.3	---	5.5	5.5	---	---

See footnote at end of table.

TABLE 5.--GRAZING YIELDS PER ACRE OF PASTURE AND FORAGE CROPS--Continued

Map symbol and soil name	Improved bermudagrass	Weeping lovegrass	Tall wheatgrass	Plains bluestem	Small grains (graze out)	Forage sorghum
	AUM*	AUM*	AUM*	AUM*	AUM*	AUM*
39-------------------- Pond Creek	7.5	7.3	7.0	6.2	5.3	3.9
40-------------------- Pond Creek	7.0	6.8	6.5	5.5	4.9	3.6
41-------------------- Port	8.5	7.8	7.0	6.2	5.9	4.0
42-------------------- Port-Pocasset	6.5	---	7.0	6.5	---	---
43-------------------- Pratt	4.0	6.0	4.0	---	2.9	1.8
44-------------------- Quinlan	3.0	3.0	---	3.0	2.6	1.8
45-------------------- Quinlan	1.5	1.5	---	1.5	2.5	1.4
46-------------------- Quinlan-Woodward	3.0	3.0	---	3.0	---	---
47-------------------- Reinach	8.5	7.0	7.0	6.2	5.8	4.3
48-------------------- Renfrow	3.0	---	---	3.0	3.6	2.1
49-------------------- Renfrow	2.5	---	---	2.5	3.1	2.0
50-------------------- Renfrow-Pawhuska	2.4	---	4.0	2.4	3.0	1.6
51-------------------- Shellabarger	5.5	5.5	5.2	5.8	4.6	3.4
52-------------------- Tabler	5.5	---	---	5.5	4.7	2.5
53-------------------- Tivoli	---	---	---	---	---	---
54-------------------- Tivoli	---	---	---	---	---	---
55-------------------- Yahola	7.5	7.5	---	6.0	4.6	3.0

*Animal-unit-month: The amount of forage or feed required to feed one animal unit (one cow, one horse, one mule, five sheep, or five goats) for a period of 30 days.

TABLE 6.--LAND CAPABILITY AND YIELDS PER ACRE OF CROPS

[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]

Map symbol and soil name	Land capability class or subclass	Wheat	Barley	Grain sorghum	Alfalfa hay
		Bu	Bu	Bu	Tons
1------------------------- Aline	IVs	20	24	25	---
2------------------------- Attica	IIe	30	37	40	2.0
3------------------------- Attica	IIIe	26	30	35	---
4------------------------- Bethany	I	39	41	50	3.5
5------------------------- Carwile-Attica	IIw	30	37	40	---
6------------------------- Dale	I	45	57	65	5.5
7------------------------- Dale	IIIe	38	44	50	3.5
8------------------------- Drummond	Vs	---	---	---	---
9------------------------- Gaddy	Vw	---	---	---	---
10------------------------ Gaddy	IIIs	20	30	30	---
11------------------------ Goltry	IVs	23	30	30	---
12------------------------ Goodnight	VIe	---	---	---	---
13------------------------ Goodnight	IVe	21	28	25	---
14------------------------ Gracemont	IVs	26	35	35	---
15------------------------ Grainola	IIIe	24	30	20	---
16------------------------ Grainola	IVe	18	22	18	---
17------------------------ Grant	IIe	37	45	50	2.5
18------------------------ Grant	IIIe	34	44	40	2.0
19------------------------ Grant	IIIe	32	37	35	---
20------------------------ Grant-Kingfisher	IVe	28	33	35	---

TABLE 6.--LAND CAPABILITY AND YIELDS PER ACRE OF CROPS--Continued

Map symbol and soil name	Land capability class or subclass	Wheat	Barley	Grain sorghum	Alfalfa hay
		Bu	Bu	Bu	Tons
21----------------------- Grant-Kingfisher	IVe	25	28	28	---
22----------------------- Grant-Port	VIe	---	---	---	---
23----------------------- Hawley	I	35	43	55	4.5
24----------------------- Kingfisher	IIe	34	44	40	---
25----------------------- Kingfisher	IIIe	30	42	35	---
26----------------------- Kingfisher	IIIe	27	30	30	---
27----------------------- Kingfisher-Wakita	IIIs	25	29	30	---
28----------------------- Kingfisher-Wakita	IVs	21	24	26	---
29----------------------- Kirkland	IIs	35	44	40	---
30----------------------- Kirkland	IIIe	32	42	35	---
31----------------------- Kirkland-Pawhuska	IIIs	25	28	32	---
32----------------------- Lela	IIIw	34	45	45	3.5
33----------------------- Masham-Port	VIe	---	---	---	---
34----------------------- McLain	I	42	52	55	4.5
35----------------------- McLain-Drummond	IIIs	34	42	44	4.0
36----------------------- Norge	IIIe	34	44	40	2.0
37----------------------- Norge	IIIe	30	38	35	1.5
38----------------------- Oscar-Grant	Vw	---	---	---	---
39----------------------- Pond Creek	I	41	50	50	3.5
40----------------------- Pond Creek	IIe	38	45	45	3.0
41----------------------- Port	IIw	44	50	56	5.0

TABLE 6.--LAND CAPABILITY AND YIELDS PER ACRE OF CROPS--Continued

Map symbol and soil name	Land capability class or subclass	Wheat	Barley	Grain sorghum	Alfalfa hay
		Bu	Bu	Bu	Tons
42------------------------ Port and Pocasset	Vw	---	---	---	---
43------------------------ Pratt	IVe	22	28	36	---
44------------------------ Quinlan	IIIe	20	27	25	---
45------------------------ Quinlan	IVe	16	22	20	---
46------------------------ Quinlan-Woodward	VIe	---	---	---	---
47------------------------ Reinach	I	45	55	60	5.0
48------------------------ Renfrow	IVe	28	36	30	---
49------------------------ Renfrow	IVe	24	30	26	---
50------------------------ Renfrow-Pawhuska	IVe	23	25	24	---
51------------------------ Shellabarger	IIe	35	43	48	2.5
52------------------------ Tabler	IIs	36	43	42	---
53, 54-------------------- Tivoli	VIIe	---	---	---	---
55------------------------ Yahola	IIw	35	39	50	3.5

TABLE 7.--RANGELAND PRODUCTIVITY

[Only the soils that support rangeland vegetation suitable for grazing are listed]

Map symbol and soil name	Range site	Potential annual production for kind of growing season		
		Favorable Lb/acre	Average Lb/acre	Unfavorable Lb/acre
1 Aline	Deep Sand	4,000	2,700	1,800
2, 3 Attica	Sandy Prairie	4,500	3,000	2,000
4 Bethany	Loamy Prairie	5,000	3,500	2,500
5*:				
Carwile	Loamy Bottomland	5,000	3,800	3,000
Attica	Sandy Prairie	4,500	3,000	2,000
6, 7 Dale	Loamy Bottomland	8,500	6,100	4,500
8 Drummond	Saline Subirrigated	7,000	5,800	5,000
9, 10 Gaddy	Sandy Bottomland	3,000	2,300	1,800
11 Goltry	Subirrigated	7,500	5,600	4,300
12, 13 Goodnight	Deep Sand	3,600	2,700	1,800
14 Gracemont	Saline Subirrigated	7,000	5,800	5,000
15, 16 Grainola	Shallow Prairie	4,000	2,800	2,000
17, 18, 19 Grant	Loamy Prairie	5,500	3,700	2,500
20*, 21*:				
Grant	Loamy Prairie	5,500	3,700	2,500
Kingfisher	Loamy Prairie	5,000	3,500	2,500
22*:				
Grant	Loamy Prairie	5,500	3,700	2,500
Port	Loamy Bottomland	8,500	6,100	4,500
23 Hawley	Loamy Bottomland	7,500	5,400	4,000
24, 25, 26 Kingfisher	Loamy Prairie	5,000	3,500	2,500

See footnote at end of table.

TABLE 7.--RANGELAND PRODUCTIVITY--Continued

Map symbol and soil name	Range site	Potential annual production for kind of growing season		
		Favorable Lb/acre	Average Lb/acre	Unfavorable Lb/acre
27*, 28*:				
Kingfisher	Loamy Prairie	5,000	3,500	2,500
Wakita	Slickspot	2,000	1,200	600
29, 30 Kirkland	Claypan Prairie	4,000	2,800	2,000
31*:				
Kirkland	Claypan Prairie	4,000	2,800	2,000
Pawhuska	Slickspot	3,000	2,100	1,500
32 Lela	Heavy Bottomland	5,500	3,700	2,500
33*:				
Masham	Red Clay Prairie	1,700	1,300	900
Port	Loamy Bottomland	7,500	5,400	4,000
34 McLain	Loamy Bottomland	8,500	5,600	4,500
35*:				
McLain	Loamy Bottomland	8,500	5,600	4,500
Drummond	Saline Subirrigated	7,000	5,800	5,000
36, 37 Norge	Loamy Prairie	5,000	3,500	2,500
38*:				
Oscar	Alkali Bottomland	3,200	2,400	1,800
Grant	Loamy Prairie	5,500	3,700	2,500
39, 40 Pond Creek	Loamy Prairie	5,000	3,300	2,200
41 Port	Loamy Bottomland	8,500	6,100	4,500
42*:				
Port	Loamy Bottomland	8,500	6,100	4,500
Pocasset	Loamy Bottomland	7,500	5,400	4,000
43 Pratt	Deep Sand	4,000	3,000	1,800
44, 45 Quinlan	Shallow Prairie	2,500	1,800	1,300
46*:				
Quinlan	Shallow Prairie	2,500	1,800	1,300
Woodward	Loamy Prairie	4,000	2,800	2,000
47 Reinach	Loamy Bottomland	8,500	6,100	4,500

See footnote at end of table.

TABLE 7.--RANGELAND PRODUCTIVITY--Continued

Map symbol and soil name	Range site	Potential annual production for kind of growing season		
		Favorable	Average	Unfavorable
		Lb/acre	Lb/acre	Lb/acre
48, 49------------------- Renfrow	Claypan Prairie------------------------	4,000	2,800	2,000
50*:				
Renfrow-----------------	Claypan Prairie------------------------	4,000	2,800	2,000
Pawhuska----------------	Slickspot------------------------------	3,000	2,100	1,500
51----------------------- Shellabarger	Sandy Prairie--------------------------	4,500	3,200	2,000
52----------------------- Tabler	Claypan Prairie------------------------	3,800	2,600	1,800
53----------------------- Tivoli	Dune-----------------------------------	3,200	2,000	1,200
54----------------------- Tivoli	Dune-----------------------------------	2,000	1,400	1,000
55----------------------- Yahola	Loamy Bottomland-----------------------	7,000	4,900	3,500

* See description of the map unit for composition and behavior characteristics of the map unit.

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]

Map symbol and soil name	Trees having predicted 20-year average height, in feet, of--				
	<8	8-15	16-25	26-35	>35
1. Aline	Lilac, skunkbush sumac, Amur honeysuckle.	American plum, redbud, Rocky Mountain juniper.	Eastern redcedar, osageorange, black locust, red mulberry.	---	---
2, 3. Attica	Lilac, skunkbush sumac.	American plum, Amur honeysuckle.	Eastern redcedar, ponderosa pine, Scotch pine, Austrian pine, green ash, hackberry.	Black locust, Chinese elm, honeylocust, silver maple.	---
4. Bethany	Lilac, skunkbush sumac.	Redbud, Austrian pine, Amur honeysuckle, osageorange, ponderosa pine.	Eastern redcedar, bur oak, Chinese elm, honeylocust, silver maple.	---	---
5*:					
Carwile	Skunkbush sumac	Lilac, Amur honeysuckle, American plum.	Redbud	Hackberry, green ash, honeylocust, osageorange, silver maple.	American sycamore, eastern cottonwood.
Attica	Lilac, skunkbush sumac.	American plum, Amur honeysuckle.	Eastern redcedar, ponderosa pine Scotch pine, Austrian pine, green ash, hackberry.	Black locust, Chinese elm, honeylocust, silver maple.	---
6, 7. Dale	Skunkbush sumac	Amur honeysuckle, American plum, lilac.	Eastern redcedar, Austrian pine, redbud.	Osageorange, Russian olive, red mulberry, green ash, hackberry.	American sycamore, honeylocust, eastern cottonwood, Chinese elm.
8. Drummond					
9, 10. Gaddy	Skunkbush sumac	American plum, Amur honeysuckle, lilac.	Eastern redcedar, autumn-olive, Austrian pine.	Chinese elm, red mulberry, osageorange.	Eastern cottonwood, American sycamore.
11. Goltry	Skunkbush sumac	American plum, lilac, Amur honeysuckle.	Eastern redcedar, Austrian pine, redbud.	Osageorange	Chinese elm, eastern cottonwood, honeylocust, American sycamore.
12, 13. Goodnight	Amur honeysuckle, lilac.	American plum, Rocky Mountain juniper, redbud.	Eastern redcedar, osageorange, red mulberry, oriental arborvitae.	---	---

See footnote at end of table.

TABLE 8.--WINDBREAKS AND ENVIRONMENTAL PLANTINGS--Continued

Map symbol and soil name	Trees having predicted 20-year average height, in feet, of--				
	<8	8-15	16-25	26-35	>35
14. Gracemont	Amur honeysuckle, lilac, skunkbush sumac.	Rocky Mountain juniper, redbud.	Eastern redcedar, Arizona cypress, oriental arborvitae, osageorange.	---	---
15, 16. Grainola	Skunkbush sumac, lilac.	Austrian pine, redbud, Rocky Mountain juniper, Amur honeysuckle.	Russian-olive, eastern redcedar, osageorange, silver maple.	---	---
17, 18, 19. Grant	Skunkbush sumac	Lilac, American plum, Amur honeysuckle.	Austrian pine, eastern redcedar, redbud.	Hackberry, osageorange, honeylocust, silver maple, Chinese elm.	---
20*, 21*:					
Grant	Skunkbush sumac	Lilac, American plum, Amur honeysuckle.	Austrian pine, eastern redcedar, redbud.	Hackberry, osageorange, honeylocust, silver maple, Chinese elm.	---
Kingfisher	Skunkbush sumac	American plum, lilac, Amur honeysuckle.	Eastern redcedar, Austrian pine, redbud.	Hackberry, Chinese elm, honeylocust, osageorange.	---
22*:					
Grant	Skunkbush sumac	Lilac, American plum, Amur honeysuckle.	Austrian pine, eastern redcedar, redbud.	Hackberry, osageorange, honeylocust, silver maple, Chinese elm.	---
Port	Skunkbush sumac	Amur honeysuckle, American plum, lilac.	Austrian pine, eastern redcedar.	Green ash, red mulberry, osageorange.	American sycamore, eastern cottonwood, Chinese elm.
23. Hawley	Skunkbush sumac	Amur honeysuckle, American plum, lilac.	Ponderosa pine, Austrian pine, eastern redcedar, Arizona cypress, redbud.	Bur oak, hackberry, green ash, osageorange, red mulberry.	American sycamore, black locust, Chinese elm, honeylocust, silver maple.
24, 25, 26. Kingfisher	Skunkbush sumac	American plum, lilac, Amur honeysuckle.	Eastern redcedar, Austrian pine, redbud.	Hackberry, Chinese elm, honeylocust, osageorange.	---
27*, 28*:					
Kingfisher	Skunkbush sumac	American plum, lilac, Amur honeysuckle. honeysuckle.	Eastern redcedar, Austrian pine, redbud.	Hackberry, Chinese elm, honeylocust, osageorange.	---
Wakita.					

See footnote at end of table.

TABLE 8.--WINDBREAKS AND ENVIRONMENTAL PLANTINGS--Continued

Map symbol and soil name	Trees having predicted 20-year average height, in feet, of--				
	<8	8-15	16-25	26-35	>35
29, 30. Kirkland	---	American plum, lilac.	Eastern redcedar, osageorange.	Austrian pine, shortleaf pine, hackberry, honeylocust, Chinese elm.	---
31*:					
Kirkland	---	American plum, lilac.	Eastern redcedar, osageorange.	Austrian pine, shortleaf pine, hackberry, honeylocust, Chinese elm.	---
Pawhuska	Lilac, Amur honeysuckle, skunkbush sumac.	Rocky Mountain juniper, redbud.	Eastern redcedar, Arizona cypress, oriental arborvitae, osageorange.	---	---
32. Lela	Skunkbush sumac	Amur honeysuckle, lilac.	Austrian pine, green ash, bur oak, eastern redcedar.	Osageorange, honeylocust, red mulberry.	Eastern cottonwood, American sycamore.
33*:					
Masham.					
Port	Skunkbush sumac	Amur honeysuckle, American plum, lilac.	Austrian pine, eastern redcedar.	Green ash, red mulberry, osageorange.	American sycamore, eastern cottonwood, Chinese elm.
34. McLain	Skunkbush sumac	Lilac, Amur honeysuckle.	Eastern redcedar, Austrian pine, redbud, green ash.	Osageorange, Chinese elm, honeylocust.	American sycamore, eastern cottonwood.
35*:					
McLain	Skunkbush sumac	Lilac, Amur honeysuckle.	Eastern redcedar, Austrian pine, redbud, green ash.	Osageorange, Chinese elm, honeylocust.	American sycamore, eastern cottonwood.
Drummond.					
36, 37. Norge	Skunkbush sumac	American plum, Amur honeysuckle, lilac.	Eastern redcedar, Austrian pine, redbud.	Osageorange, black locust, hackberry, Chinese elm, honeylocust.	---
38*:					
Oscar.					
Grant	Skunkbush sumac	Lilac, American plum, Amur honeysuckle.	Austrian pine, eastern redcedar, redbud.	Hackberry, osageorange, honeylocust, silver maple, Chinese elm.	---

See footnote at end of table.

TABLE 8.--WINDBREAKS AND ENVIRONMENTAL PLANTINGS--Continued

Map symbol and soil name	Trees having predicted 20-year average height, in feet, of--				
	<8	8-15	16-25	26-35	>35
39, 40. Pond Creek	Skunkbush sumac	American plum, Amur honeysuckle, lilac.	Austrian pine, eastern redcedar, redbud.	Honeylocust, osageorange, hackberry, Chinese elm, silver maple.	---
41. Port	Skunkbush sumac	Amur honeysuckle, American plum, lilac.	Austrian pine, eastern redcedar.	Green ash, red mulberry, osageorange.	American sycamore, eastern cottonwood, Chinese elm.
42*:					
Port	Skunkbush sumac	Amur honeysuckle, American plum, lilac.	Austrian pine, eastern redcedar.	Green ash, red mulberry, osageorange.	American sycamore, eastern cottonwood, Chinese elm.
Pocasset	Skunkbush sumac	American plum, Amur honeysuckle, lilac.	Austrian pine, eastern redcedar.	Hackberry, osageorange.	Eastern cottonwood, honeylocust, Chinese elm, American sycamore.
43. Pratt	---	Eastern redcedar, Rocky Mountain juniper.	Ponderosa pine, Austrian pine.	---	---
44, 45. Quinlan	Skunkbush sumac, lilac, Amur honeysuckle.	Rocky Mountain juniper, redbud.	Eastern redcedar, oriental arborvitae, Arizona cypress.	---	---
46*:					
Quinlan	Skunkbush sumac, lilac, Amur honeysuckle.	Rocky Mountain juniper, redbud.	Eastern redcedar, oriental arborvitae, Arizona cypress.	---	---
Woodward	Skunkbush sumac	American plum, lilac, Amur honeysuckle.	Austrian pine, redbud, eastern redcedar.	Honeylocust, hackberry, Chinese elm, osageorange, silver maple.	---
47. Reinach	Skunkbush sumac	Lilac, American plum, Amur honeysuckle.	Austrian pine, redbud, eastern redcedar.	Osageorange	Eastern cottonwood, honeylocust, American sycamore, Chinese elm.
48, 49. Renfrow	Lilac, skunkbush sumac.	Austrian pine, redbud, Amur honeysuckle.	Eastern redcedar, silver maple, hackberry, osageorange, Chinese elm, honeylocust, Russian-olive.	---	---

See footnote at end of table.

