SOIL SURVEY OF

Kittson County, Minnesota

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

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

Major fieldwork for this soil survey was completed in the period 1965–74. Soil names and descriptions were approved in 1974. Unless otherwise indicated, statements in the publication refer to conditions in the county in 1972. This survey was made cooperatively by the Soil Conservation Service, the Minnesota Agricultural Experiment Station, and the Kittson County Agricultural Extension Service. It is part of the technical assistance furnished to the Kittson Soil and Water Conservation District.

HOW TO USE THIS SOIL SURVEY

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

Locating Soils

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

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

Finding and Using Information

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

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

Farmers and those who work with farmers can learn about use and management of the soils from the soil descriptions and from the discussions of the capability units, and the range sites.

Foresters and others can refer to the section "Windbreak and environmental plantings," where the soils of the county are grouped according to their suitability for trees.

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

Ranchers and others can find, under "Range," groupings of the soils according to their suitability for range, and also the names of many of the plants that grow on each range site.

Community planners and others can read about soil properties that affect the choice of sites for dwellings and recreation areas in the sections "Building site development," "Sanitary facilities," and "Recreation."

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

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

Newcomers in Kittson County, Minnesota, may be especially interested in the section "General soil map," where broad patterns of soils are described. They may also be interested in the information about the county given in the section "General nature of the county."

Cover: **Swathing wheat on Northcote soils.**

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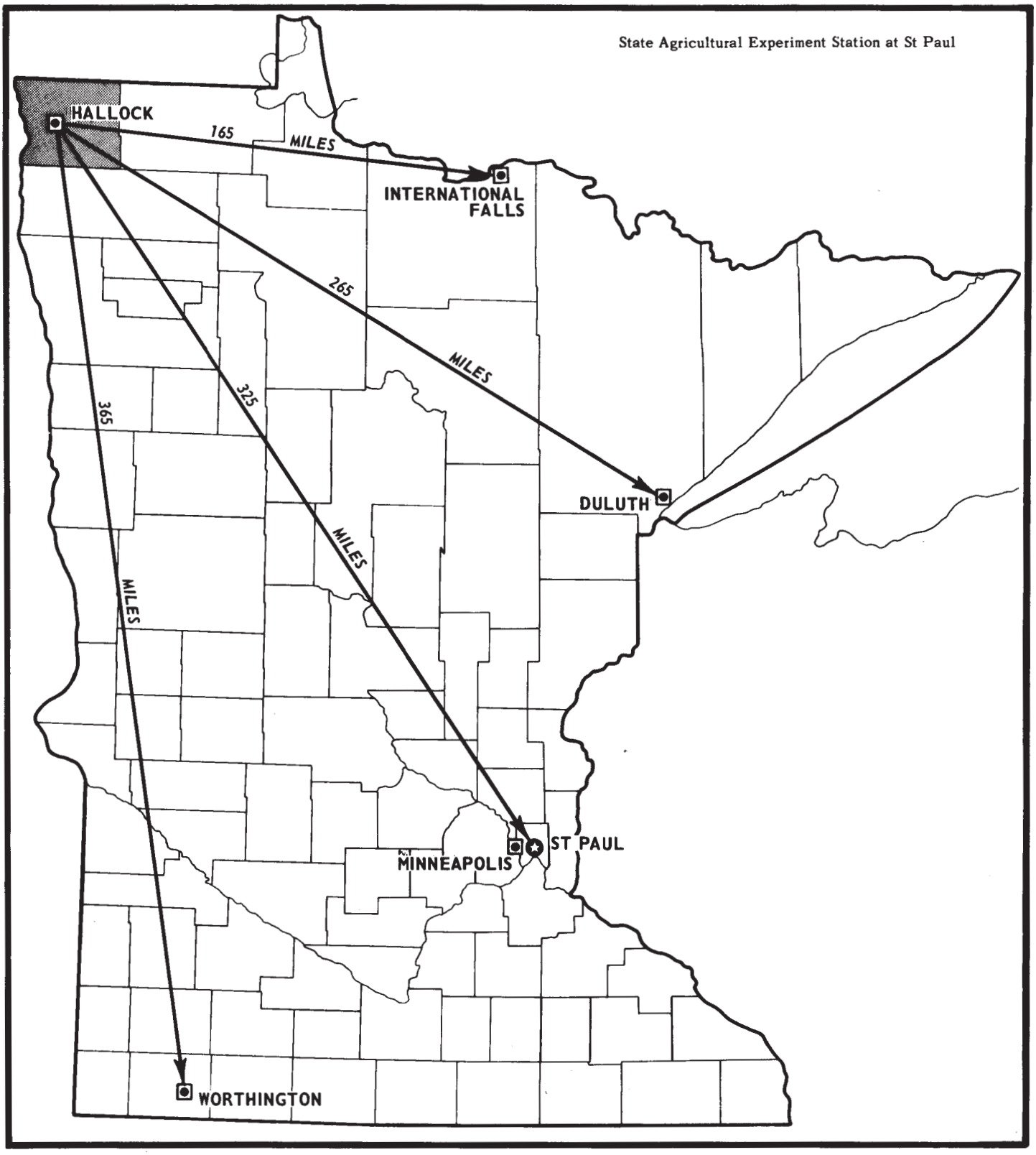

Location of Kittson County in Minnesota.

SOIL SURVEY OF KITTSON COUNTY, MINNESOTA

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FIELD SURVEY BY WARD J. AAS, DONALD D. BARRON, MALVERN N. JACOBSON, SOIL CONSERVATION SERVICE[1]

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KITTSON COUNTY is in the northwestern part of Minnesota on the North Dakota–Manitoba, Canada, border (see opposite page). Hallock, the county seat, is about 320 air miles northwest of St. Paul, the state capitol. The total area of the county is approximately 1,124 square miles. The county is mainly agricultural. Growing of wheat, barley, oats, sugar beets, potatoes, and some hay and pasture for feeding livestock are the sources of most agricultural income.

Kittson County has a variety of soil material. This material ranges in texture from clay and silt in the western part to sand, gravel, washed till soil, and muck in the eastern part of the county. The original vegetation was largely tall prairie grasses, wetland reeds, and sedges. Trees encroached into the county from the east, and some of the soils exhibit properties that indicate the influence of forest vegetation.

How this survey was made

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

The soil scientists made comparisons among the profiles they studied, and they compared these profiles with those in counties nearby and in places more distant. They classified and named the soils according to nationwide, uniform procedures. To use this soil survey efficiently, it is necessary to know the kinds of groupings most used in a local soil classification.

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

Soils of one series can differ in texture of the surface layer and in slope, stoniness, or some other characteristic that affects use of the soils by man. On the basis of such differences, a soil series is divided into phases. The name of a soil phase indicates a feature that affects management. For example, Percy bouldery soils is one of several phases within the Percy series.

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

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

A soil complex consists of areas of two or more soils, so intricately mixed or so small in size that they cannot be shown separately on the soil map. Each area of a complex contains some of each of the two or more dominant soils, and the pattern and relative proportions are about the same in all areas. Generally, the name of a soil complex consists of the names of the dominant soils, joined by a hyphen. Hegne-Northcote complex is an example.

An undifferentiated group is made up of two or more soils that could be delineated individually but are shown as one unit because, for the purpose of the soil survey, there is little value in separating them. The

[1] THOMAS C. JACKSON, CLARION J. NESETH, FRANCIS M. SCILLEY, STEPHEN C. SUHS, and DOUGLAS D. WEBER assisted in the field survey.

pattern and proportion of soils are not uniform. An area shown on the map may be made up of only one of the dominant soils, or of two or more. If there are two or more dominant series represented in the group, the name of the group ordinarily consists of the names of the dominant soils, joined by "and." Northcote and Wahpeton soils is an undifferentiated group in Kittson County.

In most areas surveyed there are places where the soil material is so rocky, so shallow, so severely eroded, or so variable that it has not been classified by soil series. These places are shown on the soil map and are described in the survey, but they are called miscellaneous areas and are given descriptive names. Dune land is a miscellaneous area in Kittson County.

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

Soil scientists observe how soils behave when used as a growing place for native and cultivated plants, and as material for structures, foundations for structures, or covering for structures. They relate this behavior to properties of the soils. For example, they observe that filter fields for onsite disposal of sewage fail on a given kind of soil, and they relate this to the slow permeability of the soil or its high water table. They see that streets, road pavements, and foundations for houses are cracked on a named kind of soil and they relate this failure to the high shrink-swell potential of the soil material. Thus, they use observation and knowledge of soil properties, together with available research data, to predict limitations or suitability of soils for present and potential uses.

After data have been collected and tested for the key, or benchmark, soils in a survey area, the soil scientists set up trial groups of soils. They test these groups by further study and by consultation with farmers, agronomists, engineers, and others. They then adjust the groups according to the results of their studies and consultation. Thus, the groups that are finally evolved reflect up-to-date knowledge of the soils and their behavior under current methods of use and management.

General soil map

The general soil map at the back of this survey shows, in color, the map units in the survey area. A map unit is a landscape that has a distinctive pattern of soils in defined proportions. It typically consists of one or more major soils. The soils in a map unit can occur in other map units, but in different patterns.

A map showing map units is useful to people who want to have a general idea of the soils in a survey area, who want to compare different parts of that area, or who want to locate large tracts that are suitable for a certain kind of land use. Such a map is a useful general guide for broad planning on a watershed, a wooded tract, or a wildlife area or for broad planning of recreational facilities, community developments and such engineering works as transportation corridors. It is not a suitable map for detailed planning for management of a farm or field or for selecting the exact location of a road or building or other structure, because the soils within a map unit ordinarily vary in slope, depth, stoniness, drainage, and other characteristics that affect their management.

The map units in this survey area have been grouped into general kinds of landscapes for broad interpretative purposes. Each of the broad groups and the units in it are described on the following pages.

Soils formed mainly in lacustrine silts and clays

The four units in this group are made up of moderately well drained to poorly drained, nearly level soils that are mostly in the western part of the county. These soils are predominantly fine and very fine textured, but some are moderately fine and medium textured. Nearly all areas are cultivated. Small grains, sugar beets, sunflowers, and potatoes are the main crops. Wetness is the main limitation.

1. Northcote

Nearly level, poorly drained, very fine textured soils formed in lacustrine clays

The soils of this unit consist of a nearly level landscape. Some areas of these soils have alternate ridges and draws generally oriented in a northwest-southeast direction. This unit makes up about 30 percent of the county. It is about 80 percent Northcote soils and about 20 percent minor soils.

In a representative profile of Northcote soils, the surface layer is about 9 inches of black clay. The subsoil is about 9 inches of dark olive gray clay. The underlying material is dark gray and olive gray, slightly to strongly effervescent clay. Tongues of the black surface layer extend into the underlying material, and distinct mottles are below 38 inches.

Minor soils are mainly the poorly drained Hegne and Colvin soils, the somewhat poorly drained Cashel soils, and moderately well drained Wahpeton soils that are commonly adjacent to or near the Red River of the North and its major tributaries. Some gently sloping areas of Northcote soils are adjacent to natural draws and streams.

Wetness limits the use of these soils. If these soils are cultivated when they are wet, structural damage and compaction occur. Occasional flooding occurs along natural water courses. Surface ditching is used to remove excess water. Soil blowing and water erosion are hazards when cultivated areas have no protective cover. Soil blowing can be controlled by stubble mulching, field windbreaks, crop residue management, and minimum tillage.

Nearly all of this unit is cultivated. The main crops are small grain, sugar beets, and sunflowers. Legumes and grasses are included in cropping sequences as green manure crops. Areas are occasionally wooded with elm and poplar, particularly along stream channels.

2. Bearden-Fargo

Nearly level, somewhat poorly drained and poorly drained, medium textured to fine textured soils formed in lacustrine silts and clays

The soils of this map unit consist of a landscape that has alternate ridges and draws generally oriented in a northwest-southeast direction. This map unit makes up about 7 percent of the county. It is about 65 percent Bearden soils, 15 percent Fargo soils, and 20 percent minor soils. The somewhat poorly drained Bearden soils occupy the ridges, and the poorly drained Fargo soils occupy the draws.

In a representative profile of Bearden soils, the surface layer is strongly effervescent, black silty clay loam to about 6 inches grading to about 4 inches of very dark gray silty clay loam. The next layer is dark grayish brown silty clay loam that grades to light yellowish brown and light brownish gray, mottled silt loam. The underlying material is prominently mottled grayish brown and light brownish gray, silty clay loam with some silt loam and silty clay layers.

In a representative profile of Fargo soils, the surface layer is about 18 inches of black silty clay. The subsoil is very dark grayish brown silty clay about 23 inches thick. The underlying material is olive gray silty clay grading with depth to mottled, olive gray silty clay loam.

Minor soils include the poorly drained Northcote, Hegne, and Colvin soils. Some gently sloping areas of Bearden soils are adjacent to natural draws and streams.

Wetness limits the use of these soils. The alternating ridges and swales make drainage difficult. Soil blowing and water erosion are hazards when cultivated areas are left with no protective cover. This hazard is most severe on Bearden soils. Soil blowing and erosion can be controlled by conservation cropping systems, stubble mulching, field windbreaks, crop residue management, and minimum tillage. A nutrient imbalance that occurs in Bearden soils because of their strongly calcareous condition can be temporarily corrected by applying commercial fertilizer.

Nearly all of this unit is cultivated. Small grain, sugar beets, and sunflowers are the most common crops. Legumes and grasses are included in cropping sequences as green manure crops.

3. Hegne-Northcote

Nearly level, poorly drained, fine textured and very fine textured soils formed in lacustrine clays

The soils of this map unit consist of a nearly level landscape that has alternate ridges and draws generally oriented in a northwest-southeast direction. This map unit makes up about 6 percent of the county. It is about 50 percent Hegne soils, 30 percent Northcote soils, and 20 percent minor soils. The Hegne soils occupy the ridges and the Northcote soils occupy the draws.

In a representative profile of Hegne soils, the surface layer is about 9 inches of black, strongly effervescent silty clay. The next layer is about 17 inches of dark gray to mottled dark grayish brown, violently effervescent silty clay. The underlying material is mottled, dark grayish brown, slightly to strongly effervescent silty clay.

In a representative profile of Northcote soils, the surface layer is about 9 inches of black clay. The subsoil is about 9 inches of dark olive gray clay. The underlying material is dark gray and olive gray, slightly to strongly effervescent clay. Tongues of the black surface layer extend into the underlying material, and distinct mottles occur below a depth of 38 inches.

Minor soils are the moderately well drained and somewhat poorly drained Bearden soils and areas of poorly drained Colvin soils.

Wetness limits the use of these soils. The alternating knolls and draws make drainage difficult. Soil compaction occurs in these soils if they are cultivated when field conditions are too wet. Soil blowing and water erosion are hazards when cultivated areas are left with no protective cover. Soil blowing and erosion can be controlled by stubble mulching, field windbreaks, crop residue management, and minimum tillage. A nutrient imbalance that occurs on the Hegne soils because of the strongly calcareous condition can be temporarily corrected by applying commercial fertilizer.

Nearly all of this map unit is cultivated. Small grains, sunflowers, and sugar beets are the most common crops. Legumes and grasses are included in cropping sequences as green manure crops.

4. Wheatville-Augsburg

Nearly level, moderately well drained to poorly drained, medium textured soils formed in lacustrine loamy and sandy material over clays

The soils of this map unit consist of a generally smooth, plane landscape, but it is alternatingly slightly convex and concave. This map unit makes up about 2 percent of the county. It is about 60 percent Wheatville soils, 15 percent Augsburg soils, and 25 percent minor soils. The Wheatville soils occupy nearly level, slightly convex areas. The Augsburg soils occupy nearly level, slightly concave areas.