TABLE 8.--WINDBREAKS AND ENVIRONMENTAL PLANTINGS--Continued

Map symbol and soil name	Trees having predicted 20-year average height, in feet, of--				
	<8	8-15	16-25	26-35	>35
50*:					
Renfrow	Lilac, skunkbush sumac.	Austrian pine, redbud, Amur honeysuckle.	Eastern redcedar, silver maple, hackberry, osageorange, Chinese elm, honeylocust, Russian-olive.	---	---
Pawhuska	Lilac, Amur honeysuckle, skunkbush sumac.	Rocky Mountain juniper, redbud.	Eastern redcedar, Arizona cypress, oriental arborvitae, osageorange.	---	---
51 Shellabarger	Lilac, skunkbush sumac.	American plum, Amur honeysuckle.	Eastern redcedar, ponderosa pine, Austrian pine, Arizona cypress, redbud.	Chinese elm, autumn-olive, black locust, bur oak, hackberry, silver maple.	---
52 Tabler	Lilac, skunkbush sumac.	Austrian pine, redbud, Amur honeysuckle.	Eastern redcedar, honeylocust, osageorange, silver maple, hackberry, Chinese elm, red mulberry.	---	---
53, 54 Tivoli	Lilac, Amur honeysuckle, skunkbush sumac.	Rocky Mountain juniper, American plum, redbud.	Eastern redcedar, oriental arborvitae, osageorange, black locust, red mulberry.	---	---
55 Yahola	Skunkbush sumac	American plum, lilac.	Austrian pine, eastern redcedar, ponderosa pine, Scotch pine.	Red mulberry, osageorange.	Eastern cottonwood, Chinese elm, American sycamore.

* See description of the map unit for composition and behavior characteristics of the map unit.

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]

Map symbol and soil name	Camp areas	Picnic areas	Playgrounds	Paths and trails	Golf fairways
1 Aline	Severe: too sandy.	Severe: too sandy.	Severe: too sandy.	Severe: too sandy.	Moderate: droughty.
2 Attica	Slight	Slight	Slight	Slight	Slight.
3 Attica	Slight	Slight	Moderate: slope.	Slight	Slight.
4 Bethany	Slight	Slight	Slight	Severe: erodes easily.	Slight.
5*:					
Carwile	Severe: ponding, wetness.	Severe: ponding, wetness.	Severe: ponding, wetness.	Severe: ponding, wetness.	Severe: ponding, wetness.
Attica	Slight	Slight	Slight	Slight	Slight.
6 Dale	Severe: flooding.	Slight	Slight	Severe: erodes easily.	Slight.
7 Dale	Severe: flooding.	Slight	Moderate: slope.	Severe: erodes easily.	Slight.
8 Drummond	Severe: flooding, excess sodium, excess salt.	Severe: excess sodium, excess salt.	Severe: excess sodium, excess salt.	Slight	Severe: excess salt, excess sodium.
9 Gaddy	Severe: flooding, too sandy.	Severe: too sandy.	Severe: too sandy, flooding.	Severe: too sandy.	Severe: flooding.
10 Gaddy	Severe: flooding, too sandy.	Slight	Moderate: flooding.	Slight	Moderate: droughty, flooding.
11 Goltry	Severe: too sandy.	Severe: too sandy.	Severe: too sandy.	Severe: too sandy.	Moderate: droughty.
12 Goodnight	Severe: too sandy.	Severe: too sandy.	Severe: slope, too sandy.	Severe: too sandy.	Moderate: droughty, slope.
13 Goodnight	Slight	Slight	Moderate: slope.	Slight	Moderate: droughty.
14 Gracemont	Severe: flooding, wetness, excess salt.	Severe: wetness, excess salt.	Severe: wetness, excess salt.	Severe: wetness.	Severe: excess salt, wetness.
15, 16 Grainola	Slight	Slight	Moderate: small stones, slope, depth to rock.	Severe: erodes easily.	Moderate: thin layer.

See footnote at end of table.

TABLE 9.--RECREATIONAL DEVELOPMENT--Continued

Map symbol and soil name	Camp areas	Picnic areas	Playgrounds	Paths and trails	Golf fairways
17, 18, 19 Grant	Slight	Slight	Moderate: slope.	Severe: erodes easily.	Slight.
20*, 21*:					
Grant	Slight	Slight	Severe: slope.	Severe: erodes easily.	Slight.
Kingfisher	Slight	Slight	Severe: slope.	Severe: erodes easily.	Moderate: thin layer.
22*:					
Grant	Moderate: slope.	Moderate: slope.	Severe: slope.	Severe: erodes easily.	Moderate: slope.
Port	Severe: flooding.	Moderate: flooding.	Severe: flooding.	Moderate: flooding.	Severe: flooding.
23 Hawley	Severe: flooding.	Slight	Slight	Slight	Slight.
24, 25, 26 Kingfisher	Slight	Slight	Moderate: slope, depth to rock.	Severe: erodes easily.	Moderate: thin layer.
27*, 28*:					
Kingfisher	Slight	Slight	Moderate: slope, depth to rock.	Severe: erodes easily.	Moderate: thin layer.
Wakita	Severe: excess sodium, excess salt.	Severe: excess sodium, excess salt.	Severe: excess sodium, excess salt.	Severe: erodes easily.	Severe: excess salt, excess sodium.
29 Kirkland	Moderate: percs slowly.	Moderate: percs slowly.	Moderate: percs slowly.	Severe: erodes easily.	Slight.
30 Kirkland	Moderate: percs slowly.	Moderate: percs slowly.	Moderate: slope, percs slowly.	Severe: erodes easily.	Slight.
31*:					
Kirkland	Moderate: percs slowly.	Moderate: percs slowly.	Moderate: percs slowly.	Severe: erodes easily.	Slight.
Pawhuska	Severe: excess sodium, excess salt.	Severe: excess sodium, excess salt.	Severe: excess sodium, excess salt.	Severe: erodes easily.	Severe: excess sodium, excess salt.
32 Lela	Severe: flooding.	Moderate: percs slowly, too clayey.	Severe: too clayey.	Moderate: too clayey.	Severe: too clayey.
33*:					
Masham	Severe: percs slowly, too clayey.	Severe: too clayey, percs slowly.	Severe: slope, too clayey, depth to rock.	Severe: too clayey, erodes easily.	Severe: thin layer, too clayey.
Port	Severe: flooding.	Moderate: flooding.	Severe: flooding.	Moderate: flooding.	Severe: flooding.

See footnote at end of table.

TABLE 9.--RECREATIONAL DEVELOPMENT--Continued

Map symbol and soil name	Camp areas	Picnic areas	Playgrounds	Paths and trails	Golf fairways
34: McLain	Severe: flooding.	Slight	Slight	Slight	Slight.
35*:					
McLain	Severe: flooding.	Slight	Slight	Slight	Slight.
Drummond	Severe: flooding, excess sodium, excess salt.	Severe: excess sodium, excess salt.	Severe: excess sodium, excess salt.	Slight	Severe: excess salt, excess sodium.
36, 37: Norge	Slight	Slight	Moderate: slope.	Severe: erodes easily.	Slight.
38*:					
Oscar	Severe: flooding, excess sodium, excess salt.	Severe: excess sodium, excess salt.	Severe: excess sodium, excess salt.	Severe: erodes easily.	Severe: excess sodium.
Grant	Slight	Slight	Severe: slope.	Severe: erodes easily.	Slight.
39: Pond Creek	Slight	Slight	Slight	Severe: erodes easily.	Slight.
40: Pond Creek	Slight	Slight	Moderate: slope.	Severe: erodes easily.	Slight.
41: Port	Severe: flooding.	Slight	Moderate: flooding.	Slight	Moderate: flooding.
42*:					
Port	Severe: flooding.	Moderate: flooding.	Severe: flooding.	Moderate: flooding.	Severe: flooding.
Pocasset	Severe: flooding.	Moderate: flooding.	Severe: flooding.	Moderate: flooding.	Severe: flooding.
43: Pratt	Moderate: too sandy.	Slight	Moderate: slope.	Slight	Moderate: droughty.
44, 45: Quinlan	Severe: depth to rock.	Severe: depth to rock.	Severe: depth to rock.	Severe: erodes easily.	Severe: thin layer.
46*:					
Quinlan	Severe: depth to rock.	Severe: depth to rock.	Severe: slope, depth to rock.	Severe: erodes easily.	Severe: thin layer.
Woodward	Slight	Slight	Severe: slope.	Severe: erodes easily.	Moderate: thin layer.
47: Reinach	Severe: flooding.	Slight	Slight	Slight	Slight.

See footnote at end of table.

TABLE 9.--RECREATIONAL DEVELOPMENT--Continued

Map symbol and soil name	Camp areas	Picnic areas	Playgrounds	Paths and trails	Golf fairways
48, 49---------------- Renfrow	Moderate: percs slowly.	Moderate: percs slowly.	Moderate: slope, percs slowly.	Severe: erodes easily.	Slight.
50*:					
Renfrow---------------	Moderate: percs slowly.	Moderate: percs slowly.	Moderate: slope, percs slowly.	Severe: erodes easily.	Slight.
Pawhuska--------------	Severe: excess sodium, excess salt.	Severe: excess sodium, excess salt.	Severe: excess sodium, excess salt.	Severe: erodes easily.	Severe: excess sodium, excess salt.
51-------------------- Shellabarger	Slight----------	Slight----------	Moderate: slope.	Slight----------	Slight.
52-------------------- Tabler	Moderate: percs slowly.	Moderate: percs slowly.	Moderate: percs slowly.	Slight----------	Slight.
53-------------------- Tivoli	Severe: too sandy.	Severe: too sandy.	Severe: slope, too sandy.	Severe: too sandy.	Severe: droughty.
54-------------------- Tivoli	Severe: slope, too sandy.	Severe: slope, too sandy.	Severe: slope, too sandy.	Severe: too sandy.	Severe: droughty, slope.
55-------------------- Yahola	Severe: flooding.	Slight----------	Moderate: flooding.	Slight----------	Moderate: flooding.

* See description of the map unit for composition and behavior characteristics of the map unit.

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]

Map symbol and soil name	Potential for habitat elements: Grain and seed crops	Grasses and legumes	Wild herbaceous plants	Shrubs	Wetland plants	Shallow water areas	Potential as habitat for--: Openland wildlife	Wetland wildlife	Rangeland wildlife
1------------------ Aline	Poor	Fair	Fair	Good	Very poor	Very poor	Fair	Very poor	Fair.
2, 3--------------- Attica	Good	Good	Good	Good	Poor	Very poor	Good	Very poor	Good.
4------------------ Bethany	Good	Good	Fair	Fair	Poor	Very poor	Good	Very poor	Fair.
5*:									
Carwile-----------	Fair	Good	Good	Good	Good	Fair	Good	Fair	Good.
Attica------------	Good	Good	Good	Good	Poor	Very poor	Good	Very poor	Good.
6------------------ Dale	Good	Good	Fair	Good	Poor	Very poor	Good	Very poor	Fair.
7------------------ Dale	Fair	Good	Fair	Good	Poor	Very poor	Fair	Very poor	Fair.
8------------------ Drummond	Poor	Fair	Fair	Poor	Fair	Fair	Fair	Fair	Poor.
9------------------ Gaddy	Poor	Fair	Fair	Fair	Very poor	Very poor	Fair	Very poor	Fair.
10----------------- Gaddy	Fair	Fair	Good	Fair	Very poor	Very poor	Fair	Very poor	Fair.
11----------------- Goltry	Poor	Fair	Fair	Good	Poor	Poor	Fair	Poor	Fair.
12----------------- Goodnight	Poor	Fair	Fair	Fair	Very poor	Very poor	Fair	Very poor	Fair.
13----------------- Goodnight	Fair	Fair	Fair	Fair	Very poor	Very poor	Fair	Very poor	Fair.
14----------------- Gracemont	Poor	Fair	Very poor	Poor	Fair	Poor	Poor	Poor	Poor.
15, 16------------- Grainola	Fair	Good	Fair	Fair	Very poor	Very poor	Fair	Very poor	Fair.
17, 18, 19--------- Grant	Good	Good	Good	Fair	Poor	Very poor	Good	Very poor	Fair.
20*:									
Grant-------------	Fair	Good	Good	Fair	Very poor	Very poor	Good	Very poor	Fair.
Kingfisher--------	Fair	Good	Good	Fair	Poor	Very poor	Good	Very poor	Fair.
21*:									
Grant-------------	Fair	Good	Good	Fair	Very poor	Very poor	Good	Very poor	Fair.
Kingfisher--------	Fair	Good	Good	Fair	Poor	Very poor	Good	Very poor	Fair.

See footnote at end of table.

TABLE 10.--WILDLIFE HABITAT--Continued

Map symbol and soil name	Potential for habitat elements						Potential as habitat for--		
	Grain and seed crops	Grasses and legumes	Wild herbaceous plants	Shrubs	Wetland plants	Shallow water areas	Openland wildlife	Wetland wildlife	Rangeland wildlife
22*:									
Grant	Fair	Good	Good	Fair	Very poor	Very poor	Good	Very poor	Fair.
Port	Poor	Fair	Fair	Good	Poor	Very poor	Fair	Very poor	Fair.
23 Hawley	Good	Good	Good	Good	Poor	Very poor	Good	Very poor	Good.
24 Kingfisher	Good	Good	Good	Fair	Poor	Very poor	Good	Very poor	Fair.
25 Kingfisher	Good	Good	Good	Fair	Poor	Very poor	Good	Very poor	Fair.
26 Kingfisher	Good	Good	Good	Fair	Poor	Very poor	Good	Very poor	Fair.
27*:									
Kingfisher	Good	Good	Good	Fair	Poor	Very poor	Good	Very poor	Fair.
Wakita	Poor	Fair	Fair	Poor	Poor	Very poor	Fair	Poor	Fair.
28*:									
Kingfisher	Good	Good	Good	Fair	Poor	Very poor	Good	Very poor	Fair.
Wakita	Poor	Fair	Fair	Poor	Poor	Very poor	Fair	Poor	Fair.
29, 30 Kirkland	Good	Good	Good	Fair	Poor	Very poor	Good	Very poor	Fair.
31*:									
Kirkland	Good	Good	Good	Fair	Poor	Very poor	Good	Very poor	Fair.
Pawhuska	Poor	Poor	Very poor	Poor	Very poor	Poor	Poor	Very poor	Very poor.
32 Lela	Fair	Fair	Poor	Fair	Poor	Fair	Fair	Poor	Poor.
33*:									
Masham	Poor	Fair	Fair	Very poor	Very poor	Very poor	Fair	Very poor	Fair.
Port	Poor	Fair	Fair	Good	Poor	Very poor	Fair	Very poor	Fair.
34 McLain	Good	Good	Fair	Good	Poor	Poor	Good	Poor	Fair.
35*:									
McLain	Good	Good	Fair	Good	Poor	Poor	Good	Poor	Fair.
Drummond	Poor	Fair	Fair	Poor	Fair	Fair	Fair	Fair	Poor.
36, 37 Norge	Good	Good	Good	Fair	Poor	Very poor	Good	Very poor	Fair.
38*:									
Oscar	Very poor	Poor	Very poor	Very poor	Poor	Poor	Very poor	Poor	Very poor.
Grant	Fair	Good	Good	Fair	Very poor	Very poor	Good	Very poor	Fair.

See footnote at end of table.

TABLE 10.--WILDLIFE HABITAT--Continued

Map symbol and soil name	Potential for habitat elements: Grain and seed crops	Grasses and legumes	Wild herbaceous plants	Shrubs	Wetland plants	Shallow water areas	Potential as habitat for--: Openland wildlife	Wetland wildlife	Rangeland wildlife
39, 40----------- Pond Creek	Good	Good	Good	Fair	Poor	Very poor	Good	Very poor	Fair.
41--------------- Port	Good	Good	Good	Good	Poor	Very poor	Good	Very poor	Good.
42*:									
Port-------------	Poor	Fair	Fair	Good	Poor	Very poor	Fair	Very poor	Fair.
Pocasset---------	Poor	Poor	Fair	Good	Poor	Very poor	Poor	Very poor	Fair.
43--------------- Pratt	Fair	Good	Fair	Fair	Very poor	Very poor	Fair	Very poor	Fair.
44, 45----------- Quinlan	Poor	Poor	Fair	Poor	Poor	Very poor	Fair	Very poor	Poor.
46*:									
Quinlan----------	Poor	Poor	Fair	Poor	Poor	Very poor	Fair	Very poor	Poor.
Woodward---------	Fair	Good	Good	Fair	Poor	Very poor	Good	Very poor	Fair.
47--------------- Reinach	Good	Good	Good	Good	Poor	Very poor	Good	Very poor	Good.
48--------------- Renfrow	Good	Good	Good	Fair	Poor	Very poor	Good	Very poor	Fair.
49--------------- Renfrow	Good	Good	Fair	Fair	Poor	Very poor	Good	Very poor	Fair.
50*:									
Renfrow----------	Good	Good	Good	Fair	Poor	Very poor	Good	Very poor	Fair.
Pawhuska---------	Poor	Poor	Very poor	Poor	Very poor	Poor	Poor	Very poor	Very poor.
51--------------- Shellabarger	Good	Good	Good	Good	Poor	Very poor	Good	Very poor	Good.
52--------------- Tabler	Good	Good	Good	Good	Poor	Poor	Good	Poor	Good.
53, 54----------- Tivoli	Poor	Poor	Fair	Poor	Very poor	Very poor	Poor	Very poor	Poor.
55--------------- Yahola	Good	Good	Good	Good	Poor	Very poor	Good	Very poor	Good.

* See description of the map unit for composition and behavior characteristics of the map unit.

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; it does not eliminate the need for onsite investigation]

Map symbol and soil name	Shallow excavations	Dwellings without basements	Dwellings with basements	Small commercial buildings	Local roads and streets	Lawns and landscaping
1 Aline	Severe: cutbanks cave.	Slight	Slight	Slight	Slight	Moderate: droughty.
2 Attica	Severe: cutbanks cave.	Slight	Slight	Slight	Slight	Slight.
3 Attica	Severe: cutbanks cave.	Slight	Slight	Moderate: slope.	Slight	Slight.
4 Bethany	Moderate: too clayey.	Severe: shrink-swell.	Severe: shrink-swell.	Severe: shrink-swell.	Severe: shrink-swell.	Slight.
5*:						
Carwile	Severe: ponding, wetness.	Severe: shrink-swell, ponding, wetness.	Severe: shrink-swell, ponding, wetness.	Severe: shrink-swell, ponding, wetness.	Severe: wetness, shrink-swell, ponding.	Severe: ponding, wetness.
Attica	Severe: cutbanks cave.	Slight	Slight	Slight	Slight	Slight.
6, 7 Dale	Slight	Severe: flooding.	Severe: flooding.	Severe: flooding.	Moderate: shrink-swell, flooding.	Slight.
8 Drummond	Severe: wetness.	Severe: flooding, shrink-swell.	Severe: flooding, wetness, shrink-swell.	Severe: flooding, shrink-swell.	Severe: shrink-swell.	Severe: excess salt, excess sodium.
9 Gaddy	Severe: cutbanks cave.	Severe: flooding.	Severe: flooding.	Severe: flooding.	Severe: flooding.	Severe: flooding.
10 Gaddy	Severe: cutbanks cave.	Severe: flooding.	Severe: flooding.	Severe: flooding.	Severe: flooding.	Moderate: droughty, flooding.
11 Goltry	Severe: cutbanks cave.	Slight	Moderate: wetness.	Slight	Slight	Moderate: droughty.
12 Goodnight	Severe: cutbanks cave.	Moderate: slope.	Moderate: slope.	Severe: slope.	Moderate: slope.	Moderate: droughty, slope.
13 Goodnight	Severe: cutbanks cave.	Slight	Slight	Moderate: slope.	Slight	Moderate: droughty.
14 Gracemont	Severe: wetness.	Severe: flooding, wetness.	Severe: flooding, wetness.	Severe: flooding, wetness.	Severe: wetness, flooding.	Severe: excess salt, wetness.
15, 16 Grainola	Moderate: depth to rock, too clayey.	Severe: shrink-swell.	Severe: shrink-swell.	Severe: shrink-swell.	Severe: shrink-swell.	Moderate: thin layer.

See footnote at end of table.