In a representative profile of moderately well drained to somewhat poorly drained Wheatville soils, the surface layer is about 8 inches of black sandy clay loam that grades to about 5 inches of strongly effervescent, very dark gray loam. The next main layer is about 5 inches of violently effervescent, dark grayish brown, very fine sandy loam. The underlying material is about 17 inches of light olive brown, loamy very fine sand that grades to very fine sandy loam. The contrasting layer below is olive gray clay.

In a representative profile of poorly drained Augsburg soils, the surface layer is black, strongly effervescent very fine sandy loam about 11 inches thick. The next layer is dark gray, violently effervescent very fine sandy loam about 7 inches thick. Below this is about 15 inches of distinctly mottled, light brownish gray loamy very fine sand. The contrasting underlying material is prominently mottled, olive gray clay.

Minor soils include the moderately well drained to somewhat poorly drained Glyndon and Bearden soils and areas of poorly drained Borup soils.

Wetness limits the use of the Augsburg soils. Sur-

face ditches are needed to remove excess water. Soil blowing is a hazard of the Augsburg and Wheatville soils when cultivated areas are left unprotected. Soil blowing can be controlled by stubble mulching, field windbreaks, crop residue management, and minimum tillage. A nutrient imbalance, that occurs on these soils because of the strongly calcareous condition, can be temporarily corrected by applying commercial fertilizers.

Most of this unit is cultivated. Small grain, sugar beets, potatoes, and sunflowers are the most common crops. Legumes and grasses are included in cropping sequences as green manure crops. A small acreage is used for hay and pasture.

Soils formed in lacustrine loams and sands

The four map units in this group are made up of moderately well drained, nearly level soils that are mostly in the central and eastern parts of the county. These soils are predominantly medium and moderately coarse textured, and some coarse textured, soils. Much of the area is cultivated. Small grain, sunflowers, and potatoes are the dominant crops. Some areas are used for hay and pasture. The rest is in trees, brush, and native grasses. Moderate to low available water capacity, soil blowing, and wetness are the main limitations.

5. Rockwell-Grimstad

Nearly level, poorly drained and moderately well drained, medium textured soils formed in lacustrine loamy and sandy material over lake-modified loamy glacial till

The soils of this map unit consist of a nearly level landscape that, in places, has alternate ridges and draws. The landscape is generally associated with areas of water-modified tills and thin, sandy or gravelly deposits where soil material changes within short distances. This map unit makes up about 8 percent of the county. It is about 65 percent Rockwell soils, 15 percent Grimstad soils, and 20 percent minor soils. The Rockwell soils occupy nearly level, slightly concave areas. The Grimstad soils occupy nearly level, slightly convex areas.

In a representative profile of poorly drained Rockwell soils, the surface layer is about 9 inches of black, fine sandy loam. The next layer is about 7 inches of violently effervescent, dark gray fine sandy loam. Below this is about 20 inches of distinctly mottled, grayish brown fine and medium sand. The contrasting underlying material is mottled, strongly effervescent, grayish brown loam.

In a representative profile of moderately well drained Grimstad soils, the surface layer is about 8 inches of black, strongly effervescent fine sandy loam. Below this is about 9 inches of dark grayish brown, violently effervescent loamy fine sand. The next main layer is about 10 inches of strongly effervescent, pale brown fine sand. Below this is 11 inches of mottled, light brownish gray fine sand. The underlying material is mottled, grayish brown loam.

Minor soils mainly include moderately well drained and somewhat poorly drained Ulen soils, areas of moderately well drained Foldahl soils, the poorly drained Arveson soils, and areas of somewhat poorly drained and moderately well drained Wheatville soils.

Moderate to low available water capacity limits the use of these soils. Soil blowing is a hazard, but it may be controlled by stubble mulching, field windbreaks, crop residue management, and minimum tillage. A nutrient imbalance that occurs in these soils because of their highly calcareous condition can be temporarily controlled with applications of commercial fertilizer. Field ditches are needed to remove excess water from wet areas.

Many areas of this unit are cultivated. Small grain, potatoes, and sunflowers are the most common crops. Some areas are used for hay and pasture. A few areas have scattered trees.

6. Arveson-Ulen

Nearly level, poorly drained to moderately well drained, medium textured and moderately coarse textured soils formed in calcareous lacustrine loamy material over fine sands

The soils of this map unit consist of a nearly level landscape. Some areas that have shallow knolls and swales are alternatingly slightly concave and convex. Soil blowing contributes to the knoll and swale condition. This map unit makes up about 10 percent of the county. It is about 50 percent Arveson soils, 30 percent Ulen soils, and 20 percent minor soils. The Arveson soils occupy nearly level and commonly slightly concave areas. The Ulen soils occupy nearly level, slightly convex areas.

In a representative profile of poorly drained Arveson soils, the surface layer is a dark gray sandy clay loam about 8 inches thick. The next main layer is about 7 inches of violently effervescent, dark gray fine sandy loam. The underlying material is mottled, light brownish gray and light gray fine sand. This material is strongly effervescent and includes some thin layers of grayish brown colors.

In a representative profile of somewhat poorly drained and moderately well drained Ulen soils, the surface layer is about 10 inches of black, strongly effervescent fine sandy loam. The next layer is about 5 inches of dark grayish brown, violently effervescent sandy loam that grades to dark brown, loamy fine sand. The underlying material is mottled, pale brown fine sand that grades with depth to mottled, grayish brown fine sand.

Minor soils include mainly moderately well drained Poppleton and Grimstad soils, and areas of poorly drained Rockwell soils.

Moderate to low available water capacity and medium fertility limit the use of these soils. Good management and application of fertilizer will help correct the fertility problem. Wetness is also a limitation on the poorly drained soils. Surface drainage helps to overcome this limitation. Soil blowing and water erosion are hazards when cultivated areas are left unprotected. Soil blowing may be controlled by stubble mulching, field windbreaks, crop residue management, and minimum tillage. Application of commercial fertilizer will temporarily help to control the nurtient im-

balance in these soils caused by their highly calcareous condition.

Many areas of this unit are cultivated. Small grain, potatoes, and sunflowers are the most common crops. A considerable acreage is also used for hay and pasture. A few scattered areas are in aspen and lowland brush.

7. Cormant-Poppleton-Redby

Nearly level, poorly drained to moderately well drained, coarse textured soils formed in lacustrine sandy material

The soils of this map unit consist of a nearly level landscape that is alternatingly slightly convex and concave. Soil blowing is largely responsible for the uneven condition. This map unit makes up about 13 percent of the county. It is about 30 percent Cormant soils, 25 percent Poppleton soils, 20 percent Redby soils, and 25 percent minor soils. The Cormant soils are on nearly level to slightly concave areas. The Poppleton soils and Redby soils are on nearly level to slightly convex areas.

In a representative profile of poorly drained Cormant soils, the surface has a layer of black organic duff about 3 inches thick. The surface layer is 6 inches of very dark grayish brown loamy fine sand. The underlying material is mottled, grayish brown fine sand. Mottling becomes less distinct with depth and is not evident below a depth of 32 inches.

In a representative profile of moderately well drained Poppleton soils, the surface layer is about 6 inches of very dark brown loamy fine sand. The next main layer is about 9 inches of very dark grayish brown loamy fine sand. The subsoil is about 15 inches of mottled, brown fine sand. The underlying material is mottled, grayish brown fine sand.

In a representative profile of somewhat poorly drained Redby soils, the surface layer is about 4 inches of very dark gray loamy fine sand. The subsurface layer is about 4 inches of dark grayish brown fine sand. The subsoil is about 25 inches of mottled, brown fine sand. The underlying material is light brownish gray fine sand.

Minor soils include areas of the moderately well drained Enstrom soils, areas of moderately well drained and somewhat poorly drained Ulen soils, areas of poorly drained Grygla and Arveson soils, and areas of well drained Maddock soils.

Low available water capacity and low fertility limit the use of these soils. Good management and applications of fertilizer help correct the fertility condition. Drainage is needed on some of the soils. The hazard of soil blowing is also a limitation. Soil blowing can be controlled by stubble mulching, field windbreaks, crop residue management, and minimum tillage.

8. Enstrom-Grygla

Nearly level, moderately well drained and poorly drained, moderately coarse textured soils formed in sandy lacustrine material over loamy glacial till

The soils of this map unit consist of a nearly level landscape that is alternatingly slightly convex and concave. Soil blowing is largely responsible for this uneven condition. This map unit makes up about 5 percent of the country. It is about 34 percent Enstrom soils, 33 percent Grygla soils, and 33 percent minor soils. The Enstrom soils are on slightly convex areas. The Grygla soils are on nearly level to slightly concave areas.

In a representative profile of moderately well drained Enstrom soils, the surface layer is about 8 inches of very dark brown loamy fine sand. The subsoil is about 15 inches of mottled, dark brown to brown fine sand. Below this is mottled, yellowish brown fine sand. The underlying material at a depth of 33 inches is mottled grayish brown loam that is about 10 percent coarse fragments.

In a representative profile of poorly drained Grygla soils, the surface layer is about 6 inches of very dark gray loamy fine sand. The subsurface layer is about 5 inches of mottled, light brownish gray fine sand. The subsoil is about 18 inches of prominently mottled, light brownish gray fine sand. The underlying material is mottled, light gray and light brownish gray, strongly effervescent loam.

Minor soils include areas of moderately well drained Poppleton soils, areas of somewhat poorly drained Redby soils, and areas of poorly drained Rockwell soils.

Low to moderate available water capacity and low fertility limit the use of these soils. Applications of commercial fertilizer help to correct the fertility problem. Wetness also limits the use of these soils and surface drainage is needed to remove excess water. Soil blowing is another limitation. It can be controlled by stubble mulching, field windbreaks, crop residue management, and minimum tillage.

Some areas of this map unit are cultivated. Small grain and potatoes are common crops, but a larger acreage is used for hay and pasture. Scattered trees, mainly aspen, bur oak, and some brush occur on this association.

Soils formed in sands and gravels

The one map unit in this group is made up of moderately well drained to excessively drained, level to sloping soils that are scattered in the southeastern, central, and north-central parts of the county. They are predominantly coarse textured soils. Much of the area is covered by trees, brush, and native grasses. When these soils are cultivated, small grain is the principal crop. Low available water capacity and soil blowing are the main limitations.

9. Lohnes-Dune land

Level to moderately steep, moderately well drained to excessively drained, coarse textured soils and Dune land, formed in sandy and gravelly deposits

The soils of this map unit occupy areas where sand has blown about, causing blowouts and forming dunes. They also are in areas on old beach ridges that formed along shorelines of Glacial Lake Agassiz. This map unit makes up about 2 percent of the county. It is about 35 percent Lohnes soils, 20 percent Dune land, and 45 percent minor soils. Lohnes soils are on level to convex ridges. Dune land occurs in sands that are level to sloping, that are droughty, and where vegetative cover is sparse.

In a representative profile of the well drained and moderately well drained Lohnes soils, the surface layer is about 9 inches of black loamy sand. The subsoil is about 4 inches of dark brown coarse sand. The underlying material is brown and pale brown coarse sand.

Dune land is fine and medium brown sand with some faint mottles. Some distinct mottles occur below a depth of 30 inches.

Minor soils include areas of well drained Maddock soils, areas of moderately well drained Poppleton soils, areas of somewhat poorly drained Redby soils, and areas of poorly drained Cormant, Strandquist, and Hangaard soils.

Low available water capacity and low inherent fertility limit the use of these soils. Soil blowing is a hazard. Good management, including applications of fertilizer, stubble mulching, field windbreaks, crop residue management, and minimum tillage are needed to help minimize these limitations. Ditches are needed to remove excess water from wet areas.

Some areas of this unit are cultivated. The rest is in woods or grass. Small grain and some potatoes are the most commonly cultivated crops. Some areas are used for hay and pasture.

Soils formed mainly in loamy till

The two map units in this group are made up of moderately well drained to poorly drained, nearly level soils that are mostly in the eastern and north-central parts of the county. They are predominantly moderately fine textured to moderately coarse textured soils. Small grain is the commonly cultivated crop. Many acres are used for hay and pasture. The rest of the area is in trees, brush, and native grasses. Wetness and stones are the main limitations.

10. Percy-Fram

Nearly level, poorly drained and moderately well drained, medium textured and moderately fine textured soils formed in lake-modified loamy glacial till

The soils of this map unit consist of a nearly level landscape, but some areas are alternatingly slightly convex and concave. This map unit makes up about 7 percent of the county. It is about 55 percent Percy soils, 10 percent Fram soils, and 35 percent minor soils. The Percy soils are on nearly level to slightly concave areas. The Fram soils are on nearly level to slightly convex areas.

In a representative profile of poorly drained Percy soils, the surface layer is about 11 inches of black and very dark brown sandy clay loam. The subsoil is very dark brown sandy clay loam about 3 inches thick. Below that is about 15 inches of violently effervescent, mottled, light brownish gray loam. The underlying material is distinctly mottled, light brownish gray loam.

In a representative profile of moderately well drained Fram soils, the surface layer is about 9 inches of very dark gray fine sandy loam. Below that is violently effervescent, pale brown clay loam about 8 inches thick. The next layer grades to a strongly effervescent, brown loam layer about 6 inches thick. The underlying material is strongly effervescent, mottled grayish brown loam.

Minor soils include areas of poorly drained Roliss soils and areas of moderately well drained Nereson, Pelan, and Garnes soils.

Wetness limits the use of much of this map unit, and surface drainage is needed to remove excess water. The presence of stones and boulders also influence use and management.

Many areas of this unit are cultivated. Small grain is the most common crop, but many acres are utilized for hayland and pasture. Some areas are wooded with aspen and bur oak. Some of these areas are included in pastureland.

11. Mavie-Foxhome

Nearly level, poorly drained and moderately well drained, medium textured and moderately coarse textured soils formed in gravelly, sandy, and loamy sediments over loamy glacial till

The soils of this map unit consist of a nearly level landscape that is often associated with interbeach areas where relief is variable and has some short, very gentle slopes. Soil material is very mixed across these areas. This map unit makes up about 2 percent of the county. It is about 50 percent Mavie soils, 15 percent Foxhome soils, and 35 percent minor soils. The Mavie soils and Foxhome soils occur on nearly level to slightly concave areas.

In a representative profile of poorly drained Mavie soils, the surface layer is black sandy clay loam about 7 inches thick. This is underlain by violently effervescent, very dark gray sandy clay loam about 3 inches thick. The next layer is about 4 inches of violently effervescent, dark grayish brown fine sandy loam. Below this is about 8 inches of grayish brown gravelly coarse sand. The underlying material is light brownish gray fine sandy loam that grades with depth to light olive gray loam.

In a representative profile of moderately well drained Foxhome soils, the surface layer is about 11 inches of black, neutral sandy loam. This is underlain by about 4 inches of very dark grayish brown, neutral gravelly loamy sand. The next layer is 21 inches of pale brown, slightly effervescent gravelly sand. The contrasting underlying material is mottled, light brownish gray and olive gray strongly effervescent fine sandy loam.

Minor soils include areas of moderately well drained Fram soils, areas of poorly drained Syrene, Percy, Rockwell, and Strandquist soils, and areas of well drained to moderately well drained Lohnes soils.

Wetness limits the uses of some soils of this map unit. Surface drainage is needed to remove excess water. Moderate to low available water capacity and medium inherent fertility influence use and management of these soils. Stones and boulders make operation of farm machines more difficult.

Some areas of this soil are cultivated, principally for the production of small grain. A substantial acreage is also used for pasture and hay. Scattered areas have trees, principally aspen, bur oak, and some willow brush.

Soils formed in organic materials

The one map unit in this group is made up of very poorly drained, depressional soils that are scattered

in the eastern part of the county. These soils are predominantly muck. The organic material is of various thicknesses in these soils. Much of the area is in native grass, brush, and a few trees. Some areas are used for hay and pasture. Wetness is the main limitation for uses other than wetland wildlife habitat.

12. Deerwood-Cathro-Markey

Depressional, very poorly drained organic soils, and very wet areas with marsh vegetation

The soils of this map unit consist of low, broad, flat areas, pocketed depressions, and portions of old stream channels. This map unit makes up 8 percent of the county. It is about 30 percent Deerwood soils, 20 percent Cathro soils, 20 percent Markey soils, and 30 percent minor soils.

In a representative profile of Deerwood soils, the surface layer is black muck about 10 inches thick. Below this is about 2 inches of black loamy sand. The underlying material is mottled, light grayish brown fine sand that grades to gravelly sand with depth.

In a representative profile of Cathro soils, the surface layer is about 15 inches of very dark brown muck. Below this is about 19 inches of black muck. The upper part of the mineral material is about 3 inches of black sandy loam over about 5 inches of olive gray, gravelly loamy sand. The underlying material is light olive gray loam.

In a representative profile of Markey soils, the surface layer is about 6 inches of black muck. The next main layer is about 10 inches of black peaty muck. The peaty muck has a dark brown face when the material is broken. The next organic layer is black muck about 9 inches thick. The underlying mineral material is black mixed loam, sandy loam, and loamy sand that grades to grayish brown fine sand.

Minor soils include some poorly drained mineral soils, areas of very poorly drained Haug soils, and areas of marsh and open water.

Wetness limits the use of these soils, and drainage is needed for crop production. In some areas, drainage is difficult because there is no adequate outlet. Muck fires are a hazard, and low inherent fertility influences use and management.

Many areas of this map unit are not cultivated. Reeds, sedges, phragmites, cattails, and scattered areas of lowland brush grow in the soils. A few areas have trees, the most common of which is aspen. Some areas are used for hay and pasture. Reed canarygrass is the most common crop in these areas. Flax and potatoes are grown in a few cultivated areas.

Saline areas

The General Soils Map shows the saline soil areas in the county. Saline areas are those that show the effect of a saline condition on the growing crop, or have a saline condition observed in the soil itself. The occurrence within the mapped area is such that the mapper often cannot separate the nonaffected from the affected soils. Commonly, there is a mixture of normal soil and saline or saline-alkali soil. No attempt is made to specifically relate the saline area to soil series and mapping units.

Within any delineated saline area, a 0 to 100 percent reduction of crop yield can be expected to occur. In some places several sections show no saline condition, and in many years there is no loss. In many places in many years, there is some loss. In some places in some years, there is complete loss. An estimate of the crop loss for the delineated saline area would be 15 to 20 percent for an average year. Areas outside the delineated area are affected to some degree in some years. The sensitivity of the growing crop makes further interpretations very difficult.

Descriptions of the soils

This section describes each soil series in detail and then, briefly, each mapping unit in that series. Unless stated otherwise, what is stated about the soil series holds true for the mapping units in that series. Thus, to get full information about any one mapping unit, it is necessary to read both the description of the mapping unit and the description of the soil series to which it belongs.

An important part of the description of each soil is the soil profile, that is, the sequence of layers from the surface down to rock or other underlying material. Each series contains two descriptions of the profile. The first is brief and in terms familiar to a layman. The second is more detailed and is included for those who need to make thorough and precise studies of soils. The profile described in the series is representative for mapping units in that series. If the profile of a given mapping unit is different from the one described for the series, these differences are stated in describing the mapping unit, or they are differences that are apparent in the name of the mapping unit. Color terms are for dry (moist) soil unless otherwise stated.

As mentioned in the section "How this survey was made," not all mapping units are members of a soil series. Alluvial land, frequently flooded, for example, does not belong to a soil series, but nevertheless, it is listed in alphabetic order along with the soil series.

Preceding the name of each mapping unit is a symbol that identifies the mapping unit on the detailed soil map. Listed at the end of each description of a mapping unit is the capability unit and range site in which the mapping unit has been placed. The page where each capablity unit and range site are described is listed in the "Guide to Mapping Units" at the back of this survey.

The acreage and proportionate extent of each mapping unit are shown in table 1. Many of the terms used in describing soils can be found in the Glossary.

Alluvial land, frequently flooded

1002—Alluvial land, frequently flooded. This land consists of alluvium that was deposited in old stream channels, oxbows, or land along the edges of rivers and smaller streams. These soils are typically nearly level and gently sloping and are dissected by narrow, winding channels of intermittent streams. Slopes are 0 to 3 percent. The soil material lacks uniformity in color, texture, and reaction. It exhibits little or no soil

TABLE 1.—*Acreage and proportionate extent of the soils*

Map symbol	Soil name	Acres	Percent	Map symbol	Soil name	Acres	Percent
45	Maddock soils, 0 to 2 percent slopes	1,510	0.2	343	Wheatville soils, 0 to 2 percent slopes	9,290	1.3
46	Borup loam	1,325	0.2	379	Percy bouldery soils	7,080	1.0
47	Colvin silty clay loam	6,415	0.9	383	Percy soils, calcareous surface	4,645	0.6
50	Cashel clay	880	0.1	384	Percy soils, depressional	2,435	0.3
52	Augsburg soils	1,770	0.3	403	Viking soils	885	0.1
59	Grimstad soils, 0 to 2 percent slopes	12,155	1.7	412	Mavie soils	8,185	1.1
60	Glyndon soils, 0 to 2 percent slopes	1,230	0.2	424	Augsburg soils, depressional	885	0.1
61	Arveson soils	45,330	6.3	425	Donaldson soils, 0 to 2 percent slopes	1,105	0.2
63	Rockwell soils	38,970	5.4	426	Foldahl soils, 0 to 2 percent slopes	2,655	0.4
64	Ulen soils, 0 to 2 percent slopes	23,225	3.2	427	Fram soils, leached, 0 to 3 percent slopes	4,325	0.6
65	Foxhome soils, 0 to 2 percent slopes	2,540	0.4	429	Northcote clay, 0 to 2 percent slopes	188,120	26.2
67	Bearden silt loam, 0 to 2 percent slopes	10,395	1.4	429B	Northcote clay, 2 to 6 percent slopes	3,985	0.6
77	Garnes soils, 0 to 2 percent slopes	650	0.1	430	Noyes soils	4,900	0.7
93	Bearden silty clay loam, 0 to 2 percent slopes	12,830	1.8	432	Strandquist soils	5,310	0.7
93B	Bearden silty clay loam, 2 to 6 percent slopes	510	0.1	433	Syrene soils, very wet	725	0.1
111	Hangaard soils	1,660	0.2	435	Syrene soils	1,715	0.2
116	Redby soils, 0 to 2 percent slopes	23,350	3.2	438	Northcote clay, depressional	5,310	0.7
117	Cormant soils	29,185	4.1	482	Grygla soils	13,050	1.8
145	Enstrom loamy fine sand, 0 to 2 percent slopes	12,200	1.7	543	Markey muck	14,820	2.1
148	Poppleton soils, 0 to 2 percent slopes	24,925	3.5	544	Cathro muck	15,260	2.1
157	Wahpeton silty clay, 0 to 2 percent slopes	2,045	0.3	547	Deerwood muck	19,025	2.6
157B	Wahpeton silty clay, 2 to 6 percent slopes	470	0.1	581	Percy soils	19,475	2.7
187	Haug muck	10,175	1.4	582	Roliss soils	1,540	0.2
205	Karlstad soils, 0 to 2 percent slopes	620	0.1	583	Nereson soils, 0 to 2 percent slopes	3,185	0.4
242	Marquette soils, 0 to 2 percent slopes	445	0.1	908	Bearden-Fargo complex	35,645	5.0
245	Lohnes soils, 0 to 6 percent slopes	5,085	0.7	937	Hegne-Northcote complex	21,680	3.0
280	Pelan soils, 0 to 2 percent slopes	760	0.1	991	Northcote and Wahpeton soils	915	0.1
296	Fram soils, 0 to 2 percent slopes	890	0.1	993	Arveson and Cormant soils, depressional	16,150	2.2
				994	Rockwell and Grygla soils, depressional	13,495	1.9
				1002	Alluvial land, frequently flooded	5,750	0.8
				1006	Breaks and Alluvial land	6,735	0.9
				1025	Dune land	2,740	0.4
				1053	Marsh	6,415	0.9
					All water	380	0.1
					Total	719,360	100.0

development, and material is deposited or washed away during each flood.

Included with this land in mapping and making up as much as 15 percent of an individual mapped area, are marsh areas and intermittent open water areas. Also included are some areas of alluvial lands that are flooded for such a short time that cultivation and cropping is possible.

Wetness limits the use of these soils. Areas of this land are flooded one or more times each year. This flooding and inaccessibility also limit the use of these soils.

Most areas of this land are not cultivated. A few areas are in pasture. Vegetative cover includes grasses, reeds, sedges, cattails, and various lowland trees and brush. Capability unit VIw–1; range site not classified.

Arveson series

The Arveson series consists of nearly level, poorly drained soils. These soils formed in calcareous loamy lacustrine sediment over sandy lacustrine sediment. They are on low flats and in depressions. Native vegetation is a wet-site community of reeds, sedges, and tall prairie grass.

In a representative profile the surface layer is a very dark gray sandy clay loam about 8 inches thick. The next layer is about 7 inches of violently effervescent, dark gray fine sandy loam. The underlying material is mottled, light brownish gray and light gray fine sand. This material is strongly effervescent and includes some thin layers of grayish brown colors.

Permeability is moderately rapid, and available

water capacity is moderate. Inherent fertility is medium. The seasonal high water table commonly fluctuates from a depth of 0 to 3 feet.

Some areas of Arveson soils are cultivated. Small grain and forage for livestock feed are the most common crops. Other areas commonly support a growth of grasses, reeds, sedges, and some trees, principally aspen and willow. Wetness is the major limitation.

Representative profile of Arveson sandy clay loam in an area of Arveson soils, in an area of grass and trees 2,660 feet west and 65 feet south of the northeast corner of sec. 19, T. 159 N., R. 46 W.:

A1—0 to 8 inches; very dark gray (10YR 3/1) sandy clay loam; weak very fine granular structure; very friable; strongly effervescent; moderately alkaline; clear wavy boundary.

C1ca—8 to 15 inches; dark gray (5Y 4/1) fine sandy loam; weak very fine subangular blocky structure; very friable; violently effervescent; moderately alkaline; clear wavy boundary.

C2—15 to 20 inches; light brownish gray (2.5Y 6/2) fine sand; few fine distinct yellowish brown (10YR 5/4) mottles; single grained; loose; strongly effervescent; strongly alkaline; gradual wavy boundary.

C3—20 to 27 inches; light gray (2.5Y 7/2) fine sand; common medium distinct yellowish brown (10YR 5/8 and 5/4) mottles; single grained; loose; strongly effervescent; moderately alkaline; abrupt wavy boundary.

C4—27 to 33 inches; grayish brown (2.5Y 5/2) fine sand; common medium faint dark yellowish brown (10YR 4/4) mottles; single grained; loose; strongly effervescent; strongly alkaline; clear wavy boundary.

C5—33 to 60 inches; light gray (10YR 7/2) fine sand; common large distinct brownish yellow (10YR 6/8) and yellowish brown (10YR 5/6 and 5/8) mottles; single grained, loose; few thin layers with some very fine gravel; strongly effervescent; moderately alkaline.

Depth to the lower boundary of the Cca horizon ranges from 14 to 20 inches. The A horizon is black and very dark gray sandy clay loam, fine sandy loam, sandy loam, loam or silt loam. The Cca horizon has a texture range of sandy loam, fine sandy loam or loam. It is dark grayish brown, grayish brown, light brownish gray, olive gray, light olive gray, dark gray and gray in color. In some places distinct and prominent mottles are in this horizon. The part of the C horizon below the Cca horizon is typically fine sand, but sand, loamy fine sand, and loamy sand are in the range. It is olive gray, light olive gray, light gray, gray, grayish brown and light brownish gray in color. Mottling ranges from faint to prominent.

Arveson soils in this county have a thinner mantle of loamy sediment over fine sand than the defined range for the series, but the difference does not alter their usefulness and behavior.

The Arveson series is associated with Grimstad, Rockwell, and Ulen soils. Arveson soils are more poorly drained than the Grimstad soils. They lack a loamy IIC horizon within depths of 20 to 40 inches, that the Grimstad and Rockwell soils have. Arveson soils are more poorly drained than Ulen soils.

61—Arveson soils. These soils are in areas of varied shapes that are commonly over 5 acres and under 80 acres in size. The surface is smooth or has slightly concave slopes. Slopes are 0 to 2 percent. The surface layer ranges in texture from fine sandy loam to sandy clay loam. When cultivated the surface layer is smooth and black with grayish spots. The presence of clean, bleached sand grains and a concentration of carbonates influences the surface color. These soils have the profile described as representative of the series.

Included with these soils in mapping, and making up as much as 15 percent of an individual mapped area, are Ulen soils. Also included, making up as much as 20 percent of an individual mapped area, are Rockwell soils. Some areas of Arveson soils have a very calcareous surface layer. Soluble salts may be present in varying degrees of concentrations in some areas. Areas with some stones and boulders exposed to the surface and areas with convolutions in the soil material that result in mixed and broken horizons are included.

Wetness limits the use of these soils. Soil blowing and erosion are hazards where cultivated areas have no protective cover. The calcareous condition of the soils affects nutrient balance. On a few areas stones and boulders restrict the operation of farm machines.

Some areas of these soils are cultivated. Small grain is the most common crop. Small acreages of sunflowers and potatoes are also grown. When not cultivated these soils commonly support grasses. Most of these areas are used for pasture or hay. In scattered areas quaking aspen and lowland brush grow in these soils. Capability unit IIIw–1; Subirrigated range site.

993—Arveson and Cormant soils, depressional. These nearly level soils are mostly in depressions that generally range from 3 to 15 acres in size, but a few areas are on the bottoms of natural draws. Most of the depressions are closed at both ends. Slopes are 0 to 2 percent.

Arveson soils make up 30 to 80 percent of an individual mapped area and Cormant soils make up 20 to 70 percent. In places, however, areas are either only Arveson soils or only Cormant soils.

The surface layer ranges from fine sandy loam to loamy fine sand. Where they are drained or cultivated, these soils generally have a black surface. In places, however, the surface has a brownish or grayish cast because of the presence in the surface layer of bleached sand grains that do not have organic stains and because of the strongly calcareous material. Except for more variation in thickness of the surface layer, these soils are similar to those described as representative of their series.

Included with these soils in mapping, and making up as much as 20 percent of an individual mapped area, are Rockwell and Grygla soils. Also included, and making up as much as 15 percent of an individual mapped area, are Deerwood muck and small areas of marsh.

Wetness limits the use of these soils. Ponding or

flooding is a hazard, in places, even where ditches have been constructed to remove excess water. Small grain and other crops have been planted in a few drained areas. Many areas of these soils support a growth of reeds, sedges, and lowland brush and, in places, are combined with areas used for hay or pasture. Capability unit IVw–2; Wetland range site.

Augsburg series

The Augsburg series consists of nearly level, poorly drained soils. These soils formed under a growth of sedges and tall grass prairie in lacustrine sediment consisting of a loamy layer and the underlying very fine sand and silt over clay. The surface is nearly level and commonly slightly concave.

In a representative profile the surface layer is about 11 inches of black and very dark grayish brown very fine sandy loam and loam that is strongly effervescent. The next layer is dark gray, violently effervescent very fine sandy loam about 7 inches thick. Below this is about 15 inches of distinctly mottled, light brownish gray, strongly effervescent loamy very fine sand. The contrasting underlying material is prominently mottled, olive gray clay.