TABLE 11.--BUILDING SITE DEVELOPMENT--Continued

Map symbol and soil name	Shallow excavations	Dwellings without basements	Dwellings with basements	Small commercial buildings	Local roads and streets	Lawns and landscaping
17 Grant	Slight	Slight	Slight	Slight	Slight	Slight.
18, 19 Grant	Slight	Slight	Slight	Moderate: slope.	Slight	Slight.
20*, 21*:						
Grant	Slight	Slight	Slight	Moderate: slope.	Slight	Slight.
Kingfisher	Moderate: depth to rock.	Moderate: shrink-swell.	Moderate: depth to rock, shrink-swell.	Moderate: shrink-swell, slope.	Moderate: shrink-swell.	Moderate: thin layer.
22*:						
Grant	Moderate: slope.	Moderate: slope.	Moderate: slope.	Severe: slope.	Moderate: slope.	Moderate: slope.
Port	Moderate: flooding.	Severe: flooding.	Severe: flooding.	Severe: flooding.	Severe: flooding.	Severe: flooding.
23 Hawley	Slight	Severe: flooding.	Severe: flooding.	Severe: flooding.	Moderate: flooding.	Slight.
24 Kingfisher	Moderate: depth to rock.	Moderate: shrink-swell.	Moderate: depth to rock, shrink-swell.	Moderate: shrink-swell.	Moderate: shrink-swell.	Moderate: thin layer.
25 Kingfisher	Moderate: depth to rock.	Moderate: shrink-swell.	Moderate: depth to rock, shrink-swell.	Moderate: shrink-swell, slope.	Moderate: shrink-swell.	Moderate: thin layer.
26 Kingfisher	Moderate: depth to rock.	Moderate: shrink-swell.	Moderate: depth to rock, shrink-swell.	Moderate: shrink-swell.	Moderate: shrink-swell.	Moderate: thin layer.
27*, 28*:						
Kingfisher	Moderate: depth to rock.	Moderate: shrink-swell.	Moderate: depth to rock, shrink-swell.	Moderate: shrink-swell.	Moderate: shrink-swell.	Moderate: thin layer.
Wakita	Severe: depth to rock, wetness.	Moderate: wetness, shrink-swell.	Severe: wetness.	Moderate: wetness, shrink-swell.	Severe: low strength.	Severe: excess salt, excess sodium.
29, 30 Kirkland	Moderate: too clayey.	Severe: shrink-swell.	Severe: shrink-swell.	Severe: shrink-swell.	Severe: low strength, shrink-swell.	Slight.
31*:						
Kirkland	Moderate: too clayey.	Severe: shrink-swell.	Severe: shrink-swell.	Severe: shrink-swell.	Severe: low strength, shrink-swell.	Slight.
Pawhuska	Moderate: too clayey.	Severe: shrink-swell.	Severe: shrink-swell.	Severe: shrink-swell.	Severe: shrink-swell.	Severe: excess sodium, excess salt.
32 Lela	Severe: cutbanks cave.	Severe: flooding, shrink-swell.	Severe: flooding, shrink-swell.	Severe: flooding, shrink-swell.	Severe: shrink-swell.	Severe: too clayey.

See footnote at end of table.

TABLE 11.--BUILDING SITE DEVELOPMENT--Continued

Map symbol and soil name	Shallow excavations	Dwellings without basements	Dwellings with basements	Small commercial buildings	Local roads and streets	Lawns and landscaping
33*:						
Masham	Severe: depth to rock.	Severe: shrink-swell.	Severe: depth to rock, shrink-swell.	Severe: shrink-swell, slope.	Severe: low strength, shrink-swell.	Severe: thin layer, too clayey.
Port	Moderate: flooding.	Severe: flooding.	Severe: flooding.	Severe: flooding.	Severe: flooding.	Severe: flooding.
34 McLain	Moderate: too clayey.	Severe: flooding, shrink-swell.	Severe: flooding, shrink-swell.	Severe: flooding, shrink-swell.	Severe: shrink-swell.	Slight.
35*:						
McLain	Moderate: too clayey.	Severe: flooding, shrink-swell.	Severe: flooding, shrink-swell.	Severe: flooding, shrink-swell.	Severe: shrink-swell.	Slight.
Drummond	Severe: wetness.	Severe: flooding, shrink-swell.	Severe: flooding, wetness, shrink-swell.	Severe: flooding, shrink-swell.	Severe: shrink-swell.	Severe: excess salt, excess sodium.
36, 37 Norge	Slight	Moderate: shrink-swell.	Moderate: shrink-swell.	Moderate: shrink-swell, slope.	Moderate: shrink-swell.	Slight.
38*:						
Oscar	Moderate: flooding.	Severe: flooding.	Severe: flooding.	Severe: flooding.	Severe: low strength, flooding.	Severe: excess sodium.
Grant	Slight	Slight	Slight	Moderate: slope.	Slight	Slight.
39, 40 Pond Creek	Slight	Moderate: shrink-swell.	Moderate: shrink-swell.	Moderate: shrink-swell.	Moderate: shrink-swell.	Slight.
41 Port	Moderate: flooding.	Severe: flooding.	Severe: flooding.	Severe: flooding.	Severe: flooding.	Moderate: flooding.
42*:						
Port	Moderate: flooding.	Severe: flooding.	Severe: flooding.	Severe: flooding.	Severe: flooding.	Severe: flooding.
Pocasset	Severe: cutbanks cave.	Severe: flooding.	Severe: flooding.	Severe: flooding.	Severe: flooding.	Severe: flooding.
43 Pratt	Severe: cutbanks cave.	Slight	Slight	Moderate: slope.	Slight	Moderate: droughty.
44, 45 Quinlan	Severe: depth to rock.	Moderate: depth to rock.	Severe: depth to rock.	Moderate: depth to rock.	Moderate: depth to rock.	Severe: thin layer.
46*:						
Quinlan	Severe: depth to rock.	Moderate: depth to rock.	Severe: depth to rock.	Moderate: depth to rock, slope.	Moderate: depth to rock.	Severe: thin layer.
Woodward	Moderate: depth to rock.	Slight	Moderate: depth to rock.	Moderate: slope.	Slight	Moderate: thin layer.

See footnote at end of table.

TABLE 11.--BUILDING SITE DEVELOPMENT--Continued

Map symbol and soil name	Shallow excavations	Dwellings without basements	Dwellings with basements	Small commercial buildings	Local roads and streets	Lawns and landscaping
47 Reinach	Slight	Severe: flooding.	Severe: flooding.	Severe: flooding.	Moderate: flooding.	Slight.
48, 49 Renfrow	Moderate: too clayey.	Severe: shrink-swell.	Severe: shrink-swell.	Severe: shrink-swell.	Severe: shrink-swell.	Slight.
50*:						
Renfrow	Moderate: too clayey.	Severe: shrink-swell.	Severe: shrink-swell.	Severe: shrink-swell.	Severe: shrink-swell.	Slight.
Pawhuska	Moderate: too clayey.	Severe: shrink-swell.	Severe: shrink-swell.	Severe: shrink-swell.	Severe: shrink-swell.	Severe: excess sodium, excess salt.
51 Shellabarger	Severe: cutbanks cave.	Slight	Slight	Slight	Slight	Slight.
52 Tabler	Moderate: too clayey, wetness.	Severe: shrink-swell.	Severe: shrink-swell.	Severe: shrink-swell.	Severe: shrink-swell.	Slight.
53 Tivoli	Severe: cutbanks cave.	Slight	Slight	Moderate: slope.	Slight	Severe: droughty.
54 Tivoli	Severe: cutbanks cave, slope.	Severe: slope.	Severe: slope.	Severe: slope.	Severe: slope.	Severe: droughty, slope.
55 Yahola	Severe: cutbanks cave.	Severe: flooding.	Severe: flooding.	Severe: flooding.	Severe: flooding.	Moderate: flooding.

* See description of the map unit for composition and behavior characteristics of the map unit.

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; it does not eliminate the need for onsite investigation]

Map symbol and soil name	Septic tank absorption fields	Sewage lagoon areas	Trench sanitary landfill	Area sanitary landfill	Daily cover for landfill
1 Aline	Severe: poor filter.	Severe: seepage.	Severe: too sandy, seepage.	Severe: seepage.	Poor: seepage, too sandy.
2, 3 Attica	Slight	Severe: seepage.	Severe: seepage.	Severe: seepage.	Good.
4 Bethany	Severe: percs slowly.	Slight	Severe: too clayey.	Slight	Poor: too clayey, hard to pack.
5*:					
Carwile	Severe: percs slowly, ponding, wetness.	Severe: ponding, wetness.	Severe: ponding, too clayey, wetness.	Severe: ponding, wetness.	Poor: ponding, too clayey, hard to pack.
Attica	Slight	Severe: seepage.	Severe: seepage.	Severe: seepage.	Good.
6 Dale	Moderate: flooding, percs slowly.	Moderate: seepage.	Moderate: flooding.	Moderate: flooding.	Good.
7 Dale	Moderate: flooding, percs slowly.	Moderate: seepage, slope.	Moderate: flooding.	Moderate: flooding.	Good.
8 Drummond	Severe: wetness, percs slowly.	Severe: wetness.	Severe: wetness, too clayey, excess sodium.	Severe: wetness.	Poor: too clayey, hard to pack, excess sodium.
9, 10 Gaddy	Severe: flooding, poor filter.	Severe: seepage, flooding.	Severe: flooding, seepage, too sandy.	Severe: flooding, seepage.	Poor: too sandy, seepage.
11 Goltry	Severe: wetness, poor filter.	Severe: seepage, wetness.	Severe: wetness, too sandy, seepage.	Severe: seepage, wetness.	Poor: seepage, too sandy.
12 Goodnight	Severe: poor filter.	Severe: seepage, slope.	Severe: seepage, too sandy.	Severe: seepage.	Poor: seepage, too sandy.
13 Goodnight	Severe: poor filter.	Severe: seepage.	Severe: seepage, too sandy.	Severe: seepage.	Poor: seepage, too sandy.
14 Gracemont	Severe: flooding, wetness.	Severe: seepage, flooding, wetness.	Severe: flooding, seepage, wetness.	Severe: flooding, seepage, wetness.	Poor: wetness.

See footnote at end of table.

TABLE 12.--SANITARY FACILITIES--Continued

Map symbol and soil name	Septic tank absorption fields	Sewage lagoon areas	Trench sanitary landfill	Area sanitary landfill	Daily cover for landfill
15, 16 Grainola	Severe: depth to rock, percs slowly.	Severe: depth to rock.	Severe: depth to rock, too clayey.	Severe: depth to rock.	Poor: area reclaim, too clayey, hard to pack.
17, 18, 19 Grant	Moderate: depth to rock, percs slowly.	Moderate: seepage, depth to rock, slope.	Severe: depth to rock.	Moderate: depth to rock.	Fair: area reclaim, too clayey.
20*, 21*:					
Grant	Moderate: depth to rock, percs slowly.	Moderate: seepage, depth to rock, slope.	Severe: depth to rock.	Moderate: depth to rock.	Fair: area reclaim, too clayey.
Kingfisher	Severe: depth to rock, percs slowly.	Severe: depth to rock.	Severe: depth to rock.	Severe: depth to rock.	Poor: area reclaim.
22*:					
Grant	Moderate: depth to rock, percs slowly, slope.	Severe: slope.	Severe: depth to rock.	Moderate: depth to rock, slope.	Fair: area reclaim, too clayey, slope.
Port	Severe: flooding.	Severe: flooding.	Severe: flooding.	Severe: flooding.	Fair: too clayey.
23 Hawley	Moderate: flooding, percs slowly.	Severe: seepage.	Severe: seepage.	Severe: seepage.	Good.
24, 25, 26 Kingfisher	Severe: depth to rock, percs slowly.	Severe: depth to rock.	Severe: depth to rock.	Severe: depth to rock.	Poor: area reclaim.
27*, 28*:					
Kingfisher	Severe: depth to rock, percs slowly.	Severe: depth to rock.	Severe: depth to rock.	Severe: depth to rock.	Poor: area reclaim.
Wakita	Severe: depth to rock, wetness.	Severe: depth to rock, wetness.	Severe: excess sodium, wetness.	Moderate: wetness.	Poor: area reclaim, thin layer, excess sodium.
29 Kirkland	Severe: percs slowly.	Slight	Severe: too clayey.	Slight	Poor: too clayey, hard to pack.
30 Kirkland	Severe: percs slowly.	Moderate: slope.	Severe: too clayey.	Slight	Poor: too clayey, hard to pack.
31*:					
Kirkland	Severe: percs slowly.	Slight	Severe: too clayey.	Slight	Poor: too clayey, hard to pack.

See footnote at end of table.

TABLE 12.--SANITARY FACILITIES--Continued

Map symbol and soil name	Septic tank absorption fields	Sewage lagoon areas	Trench sanitary landfill	Area sanitary landfill	Daily cover for landfill
31*:					
Pawhuska	Severe: percs slowly.	Slight	Severe: too clayey, excess sodium.	Slight	Poor: too clayey, hard to pack, excess sodium.
32 Lela	Severe: percs slowly.	Slight	Severe: too clayey.	Moderate: flooding.	Poor: too clayey, hard to pack.
33*:					
Masham	Severe: depth to rock.	Severe: depth to rock, slope.	Severe: depth to rock, too clayey.	Severe: depth to rock.	Poor: area reclaim, too clayey, hard to pack.
Port	Severe: flooding.	Severe: flooding.	Severe: flooding.	Severe: flooding.	Fair: too clayey.
34 McLain	Severe: percs slowly.	Slight	Moderate: flooding, too clayey.	Moderate: flooding.	Poor: hard to pack.
35*:					
McLain	Severe: percs slowly.	Slight	Moderate: flooding, too clayey.	Moderate: flooding.	Poor: hard to pack.
Drummond	Severe: wetness, percs slowly.	Severe: wetness.	Severe: wetness, too clayey, excess sodium.	Severe: wetness.	Poor: too clayey, hard to pack, excess sodium.
36, 37 Norge	Severe: percs slowly.	Moderate: slope.	Moderate: too clayey.	Slight	Fair: too clayey.
38*:					
Oscar	Severe: percs slowly, flooding.	Severe: flooding.	Severe: flooding, excess sodium.	Severe: flooding.	Poor: excess sodium.
Grant	Moderate: depth to rock, percs slowly.	Severe: slope.	Severe: depth to rock.	Moderate: depth to rock.	Fair: area reclaim, too clayey.
39 Pond Creek	Severe: percs slowly.	Slight	Moderate: too clayey.	Slight	Fair: too clayey.
40 Pond Creek	Severe: percs slowly.	Moderate: slope.	Moderate: too clayey.	Slight	Fair: too clayey.
41 Port	Severe: flooding.	Severe: flooding.	Severe: flooding.	Severe: flooding.	Fair: too clayey.
42*:					
Port	Severe: flooding.	Severe: flooding.	Severe: flooding.	Severe: flooding.	Fair: too clayey.
Pocasset	Severe: flooding.	Severe: seepage, flooding.	Severe: flooding, seepage.	Severe: flooding, seepage.	Good.

See footnote at end of table.

TABLE 12.--SANITARY FACILITIES--Continued

Map symbol and soil name	Septic tank absorption fields	Sewage lagoon areas	Trench sanitary landfill	Area sanitary landfill	Daily cover for landfill
43: Pratt	Severe: poor filter.	Severe: seepage.	Severe: seepage.	Severe: seepage.	Poor: too sandy, seepage.
44, 45: Quinlan	Severe: depth to rock.	Severe: depth to rock.	Severe: depth to rock.	Severe: depth to rock.	Poor: area reclaim.
46*:					
Quinlan	Severe: depth to rock.	Severe: depth to rock, slope.	Severe: depth to rock.	Severe: depth to rock.	Poor: area reclaim.
Woodward	Severe: depth to rock.	Severe: slope, depth to rock.	Severe: depth to rock.	Severe: depth to rock.	Poor: area reclaim.
47: Reinach	Moderate: flooding, percs slowly.	Moderate: seepage.	Moderate: flooding.	Moderate: flooding.	Good.
48, 49: Renfrow	Severe: percs slowly.	Moderate: slope.	Severe: too clayey.	Slight	Poor: too clayey, hard to pack.
50*:					
Renfrow	Severe: percs slowly.	Moderate: slope.	Severe: too clayey.	Slight	Poor: too clayey, hard to pack.
Pawhuska	Severe: percs slowly.	Moderate: slope.	Severe: too clayey, excess sodium.	Slight	Poor: too clayey, hard to pack, excess sodium.
51: Shellabarger	Slight	Moderate: seepage, slope.	Slight	Slight	Good.
52: Tabler	Severe: wetness, percs slowly.	Severe: wetness.	Severe: too clayey.	Moderate: wetness.	Poor: too clayey, hard to pack.
53: Tivoli	Severe: poor filter.	Severe: seepage, slope.	Severe: seepage, too sandy.	Severe: seepage.	Poor: seepage, too sandy.
54: Tivoli	Severe: poor filter, slope.	Severe: seepage, slope.	Severe: seepage, slope, too sandy.	Severe: seepage, slope.	Poor: seepage, too sandy, slope.
55: Yahola	Severe: flooding.	Severe: seepage, flooding.	Severe: flooding, seepage.	Severe: flooding, seepage.	Good.

* See description of the map unit for composition and behavior characteristics of the map unit.

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; it does not eliminate the need for onsite investigation]

Map symbol and soil name	Roadfill	Sand	Gravel	Topsoil
1 Aline	Good	Probable	Improbable: too sandy.	Poor: too sandy.
2, 3 Attica	Good	Improbable: excess fines.	Improbable: excess fines.	Good.
4 Bethany	Poor: shrink-swell.	Improbable: excess fines.	Improbable: excess fines.	Poor: too clayey.
5*:				
Carwile	Poor: shrink-swell, wetness.	Improbable: excess fines.	Improbable: excess fines.	Poor: too clayey, wetness.
Attica	Good	Improbable: excess fines.	Improbable: excess fines.	Fair: too sandy.
6, 7 Dale	Fair: shrink-swell.	Improbable: excess fines.	Improbable: excess fines.	Good.
8 Drummond	Poor: shrink-swell.	Improbable: excess fines.	Improbable: excess fines.	Poor: excess salt, excess sodium.
9, 10 Gaddy	Good	Probable	Improbable: too sandy.	Poor: too sandy.
11 Goltry	Fair: wetness.	Probable	Improbable: too sandy.	Poor: too sandy.
12 Goodnight	Good	Probable	Improbable: too sandy.	Poor: too sandy.
13 Goodnight	Good	Probable	Improbable: too sandy.	Fair: too sandy.
14 Gracemont	Poor: wetness.	Improbable: excess fines.	Improbable: excess fines.	Poor: excess salt, wetness.
15, 16 Grainola	Poor: area reclaim, shrink-swell.	Improbable: excess fines.	Improbable: excess fines.	Poor: too clayey.
17, 18, 19 Grant	Fair: area reclaim.	Improbable: excess fines.	Improbable: excess fines.	Fair: too clayey.
20*, 21*:				
Grant	Fair: area reclaim.	Improbable: excess fines.	Improbable: excess fines.	Fair: too clayey.
Kingfisher	Poor: area reclaim.	Improbable: excess fines.	Improbable: excess fines.	Fair: area reclaim, too clayey.

See footnote at end of table.

TABLE 13.--CONSTRUCTION MATERIALS--Continued

Map symbol and soil name	Roadfill	Sand	Gravel	Topsoil
22*:				
Grant	Fair: area reclaim.	Improbable: excess fines.	Improbable: excess fines.	Fair: slope, too clayey.
Port	Moderate: shrink-swell.	Improbable: excess fines.	Improbable: excess fines.	Good.
23 Hawley	Good	Improbable: excess fines.	Improbable: excess fines.	Good.
24, 25, 26 Kingfisher	Poor: area reclaim.	Improbable: excess fines.	Improbable: excess fines.	Fair: area reclaim, too clayey.
27*, 28*:				
Kingfisher	Poor: area reclaim.	Improbable: excess fines.	Improbable: excess fines.	Fair: area reclaim, too clayey.
Wakita	Poor: area reclaim, thin layer, low strength.	Improbable: excess fines, thin layer.	Improbable: excess fines, thin layer.	Poor: excess salt, excess sodium.
29, 30 Kirkland	Poor: low strength, shrink-swell.	Improbable: excess fines.	Improbable: excess fines.	Poor: thin layer.
31*:				
Kirkland	Poor: low strength, shrink-swell.	Improbable: excess fines.	Improbable: excess fines.	Poor: thin layer.
Pawhuska	Poor: shrink-swell.	Improbable: excess fines.	Improbable: excess fines.	Poor: excess sodium, excess salt, too clayey.
32 Lela	Poor: shrink-swell.	Improbable: excess fines.	Improbable: excess fines.	Poor: too clayey.
33*:				
Masham	Poor: area reclaim, low strength.	Improbable: excess fines.	Improbable: excess fines.	Poor: area reclaim, too clayey.
Port	Moderate: shrink-swell.	Improbable: excess fines.	Improbable: excess fines.	Fair: too clayey.
34 McLain	Poor: shrink-swell.	Improbable: excess fines.	Improbable: excess fines.	Fair: too clayey.
35*:				
McLain	Poor: shrink-swell.	Improbable: excess fines.	Improbable: excess fines.	Fair: too clayey.
Drummond	Poor: shrink-swell.	Improbable: excess fines.	Improbable: excess fines.	Poor: excess salt, excess sodium.