Permeability is moderately rapid in the upper part of the soil, but is slow in the clay layer. Available water capacity is high. Inherent fertility is high. The seasonal high water table fluctuates from a depth of 0 to 3 feet.

Most areas of Augsburg soils are cultivated. They are suited to all crops commonly grown in Kittson County. Small grain and sugar beets are the most common crops. Wetness is the major limitation.

Representative profile of Augsburg very fine sandy loam, in an area of Augsburg soils, in a cultivated field 330 feet east and 150 feet north of the southwest corner of sec. 17, T. 159 N., R. 47 W.:

A1p—0 to 8 inches; black (10YR 2/1) very fine sandy loam; weak very fine subangular blocky structure; very friable; strongly effervescent; moderately alkaline; abrupt smooth boundary.

A12ca—8 to 11 inches; very dark grayish brown (2.5Y 3/2) loam; weak very fine subangular blocky structure; very friable; strongly effervescent; moderately alkaline; clear smooth boundary.

C1ca—11 to 18 inches; dark gray (2.5Y 4/1) very fine sandy loam; weak very fine subangular blocky structure; very friable; violently effervescent; moderately alkaline; clear smooth boundary.

C2—18 to 33 inches; light brownish gray (2.5Y 6/2) loamy very fine sand; few fine distinct yellowish brown (10YR 5/6) mottles and few fine faint white (2.5Y 8/2) mottles; single grained; loose; strongly effervescent; moderately alkaline; abrupt smooth boundary.

IIC3g—33 to 60 inches; olive gray (5Y 5/2 and 4/2) clay; many medium prominent dark reddish gray (5YR 4/2), dark yellowish brown (10YR 4/4), and white (10YR 8/2) mottles; weak and moderate very fine angular blocky structure; sticky; slightly effervescent; moderately alkaline.

The A horizon is a very fine sandy loam, silt loam, or sandy clay loam. The A12ca horizon, that is very dark gray and very dark grayish brown, is lacking in some profiles. Thickness of the A horizon ranges from 6 to 16 inches. The Cca horizon is gray, dark gray, grayish brown, dark grayish brown, and olive gray in color. This horizon typically has distinct and prominent mottles, but it lacks mottles in some places. It has texture of very fine sandy loam, loamy very fine sand, loam, silt loam and sandy clay loam. The Cca horizon ranges from 6 to 16 inches in thickness. Below the Cca horizon, the C horizon is typically loamy very fine sand and very fine sandy loam and very fine sand, light silt loam, and loam. It is gray, dark gray, olive gray, olive, pale olive, grayish brown, and light brownish gray in color, and has faint to distinct mottles. Reaction of the C horizon is mildly alkaline or moderately alkaline. In some places the C horizon is lacking. Depth to the IIC horizon ranges from 20 to 40 inches. The IIC horizon is typically clay and silty clay and silty clay loam. In some profiles this horizon is over 60 percent clay. It is dark grayish brown, grayish brown, light brownish gray, dark gray, gray, olive gray, and light olive gray in color and has faint to prominent mottles.

Augsburg soils are associated with Borup, Glyndon, and Wheatville soils. They are more poorly drained than Glyndon soils. They have a clayey IIC horizon beginning at a depth of 20 to 40 inches, but the Borup and Glyndon soils are silty to a depth of at least 40 inches. Augsburg soils are more poorly drained than Wheatville soils.

52—Augsburg soils. These soils are in generally plane or very slightly concave areas that normally range from 10 to 100 acres in size. Slopes are 0 to 2 percent. The surface layer of this soil ranges from very fine sandy loam to sandy clay loam, and when cultivated it has color variations of black to dark gray. These soils have the profile described as representative of the series.

Included with these soils in mapping, and making up as much as 20 percent of an individual mapped area, are Wheatville soils. Also included, and making up as much as 15 percent of an individual mapped area, are Borup, Colvin, and Glyndon soils. A few areas of soil that has a clayey subsoil at a depth of less than 20 inches are included. In some areas soluble salts are present in various degrees of concentration.

Wetness limits the use of these soils. Soil blowing is a hazard when cultivated areas have no protective cover. The strongly calcareous condition of this soil affects its nutrient balance.

Most of these soils are cultivated. Small grain, sugar beets, sunflowers, and potatoes are the most common crops. Legumes and grasses are included in the cropping sequence usually as green manure crops. A small acreage is used for hay and pasture. Capability unit IIw–3; Subirrigated range site.

424—Augsburg soils, depressional. These soils are in nearly round to oblong shaped depressions that are usually over 3 acres and under 15 acres in size.

Slopes are 0 to 2 percent. The surface layer ranges from very fine sandy loam to sandy clay loam.

Augsburg soils are in depressions bordered by higher areas of associated soils. Water ponds in these depressions for varying lengths of time. Ponding is most common during spring runoff and periods of heavy rainfall. Cultivation of these depressions is often delayed by this wetness, and ponding sometimes drowns growing crops. The surface of these depressions is usually crusted after drying takes place.

These soils have a profile similar to that described as representative for the Augsburg series, except for more variation in the thickness of the surface layer and convolutions that have mixed soil material.

Included with these soils in mapping, and making up as much as 15 percent of an individual mapped area, is depressional Rockwell soils and depressional Northcote soils. Some spots in these depressions are noncalcareous. In some areas soluble salts are present in varying degrees of concentration.

Wetness limits the use of these soils. Ponding occurs during periods of heavy precipitation and spring runoff even where ditches are installed. Some drowning of crops is common, especially during wet seasons.

Most areas of these soils are drained by open field ditches, and are included in fields planted to small grain, sugar beets, sunflowers, and potatoes. A few areas, where ditches are not installed, are not cultivated except during dry seasons. Capability unit IIIw–1; Wetland range site.

Bearden series

The Bearden series consists of nearly level and gently sloping, somewhat poorly drained soils. These soils formed in calcareous silty and loamy lacustrine deposits. They are commonly on nearly level planes and in slightly convex areas. The gently sloping areas are usually adjacent to natural draws and streams. Native vegetation is tall grasses.

In a representative profile the surface layer is black, strongly effervescent silty clay loam, about 6 inches thick, that grades to about 4 inches of very dark gray, strongly effervescent silty clay loam. The next layer is violently effervescent, dark grayish brown, silty clay loam that grades to light yellowish brown and mottled, light brownish gray silt loam about 13 inches thick. The underlying material is strongly to slightly effervescent, prominently mottled, grayish brown and light brownish gray silt loam and some silty clay layers.

Permeability is moderate, and available water capacity is high. Inherent fertility is high. The seasonal high water table fluctuates from a depth of 3 to 5 feet.

Most areas of Bearden soils are cultivated. These soils are suited to all crops commonly grown in Kittson County. Small grain and sugar beets are the most common crops. Soil blowing is the major limitation.

Representative profile of Bearden silty clay loam, 0 to 2 percent slopes, in a stubble field 180 feet west and 2,570 feet north of the southeast corner of sec. 27, T. 159 N., R. 50 W.:

A1p—0 to 6 inches; black (10YR 2/1) silty clay loam; weak very fine subangular blocky structure; very friable; common roots; strongly effervescent; moderately alkaline; abrupt smooth boundary.

A1ca—6 to 10 inches; very dark gray (10YR 3/1) silty clay loam; weak very fine subangular blocky structure; friable; many white fine lime threads and lamella; plentiful roots; strongly effervescent; moderately alkaline; clear smooth boundary.

C1ca—10 to 14 inches; dark grayish brown (10YR 4/2) and grayish brown (10YR 5/2) silty clay loam; weak very fine granular structure; very friable; few roots; violently effervescent; moderately alkaline; clear smooth boundary.

C2ca—14 to 19 inches; light yellowish brown (2.5Y 6/4) silt loam; weak coarse subangular blocky structure parting to weak very fine granular; very friable; few fine light gray lime nodules; few roots; violently effervescent; moderately alkaline; clear smooth boundary.

C3ca—19 to 23 inches; light brownish gray (2.5Y 6/2) silt loam; few medium prominent olive yellow (2.5Y 6/6) mottles and common medium distinct light gray (2.5Y 7/2) mottles; weak medium subangular blocky structure parting to weak, very fine, granular; very friable; strongly effervescent; moderately alkaline; clear smooth boundary.

C4—23 to 28 inches; grayish brown (2.5Y 5/2) silty clay layered with silt loam; common medium prominent dark yellowish brown (10YR 4/4) and yellowish brown (10YR 5/6) mottles; weak medium platy structure parting to weak very fine subangular blocky; very friable; strongly effervescent; moderately alkaline; clear smooth boundary.

C5—28 to 60 inches; light brownish gray (2.5Y 6/3) silty clay loam layered with dark gray (5Y 4/1) silt loam; common fine prominent olive yellow (2.5Y 6/6) mottles; weak very fine subangular blocky structure; very friable; slightly effervescent; moderately alkaline.

The A horizon is silty clay loam or silt loam. In some places, the very dark gray and very dark grayish brown Aca horizon is absent. Reaction of the A horizon ranges from mildly to moderately alkaline. Thickness of the A horizon ranges from 6 to 16 inches. The Cca horizon is very dark grayish brown, dark grayish brown, grayish brown, light yellowish brown, light brownish gray, light olive brown, olive brown, and pale brown. In some places mottles are absent, but prominent or distinct mottles are present especially in the lower Cca horizon of many profiles. The Cca horizon ranges in thickness from 8 to 28 inches. The C horizon is grayish brown, light brownish gray, gray, light olive brown, olive gray, and olive with few faint to many prominent mottles. Reaction is moderately or mildly alkaline. Pockets of gypsum crystals are in the Cca and C horizons of some profiles.

Bearden soils are associated with Colvin, Fargo, and Glyndon soils. They are better drained and have more silt and less clay than Fargo soils. They are better drained than Colvin soils, and they have more clay and fine silt than Glyndon soils.

67—Bearden silt loam, 0 to 2 percent slopes. This soil is in areas that are commonly over 20 and under 400 acres in size. The surface is generally level or very slightly convex. Some areas have alternating convex and concave spots. Where the surface layer is shallow and tillage has mixed it with the underlying material, the soil is gray. The surface layer is commonly friable when cultivated. Fields have a smooth, level appearance. This soil has a profile similar to that described as representative of the Bearden series, but the upper 14 inches is coarser. The texture of this zone varies from loam and silt loam to very fine sandy loam.

Included with this soil in mapping, and making up as much as 15 percent of an individual mapped area, are Colvin soils and Glyndon or Wheatville soils. Also included, and making up as much as 15 percent of an individual mapped area, are Fargo and Hegne soils. A few areas that have a clayey C horizon at a depth of less than 30 inches are included. In some areas soluble salts are present in varying degrees of concentration.

Soil blowing is a hazard when cultivated areas are bare. A nutrient imbalance in this soil results from its strongly calcareous condition and influences use and management.

Most of this soil is cultivated. Small grain, sugar beets, sunflowers, and potatoes are the most common crops. Legumes and grasses are often included in cropping sequences as green manure crops. Capability unit IIe–1; Silty range site.

93—Bearden silty clay loam, 0 to 2 percent slopes. This soil is in areas that are commonly over 40 and under 600 acres in size. The surface is generally level or very slightly convex. Some areas have alternating convex and concave spots. The surface layer is gray where it is shallow and tillage has mixed it with the underlying material. When cultivated the surface has a fine blocky or granular appearance. If cultivated when wet the surface layer becomes cloddy and seedbed preparation is more difficult. This soil has the profile described as representative of the Bearden series.

Included with this soil in mapping, and making up as much as 15 percent of an individual mapped area, are Colvin and Fargo soils. Also included, and making up as much as 20 percent of an individual mapped area, are Hegne soils or Bearden soils that have a silt loam surface layer. Some areas that have a clayey C horizon at a depth of less than 30 inches are included. In some areas soluble salts are present in varying degrees of concentration.

Soil blowing is a hazard when cultivated areas are bare. A nutrient imbalance in this soil that results from its strongly calcareous condition influences use and management. Cultivating this soil when wet causes soil compaction and structural damage.

Most of this soil is cultivated. Small grain and sugar beets are the most common crops. A small acreage is planted to sunflowers and potatoes. Legumes and grasses are often included in cropping sequences as green manure crops. Capability unit IIe–1; Silty range site.

93B—Bearden silty clay loam, 2 to 6 percent slopes. This soil commonly is in areas that are between 3 and 40 acres in size. Most areas are elongated and parallel natural drainageways. Slopes are short, commonly ranging in length from 50 to 200 feet. This soil has a profile similar to that described as representative of the Bearden series, but, in some places, the surface layer varies in thickness and color because of the gentle slopes and the location of the soil next to drainageways. In places, the texture is more stratified.

Included with this soil in mapping, and making up as much as 15 percent of an individual mapped area, are sloping Northcote and Wahpeton soils. Also included, and making up as much as 20 percent of an individual mapped area, are moderately eroded Bearden soils, Bearden soils with a silt loam surface layer and small areas where slopes are over 6 percent. A few areas that have a clayey C horizon at a depth of less than 30 inches are included.

Soil blowing and water erosion are hazards on this soil. A nutrient imbalance in this soil that results from its strongly calcareous condition also influences use and management. Cultivating this soil when wet causes structural damage and compaction.

Nearly all of this soil is cultivated. Small grain is the most common crop, but some areas are included in fields planted to sugar beets, sunflowers, or potatoes. Grasses and legumes are often included in the cropping sequences as hay and pasture or as green manure crops. Capability unit IIe–1; Silty range site.

908—Bearden-Fargo complex. This complex is in large areas, commonly over 500 acres in size. Slopes are 0 to 2 percent. The alternate ridges and depressions are generally oriented in a northwest-southeast direction. In places a relief of high knolls and deeper depressions varies the surface elevation from 4 to 20 inches, with an average of 10 inches.

Bearden silty clay loam occupies the ridges and knolls and Fargo silty clay occupies the draws and depressions. A concentration of carbonates is near the surface of Bearden soil. In places in tilled areas, this layer of concentrated carbonates is mixed with the surface layer and gives it a grayer cast. The result of this mixing is most evident on the higher parts of ridges and knolls when the surface is dry. Fargo soil has a deeper, darker colored noncalcareous surface layer.

Bearden silty clay loam makes up 55 to 75 percent of this complex. Fargo silty clay makes up 25 to 45 percent. The Bearden soil in this complex has a profile similar to that described as representative of the series. The Fargo soil has a thicker surface layer than the one defined for the series.

Included with this complex in mapping, and making up as much as 20 percent of an individual mapped area, are Northcote soils. Also included, and making up as much as 15 percent of an individual mapped area, are Hegne and Colvin soils. In some areas soluble salts are present in varying degrees of concentration.

Wetness limits the use of this complex. The alternating ridges and depressions make drainage difficult. Soil blowing is a hazard when cultivated areas are smooth and have no protective cover. A nutrient imbalance in Bearden soils that results from the strongly calcareous condition influences use and management.

Nearly all of this complex is cultivated. Small grain, sugar beets, and sunflowers are the most common crops. Legumes and grasses are included in cropping sequences as green manure crops. A few areas are harvested for hay or are pastured before being plowed and returned to cultivated cropland. Capability unit IIw–4; range site not classified.

Borup series

The Borup series consists of nearly level, poorly drained soils. These soils formed under a growth of sedges and tall grasses in calcareous loamy lacustrine sediment underlain by very fine sandy and coarse silt. They are in nearly level, commonly slightly concave areas.

In a representative profile the surface layer is about 10 inches of black, strongly effervescent loam. The next layer is about 12 inches of light gray and gray, violently effervescent loam that grades to very fine sandy loam. The underlying material is mottled, light gray very fine sand that is strongly effervescent.