See footnote at end of table.

TABLE 13.--CONSTRUCTION MATERIALS--Continued

Map symbol and soil name	Roadfill	Sand	Gravel	Topsoil
36, 37 Norge	Fair: shrink-swell.	Improbable: excess fines.	Improbable: excess fines.	Fair: too clayey.
38*:				
Oscar	Poor: low strength.	Improbable: excess fines.	Improbable: excess fines.	Poor: excess sodium, excess salt.
Grant	Fair: area reclaim.	Improbable: excess fines.	Improbable: excess fines.	Fair: too clayey.
39, 40 Pond Creek	Fair: shrink-swell.	Improbable: excess fines.	Improbable: excess fines.	Fair: too clayey.
41 Port	Moderate: shrink-swell.	Improbable: excess fines.	Improbable: excess fines.	Good.
42*:				
Port	Moderate: shrink-swell.	Improbable: excess fines.	Improbable: excess fines.	Good.
Pocasset	Good	Improbable: excess fines.	Improbable: excess fines.	Good.
43 Pratt	Good	Probable	Improbable: too sandy.	Fair: too sandy.
44, 45 Quinlan	Poor: area reclaim.	Improbable: excess fines.	Improbable: excess fines.	Poor: area reclaim.
46*:				
Quinlan	Poor: area reclaim.	Improbable: excess fines.	Improbable: excess fines.	Poor: area reclaim.
Woodward	Poor: area reclaim.	Improbable: excess fines.	Improbable: excess fines.	Fair: area reclaim.
47 Reinach	Good	Improbable: excess fines.	Improbable: excess fines.	Good.
48, 49 Renfrow	Poor: shrink-swell.	Improbable: excess fines.	Improbable: excess fines.	Poor: too clayey.
50*:				
Renfrow	Poor: shrink-swell.	Improbable: excess fines.	Improbable: excess fines.	Poor: too clayey.
Pawhuska	Poor: shrink-swell.	Improbable: excess fines.	Improbable: excess fines.	Poor: excess sodium, excess salt, too clayey.
51 Shellabarger	Good	Improbable: excess fines.	Improbable: too sandy.	Fair: small stones, area reclaim.
52 Tabler	Poor: shrink-swell.	Improbable: excess fines.	Improbable: excess fines.	Poor: too clayey.

See footnote at end of table.

TABLE 13.--CONSTRUCTION MATERIALS--Continued

Map symbol and soil name	Roadfill	Sand	Gravel	Topsoil
53 Tivoli	Good	Probable	Improbable: too sandy.	Poor: too sandy.
54 Tivoli	Fair: slope.	Probable	Improbable: too sandy.	Poor: too sandy, slope.
55 Yahola	Good	Improbable: excess fines.	Improbable: excess fines.	Good.

* See description of the map unit for composition and behavior characteristics of the map unit.

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; it does not eliminate the need for onsite investigation]

Map symbol and soil name	Limitations for--			Features affecting--		
	Pond reservoir areas	Embankments, dikes, and levees	Aquifer-fed excavated ponds	Drainage	Terraces and diversions	Grassed waterways
1 Aline	Severe: seepage.	Severe: seepage, piping.	Severe: no water.	Deep to water	Too sandy, soil blowing.	Droughty.
2, 3 Attica	Severe: seepage.	Severe: piping.	Severe: no water.	Deep to water	Soil blowing	Favorable.
4 Bethany	Slight	Moderate: hard to pack.	Severe: no water.	Deep to water	Erodes easily, percs slowly.	Erodes easily, percs slowly.
5*: Carwile	Moderate: seepage.	Severe: ponding, hard to pack, wetness.	Severe: slow refill.	Percs slowly, ponding.	Ponding, wetness, percs slowly.	Percs slowly, wetness.
Attica	Severe: seepage.	Severe: piping.	Severe: no water.	Deep to water	Soil blowing	Favorable.
6 Dale	Moderate: seepage.	Moderate: piping.	Severe: no water.	Deep to water	Erodes easily	Erodes easily.
7 Dale	Moderate: seepage, slope.	Moderate: piping.	Severe: no water.	Deep to water	Erodes easily	Erodes easily.
8 Drummond	Slight	Severe: excess sodium.	Severe: slow refill.	Percs slowly, excess salt, excess sodium.	Percs slowly, wetness, excess sodium.	Excess salt, excess sodium, percs slowly.
9, 10 Gaddy	Severe: seepage.	Severe: seepage, piping.	Severe: no water.	Deep to water	Too sandy, soil blowing.	Droughty.
11 Goltry	Severe: seepage.	Severe: seepage, piping.	Severe: cutbanks cave.	Cutbanks cave	Wetness, too sandy, soil blowing.	Droughty.
12 Goodnight	Severe: seepage, slope.	Severe: seepage, piping.	Severe: no water.	Deep to water	Too sandy, soil blowing, slope.	Slope, droughty.
13 Goodnight	Severe: seepage.	Severe: seepage, piping.	Severe: no water.	Deep to water	Too sandy, soil blowing.	Droughty.
14 Gracemont	Severe: seepage.	Severe: piping, wetness.	Moderate: slow refill, salty water.	Flooding, excess salt.	Wetness	Wetness, excess salt.
15 Grainola	Moderate: depth to rock.	Moderate: thin layer, hard to pack.	Severe: no water.	Deep to water	Percs slowly, depth to rock, erodes easily.	Percs slowly, erodes easily, depth to rock.

See footnote at end of table.

TABLE 14.--WATER MANAGEMENT--Continued

Map symbol and soil name	Limitations for-- Pond reservoir areas	Embankments, dikes, and levees	Aquifer-fed excavated ponds	Features affecting-- Drainage	Terraces and diversions	Grassed waterways
16----------------- Grainola	Moderate: depth to rock, slope.	Moderate: thin layer, hard to pack.	Severe: no water.	Deep to water	Percs slowly, depth to rock, erodes easily.	Percs slowly, erodes easily, depth to rock.
17----------------- Grant	Moderate: seepage, depth to rock.	Moderate: piping, thin layer.	Severe: no water.	Deep to water	Erodes easily	Erodes easily.
18, 19------------ Grant	Moderate: seepage, depth to rock, slope.	Moderate: piping, thin layer.	Severe: no water.	Deep to water	Erodes easily	Erodes easily.
20*, 21*:						
Grant------------	Moderate: seepage, depth to rock, slope.	Moderate: piping, thin layer.	Severe: no water.	Deep to water	Erodes easily	Erodes easily.
Kingfisher--------	Moderate: depth to rock, slope.	Moderate: thin layer.	Severe: no water.	Deep to water	Depth to rock, erodes easily.	Erodes easily, depth to rock.
22*:						
Grant------------	Severe: slope.	Moderate: piping, thin layer.	Severe: no water.	Deep to water	Slope, erodes easily.	Slope, erodes easily.
Port-------------	Moderate: seepage.	Moderate: piping.	Severe: no water.	Deep to water	Favorable------	Favorable.
23----------------- Hawley	Severe: piping.	Severe: seepage, piping.	Severe: no water.	Deep to water	Soil blowing---	Favorable.
24----------------- Kingfisher	Moderate: depth to rock.	Moderate: thin layer.	Severe: no water.	Deep to water	Depth to rock, erodes easily.	Erodes easily, depth to rock.
25, 26------------ Kingfisher	Moderate: depth to rock, slope.	Moderate: thin layer.	Severe: no water.	Deep to water	Depth to rock, erodes easily.	Erodes easily, depth to rock.
27*:						
Kingfisher--------	Moderate: depth to rock.	Moderate: thin layer.	Severe: no water.	Deep to water	Depth to rock, erodes easily.	Erodes easily, depth to rock.
Wakita-----------	Moderate: depth to rock.	Severe: thin layer, excess sodium, excess salt.	Severe: no water.	Percs slowly, depth to rock, excess salt.	Depth to rock, erodes easily, wetness.	Excess salt, excess sodium, erodes easily.
28*:						
Kingfisher--------	Moderate: depth to rock, slope.	Moderate: thin layer.	Severe: no water.	Deep to water	Depth to rock, erodes easily.	Erodes easily, depth to rock.
Wakita-----------	Moderate: depth to rock, slope.	Severe: thin layer, excess sodium, excess salt.	Severe: no water.	Percs slowly, depth to rock, slope.	Depth to rock, erodes easily, wetness.	Excess salt, excess sodium, erodes easily.

See footnote at end of table.

TABLE 14.--WATER MANAGEMENT--Continued

Map symbol and soil name	Limitations for-- Pond reservoir areas	Embankments, dikes, and levees	Aquifer-fed excavated ponds	Features affecting-- Drainage	Terraces and diversions	Grassed waterways
29, 30 Kirkland	Slight	Moderate: hard to pack.	Severe: no water.	Deep to water	Erodes easily, percs slowly.	Erodes easily, percs slowly.
31*:						
Kirkland	Slight	Moderate: hard to pack.	Severe: no water.	Deep to water	Erodes easily, percs slowly.	Erodes easily, percs slowly.
Pawhuska	Slight	Severe: excess sodium.	Severe: no water.	Deep to water	Erodes easily, percs slowly.	Excess sodium, erodes easily, droughty.
32 Lela	Slight	Moderate: hard to pack.	Severe: no water.	Deep to water	Percs slowly	Percs slowly.
33*:						
Masham	Severe: depth to rock, slope.	Severe: thin layer.	Severe: no water.	Deep to water	Slope, depth to rock, erodes easily.	Slope, erodes easily, depth to rock.
Port	Moderate: seepage.	Moderate: piping.	Severe: no water.	Deep to water	Favorable	Favorable.
34 McLain	Slight	Severe: hard to pack.	Severe: no water.	Deep to water	Percs slowly	Percs slowly.
35*:						
McLain	Slight	Severe: hard to pack.	Severe: no water.	Deep to water	Percs slowly	Percs slowly.
Drummond	Slight	Severe: excess sodium.	Severe: slow refill.	Percs slowly, excess salt, excess sodium.	Percs slowly, wetness, excess sodium.	Excess salt, excess sodium, percs slowly.
36, 37 Norge	Moderate: slope.	Moderate: piping.	Severe: no water.	Deep to water	Erodes easily	Eroades easily.
38*:						
Oscar	Slight	Severe: piping, excess sodium.	Severe: no water.	Deep to water	Erodes easily, percs slowly.	Excess sodium, erodes easily, excess salt.
Grant	Moderate: seepage, depth to rock, slope.	Moderate: piping, thin layer.	Severe: no water.	Deep to water	Erodes easily	Erodes easily.
39, 40 Pond Creek	Slight	Moderate: piping.	Severe: no water.	Deep to water	Erodes easily	Erodes easily.
41 Port	Moderate: seepage.	Moderate: piping.	Severe: no water.	Deep to water	Favorable	Favorable.
42*:						
Port	Moderate: seepage.	Moderate: piping.	Severe: no water.	Deep to water	Favorable	Favorable.
Pocasset	Severe: seepage.	Severe: piping.	Severe: no water.	Deep to water	Favorable	Favorable.

See footnote at end of table.

TABLE 14.--WATER MANAGEMENT--Continued

Map symbol and soil name	Limitations for-- Pond reservoir areas	Embankments, dikes, and levees	Aquifer-fed excavated ponds	Features affecting-- Drainage	Terraces and diversions	Grassed waterways
43 Pratt	Severe: seepage.	Severe: seepage, piping.	Severe: no water.	Deep to water	Too sandy, soil blowing.	Droughty.
44, 45 Quinlan	Severe: depth to rock.	Severe: piping, thin layer.	Severe: no water.	Deep to water	Depth to rock	Depth to rock.
46*:						
Quinlan	Severe: depth to rock.	Severe: piping, thin layer.	Severe: no water.	Deep to water	Depth to rock	Depth to rock.
Woodward	Moderate: depth to rock, seepage, slope.	Severe: piping.	Severe: no water.	Deep to water	Depth to rock, erodes easily.	Depth to rock, erodes easily.
47 Reinach	Moderate: seepage.	Severe: piping.	Severe: no water.	Deep to water	Favorable	Favorable.
48, 49 Renfrow	Slight	Severe: hard to pack.	Severe: no water.	Deep to water	Erodes easily, percs slowly.	Erodes easily, percs slowly.
50*:						
Renfrow	Slight	Severe: hard to pack.	Severe: no water.	Deep to water	Erodes easily, percs slowly.	Erodes easily, percs slowly.
Pawhuska	Moderate: slope.	Severe: excess sodium.	Severe: no water.	Deep to water	Erodes easily, percs slowly.	Excess sodium, erodes easily, droughty.
51 Shellabarger	Moderate: seepage.	Severe: thin layer.	Severe: no water.	Deep to water	Soil blowing	Favorable.
52 Tabler	Slight	Moderate: hard to pack, wetness.	Severe: no water.	Percs slowly	Wetness, percs slowly.	Percs slowly.
53 Tivoli	Severe: seepage.	Severe: seepage, piping.	Severe: no water.	Deep to water	Too sandy, soil blowing.	Droughty.
54 Tivoli	Severe: seepage, slope.	Severe: seepage, piping.	Severe: no water.	Deep to water	Slope, too sandy, soil blowing.	Slope, droughty.
55 Yahola	Severe: seepage.	Severe: piping.	Severe: no water.	Deep to water	Soil blowing	Favorable.

* See description of the map unit for composition and behavior characteristics of the map unit.

TABLE 15.--ENGINEERING INDEX PROPERTIES

[The symbol < means less than; > means more than. Absence of an entry indicates that data were not estimated]

Map symbol and soil name	Depth	USDA texture	Classification		Fragments > 3 inches	Percentage passing sieve number--				Liquid limit	Plasticity index
			Unified	AASHTO		4	10	40	200		
	In				Pct					Pct	
1----------------- Aline	0-80	Fine sand--------	SM, SP-SM	A-2, A-3	0	100	98-100	40-100	5-35	---	NP
2, 3-------------- Attica	0-9	Fine sandy loam	SM	A-2, A-4	0	100	95-100	70-100	20-50	<20	NP-4
	9-24	Fine sandy loam, loam.	SM, ML, SM-SC, CL-ML	A-2, A-4	0	100	95-100	75-100	30-55	<26	NP-7
	24-75	Fine sandy loam, loamy fine sand.	SM, SM-SC	A-2, A-4	0	85-100	80-100	70-100	20-50	<26	NP-7
4----------------- Bethany	0-12	Silt loam--------	CL, ML, CL-ML	A-4, A-6	0	100	100	96-100	80-98	21-40	1-15
	12-16	Silty clay loam, clay loam.	CL	A-6, A-7	0	100	100	96-100	80-98	33-50	15-26
	16-72	Silty clay, clay, silty clay loam.	CL, CH	A-7, A-6	0	100	96-100	96-100	90-99	37-60	15-33
5*:											
Carwile----------	0-14	Loam-------------	CL	A-6	0	100	100	96-100	65-90	30-40	10-18
	14-59	Clay loam, clay, sandy clay.	CL, CH, SC	A-6, A-7	0	100	100	90-100	40-95	35-70	14-38
	59-72	Clay loam, sandy clay loam, clay.	CL, CH, SC	A-4, A-6, A-7	0	100	100	90-100	36-95	25-70	7-38
Attica-----------	0-12	Loamy fine sand	SM, SP-SM	A-2	0	100	95-100	70-100	10-35	---	NP
	12-44	Fine sandy loam, sandy loam.	SM, ML, SM-SC, CL-ML	A-2, A-4	0	100	95-100	75-100	30-55	<26	NP-7
	44-75	Fine sandy loam, loamy fine sand.	SM, SM-SC	A-2, A-4	0	85-100	80-100	70-100	20-50	<26	NP-7
6, 7-------------- Dale	0-36	Silt loam--------	CL, CL-ML	A-4, A-6	0	95-100	95-100	90-100	65-98	25-35	5-15
	36-72	Silt loam, loam, silty clay loam.	CL	A-4, A-6, A-7	0	95-100	95-100	90-100	65-98	30-43	8-20
8----------------- Drummond	0-9	Loam-------------	CL, ML, CL-ML	A-4, A-6	0	100	100	96-100	65-97	22-39	3-15
	9-38	Clay loam, silty clay loam, clay.	CL, CH	A-6, A-7	0	100	100	96-100	80-98	35-60	15-35
	38-60	Variable---------	---	---	---	---	---	---	---	---	---
9----------------- Gaddy	0-7	Fine sand--------	SM, SP-SM	A-2, A-3	0	100	98-100	80-100	5-35	---	NP
	7-60	Stratified fine sand to clay loam.	SM, SP-SM	A-2, A-3	0	100	98-100	80-100	5-35	---	NP
10---------------- Gaddy	0-7	Loamy fine sand	SM, SP-SM	A-2, A-3	0	100	98-100	80-100	5-35	---	NP
	7-60	Stratified fine sand to clay loam.	SM, SP-SM	A-2, A-3	0	100	98-100	80-100	5-35	---	NP
11---------------- Goltry	0-80	Fine sand--------	SM, SP-SM	A-2, A-3	0	100	98-100	82-100	5-35	---	NP
12---------------- Goodnight	0-6	Fine sand--------	SM, SP-SM	A-2, A-3	0	100	98-100	82-98	5-25	---	NP
	6-60	Loamy fine sand, fine sand.	SM, SP-SM	A-2, A-3	0	100	98-100	82-100	5-35	---	NP

See footnote at end of table.

TABLE 15.--ENGINEERING INDEX PROPERTIES--Continued

Map symbol and soil name	Depth	USDA texture	Classification		Frag- ments > 3 inches	Percentage passing sieve number--				Liquid limit	Plas- ticity index
			Unified	AASHTO		4	10	40	200		
	In				Pct					Pct	
13---------------- Goodnight	0-6	Loamy fine sand	SM	A-2	0	100	98-100	90-100	15-35	---	NP
	6-80	Loamy fine sand, fine sand.	SM, SP-SM	A-2, A-3	0	100	98-100	82-100	5-35	---	NP
14---------------- Gracemont	0-9	Loam-------------	ML, CL, CL-ML	A-4, A-6	0	100	98-100	96-100	65-90	22-40	2-18
	9-25	Fine sandy loam, loam.	ML, CL-ML, SM, SM-SC	A-4	0	100	98-100	94-100	36-90	22-29	2-7
	25-60	Fine sandy loam, loam, clay loam.	ML, CL, SM, SC	A-4, A-6	0	100	98-100	94-100	36-90	22-40	2-18
15, 16----------- Grainola	0-6	Silty clay loam	CL	A-6, A-7	0-25	75-95	75-95	60-95	60-95	37-50	14-25
	6-25	Clay loam, clay, very shaly silty clay.	CL, CH, SC, GC	A-2, A-7	0	20-90	20-90	20-90	15-90	41-70	20-40
	25-29	Weathered bedrock	---	---	---	---	---	---	---	---	---
17, 18----------- Grant	0-12	Silt loam--------	ML, CL, CL-ML	A-4	0	100	100	90-100	70-90	20-32	1-10
	12-59	Silt loam, loam, silty clay loam.	ML, CL	A-4, A-6, A-7	0	100	100	90-100	70-90	30-42	8-19
	59-65	Weathered bedrock	---	---	---	---	---	---	---	---	---
19---------------- Grant	0-8	Silt loam--------	ML, CL, CL-ML	A-4	0	100	100	90-100	70-90	20-32	1-10
	8-54	Silt loam, loam, silty clay loam.	ML, CL	A-4, A-6, A-7	0	100	100	90-100	70-90	30-42	8-19
	54-60	Weathered bedrock	---	---	---	---	---	---	---	---	---
20*: Grant-----------	0-10	Silt loam--------	ML, CL, CL-ML	A-4	0	100	100	90-100	70-90	20-32	1-10
	10-50	Silt loam, loam, silty clay loam.	ML, CL	A-4, A-6, A-7	0	100	100	90-100	70-90	30-42	8-19
	50-61	Weathered bedrock	---	---	---	---	---	---	---	---	---
Kingfisher------	0-8	Silt loam--------	CL, ML, CL-ML	A-4, A-6	0	100	100	96-100	65-97	22-37	3-14
	8-13	Silt loam, silty clay loam, clay loam.	CL	A-4, A-6	0	100	100	96-100	80-98	30-40	8-17
	13-27	Silty clay loam, clay loam.	CL	A-6, A-7	0	100	100	96-100	80-98	33-43	12-20
	27-34	Weathered bedrock	---	---	---	---	---	---	---	---	---
21*: Grant-----------	0-6	Silt loam--------	ML, CL, CL-ML	A-4	0	100	100	90-100	70-90	20-32	1-10
	6-56	Silt loam, loam, silty clay loam.	ML, CL	A-4, A-6, A-7	0	100	100	90-100	70-90	30-42	8-19
	56-60	Weathered bedrock	---	---	---	---	---	---	---	---	---
Kingfisher------	0-7	Silt loam--------	CL, ML, CL-ML	A-4, A-6	0	100	100	96-100	65-97	22-37	3-14
	7-12	Silt loam, silty clay loam, clay loam.	CL	A-4, A-6	0	100	100	96-100	80-98	30-40	8-17
	12-26	Silty clay loam, clay loam.	CL	A-6, A-7	0	100	100	96-100	80-98	33-43	12-20
	26-40	Weathered bedrock	---	---	---	---	---	---	---	---	---

See footnote at end of table.