Permeability is moderately rapid, and available water capacity is high. Inherent fertility is high. The seasonal high water table fluctuates from a depth of 1 to 3 feet.

Most areas of Borup soils are cultivated. These soils are suited to all crops commonly grown in Kittson County. Small grain and sugar beets are the most common crops.

Representative profile of Borup loam, in a cultivated field 1,484 feet north and 492 feet east from the southwest corner of sec. 35, T. 160 N., R. 47 W.:

A1—0 to 10 inches; black (10YR 2/1) loam; weak very fine subangular structure; very friable; plentiful roots; strongly effervescent; mildly alkaline; clear smooth boundary.

C1ca—10 to 15 inches; light gray (2.5Y 6/1) loam; moderate fine subangular structure; very friable; plentiful roots; violently effervescent; moderately alkaline; clear smooth boundary.

C2ca—15 to 19 inches; gray (5Y 5/1) very fine sandy loam; weak very fine subangular blocky structure; very friable; few roots; violently effervescent; moderately alkaline; clear smooth boundary.

C3ca—19 to 22 inches; light gray (2.5Y 7/2) very fine sandy loam; weak very fine subangular blocky structure; very friable; strongly effervescent; moderately alkaline; clear smooth boundary.

C4—22 to 60 inches; light gray (5Y 7/1) very fine sand; common fine prominent brownish yellow (10YR 6/6) mottles; single grained; loose; strongly effervescent; mildly alkaline.

The A horizon is typically loam, but very fine sandy loam and silt loam are also in the range. Thickness ranges from 6 to 16 inches. In places a very dark gray and very dark grayish brown Aca horizon is present. The Cca horizon is very fine sandy loam, loam, loamy very fine sand, and silt loam. Thickness ranges from 6 to 16 inches. The Cca horizon is light gray, gray, dark gray, grayish brown, dark grayish brown, and olive gray in color. Distinct and prominent mottles are common, but in some places mottles are absent. The C horizon is typically loamy very fine sand and very fine sand, and very fine sandy loam also is in the range. It is light gray, gray, dark gray, olive gray, olive, pale olive, grayish brown, and light brownish gray in color and has faint to distinct mottles. Reaction is mildly or moderately alkaline.

Borup soils are associated with Augsburg, Colvin, and Glyndon soils. Borup soils lack the finer textured IIC horizon within a depth of 40 inches that Augsburg soils have. They have more coarse silt and very fine sand and less clay than the finer textured Colvin soils. Borup soils are more poorly drained than Glyndon soils.

46—Borup loam. This soil is in areas that normally range in size from 10 to 100 acres. Slopes are 0 to 2 percent. The surface is generally smooth and is slightly concave. Where cultivated the surface layer has a smooth, black appearance and some gray areas. A concentration of carbonates is nearer the surface in these grayer areas. This condition is more evident when the surface is dry.

Included with this soil in mapping, and making up as much as 20 percent of an individual mapped area, are Glyndon soils and Augsburg soils. Also included, and making up as much as 15 percent of an individual mapped area, are Arveson and Colvin soils. Some areas where the surface layer is thinner and more calcareous are included. In some areas soluble salts are present in varying degrees of concentrations.

Wetness limits the use of this soil. Soil blowing is a hazard when cultivated areas have no protective cover. The strongly calcareous condition of this soil affects its nutrient balance.

Most of this soil is cultivated. Small grain, sugar beets, sunflowers, and potatoes are the most common crops. Legumes and grasses are included in cropping sequences usually as green manure crops. A small acreage is used for hay and pasture. Capability unit IIw–3; Subirrigated range site.

Breaks and Alluvial land

1006—Breaks and Alluvial land. This land is in moderately steep and steeper areas along rivers and streams and their flood plains. Slopes range from 0 to 2 percent and from 12 to 30 percent. The length of slope on these breaks is short, commonly ranging from 50 to 200 feet. These areas are often dissected by channels of drains leading into the larger rivers and streams. The soil material of this unit is normally moderately fine and fine textured and dark to moderately dark colored, but it is mixed with many variations and stratified material.

Included in mapping, and making up as much as 25 percent of an individual mapped area, is Alluvial land, frequently flooded. Also included in mapping, and making up as much as 15 percent of an individual mapped area, are gently sloping and sloping Cashel, Fargo, Wahpeton, and Bearden soils.

Susceptibility to water erosion limits the use of this land type. Steepness of slope and the dissected nature of these lands limit their use.

Breaks and alluvial land are seldom cultivated. The most common vegetative cover is trees. These are commonly such bottom land hardwoods as basswood, elm, ash, and cottonwood. Some areas are in pasture. Capability unit VIe–1; range site not classified.

Cashel series

The Cashel series consists of nearly level, somewhat poorly drained soils. These soils formed in fine textured alluvial material. They are commonly on narrow terraces and in partially filled meanders and oxbows. These areas are associated with major streams in the western part of the county. Areas of Cashel soils are flooded by adjacent streams. Although these soils often support a growth of trees with grassed openings, vegetation has had little influence on soil development because each flooding deposits new alluvium.

In a representative profile the surface layer is about 6 inches of black clay. The next layer is about 26 inches of very dark gray clay that grades to dark olive gray clay. This layer is mixed with some shell fragments and lime nodules. The underlying material is alternating layers of very dark gray, dark olive gray, and dark gray clay. This material contains some lime nodules and pockets of gypsum crystals.

Permeability is slow, and available water capacity is moderate. Inherent fertility is high. The seasonal high water table fluctuates from a depth of 1 to 6 feet.

When they are not subject to prolonged flooding, Cashel soils are suited to crops commonly grown in Kittson County. The sloping areas are not well suited to row crops like sugar beets. Some areas of this soil are quite inaccessible and are supporting a growth of trees and grasses. Wetness is the major limitation of these soils.

Representative profile of Cashel clay, on a nearly level area in a cultivated field 2,112 feet north and 250 feet east of the southwest corner of sec. 9, T. 159 N., R. 50 W.:

Ap—0 to 6 inches; black (10YR 2/1) clay; weak very fine subangular blocky structure; sticky; mildly alkaline; abrupt smooth boundary.

C1—6 to 12 inches; very dark gray (2.5Y 3/1) clay; weak very fine subangular blocky structure; sticky; layers of slightly variable color and thin strata of silty clay and clay; neutral; gradual smooth boundary.

C2g—12 to 32 inches; layered dark olive gray (5Y 3/2) and very dark gray (2.5Y 3/1) clay; few fine distinct dark grayish brown (2.5Y 4/3) and very dark grayish brown (2.5Y 3/2) mottles; weak and moderate very fine angular blocky structure; sticky; many fine lime nodules; some shell fragments; strongly effervescent; mildly alkaline; clear smooth boundary.

C3g—32 to 60 inches; alternating layers of very dark gray (5Y 3/1), dark olive gray (5Y 3/2), and dark gray (5Y 4/1) clay; weak and moderate very fine angular blocky structure; sticky; thin white (2.5Y 8/1) lime layers and fine lime nodules; few masses of gypsum crystals; strongly effervescent; mildly alkaline.

Clay content in Cashel soils typically ranges from 45 to 55 percent with extreme ranges of from 40 to 60 percent. Texture is clays and silty clays. The A horizon typically is very dark brown and very dark grayish brown, but in some pedons the A horizon is black. In some places the lower part of the A horizon has layering of various colors and shell and wood fragments. The C horizon is very dark gray, dark olive gray, dark gray, black, olive, olive gray, very dark grayish brown, dark grayish brown, very dark brown, and dark brown. In some places thin layers and masses of lime, shell, and wood fragments occur.

Cashel soils are associated with Northcote and Wahpeton soils. They lack the profile development, are more stratified, and contain less clay than Northcote soils. Cashel soils are more subject to flooding and are less developed than Wahpeton soils.

50—Cashel clay. This soil is on low terraces, flood plains, or partially filled bottoms of old stream meanders and oxbows. These areas commonly range in size from 3 to 15 acres. Slopes are 0 to 2 percent. They are characteristically uneven, narrow or irregularly shaped and cut up by drains leading into streams. When cultivated the surface layer of this soil has a smooth, fine blocky appearance. If cultivated when wet the surface layer has a rougher, cloddy appearance.

Included with this soil in mapping, and making up as much as 20 percent of an individual mapped area, are Northcote soils. Also included are areas of soils that are more silty and more calcareous. In some areas are soils that have an average clay content of over 60 percent.

Wetness limits the use of this soil. Areas of this soil are flooded by medium to high water levels from adjoining streams. Cultivating this soil when wet causes structural damage and compaction.

Many areas of this soil are used for pasture. These areas support a growth of native and introduced grasses and trees, principally bottom land hardwoods. Some areas are cultivated, usually for the production of small grain. Capability unit IIIw–2; Clayey range site.

Cathro series

The Cathro series consists of level or depressional, very poorly drained soils. These soils formed in a mantle of organic soil material over loamy glacial sediment. They commonly occupy broad, flat, slightly depressional areas. Native vegetation is reeds, sedges and other water-tolerant plants.

In a representative profile the surface is about 15 inches of very dark brown muck. Below this is about 19 inches of black muck. The top of the mineral material is about 3 inches of black sandy loam that grades to about 5 inches of olive gray, gravelly, loamy sand. The underlying material is light olive gray loam.

Permeability is moderate, and available water capacity is very high. Inherent fertility is low. The seasonal high water table commonly fluctuates from a depth of 0 to 3 feet.

Most areas of these soils are not cultivated. Reeds,

sedges, willow brush, and some trees, principally aspen, grow on these areas. A few areas are used for hay and pasture or are cultivated for the production of small grain. Wetness is the major limitation.

Representative profile of Cathro muck, in an area of sedges, grasses, and willows 1,900 feet east and 60 feet north of the southwest corner of sec. 23, T. 161 N., R. 45 W.:

Oa1—0 to 15 inches; very dark brown (10YR 2/2), broken face and rubbed sapric material, dark brown (7.5YR 3/2; 7.5YR 4/4), broken face, fiber; about 50 percent fiber, about 15 percent rubbed; weak fine crumb structure; very friable; herbaceous fiber; about 12 percent mineral material; slightly acid; clear smooth boundary.

Oa2—15 to 27 inches; black (10YR 2/1), broken face, sapric material, very dark brown (10YR 2/2), broken face, fiber, black (N/2) rubbed; about 20 percent fiber, trace rubbed; weak thick platy structure; very friable; herbaceous fiber; about 20 percent mineral material in upper part grading to 30 percent in lower part; slightly acid; gradual smooth boundary.

Oa3—27 to 34 inches; black (N/2), broken face and rubbed, sapric material; about 15 percent fiber, trace rubbed; massive with a few pressure faces; very friable; herbaceous fiber; about 40 percent mineral material in upper part grading to 60 percent in lower part; slightly acid; clear smooth boundary.

IIA1b—34 to 37 inches; black (N/2) weak sandy loam; massive; slightly sticky; neutral; clear smooth boundary.

IIC1g—37 to 42 inches; olive gray (5Y 4/2) gravelly loamy sand; single grain; loose; slightly alkaline; clear smooth boundary.

IIIC2g—42 to 60 inches; light olive gray (5Y 6/2) loam; common medium prominent light olive brown (2.5Y 5/6) mottles; weak very fine subangular blocky structure; friable; moderately alkaline.

The organic soil material ranges from 16 to 50 inches in thickness. The surface layer is made up of sapric material with a rubbed fiber content of from 15 to less than 10 percent. The underlying organic soil material mostly is sapric with a fiber content of less than 10 percent after rubbing in more than half of the organic material above the IIA1b horizon. In some pedons layers of hemic materials are within this organic material but have a combined thickness of less than 10 inches. The organic soil material is black, very dark gray, very dark grayish brown, very dark brown, dark brown, and dark reddish brown. Reaction in the organic soil material ranges from moderately acid to slightly alkaline. In some places, a gravelly sandy loam, coarse sandy loam, sandy loam, and loam IIA1b horizon occurs. This horizon is black, very dark gray, dark olive gray, and very dark grayish brown. The IIC horizon is sandy loam, loam, silt loam, light clay loam, and light silty clay loam, but in some places, it is thin layers of coarser texture. It is dark grayish brown, grayish brown, light brownish gray, dark gray, gray, olive gray, and light olive gray in color.

The Cathro series is associated with Haug, Percy, and Markey soils. The Cathro soils have a thicker layer of organic soil material than Haug soils. They are more poorly drained than the Percy soils and have a 16 to 50 inch thickness of organic soil material which is lacking in those soils. Cathro soils have finer textured mineral material beneath the muck than the Markey soils.

544—Cathro muck. This soil is in depressions, parts of old stream channels, and low, broad, flat areas. These areas normally range in size from 10 to 640 acres. Slopes are 0 to 2 percent. The surface layer of this soil has a black, mellow, granular appearance when cultivated. Some surface material may be root-bound, so it becomes lumpy when it is first cultivated.

Included with this soil in mapping, and making up as much as 15 percent of an individual mapped area, are soils with organic soil material deeper than 50 inches and Markey muck. Also included are areas of soils that have a calcareous surface layer and carbonates in all parts of the organic soil material. Other inclusions, and making up as much as 15 percent of an individual mapped area, are marshy areas where soil material has not been determined and areas that have less highly decomposed organic material. A few areas that have stones and boulders exposed at the surface are also included.

Wetness limits the use of this soil. A low inherent fertility influences use and management. Muck fires are a hazard on this soil.

Reeds, sedges, phragmites, cattails, and scattered areas of lowland brush grow on this soil. A few areas are wooded, and quaking aspen is the most common tree. Some areas are used for hay and pasture. Reed canarygrass is grown in some areas. A few areas have been cultivated, usually for the production of flax and small grain. Capability unit IVw–3; Grazeable Muck range site.

Colvin series

The Colvin series consists of nearly level, poorly drained soils. These soils formed in calcareous, silty and loamy lacustrine sediment. They are on flats and in depressions. Native vegetation is reeds, sedges and tall grass prairie.

In a representative profile the surface layer is black, slightly to strongly effervescent silty clay loam about 12 inches thick. The next layer is about 6 inches of gray, very strongly effervescent silt loam. The underlying material is mottled, olive gray silt loam.

Permeability is moderately slow, and available water capacity is high. Inherent fertility is high. The seasonal high water table fluctuates from a depth of 0 to 3 feet.

Nearly all areas of Colvin soils are cultivated. Small grain and sugar beets are the most common crops. Wetness is the major limitation.

Representative profile of Colvin silty clay loam, in a cultivated field 660 feet west and 50 feet south of the northeast corner of sec. 31, T. 160 N., R. 47 W.:

Ap—0 to 7 inches; black (10YR 2/1) silty clay

loam; moderate fine subangular blocky structure; sticky; slightly effervescent; mildly alkaline; abrupt smooth boundary.

A12—7 to 12 inches; black (10YR 2/1) silty clay loam; weak very fine subangular blocky structure; sticky; strongly effervescent; mildly alkaline; abrupt wavy boundary.

C1gca—12 to 18 inches; gray (5Y 5/1) silt loam; weak very fine subangular blocky structure; friable; very strongly effervescent; moderately alkaline; common masses of dark gray (5Y 4/1); clear wavy boundary.

C2g—18 to 25 inches; olive gray (5Y 5/2) silt loam; few fine faint olive (5Y 5/4) mottles; weak very fine subangular blocky structure; friable; strongly effervescent; moderately alkaline; clear smooth boundary.

C3g—25 to 60 inches; olive gray (5Y 4/2) silt loam; many medium faint olive (5Y 4/4) mottles; weak very fine subangular blocky structure; sticky; strongly effervescent; moderately alkaline.