TABLE 15.--ENGINEERING INDEX PROPERTIES--Continued

Map symbol and soil name	Depth	USDA texture	Classification		Frag- ments > 3 inches	Percentage passing sieve number--				Liquid limit	Plas- ticity index
			Unified	AASHTO		4	10	40	200		
	In				Pct					Pct	
22*:											
Grant	0-11	Silt loam	ML, CL, CL-ML	A-4	0	100	100	90-100	70-90	20-32	1-10
	11-55	Silt loam, loam, silty clay loam.	ML, CL	A-4, A-6, A-7	0	100	100	90-100	70-90	30-42	8-19
	55-65	Weathered bedrock	---	---	---	---	---	---	---	---	---
Port	0-24	Silt loam	CL	A-4, A-6	0	100	100	96-100	65-97	27-37	8-14
	24-80	Silty clay loam, clay loam, loam.	CL	A-4, A-6, A-7	0	100	100	96-100	65-98	27-43	8-20
23 Hawley	0-9	Fine sandy loam	ML, SM	A-4	0	100	98-100	94-100	36-60	<26	NP-4
	9-34	Fine sandy loam, loam.	SM, SC, SM-SC, CL-ML	A-4	0	100	98-100	90-100	45-75	<30	NP-10
	34-66	Stratified loamy fine sand to silty clay loam.	SM, ML, SM-SC, CL-ML	A-2, A-4	0	100	98-100	90-100	30-70	<30	NP-7
24, 25, 26 Kingfisher	0-11	Silt loam	CL, ML, CL-ML	A-4, A-6	0	100	100	96-100	65-97	22-37	3-14
	11-17	Silt loam, silty clay loam, clay loam.	CL	A-4, A-6	0	100	100	96-100	80-98	30-40	8-17
	17-29	Silty clay loam, clay loam.	CL	A-6, A-7	0	100	100	96-100	80-98	33-43	12-20
	29-41	Weathered bedrock	---	---	---	---	---	---	---	---	---
27*:											
Kingfisher	0-7	Silt loam	CL, ML, CL-ML	A-4, A-6	0	100	100	96-100	65-97	22-37	3-14
	7-12	Silt loam, silty clay loam, clay loam.	CL	A-4, A-6	0	100	100	96-100	80-98	30-40	8-17
	12-25	Silty clay loam, clay loam.	CL	A-6, A-7	0	100	100	96-100	80-98	33-43	12-20
	25-30	Weathered bedrock	---	---	---	---	---	---	---	---	---
Wakita	0-5	Silt loam	CL	A-4, A-6	0	100	95-100	90-100	75-97	30-37	8-13
	5-14	Silt loam, clay loam, silty clay loam.	CL	A-4, A-6, A-7	0	100	80-100	75-100	65-98	30-42	10-20
	14-32	Silt loam, clay loam, silty clay loam.	CL	A-4, A-6, A-7	0	80-100	75-100	70-95	60-93	30-42	10-20
	32-37	Weathered bedrock	---	---	---	---	---	---	---	---	---
28*:											
Kingfisher	0-6	Silt loam	CL, ML, CL-ML	A-4, A-6	0	100	100	96-100	65-97	22-37	3-14
	6-11	Silt loam, silty clay loam, clay loam.	CL	A-4, A-6	0	100	100	96-100	80-98	30-40	8-17
	11-26	Silty clay loam, clay loam.	CL	A-6, A-7	0	100	100	96-100	80-98	33-43	12-20
	26-32	Weathered bedrock	---	---	---	---	---	---	---	---	---

See footnote at end of table.

TABLE 15.--ENGINEERING INDEX PROPERTIES--Continued

Map symbol and soil name	Depth	USDA texture	Classification		Frag- ments > 3 inches	Percentage passing sieve number--				Liquid limit	Plas- ticity index
			Unified	AASHTO		4	10	40	200		
	In				Pct					Pct	
28*:											
Wakita----------	0-6	Silt loam--------	CL	A-4, A-6	0	100	95-100	90-100	75-97	30-37	8-13
	6-9	Silt loam, clay loam, silty clay loam.	CL	A-4, A-6, A-7	0	100	80-100	75-100	65-98	30-42	10-20
	9-34	Silt loam, clay loam, silty clay loam.	CL	A-4, A-6, A-7	0	80-100	75-100	70-95	60-93	30-42	10-20
	34-42	Weathered bedrock	---	---	---	---	---	---	---	---	---
29, 30----------- Kirkland	0-10	Silt loam--------	CL	A-4, A-6	0	100	100	96-100	80-97	30-37	8-13
	10-38	Silty clay, clay	CL, CH	A-7	0	100	100	96-100	90-99	41-65	18-38
	38-72	Clay, silty clay, clay loam.	CL, CH	A-6, A-7	0	100	100	96-100	80-99	37-65	15-38
31*:											
Kirkland--------	0-11	Silt loam--------	CL	A-4, A-6	0	100	100	96-100	80-97	30-37	8-13
	11-47	Silty clay, clay	CL, CH	A-7	0	100	100	96-100	90-99	41-65	18-38
	47-75	Clay, silty clay, clay loam.	CL, CH	A-6, A-7	0	100	100	96-100	80-99	37-65	15-38
Pawhuska--------	0-5	Silt loam--------	ML, CL-ML	A-4	0	100	100	96-100	80-97	22-30	2-7
	5-65	Silty clay loam, silty clay, clay.	CL, CH	A-7	0	90-100	90-100	85-100	85-99	41-70	20-40
	65-68	Weathered bedrock	---	---	---	---	---	---	---	---	---
32--------------- Lela	0-20	Clay-------------	CL, CH	A-7	0	100	100	96-100	90-99	41-70	20-38
	20-72	Silty clay, clay	CL, CH	A-7	0	75-98	75-98	70-98	52-95	41-70	20-38
33*:											
Masham----------	0-4	Silty clay-------	CL, CH	A-7	0	90-100	85-100	80-100	75-99	41-60	18-34
	4-12	Silty clay loam, silty clay.	CL, CH	A-6, A-7	0	90-100	90-100	85-100	80-99	37-60	15-34
	12-37	Weathered bedrock	---	---	---	---	---	---	---	---	---
Port------------	0-15	Silty clay loam	CL	A-6, A-7	0	100	100	96-100	80-98	33-43	12-20
	15-53	Silty clay loam, clay loam, loam.	CL	A-4, A-6, A-7	0	100	100	96-100	65-98	27-43	8-20
	53-70	Weathered bedrock	---	---	---	---	---	---	---	---	---
34--------------- McLain	0-14	Silt loam--------	CL	A-4, A-6	0	100	100	96-100	65-97	30-37	8-14
	14-59	Silty clay loam, clay loam, silty clay.	CL, CH	A-6, A-7	0	100	100	96-100	80-99	37-60	15-34
	59-75	Silt loam, loam, silty clay loam.	CL, CH	A-4, A-6, A-7	0	100	95-100	95-100	65-99	27-60	7-34
35*:											
McLain----------	0-12	Silt loam--------	CL	A-4, A-6	0	100	100	96-100	65-97	30-37	8-14
	12-46	Silty clay loam, clay loam, silty clay.	CL, CH	A-6, A-7	0	100	100	96-100	80-99	37-60	15-34
	46-75	Silt loam, loam, silty clay loam.	CL, CH	A-4, A-6, A-7	0	100	95-100	95-100	65-99	27-60	7-34
Drummond--------	0-9	Silt loam--------	CL, ML, CL-ML	A-4, A-6	0	100	100	96-100	65-97	22-39	3-15
	9-38	Clay loam, silty clay loam, clay.	CL, CH	A-6, A-7	0	100	100	96-100	80-98	35-60	15-35
	38-60	Variable---------	---	---	---	---	---	---	---	---	---

See footnote at end of table.

TABLE 15.--ENGINEERING INDEX PROPERTIES--Continued

Map symbol and soil name	Depth	USDA texture	Classification		Frag- ments > 3 inches	Percentage passing sieve number--				Liquid limit	Plas- ticity index
			Unified	AASHTO		4	10	40	200		
	In				Pct					Pct	
36, 37----------- Norge	0-12	Silt loam--------	ML, CL, CL-ML	A-4, A-6	0	100	100	96-100	65-97	22-37	2-14
	12-17	Silty clay loam, clay loam, silt loam.	ML, CL, CL-ML	A-4, A-6, A-7	0	100	100	96-100	65-98	22-43	2-20
	17-50	Silty clay loam, clay loam.	CL	A-6, A-7	0	100	100	96-100	80-98	33-43	12-20
	50-66	Silty clay loam, clay loam.	CL	A-6, A-7	0	100	100	96-100	80-98	33-43	12-20
38*:											
Oscar-----------	0-11	Silt loam--------	ML, CL, CL-ML	A-4	0	100	100	94-100	51-97	<31	NP-10
	11-48	Silty clay loam, clay loam.	CL	A-6, A-7	0	100	100	96-100	80-98	33-43	12-20
	48-76	Silty clay loam, clay loam, silt loam.	CL, CL-ML	A-4, A-6	0	100	100	96-100	65-98	25-40	5-18
Grant-----------	0-10	Silt loam--------	ML, CL, CL-ML	A-4	0	100	100	90-100	70-90	20-32	1-10
	10-45	Silt loam, loam, silty clay loam.	ML, CL	A-4, A-6, A-7	0	100	100	90-100	70-90	30-42	8-19
	45-75	Weathered bedrock	---	---	---	---	---	---	---	---	---
39, 40----------- Pond Creek	0-14	Silt loam--------	ML, CL, CL-ML	A-4, A-6	0	100	100	96-100	65-97	22-37	3-14
	14-72	Silty clay loam, clay loam, silt loam.	CL, ML	A-4, A-6, A-7	0	100	100	96-100	65-98	30-43	8-20
41--------------- Port	0-27	Silt loam--------	CL	A-4, A-6	0	100	100	96-100	65-97	27-37	8-14
	27-72	Silty clay loam, clay loam, loam.	CL	A-4, A-6, A-7	0	100	100	96-100	65-98	27-43	8-20
42*:											
Port------------	0-22	Silt loam--------	CL	A-4, A-6	0	100	100	96-100	65-97	27-37	8-14
	22-72	Silty clay loam, clay loam, loam.	CL	A-4, A-6, A-7	0	100	100	96-100	65-98	27-43	8-20
Pocasset---------	0-14	Silt loam--------	ML, CL-ML	A-4	0	100	100	96-100	65-90	22-30	2-7
	14-40	Fine sandy loam	SC, SM, CL, ML	A-4	0	100	98-100	94-100	36-60	<30	NP-10
	40-72	Fine sandy loam, loamy fine sand.	SC, SM, CL, ML	A-2, A-4	0	100	98-100	90-100	15-60	<30	NP-10
43--------------- Pratt	0-11	Loamy fine sand	SM	A-2	0	100	95-100	70-100	15-35	---	NP
	11-40	Loamy fine sand, loamy sand, fine sandy loam.	SM, SM-SC	A-2, A-4	0	100	95-100	90-100	15-40	<20	NP-6
	40-66	Loamy fine sand, fine sand.	SM, SP-SM	A-2, A-3	0	100	95-100	80-100	5-35	---	NP
44, 45----------- Quinlan	0-14	Loam-------------	CL, ML, CL-ML	A-4, A-6	0	100	95-100	90-100	51-97	<37	NP-14
	14-30	Weathered bedrock	---	---	---	---	---	---	---	---	---

See footnote at end of table.

TABLE 15.--ENGINEERING INDEX PROPERTIES--Continued

Map symbol and soil name	Depth	USDA texture	Classification		Frag-ments > 3 inches	Percentage passing sieve number--				Liquid limit	Plas-ticity index
			Unified	AASHTO		4	10	40	200		
	In				Pct					Pct	
46*:											
Quinlan	0-14	Loam	CL, ML, CL-ML	A-4, A-6	0	100	95-100	90-100	51-97	<37	NP-14
	14-28	Weathered bedrock	---	---	---	---	---	---	---	---	---
Woodward	0-35	Loam	ML, CL, CL-ML	A-4, A-6	0	100	100	90-100	51-95	<31	NP-12
	35-40	Weathered bedrock	---	---	---	---	---	---	---	---	---
47 Reinach	0-75	Very fine sandy loam.	CL, ML, CL-ML	A-4	0	100	100	94-100	51-97	<31	NP-10
48 Renfrow	0-9	Silt loam	CL	A-4, A-6	0	100	100	96-100	65-97	30-37	8-14
	9-12	Clay loam, silty clay loam.	CL	A-6, A-7	0	100	100	96-100	80-98	37-49	15-26
	12-68	Clay, silty clay, silty clay loam.	CL, CH	A-6, A-7	0	100	100	96-100	80-99	37-70	15-38
	68-75	Weathered bedrock	---	---	---	---	---	---	---	---	---
49 Renfrow	0-6	Silty clay loam	CL	A-6, A-7	0	100	100	96-100	80-98	33-49	12-26
	6-62	Clay, silty clay, silty clay loam.	CL, CH	A-6, A-7	0	100	100	96-100	80-99	37-70	15-38
	62-70	Weathered bedrock	---	---	---	---	---	---	---	---	---
50*:											
Renfrow	0-7	Silt loam	CL	A-4, A-6	0	100	100	96-100	65-97	30-37	8-14
	7-66	Clay, silty clay, silty clay loam.	CL, CH	A-6, A-7	0	100	100	96-100	80-99	37-70	15-38
Pawhuska	0-5	Silt loam	ML, CL-ML	A-4	0	100	100	96-100	80-97	22-30	2-7
	5-65	Silty clay loam, silty clay, clay.	CL, CH	A-7	0	90-100	90-100	85-100	85-99	41-70	20-40
51 Shellabarger	0-7	Fine sandy loam	SM, ML	A-4, A-2	0	95-100	95-100	75-100	30-55	<30	NP-5
	7-42	Sandy clay loam, sandy loam, fine sandy loam.	SC	A-4, A-6	0	95-100	85-100	70-90	35-50	25-40	8-20
	42-72	Coarse sandy loam, fine sandy loam, sand.	SC, SM, SP-SM, SM-SC	A-2, A-4	0	80-100	70-100	50-80	10-40	<30	NP-10
52 Tabler	0-10	Silt loam	CL, ML, CL-ML	A-4	0	100	100	96-100	65-97	22-31	2-10
	10-30	Silty clay, clay	CL, CH	A-7	0	100	100	96-100	90-99	41-65	18-35
	30-60	Silty clay, clay, silty clay loam.	CL, CH	A-7, A-6	0	96-100	96-100	92-100	80-99	38-60	15-35
53, 54 Tivoli	0-7	Fine sand	SM, SP-SM	A-2, A-3	0	100	95-100	80-100	5-25	---	NP
	7-72	Fine sand, sand	SM, SP-SM	A-2, A-3	0	100	95-100	80-100	5-25	---	NP
55 Yahola	0-12	Fine sandy loam	SM, ML, CL-ML, SM-SC	A-4	0	100	95-100	70-100	36-60	<26	NP-7
	12-24	Fine sandy loam, loam, very fine sandy loam.	SM, ML, CL-ML, SM-SC	A-4	0	100	95-100	90-100	36-85	<26	NP-7
	24-72	Stratified clay loam to loamy fine sand.	SM, ML, CL-ML, SM-SC	A-2, A-4	0	100	95-100	90-100	15-85	<26	NP-7

* See description of the map unit for composition and behavior characteristics of the map unit.

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]

Map symbol and soil name	Depth	Clay	Moist bulk density	Permea- bility	Available water capacity	Soil reaction	Salinity	Shrink- swell potential	Erosion factors K	Erosion factors T	Wind erodi- bility group	Organic matter
	In	Pct	G/cm	In/hr	In/in	pH	mmhos/cm					Pct
1----------------- Aline	0-80	3-10	1.40-1.60	6.0-20	0.05-0.11	5.6-7.3	<2	Low--------	0.17	5	2	.5-1
2, 3------------- Attica	0-9	6-12	1.45-1.55	2.0-6.0	0.16-0.18	5.6-7.3	<2	Low--------	0.24	5	3	.5-1
	9-24	8-18	1.50-1.60	2.0-6.0	0.12-0.17	5.6-6.5	<2	Low--------	0.24			
	24-75	4-18	1.50-1.60	2.0-6.0	0.08-0.16	6.1-7.8	<2	Low--------	0.24			
4----------------- Bethany	0-12	15-26	1.30-1.50	0.6-2.0	0.16-0.24	5.6-7.3	<2	Low--------	0.43	5	5	1-3
	12-16	27-35	1.45-1.70	0.2-0.6	0.16-0.20	6.1-7.3	<2	Moderate	0.37			
	16-72	35-50	1.40-1.70	0.06-0.2	0.14-0.18	6.6-8.4	<2	High-------	0.37			
5*:												
Carwile----------	0-14	18-30	1.30-1.60	0.6-2.0	0.15-0.20	7.9-8.4	<2	Low--------	0.37	5	6	1-3
	14-59	35-60	1.35-1.75	0.06-0.2	0.12-0.20	7.9-8.4	<2	High-------	0.37			
	59-72	20-45	1.35-1.75	0.2-2.0	0.12-0.20	7.9-8.4	<2	High-------	0.32			
Attica-----------	0-12	2-10	1.50-1.60	2.0-6.0	0.10-0.13	5.6-7.3	<2	Low--------	0.17	5	2	.5-1
	12-44	8-18	1.50-1.60	2.0-6.0	0.12-0.17	5.6-6.5	<2	Low--------	0.24			
	44-75	4-18	1.50-1.60	2.0-6.0	0.08-0.16	6.1-7.8	<2	Low--------	0.24			
6, 7------------- Dale	0-36	15-26	1.30-1.50	0.6-2.0	0.15-0.24	6.1-7.8	<2	Low--------	0.37	5	5	1-3
	36-72	18-35	1.40-1.70	0.6-2.0	0.15-0.24	7.4-8.4	<2	Moderate	0.37			
8----------------- Drummond	0-9	20-30	1.35-1.55	0.6-2.0	0.08-0.12	7.4-8.4	4-16	Low--------	0.48	3	6	.5-1
	9-38	35-60	1.40-1.65	<0.06	0.06-0.12	7.9-9.0	4-16	High-------	0.37			
	38-60	---	---	---	---	---	---	-----------	----			
9, 10------------ Gaddy	0-7	5-15	1.35-1.50	6.0-20	0.07-0.11	7.4-8.4	<2	Low--------	0.17	5	2	<.5
	7-60	5-15	1.50-1.70	6.0-20	0.06-0.10	7.9-8.4	<2	Low--------	0.17			
11---------------- Goltry	0-80	5-12	1.35-1.50	6.0-20	0.05-0.11	6.1-8.4	<2	Low--------	0.17	5	2	.5-1
12---------------- Goodnight	0-6	2-10	1.35-1.50	6.0-20.0	0.02-0.06	6.1-8.4	<2	Low--------	0.15	5	1	<1
	6-60	2-12	1.50-1.70	6.0-20.0	0.02-0.11	6.6-8.4	<2	Low--------	0.15			
13---------------- Goodnight	0-6	5-12	1.35-1.50	6.0-20.0	0.05-0.11	6.1-8.4	<2	Low--------	0.17	5	2	<1
	6-80	2-12	1.50-1.70	6.0-20.0	0.02-0.11	6.6-8.4	<2	Low--------	0.15			
14---------------- Gracemont	0-9	15-28	1.30-1.55	0.6-2.0	0.15-0.20	6.6-8.4	4-16	Low--------	0.32	1	5	.5-1
	9-25	10-18	1.45-1.65	0.6-6.0	0.11-0.20	7.9-8.4	4-16	Low--------	0.32			
	25-60	10-28	1.45-1.70	0.6-6.0	0.11-0.20	7.9-8.4	4-16	Low--------	0.32			
15, 16----------- Grainola	0-6	27-35	1.30-1.60	0.2-0.6	0.15-0.22	7.4-8.4	<2	Moderate	0.43	3	4	.5-1
	6-25	35-60	1.35-1.65	0.06-0.2	0.12-0.20	7.9-8.4	<2	High-------	0.37			
	25-29	---	---	---	---	---	---	-----------	----			
17, 18----------- Grant	0-12	15-26	1.30-1.50	0.6-6.0	0.15-0.20	6.1-7.8	<2	Low--------	0.37	5	5	1-3
	12-59	18-35	1.40-1.70	0.6-2.0	0.15-0.20	6.1-8.4	<2	Low--------	0.37			
	59-65	---	---	---	---	---	---	-----------	----			
19---------------- Grant	0-8	15-26	1.30-1.50	0.6-6.0	0.15-0.20	6.1-7.8	<2	Low--------	0.37	5	5	1-3
	8-54	18-35	1.40-1.70	0.6-2.0	0.15-0.20	6.1-8.4	<2	Low--------	0.37			
	54-60	---	---	---	---	---	---	-----------	----			

See footnote at end of table.

TABLE 16.--PHYSICAL AND CHEMICAL PROPERTIES OF THE SOILS--Continued

Map symbol and soil name	Depth	Clay	Moist bulk density	Permea- bility	Available water capacity	Soil reaction	Salinity	Shrink- swell potential	Erosion factors K	Erosion factors T	Wind erodi- bility group	Organic matter
	In	Pct	G/cm	In/hr	In/in	pH	mmhos/cm					Pct
20*:												
Grant-----------	0-10	15-26	1.30-1.50	0.6-6.0	0.15-0.20	6.1-7.8	<2	Low--------	0.37	5	5	1-3
	10-50	18-35	1.40-1.70	0.6-2.0	0.15-0.20	6.1-8.4	<2	Low--------	0.37			
	50-61	---	---	---	---	---	---	-----------	----			
Kingfisher------	0-8	15-27	1.30-1.55	0.6-2.0	0.15-0.24	6.1-7.8	<2	Low--------	0.37	4	5	1-3
	8-13	25-35	1.40-1.70	0.2-0.6	0.15-0.24	6.1-7.8	<2	Moderate	0.37			
	13-27	27-35	1.45-1.70	0.2-0.6	0.15-0.22	7.4-8.4	<2	Moderate	0.32			
	27-34	---	---	---	---	---	---	-----------	----			
21*:												
Grant-----------	0-6	15-26	1.30-1.50	0.6-6.0	0.15-0.20	6.1-7.8	<2	Low--------	0.37	5	5	1-3
	6-56	18-35	1.40-1.70	0.6-2.0	0.15-0.20	6.1-8.4	<2	Low--------	0.37			
	56-60	---	---	---	---	---	---	-----------	----			
Kingfisher------	0-7	15-27	1.30-1.55	0.6-2.0	0.15-0.24	6.1-7.8	<2	Low--------	0.37	4	5	1-3
	7-12	25-35	1.40-1.70	0.2-0.6	0.15-0.24	6.1-7.8	<2	Moderate	0.37			
	12-26	27-35	1.45-1.70	0.2-0.6	0.15-0.22	7.4-8.4	<2	Moderate	0.32			
	26-40	---	---	---	---	---	---	-----------	----			
22*:												
Grant-----------	0-11	15-26	1.30-1.50	0.6-6.0	0.15-0.20	7.9-8.4	<2	Low--------	0.37	5	5	1-3
	11-55	18-35	1.40-1.70	0.6-2.0	0.15-0.20	7.9-8.4	<2	Low--------	0.37			
	55-65	---	---	---	---	---	---	-----------	----			
Port------------	0-24	12-26	1.30-1.55	0.6-2.0	0.15-0.24	5.6-7.8	<2	Low--------	0.37	5	5	1-3
	24-80	20-35	1.30-1.60	0.6-2.0	0.15-0.24	6.1-8.4	<2	Moderate	0.37			
23--------------- Hawley	0-9	10-18	1.30-1.60	2.0-6.0	0.11-0.15	5.6-7.8	<2	Low--------	0.24	5	3	0-1
	9-34	7-18	1.45-1.70	0.6-2.0	0.11-0.20	6.1-8.4	<2	Low--------	0.20			
	34-66	5-27	1.40-1.70	0.6-6.0	0.07-0.18	6.6-8.4	<2	Low--------	0.24			
24, 25, 26-------- Kingfisher	0-11	15-27	1.30-1.55	0.6-2.0	0.15-0.24	6.1-7.8	<2	Low--------	0.37	4	5	1-3
	11-17	25-35	1.40-1.70	0.2-0.6	0.15-0.24	6.1-7.8	<2	Moderate	0.37			
	17-29	27-35	1.45-1.70	0.2-0.6	0.15-0.22	7.4-8.4	<2	Moderate	0.32			
	29-41	---	---	---	---	---	---	-----------	----			
27*:												
Kingfisher------	0-7	15-27	1.30-1.55	0.6-2.0	0.15-0.24	5.6-7.8	<2	Low--------	0.37	4	5	1-3
	7-12	25-35	1.40-1.70	0.2-0.6	0.15-0.24	6.1-7.8	<2	Moderate	0.37			
	12-25	27-35	1.45-1.70	0.2-0.6	0.15-0.22	7.4-8.4	<2	Moderate	0.32			
	25-30	---	---	---	---	---	---	-----------	----			
Wakita----------	0-5	18-22	1.30-1.50	0.6-2.0	0.12-0.18	6.1-8.4	0-15	Low--------	0.43	3	4	.5-1
	5-14	25-35	1.45-1.70	0.06-0.2	0.08-0.12	6.6-8.4	0-12	-----------	0.55			
	14-32	25-35	1.45-1.70	0.06-0.2	0.08-0.12	7.4-8.4	0-12	-----------	0.55			
	32-37	---	---	---	---	---	---	-----------	----			
28*:												
Kingfisher------	0-6	15-27	1.30-1.55	0.6-2.0	0.15-0.24	6.1-7.8	<2	Low--------	0.37	4	5	1-3
	6-11	25-35	1.40-1.70	0.2-0.6	0.15-0.24	6.1-7.8	<2	Moderate	0.37			
	11-26	27-35	1.45-1.70	0.2-0.6	0.15-0.22	7.4-8.4	<2	Moderate	0.32			
	26-32	---	---	---	---	---	---	-----------	----			
Wakita----------	0-6	18-22	1.30-1.50	0.6-2.0	0.12-0.18	5.6-8.4	0-15	Low--------	0.43	3	4	.5-1
	6-9	25-35	1.45-1.70	0.06-0.2	0.08-0.12	6.6-8.4	0-12	-----------	0.55			
	9-34	25-35	1.45-1.70	0.06-0.2	0.08-0.12	7.4-8.4	0-12	-----------	0.55			
	34-42	---	---	---	---	---	---	-----------	----			
29, 30----------- Kirkland	0-10	18-27	1.30-1.50	0.6-2.0	0.16-0.24	5.6-7.3	<2	Low--------	0.49	5	6	1-3
	10-38	40-60	1.35-1.60	<0.06	0.12-0.18	6.6-8.4	<2	High-------	0.37			
	38-72	35-60	1.40-1.65	0.2-0.6	0.12-0.22	7.4-8.4	<2	High-------	0.32			

See footnote at end of table.

TABLE 16.--PHYSICAL AND CHEMICAL PROPERTIES OF THE SOILS--Continued

Map symbol and soil name	Depth	Clay	Moist bulk density	Permea- bility	Available water capacity	Soil reaction	Salinity	Shrink-swell potential	Erosion factors K	Erosion factors T	Wind erodi- bility group	Organic matter
	In	Pct	G/cm	In/hr	In/in	pH	mmhos/cm					Pct
31*:												
Kirkland--------	0-11	18-27	1.30-1.50	0.6-2.0	0.16-0.24	5.6-7.3	<2	Low-------	0.49	5	6	1-3
	11-47	40-60	1.35-1.60	<0.06	0.12-0.18	7.9-8.4	<2	High------	0.37			
	47-75	32-42	1.40-1.65	0.2-0.6	0.12-0.22	7.9-8.4	<2	High------	0.32			
Pawhuska--------	0-5	18-27	1.30-1.50	0.6-2.0	0.12-0.18	6.1-8.4	0-16	Low-------	0.49	1	6	.5-1
	5-65	35-50	1.35-1.65	<0.06	0.06-0.10	6.1-8.4	2-16	High------	0.43			
	65-68	---	---	---	---	---	---	----------	---			
32--------------- Lela	0-20	40-60	1.25-1.45	<0.06	0.10-0.18	6.1-8.4	<2	High------	0.37	5	4	1-3
	20-72	40-60	1.35-1.60	<0.06	0.10-0.14	7.4-8.4	<2	High------	0.37			
33*:												
Masham----------	0-4	40-60	1.35-1.60	<0.06	0.14-0.18	7.9-8.4	<2	High------	0.37	2	4	<2
	4-12	35-60	1.30-1.60	<0.06	0.14-0.22	7.9-8.4	<2	High------	0.37			
	12-37	---	---	---	---	---	---	----------	----			
Port------------	0-15	27-35	1.30-1.60	0.6-2.0	0.15-0.24	5.6-7.8	<2	Moderate	0.32	5	6	1-3
	15-53	20-35	1.30-1.60	0.6-2.0	0.15-0.24	7.9-8.4	<2	Moderate	0.37			
	53-70	---	---	---	---	---	---	----------	---		---	
34--------------- McLain	0-14	18-27	1.30-1.55	0.2-0.6	0.15-0.24	6.1-8.4	<2	Low-------	0.43	5	6	1-3
	14-59	35-50	1.45-1.70	0.06-0.2	0.12-0.22	6.1-8.4	<2	High------	0.37			
	59-75	20-45	1.40-1.70	0.06-0.6	0.12-0.24	6.6-8.4	<2	High------	0.43			
35*:												
McLain----------	0-12	18-27	1.30-1.55	0.2-0.6	0.15-0.24	6.1-8.4	<2	Low-------	0.43	5	6	1-3
	12-46	35-50	1.45-1.70	0.06-0.2	0.12-0.22	6.1-8.4	<2	High------	0.37			
	46-75	20-45	1.40-1.70	0.06-0.6	0.12-0.24	6.6-8.4	<2	High------	0.43			
Drummond--------	0-9	20-30	1.35-1.55	0.6-2.0	0.08-0.12	7.4-8.4	4-16	Low-------	0.48	3	6	.5-1
	9-38	35-60	1.40-1.65	<0.06	0.06-0.12	7.9-9.0	4-16	High------	0.37			
	38-60	---	---	---	---	---	---	----------	-----			
36, 37----------- Norge	0-12	15-26	1.30-1.50	0.6-2.0	0.15-0.24	5.6-7.3	<2	Low-------	0.37	5	6	1-3
	12-17	18-35	1.40-1.70	0.2-2.0	0.15-0.24	5.6-7.3	<2	Moderate	0.32			
	17-50	27-35	1.45-1.70	0.2-0.6	0.15-0.22	5.6-7.8	<2	Moderate	0.32			
	50-60	27-39	1.45-1.70	0.2-0.6	0.15-0.22	6.1-8.4	<2	Moderate	0.32			
38*:												
Oscar-----------	0-11	15-27	1.35-1.60	0.6-2.0	0.13-0.21	5.6-7.3	<2-16	Low-------	0.43	5	5	.5-1
	11-48	27-35	1.45-1.70	0.06-0.2	0.10-0.15	6.6-8.4	4-16	Moderate	0.55			
	48-76	24-35	1.40-1.65	0.06-0.2	0.10-0.15	7.4-8.4	4-16	Moderate	0.55			
Grant-----------	0-10	15-26	1.30-1.50	0.6-6.0	0.15-0.20	6.1-7.8	<2	Low-------	0.37	5	5	1-3
	10-45	18-35	1.40-1.70	0.6-2.0	0.15-0.20	6.1-8.4	<2	Low-------	0.37			
	45-75	---	---	---	---	---	---	----------	----			
39, 40----------- Pond Creek	0-14	15-26	1.30-1.50	0.6-2.0	0.15-0.20	5.6-7.3	<2	Low-------	0.37	5	6	1-3
	14-72	20-35	1.40-1.70	0.2-0.6	0.15-0.22	6.1-8.4	<2	Moderate	0.37			
41--------------- Port	0-27	12-26	1.30-1.55	0.6-2.0	0.15-0.24	5.6-7.8	<2	Low-------	0.37	5	5	1-3
	27-72	20-35	1.30-1.60	0.6-2.0	0.15-0.24	7.9-8.4	<2	Moderate	0.37			
42*:												
Port------------	0-22	12-26	1.30-1.55	0.6-2.0	0.15-0.24	5.6-7.8	<2	Low-------	0.37	5	5	1-3
	22-72	20-35	1.30-1.60	0.6-2.0	0.15-0.24	7.9-8.4	<2	Moderate	0.37			

See footnote at end of table.

TABLE 16.--PHYSICAL AND CHEMICAL PROPERTIES OF THE SOILS--Continued

Map symbol and soil name	Depth	Clay	Moist bulk density	Permeability	Available water capacity	Soil reaction	Salinity	Shrink-swell potential	Erosion factors K	Erosion factors T	Wind erodibility group	Organic matter
	In	Pct	G/cm	In/hr	In/in	pH	mmhos/cm					Pct
42*:												
Pocasset--------	0-14	12-24	1.35-1.65	0.6-2.0	0.15-0.20	6.6-8.4	<2	Low--------	0.32	5	5	1-2
	14-40	10-18	1.50-1.70	2.0-6.0	0.11-0.15	7.9-8.4	<2	Low--------	0.20			
	40-72	5-18	1.50-1.70	2.0-6.0	0.07-0.15	7.9-8.4	<2	Low--------	0.20			
43--------------- Pratt	0-11	2-8	1.40-1.55	6.0-20	0.10-0.13	5.6-7.3	<2	Low--------	0.17	5	2	.5-1
	11-40	4-11	1.45-1.55	6.0-20	0.09-0.12	5.6-7.3	<2	Low--------	0.17			
	40-66	1-8	1.45-1.60	6.0-20	0.08-0.12	6.1-7.3	<2	Low--------	0.17			
44, 45----------- Quinlan	0-14	15-27	1.30-1.55	0.6-2.0	0.13-0.24	7.4-8.4	<2	Low--------	0.37	2	4L	<1
	14-30	---	---	---	---	---	---	-----------	----			
46*:												
Quinlan---------	0-14	15-27	1.30-1.55	0.6-2.0	0.13-0.24	7.4-8.4	<2	Low--------	0.37	2	4L	<1
	14-28	---	---	---	---	---	---	-----------	----			
Woodward--------	0-35	10-18	1.30-1.60	0.6-2.0	0.13-0.20	6.6-8.4	<2	Low--------	0.37	3	4L	.5-2
	35-40	---	---	---	---	---	---	-----------	----			
47--------------- Reinach	0-75	12-18	1.30-1.55	0.6-2.0	0.13-0.24	6.1-8.4	<2	Low--------	0.37	5	5	1-3
48--------------- Renfrow	0-9	18-26	1.30-1.55	0.6-2.0	0.15-0.24	6.1-7.8	<2	Low--------	0.49	4	6	1-3
	9-12	32-40	1.45-1.70	0.2-0.6	0.15-0.20	6.1-7.8	<2	Moderate	0.43			
	12-68	35-55	1.40-1.70	<0.06	0.12-0.18	6.1-8.4	<2	High-------	0.43			
	68-75	---	---	---	---	---	---	-----------	---			
49--------------- Renfrow	0-6	27-35	1.30-1.60	0.2-0.6	0.15-0.22	6.1-7.8	<2	Moderate	0.43	4	6	1-3
	6-62	35-55	1.40-1.70	<0.06	0.12-0.18	6.1-8.4	<2	High-------	0.43			
	62-70	---	---	---	---	---	---	-----------	---		---	
50*:												
Renfrow---------	0-7	18-26	1.30-1.55	0.6-2.0	0.15-0.24	7.4-8.4	<2	Low--------	0.49	4	6	1-3
	7-42	35-55	1.40-1.70	<0.06	0.12-0.18	6.1-8.4	<2	High-------	0.43			
Pawhuska--------	0-5	18-27	1.30-1.50	0.6-2.0	0.12-0.18	6.1-8.4	0-16	Low--------	0.49	1	6	.5-1
	5-65	35-50	1.35-1.65	<0.06	0.06-0.10	6.1-8.4	2-16	High-------	0.43			
51--------------- Shellabarger	0-7	8-16	1.35-1.50	0.6-2.0	0.13-0.21	5.1-6.5	<2	Low--------	0.20	5	3	1-2
	7-42	18-27	1.45-1.60	0.6-2.0	0.16-0.18	6.1-7.8	<2	Low--------	0.28			
	42-72	3-18	1.50-1.65	0.6-2.0	0.05-0.16	6.1-8.4	<2	Low--------	0.28			
52--------------- Tabler	0-10	12-27	1.30-1.55	0.6-2.0	0.15-0.24	5.6-8.4	<2	Low--------	0.49	5	6	1-3
	10-30	40-55	1.35-1.60	<0.06	0.12-0.18	6.1-8.4	<2	High-------	0.37			
	30-60	35-55	1.35-1.65	<0.06	0.12-0.22	7.4-8.4	<2	High-------	0.37			
53, 54----------- Tivoli	0-7	1-10	1.35-1.50	6.0-20.0	0.02-0.08	6.1-7.8	<2	Low--------	0.17	5	1	<1
	7-72	1-10	1.50-1.70	6.0-20.0	0.02-0.08	6.1-8.4	<2	Low--------	0.17			
55--------------- Yahola	0-12	10-18	1.30-1.60	2.0-6.0	0.11-0.15	7.4-8.4	<2	Low--------	0.20	5	3	.5-1
	12-24	5-18	1.40-1.70	2.0-6.0	0.11-0.20	7.9-8.4	<2	Low--------	0.20			
	24-72	2-30	1.45-1.70	2.0-6.0	0.07-0.20	7.9-8.4	<2	Low--------	0.20			

* See description of the map unit for composition and behavior characteristics of the map unit.