The A horizon is black or very dark gray silt loam or silty clay loam about 7 to 16 inches thick. It ranges from mildly to moderately alkaline in reaction. A thin very dark gray Aca horizon is in some pedons. The Cca horizon is silt loam to silty clay loam. It is light gray, gray, dark gray, olive gray or grayish brown in color. The Cca horizon ranges from 6 to 16 inches in thickness. The C horizon is silt loam, silty clay loam and, in some pedons, it has layers of silt loam, clay, or silty clay. It is light gray, gray, olive gray, light olive gray or pale olive in color, and has mottles that range from faint to distinct. Reaction is mildly to moderately alkaline. In some places, masses of gypsum crystals are in this horizon.

The Colvin series is associated with Augsburg, Bearden, Hegne, and Northcote soils. The Colvin soils have less very fine sand and more clay in the upper part of the profile, and have less clay and more silt in the lower part than Augsburg soils. They are more poorly drained than Bearden soils. They have less clay and more silt than Hegne and Northcote soils.

47—Colvin silty clay loam. This soil is in areas that commonly range between 10 and 150 acres in size. Slopes are 0 to 2 percent. The surface is slightly concave. Where cultivated the surface layer has a black, fine blocky appearance. If cultivated wet the surface layer becomes cloddy and seedbed preparation is more difficult.

Included with this soil in mapping, and making up as much as 15 percent of an individual mapped area, are Northcote soils and Bearden soils. Also included are small areas of Hegne, Borup, and Augsburg soils. Spots that have a shallow, strongly calcareous surface layer are included. In some areas soluble salts are present in varying degrees of concentration.

Wetness limits the use of this soil. Cultivating this soil when wet causes soil compaction and damages structure. A nutrient imbalance in this soil that results from its strongly calcareous condition influences use and management.

Most areas of this soil are cultivated. Small grain and sugar beets are the most common crops. A small acreage is planted to sunflowers and potatoes. Legumes and grasses are often included in the cropping sequence as green manure crops. Capability unit IIw–3; Subirrigated range site.

Cormant series

The Cormant series consists of nearly level, poorly drained soils. These soils formed in lake sediment consisting mostly of fine sand. They are commonly in low, flat and depressional areas. Native vegetation is largely aspen, balsam poplar, and willows mixed with grasses.

In a representative profile the surface has a layer of black organic duff about 3 inches thick. The surface layer is 6 inches of very dark grayish brown, loamy fine sand. The underlying material is mottled, grayish brown fine sand. Mottling becomes less distinct with depth and is not evident below 32 inches.

Permeability is rapid, and available water capacity is low. Inherent fertility is low. The seasonal high water table commonly fluctuates from a depth of 0 to 3 feet.

Some areas of Cormant soils are cultivated. Small grain and forage for livestock are the most common crops. Other areas support a growth of aspen, grasses, reeds, and sedges. Wetness is the major limitation.

Representative profile of Cormant loamy fine sand, from an area of Cormant soils, in a wooded area 3,168 feet east and 1,056 feet south of the northwest corner of sec. 26, T. 161 N., R. 46 W.:

Oa—3 inches to 0; black (N/2) sapric material; weak fine granular structure, very friable; high in content of sand; slightly acid; clear smooth boundary.

A1—0 to 6 inches; very dark grayish brown (2.5Y 3/2) loamy fine sand; weak very fine subangular blocky structure; very friable; abundant roots; neutral; abrupt smooth boundary.

A2—6 to 7 inches; dark grayish brown (10YR 4/2) fine sand; few fine distinct yellowish brown (10YR 5/6) mottles; single grained; loose; neutral; clear smooth boundary.

C1—7 to 23 inches; grayish brown (2.5Y 5/2) fine sand; many fine and medium distinct light olive brown (2.5Y 5/6) and olive (5Y 5/4) mottles and few fine prominent yellowish red (5YR 5/6) mottles; single grained; loose; neutral; gradual smooth boundary.

C2—23 to 32 inches; grayish brown (2.5Y 5/2) fine sand; few fine faint light olive brown (2.5Y 5/4) mottles; single grained; loose; neutral; gradual smooth boundary.

C3—32 to 60 inches; grayish brown (2.5Y 5/2) fine sand; single grained, loose; neutral.

Depth to free lime is 36 to 80 inches. The Ap or A1 horizons are loamy fine sand, loamy sand, fine sand, or sand. They are black, very dark gray, very dark grayish brown, and very dark brown in color. Reaction is slightly acid or neutral. In some places, principally those not cultivated, an A2 horizon is 0 to 4 inches

thick. It is dark grayish brown, grayish brown, and light brownish gray. Reaction is slightly acid or neutral. The C horizon is dark grayish brown, grayish brown, light brownish gray, olive gray, light olive gray, dark gray, and gray. Mottling is in part or all of the C horizon, but in some pedons it is very faint or does not exist below 25 inches. The C horizon typically is fine sand, but the range includes sands. Reaction ranges from slightly acid to neutral in the upper part of the C horizon and is neutral to mildly alkaline in the lower part.

Cormant soils are associated with Deerwood, Grygla, Markey, Poppleton, and Redby soils. The Cormant soils lack or have a thinner layer of organic soil material than Deerwood and Markey soils. They lack the loamy IIC horizon of Grygla soils. They are more poorly drained than Poppleton soils. Cormant soils are more poorly drained and lack the intensity of mottling that occurs in Redby soils.

117—Cormant soils. These soils are in plane or slightly concave areas that have varied shapes. These areas are commonly between 5 and 80 acres in size. Slopes are 0 to 2 percent. Soil blowing has affected a few areas, and alternate areas of erosion and accumulation are evident. The surface layer ranges in texture from loamy fine sand to fine sand and is moderately dark with numerous clean, bleached sand grains that modify the color. These soils have the profile described as representative of the series.

Included with these soils in mapping, and making up as much as 15 percent of an individual mapped area, are Redby soils, Grygla soils, and soils that have a slightly thicker, dark colored surface layer. Also included and making up as much as 10 percent of an individual mapped area, are Arveson soils and small areas that have been affected by moderate to severe degrees of soil blowing.

Wetness limits the use of this soil. A low available water capacity and low inherent fertility are also limitations. Soil blowing is a hazard.

Some areas of these soils are cultivated. Small grain and potatoes are the most common crops. Another use of these soils is for hay and pasture. Scattered areas support growth of quaking aspen and lowland brush. Many areas are in idle land. Capability unit IVw–1; Subirrigated range site.

Deerwood series

The Deerwood series consists of level or depressional, very poorly drained soils. These soils formed in a thin layer of organic soil material and underlying sandy glacial lacustrine sediment. They commonly are on low flats and in broad depressions. Native vegetation is reeds, sedges and other water-tolerant plants.

In a representative profile the surface layer is about 10 inches of black muck. Below this is about 2 inches of black loamy sand. The underlying material is mottled, light grayish brown fine sand that grades with depth to gravelly sand.

Permeability is moderately rapid, and available water capacity is moderate. Inherent fertility is low. The seasonal high water table fluctuates from a depth of 0 to 3 feet.

Reeds, sedges, willow brush, and some trees, principally quaking aspen, grow on these areas. Some areas are used for hay and pasture or are cultivated for the production of small grain crops. Wetness is the major limitation.

Representative profile of Deerwood muck, in a shallow depression with sedge vegetation 1,600 feet east and 1,420 feet north of the southwest corner of sec. 23, T. 160 N., R. 46 W.:

Oa—0 to 10 inches; black (10YR 2/1), broken face and rubbed, sapric material; about 25 percent fiber, about 10 percent fiber rubbed; weak very fine granular structure; very friable; herbaceous fiber; about 40 percent mineral material; slightly effervescent; mildly alkaline; abrupt smooth boundary.

IIA1b—10 to 12 inches; black (10YR 2/1) loamy sand; many medium distinct gray (10YR 5/1) mottles and inclusions; massive; loose; strongly effervescent; moderately alkaline; gradual smooth boundary.

IIC1g—12 to 30 inches; light grayish brown (2.5Y 6/2) fine sand; few fine distinct light olive brown (2.5Y 5/4) mottles; single grained; loose; strongly effervescent; moderately alkaline; clear smooth boundary.

IIC2g—30 to 60 inches; light grayish brown (2.5Y 6/2) gravelly sand; few fine distinct light olive brown (2.5Y 5/4) mottles; single grained; loose; strongly effervescent; moderately alkaline.

The Oa horizon is 4 to 16 inches thick. Free carbonates are commonly in all of the profile, but in places they are not in the upper part of the organic soil material. A few cobblestones and larger fragments are on or in the mineral soil surface of some pedons. The Oa horizon is typically sapric material but in some profiles it is partly hemic material. It is black, very dark gray, very dark grayish brown, very dark brown, and dark olive gray. The IIAb horizon ranges in thickness from 2 to 6 inches. It is coarse sand, sand, fine sand, loamy coarse sand, loamy sand, loamy fine sand, coarse sandy loam, sandy loam, and fine sandy loam. It is black or very dark gray in color. The IIC horizon is coarse sand, sand, fine sand, loamy coarse sand, loamy sand, and loamy fine sand. It is dark gray, gray, light gray, light olive gray, olive gray, dark grayish brown, grayish brown, and light brownish gray in color. In some pedons the IIA1b and the IIC horizons have as much as 35 percent gravel.

The Deerwood series is associated with Cormant, Markey, and Redby soils. The Deerwood soils have a 4 to 16 inch thick O horizon, but the Cormant soils either lack an O horizon or have one that is less than 4 inches thick. They have an O horizon that is thinner than the Markey soils. They are more poorly drained than the Redby soils.

547—Deerwood muck. This soil occupies depressions, parts of old stream channels and low, broad, flat areas. These areas normally range in size from 10 to 300 acres. Slopes are 0 to 2 percent. The surface layer of this soil has a black, friable, granular appearance where cultivated. Some surface material is rootbound, so it becomes lumpy when it is first cultivated.

Included with this soil in mapping, and making up as much as 20 percent of an individual mapped area, are Arveson and Cormant soils, depressional. Also included, and making up as much as 15 percent of an individual mapped area, are Markey muck and Rockwell and Grygla soils, depressional. Small areas that have a strongly calcareous surface layer and small marshy areas where soil materials have not been determined are also included. Some areas where stones and boulders are exposed at the surface are included.

Wetness limits the use of this soil. Low inherent fertility influences use and management.

Reeds, sedges, phragmites, cattails, and scattered areas of lowland brush are supported by this soil. Some areas are wooded, and quaking aspen is the most common tree. A few areas are used for hay and pasture. Reed canarygrass is grown on some of these areas. Capability unit IVw–3; Grazeable Muck range site.

Donaldson series

The Donaldson series consists of nearly level, somewhat poorly drained to moderately well drained soils. These soils formed in loamy material and the underlying sandy sediment over clayey material. They are commonly on slightly convex areas. Native vegetation is tall grasses.

In a representative profile the surface layer is about 9 inches of black, neutral very fine sandy loam, and the subsoil is about 5 inches of dark brown loamy very fine sand. It is mottled and noneffervescent. The next layer is about 10 inches of mottled, pale brown, slightly effervescent loamy very fine sand. The contrasting underlying material is strongly effervescent, olive gray clay.

Permeability is moderate in the upper part and slow in the clay, and available water capacity is high. Inherent fertility is medium. The seasonal high water table fluctuates from a depth of 2.5 to 6 feet.

Most areas of Donaldson soils are cultivated. They are suited to all crops commonly grown in Kittson County. Small grains and sugar beets are the most common crops. Climate is the major limitation.

Representative profile of Donaldson very fine sandy loam, from an area of Donaldson soils, 0 to 2 percent slopes, in a cultivated field 1,720 feet south and 150 feet west of the northeast corner of sec. 24, T. 159 N., R. 48 W.:

A1—0 to 9 inches; black (10YR 2/1) very fine sandy loam; weak very fine subangular blocky structure; very friable; many clear quartz grains; neutral; clear smooth boundary.

B2—9 to 14 inches; dark brown (10YR 3/3) loamy very fine sand; common fine distinct yellowish brown (10YR 5/6) and dark yellowish brown (10YR 4/4) mottles and common fine prominent yellowish red (5YR 5/8) mottles; massive; very friable; neutral; clear wavy boundary.

C1—14 to 24 inches; pale brown (10YR 6/3) loamy very fine sand; common medium distinct brownish yellow (10YR 6/6), yellow (2.5Y 7/6), and pale yellow (2.5Y 8/3) mottles; massive; loose; slightly effervescent; mildly alkaline; clear wavy boundary.

IIC2—24 to 60 inches; olive gray (5Y 4/2) clay; common medium distinct olive (2.5Y 4/3) and light gray (2.5Y 7/2) mottles; moderate coarse prismatic structure parting to moderate very fine angular blocky; sticky; few black concretions 1 to 5 millimeters in size and bands of silty material 1 to 4 millimeters thick below 50 inches; strongly effervescent; moderately alkaline.

Thickness of solum and depth to free carbonates range from 10 to 20 inches. Depth to the IIC horizon ranges from 20 to 40 inches. Carbonate content increases with depth but no calcic horizon occurs within 16 inches of the surface. The A horizon is typically very fine sandy loam, but loam, silt loam and sandy clay loam are also in the range. It is typically black but may also be very dark gray, very dark brown, and very dark grayish brown in color. The B horizon is typically loamy very fine sand, but very fine sandy loam, loam, silt loam, or silt is also in the range. The B horizon is commonly massive but weak or moderate subangular blocky structure occurs in some pedons. It is pale brown, light brownish gray, brown, and grayish brown in color and has few faint mottles ranging to common, prominent mottles. The C horizon is typically loamy very fine sand, but very fine sandy loam, loam, silt loam, and silt are also in the range. It is single grained or has weak to moderate subangular blocky structure. Color is typically pale brown, but light yellowish brown, yellowish brown, brown, and light olive brown also occur. Mottling in the C horizon is distinct or prominent. The IIC horizon is typically clay, but in some places is silty clay loam, silty clay, and bands of silt. Structure ranges from coarse prismatic to very fine subangular blocky. Some platy structure is associated with silt bands. The IIC horizon is typically olive gray, but gray, dark gray, very dark gray, and dark olive gray also occur.

Donaldson soils are associated with Foldahl, Noyes, Viking, and Wheatville soils. Donaldson soils occupy similar positions but are finer textured than Foldahl soils. They occupy slightly higher positions and are better drained than Noyes and Viking soils. Donaldson soils lack the calcareous surface and calcic horizon that is present in Wheatville soils.

425—Donaldson soils, 0 to 2 percent slopes. These soils occupy areas that are commonly between 10 and 100 acres in size. The surface is smooth or very slightly convex. The surface layer ranges in texture from very fine sandy loam to silt loam and has very fine granular or fine blocky appearance when cultivated.

Included with these soils in mapping, and making up as much as 15 percent of an individual mapped area, are Wheatville, Bearden, Noyes, and Foldahl soils. Also included are small areas of soils that have more than 16 inches of a dark surface layer and soils that are coarser textured in the IIC horizon. In some areas soluble salts are present in varying degrees of concentrations.

Climate limits the crops that mature and provide an

economic return. Soil blowing is a hazard where cultivated areas have no protective cover.

Nearly all areas of these soils are cultivated. Small grain, sugar beets, and sunflowers are the most common crops. A smaller acreage is planted to potatoes. Legumes and grasses are included in cropping sequences, generally for use as green manure crops. Capability unit IIc–1; Silty range site.

Dune land

1025—Dune land. Dune land is areas where sand has blown about causing blowouts and forming dunes. Relief on these areas is commonly complex where elevation changes quite abruptly. These areas normally range in size from 5 to 60 acres. Slopes are 0 to 18 percent. The material in these areas is fine and medium sand that has little evidence of soil development and a 1- to 2-inch layer of organic debris and associated staining. The fine and medium sand in Dune land is brown with some faint mottles. Distinct mottles occur below 30 inches.