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]

Map symbol and soil name	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			
1----------------- Aline	A	None--------	---	---	>6.0	---	---	>60	---	Low------	Moderate.
2, 3-------------- Attica	B	None--------	---	---	>6.0	---	---	>60	---	Low------	Low.
4----------------- Bethany	C	None--------	---	---	>6.0	---	---	>60	---	High-----	Low.
5*:											
Carwile**---------	D	None--------	---	---	+1-2.0	Apparent	Oct-Apr	>60	---	High-----	Moderate.
Attica-----------	B	None--------	---	---	>6.0	---	---	>60	---	Low------	Low.
6, 7-------------- Dale	B	Rare--------	---	---	>6.0	---	---	>60	---	Moderate	Low.
8----------------- Drummond	D	Rare--------	---	---	2.0-4.0	Apparent	Nov-Apr	>60	---	High-----	High.
9----------------- Gaddy	A	Frequent----	Very brief	Mar-Aug	>6.0	---	---	>60	---	Low------	Low.
10---------------- Gaddy	A	Occasional	Very brief	Mar-Aug	>6.0	---	---	>60	---	Low------	Low.
11---------------- Goltry	A	None--------	---	---	2.5-6.0	Apparent	Nov-Apr	>60	---	Moderate	Low.
12---------------- Goodnight	A	None--------	---	---	>6.0	---	---	>60	---	Low------	Low.
13---------------- Goodnight	A	Rare--------	---	---	>6.0	---	---	>60	---	Low------	Low.
14---------------- Gracemont	C	Occasional	Very brief to brief.	Mar-Aug	0.5-3.0	Apparent	Nov-May	>60	---	High-----	High.
15, 16------------ Grainola	D	None--------	---	---	>6.0	---	---	20-40	Soft	High-----	Low.
17, 18, 19-------- Grant	B	None--------	---	---	>6.0	---	---	40-60	Soft	Moderate	Low.
20*, 21*:											
Grant------------	B	None--------	---	---	>6.0	---	---	40-60	Soft	Moderate	Low.
Kingfisher-------	B	None--------	---	---	>6.0	---	---	20-40	Soft	Moderate	Low.
22*:											
Grant------------	B	None--------	---	---	>6.0	---	---	40-60	Soft	Moderate	Low.
Port-------------	B	Frequent----	Very brief to brief.	Mar-Aug	>6.0	---	---	>60	---	Moderate	Low.
23---------------- Hawley	B	Rare--------	---	---	>6.0	---	---	>60	---	Low------	Moderate.

See footnotes at end of table.

TABLE 17.--SOIL AND WATER FEATURES--Continued

Map symbol and soil name	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			
24, 25, 26-------- Kingfisher	B	None--------	---	---	>6.0	---	---	20-40	Soft	Moderate	Low.
27*, 28*:											
Kingfisher-------	B	None--------	---	---	>6.0	---	---	20-40	Soft	Moderate	Low.
Wakita-----------	C	None--------	---	---	2.0-3.0	Perched	Apr-Jun	20-40	Soft	High-----	High.
29, 30------------ Kirkland	D	None--------	---	---	>6.0	---	---	>60	---	High-----	Low.
31*:											
Kirkland---------	D	None--------	---	---	>6.0	---	---	>60	---	High-----	Low.
Pawhuska---------	D	None--------	---	---	>6.0	---	---	>60	---	High-----	High.
32---------------- Lela	D	Rare---------	---	---	>6.0	---	---	>60	---	High-----	Low.
33*:											
Masham-----------	D	None--------	---	---	>6.0	---	---	10-20	Soft	High-----	Low.
Port-------------	B	Frequent----	Very brief to brief.	Mar-Aug	>6.0	---	---	40-60	Soft	Moderate	Low.
34---------------- McLain	C	Rare---------	---	---	>6.0	---	---	>60	---	High-----	Low.
35*:											
McLain-----------	C	Rare---------	---	---	>6.0	---	---	>60	---	High-----	Low.
Drummond---------	D	Rare---------	---	---	3.0-6.0	Apparent	Nov-Apr	>60	---	High-----	High.
36, 37------------ Norge	B	None--------	---	---	>6.0	---	---	>60	---	Moderate	Low.
38*:											
Oscar------------	D	Frequent----	Very brief	Apr-Aug	>6.0	---	---	>60	---	High-----	Moderate.
Grant------------	B	None--------	---	---	>6.0	---	---	40-60	Soft	Moderate	Low.
39, 40------------ Pond Creek	B	None--------	---	---	>6.0	---	---	>60	---	Moderate	Moderate.
41---------------- Port	B	Occasional	Very brief to brief.	Mar-Aug	>6.0	---	---	>60	---	Moderate	Low.
42*:											
Port-------------	B	Frequent----	Very brief to brief.	Mar-Aug	>6.0	---	---	>60	---	Moderate	Low.
Pocasset---------	B	Frequent----	Very brief to brief.	Mar-Aug	>6.0	---	---	>60	---	Low------	Low.
43---------------- Pratt	A	None--------	---	---	>6.0	---	---	>60	---	Low------	Moderate
44, 45------------ Quinlan	C	None--------	---	---	>6.0	---	---	10-20	Soft	Moderate	Low.

See footnote at end of table.

TABLE 17.--SOIL AND WATER FEATURES--Continued

Map symbol and soil name*	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			
46*:											
Quinlan----------	C	None--------	---	---	>6.0	---	---	10-20	Soft	Moderate	Low.
Woodward---------	B	None--------	---	---	>6.0	---	---	20-40	Soft	Low------	Low.
47---------------- Reinach	B	Rare--------	---	---	>6.0	---	---	>60	---	Low------	Low.
48, 49------------ Renfrow	D	None--------	---	---	>6.0	---	---	>60	---	High-----	Low.
50*:											
Renfrow----------	D	None--------	---	---	>6.0	---	---	40-60	Soft	High-----	Low.
Pawhuska---------	D	None--------	---	---	>6.0	---	---	>60	---	High-----	High.
51---------------- Shellabarger	B	None--------	---	---	>6.0	---	---	>60	---	Low------	Moderate.
52---------------- Tabler	D	None--------	---	---	2.5-3.5	Perched	Oct-Apr	>60	---	High-----	Low.
53, 54------------ Tivoli	A	None--------	---	---	>6.0	---	---	>60	---	Low------	Low.
55---------------- Yahola	B	Occasional	Very brief to brief.	Apr-Aug	>6.0	---	---	>60	---	Low------	Low.

* See description of the map unit for composition and behavior characteristics of the map unit.

** In the "High water table--Depth" column, a plus sign preceding the range in depth indicates that the water table is above the surface of the soil. The first numeral in the range indicates how high the water rises above the surface. The second numeral indicates the depth below the surface.

TABLE 18.--PHYSICAL ANALYSES OF SELECTED SOILS

Soil name and sample number	Depth	Horizon	Particle-size distribution							
			Very coarse sand (2.0-1.0 mm)	Coarse sand (1.0-0.5 mm)	Medium sand (0.5-0.25 mm)	Fine sand (0.25-0.10 mm)	Very fine sand (0.10-0.05 mm)	Total sand (2.0-0.05 mm)	Silt (0.05-0.002 mm)	Clay (<0.002 mm)
	In		Pct	Pct	Pct	Pct	Pct	Pct	Pct	Pct
Aline sand[1]: S75-OK-27-1	0- 9	A1	0.1	5.8	47.6	33.2	4.0	90.7	4.3	5.0
	9-32	A21	0.1	4.5	44.4	40.1	4.1	93.2	1.8	5.0
	32-72	A22	0.1	4.5	46.9	41.2	4.1	96.8	0.7	2.5
	32-72	B21t	0.1	0.4	18.6	63.2	7.5	89.9	1.3	8.8
	72-80	B22t	0.1	1.6	12.5	39.5	20.5	74.2	15.1	10.7
Drummond silty clay loam:[2] S78-OK-27-5	0- 5	Ap	<0.1	0.3	3.0	2.1	2.6	8.0	54.5	37.5
	5-15	B21t	<0.1	0.3	3.0	2.0	2.7	8.0	44.5	47.5
	15-26	B22t	0.1	1.6	2.7	1.9	2.2	8.5	42.4	49.1
	26-45	B23t	0.1	0.2	1.4	1.4	1.9	5.0	38.7	56.3
	45-66	IIC1	<0.1	0.1	0.6	1.0	2.3	4.0	46.5	49.5
	66-70	IIC2	<0.1	0.5	2.3	8.5	4.8	16.1	53.3	30.6
Drummond silt loam[3]: S78-OK-27-13	0- 6	Ap	0.0	0.1	0.4	0.7	5.1	6.3	74.3	19.4
	6-21	B21t	0.0	0.1	1.0	1.4	9.3	11.8	75.1	13.1
	21-33	B22t	0.0	0.4	4.2	2.1	8.2	14.9	63.2	21.9
	33-44	B23t	0.0	0.1	1.1	0.8	4.5	6.5	69.1	24.4
	44-66	B24t	0.0	0.0	0.1	0.4	3.2	3.7	68.8	27.5
	66-86	B3	0.0	0.0	0.1	0.6	3.3	4.0	67.9	28.1
Drummond silt loam[4]: S79-OK-27-30 S79-OK-27-30	0- 6	Ap	0.1	0.1	0.2	0.3	8.0	8.7	74.8	16.5
	16-22	B21t	0.0	0.0	0.3	0.5	5.4	6.2	61.6	32.2
	26-30	B22t	0.5	0.5	0.8	1.2	7.9	10.9	53.3	35.8
	39-45	B3	0.1	0.2	6.0	10.4	17.9	34.6	41.3	24.1
	45-52	C	0.1	0.1	0.2	0.4	10.2	11.0	69.0	20.0
Oscar silt loam[5]: S78-OK-27-7	0- 5	Ap	<0.1	0.2	0.7	0.5	1.9	3.3	69.8	26.9
	5-13	B21t	<0.1	0.1	0.2	0.2	1.6	2.1	63.5	34.4
	13-28	B22t	<0.1	<0.1	0.1	0.2	2.6	2.9	66.5	30.6
	28-74	B3	<0.1	<0.1	0.1	0.7	4.6	5.4	65.2	29.4
	74-78	C	<0.1	<0.1	0.2	1.0	5.8	7.0	66.1	26.9
Oscar silt loam[6]: S78-OK-27-9	0- 2	A1	0.1	1.5	9.7	9.0	8.3	28.6	53.3	18.1
	2-16	B21t	0.3	2.1	9.5	10.2	7.6	29.7	39.1	31.2
	16-25	B22t	0.1	2.0	9.5	7.7	6.2	25.5	41.1	33.4
	25-34	B23t	0.1	1.3	7.6	5.8	3.3	18.1	45.1	36.8
	34-47	B24t	0.1	0.6	5.9	4.7	2.5	13.8	46.2	40.0
	47-73	C	0.1	0.9	7.5	5.4	2.9	16.8	45.4	37.8
Oscar silt loam[7]: S79-OK-27-34	0-11	A1	0.0	0.1	0.1	0.2	15.0	15.4	61.2	23.4
	11-22	B21t	0.4	0.9	1.5	0.9	10.6	14.3	66.2	19.5
	22-34	B22t	2.1	2.9	3.0	1.3	11.5	20.8	54.1	25.1
	34-50	B3	1.5	1.5	1.3	0.8	10.1	15.2	58.9	25.9
Pawhuska silt loam[8]: S79-OK-27-25	0- 6	Ap	0.0	0.2	0.9	1.2	19.8	22.1	66.0	11.9
	9-13	B21t	0.0	0.2	0.9	1.1	16.2	18.4	43.9	37.7
	14-19	B22t	1.0	1.5	1.8	1.7	17.1	23.1	42.8	34.1
	22-28	B23t	1.4	1.3	2.0	3.0	19.3	27.0	43.5	29.5
	36-46	B24t	0.3	0.4	1.4	2.0	22.4	26.5	46.3	27.2

See footnotes at end of table.

TABLE 18.--PHYSICAL ANALYSES OF SELECTED SOILS--Continued

Soil name and sample number	Depth	Horizon	Particle-size distribution							
			Very coarse sand (2.0-1.0 mm)	Coarse sand (1.0-0.5 mm)	Medium sand (0.5-0.25 mm)	Fine sand (0.25-0.10 mm)	Very fine sand (0.10-0.05 mm)	Total sand (2.0-0.05 mm)	Silt (0.05-0.002 mm)	Clay (<0.002 mm)
	In		Pct	Pct	Pct	Pct	Pct	Pct	Pct	Pct
Pawhuska	0- 7	Ap	0.4	1.3	7.2	4.5	4.4	17.8	47.1	35.1
silty clay loam[9]:	7-25	B21t	0.1	0.6	2.7	2.1	8.0	13.5	49.0	37.5
S79-OK-27-23	25-35	B22t	0.2	0.4	2.1	1.5	4.1	8.3	55.3	36.4
	35-44	B23t	0.2	0.3	1.5	1.4	4.9	8.3	49.7	42.0
Pawhuska	0- 5	Ap	0.0	0.3	3.0	2.1	2.6	8.0	54.5	37.5
silty clay loam[10]:	5-15	B21t	0.0	0.3	3.0	2.0	2.6	7.9	44.6	47.5
S78-OK-27-12	15-26	B22t	0.1	1.6	2.7	1.9	2.2	8.5	42.4	49.1
	26-44	B23t	0.1	0.2	1.4	1.4	2.0	5.1	38.6	56.3
	44-60	B31	0.1	0.1	0.6	1.0	2.3	4.1	46.4	49.5
	60-66	B32	0.0	0.1	2.4	8.8	4.9	16.2	53.2	30.6
Pawhuska	0- 7	Ap	0.1	0.7	1.9	1.6	9.7	14.0	63.4	22.6
silt loam[11]:	7-13	B21t	0.2	0.8	2.4	1.3	7.0	11.7	58.2	30.1
S81-OK-27-1	13-20	B22t	0.3	1.4	3.0	2.2	11.1	18.0	56.2	25.8
	20-26	B23t	0.5	1.6	3.6	2.1	11.7	19.5	54.6	25.9
	26-34	B24t	0.4	1.4	3.8	2.1	12.6	20.3	52.1	27.6
	34-42	B31	0.3	1.5	4.1	2.4	14.2	22.5	51.5	26.0
	42-60	B32	0.2	1.2	3.2	2.1	16.8	23.5	55.2	21.3
Pawhuska	0- 4	Ap	0.0	0.3	0.7	1.1	6.3	8.4	73.3	18.3
silt loam[12]:	4-12	B21t	0.0	0.1	0.3	0.6	2.8	3.8	59.2	37.0
S81-OK-27-2	12-20	B22t	0.1	0.3	0.8	1.7	2.5	5.4	55.7	38.9
	20-30	B23t	0.0	0.0	0.0	0.3	0.9	1.2	73.0	25.8
	30-35	B3	0.0	0.0	0.0	0.6	2.4	3.0	81.2	15.8
Pawhuska	0- 4	Ap	0.1	0.2	0.6	0.9	6.9	8.7	74.3	17.0
silt loam[13]:	4-10	B21t	0.1	0.1	0.3	0.4	3.2	4.1	50.2	45.7
S78-OK-27-4	10-19	B22t	0.1	0.1	0.2	0.4	2.6	3.4	55.3	41.3
	19-45	B23t	0.2	0.1	0.1	0.3	1.3	2.0	70.8	27.2
	45-53	B31	0.2	0.7	0.8	0.8	1.1	3.6	71.3	25.1
	53-57	B32	0.1	0.1	0.1	0.1	0.5	0.9	78.9	20.2
Tivoli sand[14]:	0- 7	A	0.1	8.8	47.8	33.4	3.3	93.4	2.8	3.8
S75-OK-27-5	7-18	AC	0.2	9.1	49.3	34.6	3.2	96.4	1.1	2.5
	18-73	C	0.3	20.0	51.3	22.5	2.4	96.5	1.0	2.5
Wakita silt loam[15]:	0- 4	Ap	0.0	0.3	0.7	1.1	6.3	8.4	73.3	18.3
S77-OK-27-2	4-12	B21t	0.0	0.1	0.2	0.6	2.9	3.7	59.2	37.0
	12-20	B22t	0.1	0.3	0.8	1.7	2.6	5.5	55.7	38.8
	20-30	B23t	0.0	0.0	0.0	0.3	0.9	1.2	73.0	25.8
	30-36	B3	0.0	0.0	0.0	0.6	2.4	3.0	81.2	15.8
Wakita silt loam[16]:	0- 3	Ap	0.0	0.2	0.4	0.6	5.4	6.6	74.0	19.4
S-77-OK-27-3	3- 9	A1	0.0	0.1	0.2	0.5	5.9	6.7	70.8	22.5
	9-15	B21t	0.0	0.1	0.2	0.5	5.3	6.1	60.8	33.1
	15-26	B22t	0.0	0.1	0.3	0.5	2.4	3.4	59.7	36.9
	26-40	B23t	0.0	0.0	0.1	0.3	2.7	3.1	68.1	28.8
	40-50	Cr	0.5	0.2	0.1	0.2	1.1	2.1	77.2	20.7

See footnotes at end of table.

TABLE 18.--PHYSICAL ANALYSES OF SELECTED SOILS--Continued

Soil name and sample number	Depth	Horizon	Particle-size distribution							
			Very coarse sand (2.0-1.0 mm)	Coarse sand (1.0-0.5 mm)	Medium sand (0.5-0.25 mm)	Fine sand (0.25-0.10 mm)	Very fine sand (0.10-0.05 mm)	Total sand (2.0-0.05 mm)	Silt (0.05-0.002 mm)	Clay (<0.002 mm)
	In		Pct	Pct	Pct	Pct	Pct	Pct	Pct	Pct
Wakita silt loam[17]: S77-OK-27-4	0- 4	Ap	0.0	0.2	0.7	0.9	6.9	8.7	74.3	17.0
	4-10	B21t	0.0	0.1	0.3	0.4	3.2	4.0	50.2	45.8
	10-19	B22t	0.0	0.1	0.2	0.4	2.8	3.5	55.3	41.2
	19-45	B3	0.2	0.1	0.1	0.3	1.3	2.0	70.8	27.2
	45-53	Cr1	0.2	0.7	0.8	0.8	1.1	3.6	71.3	25.1
	53-60	Cr2	0.1	0.1	0.1	0.1	0.6	1.0	78.9	20.1
Wakita silt loam[18]: S78-OK-27-1 (S77-OK-27-1)	0- 5	Ap	0.0	0.1	0.2	0.5	12.4	13.2	73.8	13.0
	5-14	B21t	0.0	0.1	0.2	0.4	7.3	8.0	65.9	16.1
	14-22	B22t	0.0	0.1	0.2	0.4	2.3	3.0	57.8	39.2
	22-23	B3	0.0	0.0	0.0	0.1	0.7	0.8	78.7	20.5
	33-37	Cr	0.0	0.0	0.0	0.2	0.8	1.0	84.8	14.2
Wakita silt loam[19]: S79-OK-27-22	0- 6	Ap	2.4	5.5	11.0	4.3	20.0	43.2	47.0	9.8
	6-18	B21t	1.8	4.6	5.8	2.2	15.1	29.5	44.3	26.2
	18-27	B22t	1.5	2.6	2.4	0.9	3.6	11.0	53.2	35.8
	27-34	B3	0.0	0.3	0.5	0.2	3.3	4.3	66.2	29.5
	34-42	Cr	0.0	0.1	0.1	0.1	3.8	4.1	73.5	22.4

[1] Located 1,200 feet east and 2,200 feet north of the southwest corner of sec. 7, T. 27 N., R. 8 E. The 32-to-72-inch layer, which consists of layers of A2 and B2 material, was subdivided for sampling purposes.

[2] Located 530 feet north and 86 feet east of the southwest corner of sec. 5, T. 27 N., R. 6 W.

[3] Located 650 feet west and 1,050 feet north of the southeast corner of sec. 36, T. 27 N., R. 3 W. The clay content is slightly less than allowed in the control section of the Drummond series, and this pedon is considered a taxadjunct. It is classified as fine-silty, mixed, thermic Mollic Natrustalfs.

[4] Located 800 feet east and 600 feet north of the southwest corner of sec. 4, T. 26 N., R. 4 W. The A12 horizon (8 to 16 inches) and B22t horizon (22 to 28 inches) were not sampled. The clay content of the control section averages slightly less than allowed in the Drummond series. This pedon is considered a taxadjunct and is classified as fine-silty, mixed, thermic Mollic Natrustalfs.

[5] Located 650 feet west and 1,020 feet north of the southeast corner of sec. 36, T. 27 N., R. 3 W. This pedon has an A horizon with moist colors of 3 or less and is considered a taxadjunct of the Oscar series. It is classified as fine-silty, mixed, thermic Mollic Natrustalfs.

[6] Located 1,410 feet south and 360 feet west of the northeast corner of sec. 22, T. 27 N., R. 8 W. This pedon has a natric horizon that is less silty than allowed for the Oscar series. This pedon is considered a taxadjunct. It is classified as fine-loamy, mixed, thermic Typic Natrustalfs.