Included with Dune land in mapping, and making up as much as 20 percent of an individual mapped area, are Poppleton and Maddock soils. Also included, and making up as much as 15 percent of an individual mapped area, are Redby soils and Cormant soils. Some areas that have short, sharp slopes up to 18 percent are included.

Low available water capacity and low inherent fertility limit uses of this land. This soil is very susceptible to soil blowing.

This land normally has a vegetative cover of mixed introduced and native grasses and scattered trees. The native grasses include prairie sandreed, little and big bluestem, and indiangrass. Bur oak, basswood, and quaking aspen are the most common trees. Various shrubs, moss, lichenlike growths, and prostrate cedar also are on these dunes. A few areas are nearly devoid of vegetation (fig. 1).

A few areas are used for limited grazing. Capability unit VIs–1; Sands range site.

Enstrom series

The Enstrom series consists of nearly level, moderately well drained soils. These soils formed in sandy lacustrine sediment over loamy till or lacustrine ma-

Figure 1.—**Dune land area showing varied vegetative cover. Area almost devoid of vegetation, foreground, indicates low fertility and low available water capacity.**

terials. They commonly are on very slightly convex slopes. Native vegetation is mixed or alternating tall prairie grass and deciduous forest.

In a representative profile the surface layer is about 8 inches of very dark brown loamy fine sand, and the subsoil is about 15 inches of mottled, dark brown to brown fine sand. Below this is mottled, yellowish brown fine sand. The contrasting underlying material is mottled, grayish brown loam and is at a depth of 33 inches. It is about 10 percent coarse fragments.

Permeability is rapid in the upper part and moderate in the loamy till, and available water capacity is low to moderate. Inherent fertility is low. The seasonal high water table fluctuates from a depth of 2.5 to 6 feet.

Some areas of Enstrom soils are cultivated. Small grain and forage for livestock are the most common crops. Other areas support a growth of grasses or trees. Droughtiness is the major limitation.

Representative profile of Enstrom loamy fine sand, 0 to 2 percent slopes, in an alfalfa-brome pasture 2,475 feet south and 35 feet east of the northwest corner of sec. 28, T. 160 N., R. 46 W.:

Ap—0 to 8 inches; very dark brown (10YR 2/2) loamy fine sand, dark gray (10YR 4/1) dry; very weak subangular blocky structure parting to single grained; loose; neutral; abrupt wavy boundary.

B1—8 to 15 inches; dark brown (10YR 3/3) fine sand, grayish brown (10YR 5/2) dry; few fine faint dark yellowish brown (10YR 3/4) mottles; single grained; loose; neutral; gradual wavy boundary.

B2—15 to 23 inches; brown (10YR 4/3) fine sand; few fine faint brown (10YR 5/3) and dark yellowish brown (10YR 4/4) mottles; single grained; loose; neutral; abrupt smooth boundary.

C1—23 to 33 inches; yellowish brown (10YR 5/4) fine sand; few fine faint brown (7.5YR 5/4), strong brown (7.5YR 5/6), and yellowish brown (10YR 5/6) mottles; single grained; loose; lag line of gravelly fine sand in lower part; slightly effervescent; mildly alkaline; abrupt wavy boundary.

IIC2g—33 to 60 inches; grayish brown (2.5Y 5/2) loam; many medium prominent yellowish brown (10YR 5/6), brownish yellow (10YR 6/6), and yellowish red (5YR 5/6) mottles; weak medium platy structure parting to weak very fine, subangular blocky; very friable; 10 percent coarse fragments; strongly effervescent; moderately alkaline.

The A and B horizons range from 15 to 36 inches in thickness. Thickness of the sandy mantle over the loamy IIC horizon ranges from 20 to 40 inches. In some pedons a lag line with up to 35 percent of coarse fragments is present in the lower few inches of the sandy mantle. The A horizon is sand, fine sand, loamy sand, and loamy fine sand. Its moist color is black, very dark gray, very dark grayish brown, and very dark brown. The A horizon has a neutral or mildly alkaline reaction. The B horizon is typically sand or fine sand, but in some pedons its upper part is loamy sand or loamy fine sand. It is dark brown, brown, dark yellowish brown, and yellowish brown in color and has mottles in at least some part. It is neutral or mildly alkaline in reaction. The C horizon is sand, fine sand, loamy sand, or loamy fine sand. It is grayish brown, light brownish gray, pale brown, brown, yellowish brown, light yellowish brown, and light olive brown in color and has faint to prominent mottles. Its reaction is mildly or moderately alkaline. The IIC horizon is fine sandy loam, loam glacial till, or silt loam and silty clay loam lacustrine sediment. It is grayish brown, light brownish gray, olive gray, light olive gray, pale olive, and olive in color. The IIC horizon has a mildly or moderately alkaline reaction.

Enstrom soils are associated with Grygla and Poppleton soils. Enstrom soils are better drained than Grygla soils. They have a loamy IIC horizon within a depth of 40 inches that Poppleton soils lack.

145—Enstrom loamy fine sand, 0 to 2 percent slopes. This soil is in plane or very slightly convex areas. Soil blowing contributes to the uneven condition. Areas of this soil normally range from 5 to 80 acres in size. Where cultivated this soil exhibits a varied pattern of black, grayish and brownish color. Areas of soil accumulation sometimes occur along old fence lines, field boundaries, and the edge of wooded areas.

Included with this soil in mapping, and making up as much as 20 percent of an individual mapped area, are Poppleton soils and soils that have a slightly thicker, darker colored surface layer. Also included, and making up as much as 15 percent of an individual mapped area, are Redby soils. Some spots that are moderately and severely eroded are also included.

Low to moderate available water capacity and low inherent fertility limit the use of this soil. The hazard of soil blowing is also a limitation.

Some areas of this soil are cultivated. Small grain and potatoes are the most common crops. A larger acreage is used for hay and pasture. Introduced grasses are commonly used for this purpose. Scattered trees, principally quaking aspen, bur oak, and some hazel and other brush also grow on this soil. Capability unit IVs–1; Sands range site.

Fargo series

The Fargo series consists of nearly level, poorly drained soils. These soils formed in clayey lacustrine sediment. They are in shallow swales and depressions in complex with slightly higher, convex areas of Bearden soils. These areas are in the western portion of the Glacial Lake Agassiz Basin. Native vegetation is tall grasses.

The Fargo series is mapped only in complex with Bearden soils.

In a representative profile the surface layer is about 18 inches of black silty clay, and the subsoil about 23 inches is very dark grayish brown silty clay. The next layer is olive gray silty clay. The underlying material is mottled, olive gray silty clay loam.

Available water capacity is moderate. Inherent fertility is high. The seasonal high water table commonly fluctuates from a depth of 1 to 5 feet.

Small grain and sugar beets are the most common crops. Wetness is the major limitation.

Representative profile of Fargo silty clay, in an area of Bearden-Fargo complex, in a cultivated field 250 feet north and 135 feet east of the southwest corner of sec. 13, T. 159 N., R. 50 W.:

A1—0 to 18 inches; black (N/2) silty clay; moderate and strong very fine subangular blocky structure; sticky; mildly alkaline; gradual wavy boundary broken by tongues of A1 material extending to 40 inches.

B2g—18 to 41 inches; very dark grayish brown (2.5Y 3/1) silty clay; weak coarse prismatic structure parting to moderate very fine subangular blocky; sticky; mildly alkaline; gradual wavy boundary.

C1g—41 to 54 inches; olive gray (5Y 4/2) silty clay; few fine faint olive (5Y 5/3) mottles; moderate very fine subangular blocky structure; sticky; slightly effervescent; moderately alkaline; gradual wavy boundary.

C2—54 to 60 inches; olive gray (5Y 5/2) silty clay loam; many medium prominent strong brown (7.5YR 5/8), dark brown (7.5YR 4/4), white (10YR 8/2), and light yellowish brown (10YR 6/4) mottles; weak thin platy structure parting to weak very fine subangular blocky; slightly sticky; strongly effervescent; moderately alkaline.

The A and B horizons range from 16 to 41 inches in thickness. Tongues of A1 material extend to a depth of 41 inches, and the greatest thickness of the A and B horizons is commonly along these tongues. The A horizon is silty clay and clay. The B horizon is silty clay and clay. It is very dark gray, dark gray, gray, grayish brown, dark grayish brown, very dark grayish brown, olive gray, and dark olive gray in color. The lower portion of the B horizon is calcareous in some pedons. The C horizon is silty clay, clay, and silty clay loam. It has hue of 5Y, and mottling is in its lower portions.

These soils have thick A and B horizons and a thicker and deeper tonguing than is defined for the Fargo series, and a silty clay loam C horizon that is too coarse for the defined series range. These differences, however, do not alter appreciably the usefulness and behavior of the soils.

The Fargo series is mapped only in complex with Bearden soils. Fargo soils are finer textured, more poorly drained and less calcareous at and near the surface than Bearden soils.

Foldahl series

The Foldahl series consists of nearly level, moderately well drained soils. These soils formed in loamy and sandy lacustrine sediment over loamy glacial till material. They commonly are in convex areas in the central and eastern parts of the Glacial Lake Agassiz Basin. Native vegetation is tall grasses and some trees, mainly aspen and bur oak.

In a representative profile the surface layer is about 9 inches of a black sandy loam, and the subsoil is about 19 inches of dark brown and dark yellowish brown loamy sand that grades with depth to sand. The contrasting underlying material is mottled grayish brown loam that is moderately alkaline and violently effervescent (fig. 2).

Permeability is rapid in upper part of the soil and moderate in the loamy till. Available water capacity is moderate to low. Inherent fertility is medium to low. The seasonal high water table fluctuates from a depth of 2.5 to 6 feet.

Many areas of Foldahl soils are cultivated. They are suited to most grain and hay crops. Potatoes, corn for silage or fodder, and sunflowers are also grown on Foldahl soils. The possibility of droughty conditions is a major limitation.

Representative profile of Foldahl sandy loam from an area of Foldahl soils, 0 to 2 percent slopes, in a hay meadow 2,140 feet north and 400 feet east of the southwest corner of sec. 24, T. 159 N., R. 46 W.:

A1p—0 to 9 inches; black (10YR 2/1) sandy loam; weak very fine granular structure; very friable; neutral; gradual wavy boundary.

B21—9 to 14 inches; dark brown (10YR 3/3) loamy sand; massive in place breaking to single grained; very friable; trace of gravel; neutral; clear wavy boundary.

B22—14 to 28 inches; dark yellowish brown (10YR 4/4) sand; massive in place breaking to single grained; loose; about 8 percent gravel; neutral; abrupt smooth boundary.

IIC1gca—28 to 34 inches; grayish brown (2.5Y 5/2) loam; many fine distinct yellowish brown (10YR 5/6) and light olive brown (2.5Y 5/6) mottles; weak thin platy structure parting to weak very fine subangular blocky; very friable; about 8 percent coarse fragments; violently effervescent; moderately alkaline; gradual smooth boundary.

IIC2g—34 to 60 inches; grayish brown (2.5Y 5/2) loam; common medium prominent yellowish brown (10YR 5/6) and strong brown (7.5YR 5/6) mottles; weak to moderate medium platy structure parting to weak very fine subangular blocky; friable; 5 to 10 percent coarse fragments; strongly effervescent; moderately alkaline.

The loamy IIC horizon ranges in depth from 20 to 40 inches. In some pedons a lag line up to 6 inches thick, that is up to 35 percent coarse fragments, is in the lower part of the upper sediment and just above the IIC horizon. The A horizon ranges in thickness from 7 to 16 inches. It is typically sandy loam, but fine sandy loam and loamy fine sand are also in the range. The A horizon is black, very dark brown, very dark gray, and very dark grayish brown. It has weak granular or subangular blocky structure or is single grained. The B horizon ranges in thickness from 5 to 25 inches. It is typically loamy sand, but loamy fine sand, fine sand, and sand are also in the range. The B horizon is grayish brown, brown, dark brown, and

Figure 2.—**Profile of Foldahl fine sandy loam. Dark colored surface layer is about 9 inches thick. The underlying sandy layer is lighter colored with a concentration of coarse fragments in the lower part. The underlying material is grayish colored loam till.**

dark yellowish brown. In some pedons a C horizon ranges in thickness from 8 to 22 inches. It is typically fine sand, but sand, loamy fine sand, and loamy sand are also in the range. The C horizon is dark grayish brown, grayish brown, light brownish gray, and light yellowish brown. When it is present in some pedons the C horizon has a concentration of carbonates just below the B horizon. The IIC horizon is typically loam, but silty clay loam, clay loam, silt loam, and sandy loam are also in the range. It is dark grayish brown, grayish brown, light brownish gray, light gray, pale yellow, light yellowish brown, light olive, and pale olive in color and has few to common, fine or medium, and faint, distinct, or prominent mottles. Effervescence in the IIC horizon ranges from slight to strong. The content of coarse fragments in the IIC horizon ranges from 5 to 20 percent.

Foldahl soils are associated with Poppleton, Grimstad, Grygla, and Rockwell soils. They have a loamy IIC horizon within a depth of 40 inches that Poppleton soils lack. They lack a calcic horizon beginning within a depth of 16 inches that is a characteristic of the Grimstad and Rockwell soils. They are better drained than Grygla and Rockwell soils.

426—Foldahl soils, 0 to 2 percent slopes. These soils are in areas that vary considerably in shape and commonly range from 5 to 80 acres in size. The surface is smooth or has a very slight convex slope. The surface layer ranges in texture from sandy loam to fine sandy loam, is black and has a smooth, granular appearance when cultivated. Soil accumulations occasionally are present along old fence lines and field boundaries.

Included with these soils in mapping, and making up as much as 15 percent of an individual mapped area, are Grimstad and Donaldson soils. Also included are small areas of Wheatville soils, Fram soils, and soils that have a thinner or coarser surface layer. A few areas that have up to 3 to 15 percent stones and boulders exposed at the surface are also included.

Moderate available water capacity and medium inherent fertility limit the uses of this soil. The hazard of soil blowing influences use and management.

Most areas of this soil are cultivated. Small grain is

the most common crop. Some areas are planted to potatoes or sunflowers, or are used for hay and pasture. Capability unit IIIs–1; Sandy range site.

Foxhome series

The Foxhome series consists of nearly level, moderately well drained soils. These soils formed in loamy and sandy sediment over loamy glacial till. They are commonly in nearly level to slightly convex areas. Native vegetation is tall grasses.

In a representative profile the surface layer is about 11 inches of black, neutral sandy loam, that is underlain by about 4 inches of very dark grayish brown, neutral gravelly loamy sand. The next layer is 21 inches of pale brown, slightly effervescent gravelly sand. The contrasting underlying material is mottled, light brownish gray and olive gray, strongly effervescent fine sandy loam.

Available water capacity is moderate to low. Permeability is rapid in the upper part and moderate in the loamy till. Inherent fertility is medium to low. The seasonal high water table fluctuates from a depth of 2.5 to 6 feet.

Most areas of Foxhome soils are cultivated. Small grain and forage for livestock are the most common crops. A few areas support a growth of grasses and some trees.

Representative profile of Foxhome sandy loam from an area of Foxhome soils, 0 to 2 percent slopes, in a field 275 feet south and 150 feet east of the northwest corner of sec. 17, T. 163 N., R. 48 W.:

A1—0 to 11 inches; black (10YR 2/1) sandy loam; weak very fine subangular blocky structure; very friable; neutral; clear smooth boundary.

IIB2—11 to 15 inches; very dark grayish brown (10YR 3/2) gravelly loamy sand, single grained; loose; about 30 percent gravel; neutral; clear smooth boundary.