[7] Located 900 feet east and 340 feet north of the southwest corner of sec. 33, T. 28 N., R. 5 W. (Typical pedon for the series in Grant County.)

[8] Located 1,300 feet east and 230 feet south of the northwest corner of sec. 35, T. 25N., R. 7 W. This pedon is less red in the lower part of the natric horizon and has less clay than is typical for the Pawhuska series. This pedon is a taxadjunct.

[9] Located 580 feet east and 2,250 feet south of the northwest corner of sec. 14, T. 27 N., R. 7 W.

[10] Located 600 feet north and 75 feet east of the southwest corner of sec. 5, T. 27 N., R. 6 W.

[11] Located 1,600 feet east and 620 feet north of the southwest corner of sec. 29, T. 25 N., R. 4 W. The pedon is less clayey in the natric horizon than allowed for the Pawhuska soils. It is a taxadjunct to the Pawhuska series and is included in map unit 31 of this survey.

[12] Located 1,830 feet south and 580 feet east of the northwest corner of sec. 12, T. 25 N., R. 7 W.

[13] Located 1,630 feet south and 380 feet east of the northwest corner of sec. 13, T. 25 N., R. 7 W.

[14] Located 360 feet west and 1,320 feet north of the southeast corner of sec. 31, T. 27 N., R. 8 W. This soil has lamellae in the lower part of the pedon and is moist for longer periods of time than is allowed in the Tivoli series. It is a taxadjunct to the Tivoli series and is classified as mixed, thermic Alfic Ustipsamments. (Typical pedon for the series in Grant County.)

[15] Located 1,740 feet south and 400 feet east of the northwest corner of sec. 12, T. 25 N., R. 7 W. The clay content of the natric horizon is more than allowed for the Wakita series, and this pedon is a taxadjunct. It is classified as fine, mixed, thermic Mollic Natrustalfs and is included in map unit 27 of this survey.

[16] Located 1,800 feet south and 200 feet east of the northwest corner of sec. 12, T. 25 N., R. 7 W.

[17] Located 1,690 feet south and 412 feet east of the northwest corner of sec. 12, T. 25 N., R. 7 W. The clay content of the natric horizon is more than allowed for the Wakita series, and this pedon is a taxadjunct. It is classified as fine, mixed, thermic Mollic Natrustalfs and is included in map unit 27 of this survey.

[18] Located 1,834 feet south and 444 feet east of the northwest corner of sec. 12, T. 25 N., R. 7 W. (Typical pedon for the official series.)

[19] Located 1,550 feet west and 460 feet south of the northeast corner of sec. 12, T. 25 N., R. 7 W. This pedon has a lighter colored surface layer than is typical for the Wakita series and is considered a taxadjunct. It is classified as fine-silty, mixed, thermic Typic Natrustalfs.

TABLE 19.--CHEMICAL ANALYSES OF SELECTED SOILS

[The location of each pedon and other pertinent information are given in the footnotes following Table 18. Dashes indicate that data were not available]

Soil name and sample number	Depth	Horizon	Extractable bases (milliequivalents per 100 grams of soil)				Cation exchange capacity	Base saturation	Reaction 1:1 soil:water	Organic matter	Electrical conductivity	Sodium absorption
			Ca	Mg	K	Na						
	In							Pct	pH	Pct	mmhos/CM	
Aline sand: S78-OK-27-1	0- 9	A1	1.15	0.38	0.12	0.11	1.7	45.9	5.8	0.92	---	---
	9-32	A21	0.72	0.21	0.08	0.10	1.3	55.2	5.6	0.17	---	---
	32-72	A22	0.81	0.30	0.08	0.13	1.4	62.8	6.0	0.12	---	---
	32-72	B21t	1.91	1.44	0.19	0.13	5.5	65.4	5.8	0.12	---	---
	72-80	B22t	2.63	1.74	0.25	0.13	6.9	68.3	5.7	0.20	---	---
Drummond silty clay loam: S78-OK-27-5	0- 5	Ap	21.40	4.10	0.90	4.10	18.8	95.3	7.8	1.40	13.0	27.0
	5-15	B21t	20.40	9.80	0.90	9.80	22.0	95.5	7.9	1.10	9.0	25.0
	15-26	B22t	32.90	12.40	0.80	12.40	32.8	98.2	8.0	0.60	7.9	20.0
	26-45	B23t	23.80	4.30	0.70	4.30	35.7	95.9	7.9	0.30	9.9	26.0
	45-66	IIC1	14.40	12.90	0.70	12.90	30.4	96.7	3.2	0.20	4.0	28.0
	66-70	IIC2	15.30	16.60	0.60	16.60	22.7	96.3	8.2	0.20	3.9	26.0
Drummond silt loam: S78-OK-27-13	0- 6	Ap	---	---	0.42	4.50	14.4	---	7.6	0.94	1.3	19.5
	6-21	B21t	---	---	0.54	11.96	18.3	---	8.0	0.75	4.2	15.7
	21-33	B22t	---	---	0.54	12.18	17.1	---	8.1	0.40	9.1	16.7
	33-44	B23t	---	---	0.50	7.18	15.6	---	8.2	0.23	2.5	28.3
	44-66	B24t	---	---	0.56	11.70	12.4	---	8.4	0.17	1.0	11.9
	66-86	B3	---	---	---	---	---	---	---	---	---	---
Drummond silt loam S79-OK-27-30	0- 8	Ap	7.90	3.60	0.40	1.70	13.1	88.0	6.9	---	1.20	10.0
	16-22	B21t	6.70	10.50	0.60	11.70	19.9	90.0	8.3	---	5.9	28.0
	28-39	B23t	---	12.10	0.70	13.70	20.3	---	8.5	---	5.7	33.0
	39-47	B3	4.60	7.50	0.40	7.70	13.7	97.0	8.6	---	3.9	32.0
	47-52	C	4.90	7.20	0.30	6.30	13.5	97.0	8.6	---	3.4	26.0
Oscar silt loam: S78-OK-27-7	0- 5	Ap	6.60	6.50	0.40	3.10	14.4	88.3	7.6	0.90	1.4	17.0
	5-13	B21t	60.00	5.70	0.50	7.90	18.3	98.1	8.0	0.80	4.2	18.0
	13-28	B22t	36.20	7.40	0.40	3.30	17.0	98.7	8.1	0.40	9.1	24.0
	28-74	B3	9.50	9.00	0.50	4.40	15.6	95.1	8.2	0.20	2.6	14.0
	74-78	C	28.10	11.10	0.50	10.70	12.4	97.3	8.4	0.20	1.0	12.0
Oscar silt loam: S78-OK-27-9	0- 2	A1	15.20	11.90	1.80	1.50	20.4	93.5	7.7	4.20	1.1	11.0
	2-16	B21t	25.80	13.30	0.70	10.60	17.5	98.4	8.5	0.80	9.4	56.0
	16-25	B22t	13.50	13.60	0.60	17.20	15.9	98.7	8.8	0.30	7.8	66.0
	25-34	B23t	19.00	13.50	0.70	11.40	20.3	96.1	8.7	0.30	5.1	50.0
	34-47	B24t	23.70	10.90	0.80	20.20	21.3	96.7	8.7	0.40	5.2	48.0
	47-73	C	18.20	13.90	0.70	18.60	21.4	96.4	8.6	0.30	3.8	40.0

TABLE 19.--CHEMICAL ANALYSES OF SELECTED SOILS--Continued

Soil name and sample number	Depth	Horizon	Extractable bases (milliequivalents per 100 grams of soil)				Cation exchange capacity	Base saturation	Reaction 1:1 soil:water	Organic matter	Electrical conductivity	Sodium absorption
			Ca	Mg	K	Na						
	In							Pct	pH	Pct	mmhos/CM	
Oscar silt loam:	0-11	A	14.60	4.70	0.50	25.7	15.1	46.1	7.7	---	15.1	53.0
S79-OK-27-34	11-22	B21t	11.60	5.60	0.30	23.5	12.9	41.0	8.7	---	16.1	86.0
	23-34	B22t	---	7.50	0.40	21.3	18.0	---	9.1	---	8.9	104.0
	34-48	B3	---	5.50	0.40	20.3	14.3	---	9.1	---	6.4	100.0
Pawhuska silt	0- 6	Ap	4.30	2.80	0.40	2.20	9.3	10.7	7.6	---	1.5	17.0
loam:	9-13	B21t	12.40	8.40	0.60	9.60	27.8	32.0	7.9	---	4.2	24.0
S79-OK-27-25	14-19	B22t	---	8.20	0.50	10.20	22.8	---	8.0	---	7.9	21.0
	22-28	B23t	---	8.10	0.50	10.80	19.1	---	8.0	---	9.7	19.0
	36-46	B24t	---	7.30	0.50	10.60	17.0	---	7.9	---	11.7	21.0
Pawhuska silty	0- 7	Ap	12.96	9.50	0.76	1.48	29.9	79.3	7.2	1.55	3.2	4.9
clay loam:	0-25	B21t	26.14	8.60	0.53	4.26	33.6	91.2	8.2	0.85	2.2	12.7
S79-OK-27-23	25-35	B22t	24.28	12.01	0.51	6.72	41.9	92.7	7.9	0.76	4.5	16.0
	35-44	B23t	21.86	12.70	0.58	7.66	45.9	93.1	7.7	0.65	4.7	16.6
Pawhuska silty	0- 5	Ap	---	---	0.94	17.49	18.8	---	7.8	1.43	13.0	25.4
clay loam:	5-15	B21t	---	---	0.91	16.53	22.0	---	7.9	1.09	9.0	30.4
S78-OK-27-12	15-20	B22t	---	---	0.81	16.09	37.8	---	8.0	0.61	7.9	27.3
	26-44	B23t	---	---	0.73	16.44	35.7	---	7.9	0.29	9.9	21.9
	44-60	B31	---	---	0.66	12.31	30.4	---	8.2	0.17	4.0	28.1
	60-66	B32	---	---	0.57	10.44	22.7	---	8.2	0.18	3.9	25.1
Pawhuska silt	0- 7	Ap	10.63	9.06	0.47	4.79	23.4	95.4	7.5	1.03	2.9	18.0
loam:	7-13	B21t	30.04	12.69	0.36	10.05	29.2	97.6	7.3	0.63	8.8	35.0
(S81-OK-27-1)	13-20	B22t	12.03	9.89	0.30	10.58	25.6	95.9	7.3	0.33	8.6	41.0
	20-26	B23t	10.92	10.14	0.30	11.01	26.0	96.8	7.8	0.26	8.6	42.0
	26-34	B24t	9.02	8.57	0.31	10.19	26.3	95.9	7.7	0.18	8.2	38.0
	34-42	B31	9.27	8.16	0.33	9.13	25.5	98.0	6.4	0.19	7.5	35.0
	42-60	B32	7.25	5.73	0.26	6.59	21.5	97.3	7.3	0.14	7.6	30.0
Pawhuska silt	0- 4	Ap	4.90	3.90	0.50	0.90	13.8	75.0	6.0	1.70	1.1	12.0
loam:	4-12	B21t	6.50	9.90	0.90	4.10	23.5	93.0	7.3	1.30	4.2	23.0
S78-OK-27-2	12-20	B22t	28.40	15.50	0.90	5.70	24.0	99.8	8.0	0.70	5.7	25.0
	20-30	B23t	20.90	11.00	0.30	2.90	10.5	99.7	8.7	0.20	5.0	22.0
	30-35	B3	30.20	7.50	0.30	1.90	8.1	99.0	8.2	0.10	4.1	20.0

TABLE 19.--CHEMICAL ANALYSES OF SELECTED SOILS--Continued

Soil name and sample number	Depth	Horizon	Extractable bases (milliequivalents per 100 grams of soil)				Cation exchange capacity	Base saturation	Reaction 1:1 soil:water	Organic matter	Electrical conductivity	Sodium absorption
			Ca	Mg	K	Na						
	In							Pct	pH	Pct	mmhos/CM	
Pawhuska silt loam: S78-OK-27-4	0- 4	Ap	4.80	3.70	0.50	1.30	11.1	73.0	6.3	1.40	5.0	18.0
	4-10	B21t	8.10	11.10	0.70	5.80	26.0	89.5	7.6	1.30	5.0	21.0
	10-19	B22t	32.70	10.80	0.60	4.10	26.7	99.8	7.8	0.70	8.4	21.0
	19-45	B23t	33.70	7.10	0.30	3.00	12.1	99.1	8.0	0.40	6.8	25.0
	45-53	B31	30.00	6.70	0.30	2.60	8.8	98.0	8.3	0.20	2.7	24.0
	53-57	B32	29.70	7.00	0.30	3.40	10.5	97.6	8.4	0.30	3.1	23.0
Tivoli sand: S75-OK-27-5	0- 7	A	1.27	0.51	0.09	0.13	1.5	79.4	6.4	0.51	---	---
	7-18	C1	1.15	0.30	0.07	0.13	1.3	86.3	6.4	0.29	---	---
	18-73	C2	0.81	0.51	0.06	0.13	2.2	79.4	6.7	0.21	---	---
Wakita silt loam: S77-OK-27-2	0- 4	Ap	5.14	4.06	0.72	1.83	13.8	77.4	6.0	1.70	1.1	6.4
	4-12	B21t	6.91	10.67	0.86	8.70	23.5	94.3	7.3	1.26	4.2	18.8
	12-20	B22t	28.81	16.68	0.86	12.35	24.0	100.0	8.0	0.69	5.7	24.4
	20-30	B23t	31.26	11.68	0.32	8.35	10.5	100.0	8.7	0.24	5.0	22.8
	30-36	B3	30.50	7.99	0.26	6.31	8.1	99.1	8.2	0.12	4.1	21.6
Wakita silt loam: S77-OK-27-3	0- 3	Ap	7.21	4.49	0.94	0.20	14.2	76.1	6.1	1.89	1.5	0.5
	3- 9	A1	6.52	5.36	0.53	0.30	15.4	67.8	6.3	1.77	0.3	1.3
	9-15	B21t	6.35	10.71	0.52	1.22	20.8	86.2	7.5	1.06	0.5	4.1
	15-26	B22t	28.07	16.68	0.52	3.28	20.4	98.3	8.5	0.54	1.6	10.8
	26-40	B23t	29.64	12.53	0.28	3.44	11.6	97.1	8.7	0.24	2.1	16.4
	40-50	Cr	28.81	7.65	0.28	2.81	8.4	97.6	8.7	0.16	1.5	18.0
Wakita silt loam: S77-OK-27-4	0- 4	Ap	5.62	4.84	0.47	5.66	11.1	81.2	6.3	1.40	5.0	14.4
	4-10	B21t	8.47	11.75	0.66	10.92	26.0	91.4	7.6	1.31	5.0	22.3
	10-19	B22t	34.17	13.26	0.61	12.62	27.7	100.0	7.8	0.73	8.4	18.9
	19-45	B3	34.43	8.25	0.32	10.18	12.1	99.2	8.0	0.37	6.8	24.1
	45-53	Cr1	30.46	6.78	0.28	7.05	8.8	98.2	8.3	0.21	2.7	24.3
	53-60	Cr2	30.02	7.08	0.33	6.74	10.5	97.9	8.4	0.26	3.1	23.7
Wakita silt loam: S78-OK-27-1 (S77-OK-27-1)	0- 5	Ap	2.68	6.70	0.40	18.44	9.2	93.6	5.8	0.82	14.1	32.8
	5-14	B21t	3.15	6.70	0.36	10.40	14.9	93.8	7.6	0.94	6.2	30.7
	14-22	B22t	27.48	11.23	0.60	16.62	22.8	97.8	7.7	0.80	10.4	22.1
	22-32	B3	33.87	8.16	0.31	10.83	12.3	99.5	8.2	0.34	8.4	20.1
	32-37	Cr	29.07	5.27	0.19	7.13	6.6	83.6	8.4	0.06	4.5	34.9
Wakita silt loam: S79-OK-27-22	0- 6	Ap	6.60	2.40	0.50	4.40	7.1	100	8.8	---	3.9	37.0
	6-18	B21t	8.70	5.50	0.40	13.80	13.1	100	9.3	---	4.8	87.0
	18-27	B22t	---	7.60	0.40	15.00	13.7	---	9.3	---	5.0	101.0
	27-34	B3	---	6.90	0.40	14.30	14.7	---	9.4	---	4.2	97.0
	34-42	Cr	---	4.10	0.30	8.10	9.9	---	9.7	---	1.8	76.0

TABLE 20.--ENGINEERING INDEX TEST DATA

[Dashes indicate data were not available. NP means nonplastic]

Soil name, report number, horizon and depth in inches	Classification		Grain-size distribution						Liquid limit	Plasticity index
			Percentage passing sieve--				Percentage smaller than--			
	AASHTO	Unified	No. 4	No. 10	No. 40	No. 200	.005 mm	.002 mm		
									Pct	
Aline sand*:										
(S75-OK-27-1)										
A1-----------0 to 9	A-2-4(0)	SP-SM	100	100	89	11	1	1	---	NP
A2-----------9 to 32	A-3 (0)	SP-SM	100	100	94	7	3	2	---	NP
A22&B21t----32 to 72	A-2-4(0)	SM	100	100	99	15	9	9	---	NP
B22t&A23----72 to 80	A-4 (0)	SM	100	100	98	40	12	11	---	NP
Tivoli fine sand**:										
(S75-OK-27-5)										
A------------0 to 7	A-2-4(C)	SM	100	100	94	22	2	1	---	NP
C2----------18 to 72	A-2-4(0)	SM	100	100	82	24	3	2	---	NP

*Location of sample pedon: 1,200 feet east and 2,200 feet north of the southwest corner of sec. 7, T. 27 N., R. 8 W.

**Typical pedon for the series in Grant County.

TABLE 21.--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
Aline	Sandy, mixed, thermic Psammentic Paleustalfs
Attica	Coarse-loamy, mixed, thermic Udic Haplustalfs
Bethany	Fine, mixed, thermic Pachic Paleustolls
*Carwile	Fine, mixed, thermic Typic Argiaquolls
Dale	Fine-silty, mixed, thermic Pachic Haplustolls
Drummond	Fine, mixed, thermic Mollic Natrustalfs
Gaddy	Sandy, mixed, thermic Typic Ustifluvents
Goltry	Sandy, mixed, thermic Psammentic Paleustalfs
Goodnight	Mixed, thermic Typic Ustipsamments
Gracemont	Coarse-loamy, mixed (calcareous), thermic Aquic Udifluvents
Grainola	Fine, mixed, thermic Vertic Haplustalfs
*Grant	Fine-silty, mixed, thermic Udic Argiustolls
Hawley	Coarse-loamy, mixed, thermic Fluventic Ustochrepts
*Kingfisher	Fine-silty, mixed, thermic Udic Argiustolls
*Kirkland	Fine, mixed, thermic Udertic Paleustolls
Lela	Fine, mixed, thermic Udic Chromusterts
Masham	Clayey, mixed, thermic, shallow Typic Ustochrepts
McLain	Fine, mixed, thermic Pachic Argiustolls
Norge	Fine-silty, mixed, thermic Udic Paleustolls
Oscar	Fine-silty, mixed, thermic Typic Natrustalfs
Pawhuska	Fine, mixed, thermic Mollic Natrustalfs
*Pocasset	Coarse-loamy, mixed, thermic Fluventic Haplustolls
Pond Creek	Fine-silty, mixed, thermic Pachic Argiustolls
*Port	Fine-silty, mixed, thermic Cumulic Haplustolls
Pratt	Sandy, mixed, thermic Psammentic Haplustalfs
Quinlan	Loamy, mixed, thermic, shallow Typic Ustochrepts
Reinach	Coarse-silty, mixed, thermic Pachic Haplustolls
*Renfrow	Fine, mixed, thermic Udertic Paleustolls
Shellabarger	Fine-loamy, mixed, thermic Udic Argiustolls
Tabler	Fine, montmorillonitic, thermic Vertic Argiustolls
*Tivoli	Mixed, thermic Typic Ustipsamments
Wakita	Fine-silty, mixed, thermic Mollic Natrustalfs
*Woodward	Coarse-silty, mixed, thermic Typic Ustochrepts
Yahola	Coarse-loamy, mixed (calcareous), thermic Typic Ustifluvents

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