IIC1—15 to 36 inches; pale brown (10YR 6/3) gravelly sand; common medium distinct yellowish brown (10YR 5/6) and grayish brown (2.5Y 5/2) mottles; single grained; loose; about 40 percent gravel; slight effervescence; mildly alkaline; abrupt smooth boundary.

IIIC2g—36 to 45 inches; light brownish gray (2.5Y 6/2) fine sandy loam; many coarse prominent brownish yellow (10YR 6/8) mottles; weak very fine subangular blocky structure; very friable; strong effervescence; moderately alkaline; gradual smooth boundary.

IIIC3g—45 to 60 inches; olive gray (5Y 5/2) fine sandy loam; common medium prominent yellowish brown (10YR 5/8) and light olive brown (2.5Y 5/6) mottles; weak very fine subangular blocky structure; very friable; strong effervescence; moderately alkaline.

The A horizon ranges from 7 to 12 inches in thickness. Depth to IIIC finer textured material ranges from 20 to 40 inches. The coarse fragments in the upper sediment range from 0 to 15 percent in the A1 horizon, 15 to 35 percent in the IIB horizon, 30 to 60 percent in the IIC horizon and 6 to 20 percent in the IIIC horizon. The A horizon is typically sandy loam or loam. It is black, very dark gray, and very dark brown in color. The B horizon ranges from loamy sand to gravelly loamy sand. It is very dark grayish brown, dark brown, dark grayish brown, and brown in color. The IIC horizon is gravelly sand or gravelly coarse sand with layers of fine sand scattered throughout. It is pale brown, brown, light yellowish brown, light olive brown in color and commonly has distinct mottles. Reaction is mildly to moderately alkaline. The IIIC horizon is sandy loam, loam, fine sandy loam, and clay loam. It is light brownish gray, grayish brown, and olive gray in color and commonly has mottles with higher chroma. It is mildly or moderately alkaline.

The Foxhome series is associated with Fram, Grimstad, Mavie, Percy, and Strandquist soils. Foxhome soils have a thicker, gravelly, sandy horizon than Fram and Grimstad soils. They are better drained than Mavie, Percy, and Strandquist soils.

65—Foxhome soils, 0 to 2 percent slopes. These soils are in areas that vary considerably in shape and commonly range in size from 5 to 35 acres. These areas are often associated with interbeach areas that have variable relief and some short, very gentle slopes. Soil material is very mixed across these areas. The surface layer ranges from sandy loam to loam and has a black, fine granular appearance when cultivated. In most areas some cobbles and stones are scattered on the surface.

Included with these soils in mapping, and making up as much as 20 percent of an individual mapped area, are Fram soils or Percy soils. Also included and making up as much as 15 percent of an individual mapped area are Lohnes soils, Strandquist soils, and Pelan soils. Small areas of Foldahl sandy loam soils, some areas that have up to 3 to 15 percent of stones and boulders exposed at the surface, and a few areas that have clayey material underlying the gravel layer are included.

Moderate to low available water capacity and medium inherent fertility limit the uses of this soil. Soil blowing is a hazard. In places, cobbles and stones scattered on the surface and buried in the soil make operation of farm machines difficult.

Some areas of these soils are cultivated, principally for the production of small grain. Many areas are used for hay and pasture. Some areas are seeded to alfalfa or a grass-legume mixture. Scattered trees, mainly quaking aspen and bur oak, also grow on this soil. Capability unit IIIs–1; Sandy range site.

Fram series

The Fram series consists of nearly level, moderately well drained soils. These soils formed in lake washed, loamy glacial till. They are commonly on very slightly convex slopes. Native vegetation is tall grass prairie. Trees, such as quaking aspen and oak, have invaded some areas.

In a representative profile the surface layer is about 9 inches of very dark gray fine sandy loam. The next layer is about 8 inches of violently effervescent, pale brown clay loam. The upper part of the underlying

material is 6 inches of strongly effervescent, brown loam, and the lower part is strongly effervescent, mottled, grayish brown loam.

Permeability is moderate. Available water capacity is high. Inherent fertility is medium. The seasonal high water table commonly fluctuates from a depth of 2½ to 5 feet.

Most areas of Fram soils are cultivated. Small grain and forage for livestock are the most common crops. A few areas grow grasses and some trees. Many of these areas are in pasture. Soil blowing is the major limitation.

Representative profile of Fram fine sandy loam from an area of Fram soils, 0 to 2 percent slopes, in a cultivated field 600 feet south and 1,360 feet west of the northeast corner of sec. 1, T. 160 N., R. 48 W.:

Ap—0 to 9 inches; very dark gray (10YR 3/1) fine sandy loam; weak very fine granular structure; very friable; about 5 percent coarse fragments; violently effervescent; mildly alkaline; abrupt smooth boundary.

C1ca—9 to 17 inches; pale brown (10YR 6/3) clay loam; weak coarse prismatic structure parting to weak, very fine subangular blocky; very friable; about 3 percent coarse fragments; violently effervescent; moderately alkaline; clear smooth boundary.

C2—17 to 23 inches; brown (10YR 5/3) loam; weak coarse prismatic primary structure parting to weak very fine subangular blocky; very friable; about 5 percent coarse fragments; few light gray (10YR 7/1) lime filaments; strongly effervescent; moderately alkaline; clear smooth boundary.

C3g—23 to 33 inches; grayish brown (2.5Y 5/2) loam; many medium distinct olive brown (2.5Y 4/4), light olive brown (2.5Y 5/6), and olive yellow (2.5Y 6/8) mottles; weak very fine subangular blocky structure; firm; about 10 percent coarse fragments; strongly effervescent; moderately alkaline; gradual wavy boundary.

C4g—33 to 60 inches; grayish brown (2.5Y 5/2) loam; many medium prominent yellowish brown (10YR 5/8) mottles and few fine prominent yellowish red (5YR 5/8) mottles; weak very fine subangular blocky structure; friable; about 10 percent coarse fragments; strongly effervescent; moderately alkaline.

The A horizon ranges from 7 to 16 inches in thickness. A calcic horizon begins within 16 inches of the surface. In many pedons cobblestones and larger fragments are on the surface. The A horizon is sandy loam, fine sandy loam, loam, sandy clay loam, and clay loam. It is black, very dark gray, very dark grayish brown, and very dark brown in color. In places, the A horizon contains as much as 30 percent lime, but in other places part or all of it lacks free lime. The Cca horizon is sandy loam, fine sandy loam, loam, sandy clay loam, and clay loam. The C horizon is sandy loam, fine sandy loam, and loam. It is dark grayish brown, grayish brown, light brownish gray, and brown with faint to prominent mottles. The content of coarse fragments ranges from a trace to 25 percent in the A horizon and upper part of the C horizon and from 5 to 20 percent in the lower part of the C horizon. In some pedons a lag line is in the upper C horizon that contains from 20 to 35 percent of coarse fragments.

The Fram series is associated with Nereson and Percy soils. Fram soils lack the horizon of clay accumulation which is characteristic of Nereson soils. They are better drained than the poorly drained Percy soils.

296—Fram soils, 0 to 2 percent slopes. These soils are in areas that vary considerably in shape and range from 5 to about 80 acres in size. The surface is smooth or very slightly convex. The surface layer ranges from fine sandy loam to clay loam and has a fine granular or blocky appearance when cultivated. It ranges from black to dark gray because of variations in carbonate content. Stones, boulders, and other coarse fragments are scattered on the surface. The number of stones and boulders varies considerably but usually covers less than 3 percent of the surface. These soils have the profiles described as representative of the series.

Included with these soils in mapping, and making up as much as 15 percent of an individual mapped area, are Percy soils. Also included, and making up to as much as 10 percent of an individual mapped area, are Nereson soils and Roliss soils. A few small areas of this soil that have the surface covered with stones and boulders, some areas that have a leached surface layer, and some areas where soluble salts are present in varying degrees of concentration are included.

The hazard of soil blowing limits the use of soil. The strongly calcareous condition of this soil affects its nutrient balance. The presence of stones and boulders also affects use and management of some areas.

Some areas of these soils are cultivated. Small grain is the most common crop. Other areas grow introduced grasses or are seeded to legumes and grasses. These are utilized for hay and pasture. Some areas are wooded, and quaking aspen and bur oak are the most common trees. These areas may be used as pasture. Capability unit IIe–2; Silty range site.

427—Fram soils, leached, 0 to 3 percent slopes. These soils are in areas that vary considerably in shape and are commonly between 5 and 80 acres in size. The landscape is commonly associated with interbeach areas where soil material changes within short distances. The relief is variable, but generally is very slightly convex. The surface layer ranges from fine sandy loam to clay loam and has a fine granular or blocky appearance when cultivated. Cobbles and stones are scattered on the surface and buried in the upper layers. These soils have a profile like that described as representative of the series, but the surface layer is noncalcareous.

Included with these soils in mapping, and making up as much as 20 percent of an individual mapped area, are Nereson soils. Also included, and making up as much as 15 percent of an individual mapped area, are Foxhome, Roliss and Percy soils. A few areas of soils that have a layer of cobbles, 6 inches or more thick, just above the loamy underlying material, and some areas of this soil that have a finer textured surface layer are included.

The hazard of soil blowing and water erosion limit the uses of this soil. In places stones and cobbles make the operation of farm machines difficult.

Some areas of these soils are cultivated. Small grain is the most common crop. Other areas grow introduced grasses or are seeded to legumes and grasses. These areas are used for hay and pasture. Scattered trees, mainly quaking aspen and bur oak, also grow on this soil. Capability unit IIe–2; Silty range site.

Garnes series

The Garnes series consists of nearly level, moderately well drained soils. These soils formed in loamy, calcareous till. They are associated with areas of lake washed glacial till. Native vegetation is quaking aspen, oak, and elm.

In a representative profile the surface is covered with about 2 inches of partly decomposed forest litter. The surface layer is about 6 inches of dark grayish brown loam and the subsoil is about 4 inches of dark brown sandy clay loam. The next layer is strongly effervescent, mottled, grayish brown loam. The underlying material is strongly effervescent, grayish brown sandy loam. This material is 10 to 20 percent coarse fragments.

Permeability is moderate, and available water capacity is high. Inherent fertility is medium. The seasonal high water table fluctuates from a depth of 2.5 to 6 feet.

Some areas of Garnes soils are cultivated. Small grain and forage for livestock are the most common crops. Many areas have a growth of trees, principally bur oak and quaking aspen. Climate is the major limitation.

Representative profile of Garnes loam from an area of Garnes soils, 0 to 2 percent slopes, in an aspen forest 1,200 feet east and 1,480 feet north of the southwest corner of sec. 12, T. 161 N., R. 46 W.:

O1—2 inches to 0; partly decomposed forest litter.

A2—0 to 6 inches; dark grayish brown (10YR 4/2), light grayish brown loam (10YR 6/2) dry; weak very thin platy structure; very friable; neutral; abrupt smooth boundary.

B2t—6 to 10 inches; dark brown (10YR 4/3) sandy clay loam; many fine faint very dark grayish brown (10YR 3/2) mottles; moderate and strong fine angular blocky structure; friable to firm; thin nearly continuous clay films on ped faces; about 12 percent coarse fragments; neutral; clear smooth boundary.

C1gca—10 to 17 inches; grayish brown (2.5Y 5/2) loam; few fine faint light olive brown (2.5Y 5/4) mottles; weak very fine subangular blocky structure; very friable; about 15 percent coarse fragments; strongly effervescent; moderately alkaline; gradual smooth boundary.

C2g—17 to 60 inches; grayish brown (2.5Y 5/2) sandy loam; common medium distinct yellowish brown (10YR 5/4 and 5/8) mottles; very weak very fine subangular blocky structure; very friable; about 15 percent coarse fragments; strongly effervescent; moderately alkaline.

Thickness of the solum ranges from 10 to 20 inches. In forested areas the O horizon is ½ to 3 inches thick. In some pedons a fine sandy loam or loam A1 horizon is as much as 3 inches thick and black, very dark gray, very dark grayish brown or very dark gray. In cultivated areas the Ap horizon is very dark gray, dark gray, dark grayish brown, or very dark grayish brown in color. The A2 horizon ranges from 2 to 11 inches in thickness. It is loamy coarse sand, loamy sand, coarse sandy loam, fine sandy loam, and loam. The A2 horizon is dark gray, gray, light brownish gray, grayish brown, and dark grayish brown in color. The Bt horizon is clay loam, sandy clay loam, and loam about 3 to 10 inches thick. It is dark grayish brown, grayish brown, brown, and dark brown. In some pedons there is a thin transitional B3 horizon. The C horizon is clay loam, loam, and sandy loam and is dark grayish brown, grayish brown, light yellowish brown, light olive brown, and olive brown in color and has fine to coarse, few to common, and distinct or prominent mottles. The content of coarse fragments ranges from a trace to 20 percent in all horizons. Effervescence ranges from slight to violent.

The Garnes series is associated with the Nereson, Pelan, and Percy soils. Garnes soils lack or have a thinner A1 horizon than Nereson soils. They lack the gravelly coarse sand IIC horizon that is characteristic of Pelan soils. They are better drained than Percy soils.

77—Garnes soils, 0 to 2 percent slopes. These soils are in areas that vary considerably in shape and are between 5 and 50 acres in size. The landscape is associated with water worked tills that often occur in interbeach areas. In these areas soil material changes within short distances. These soils are located in areas with very slightly convex slopes. The surface layer ranges from loam to sandy loam and has a fine granular appearance and numerous clean bleached sand grains that are visible when the soil is cultivated. Cobbles and stones are commonly on the surface of this soil.

Included with these soils in mapping, and making up as much as 15 percent of an individual mapped area, are Nereson soils and Pelan soils. Also included, and making up as much as 10 percent of an individual mapped area, are Fram soils and Percy soils. Some areas that have a coarser textured surface layer and a few areas that have stones and boulders exposed at the surface are also included.

Climate limits the selection of crops that will mature and provide an economic return. In places stones and boulders make the operation of farm machines difficult. Some areas of these soils are cultivated. Small grain is the common crop. Other areas grow introduced grasses or are seeded to legumes and grasses. These areas are used for hay and pasture. Scattered trees, mainly bur oak and quaking aspen, also grow on these soils. Capability unit IIc–1; Silty range site.

Glyndon series

The Glyndon series consists of nearly level, somewhat poorly drained and moderately well drained soils.

These soils formed in calcareous, loamy lacustrine sediment and the underlying very fine sand and silt particles. They commonly occupy very slightly convex areas. Native vegetation is tall grasses.

In a representative profile the surface layer is about 13 inches of black, strongly effervescent very fine sandy loam. Below this is about 9 inches of dark grayish brown, violently effervescent very fine sandy loam. The upper part of the underlying material is about 13 inches of faintly mottled, pale brown loamy very fine sand that is violently effervescent. The lower part is distinctly and prominently mottled, light yellowish brown and light brownish gray very fine sand.

Permeability is moderate. Available water capacity is high. Inherent fertility is high. The seasonal high water table fluctuates from a depth of 2½ to 6 feet.

Most areas of Glyndon soils are cultivated. They are suited to all crops commonly grown in Kittson County. Small grain and sugar beets are the most common crops. Soil blowing is the major limitation.

Representative profile of Glyndon very fine sandy loam from an area of Glyndon soils, 0 to 2 percent slopes, in a cultivated field 560 feet west and 75 feet south of the northeast corner of sec. 19, T. 160 N., R. 47 W.:

A1—0 to 13 inches; black (10YR 2/1) very fine sandy loam; weak very fine subangular blocky structure; very friable; strongly effervescent; moderately alkaline; clear wavy boundary.

C1ca—13 to 22 inches; dark grayish brown (10YR 4/2) very fine sandy loam; weak very fine subangular blocky structure; very friable; violently effervescent; moderately alkaline; gradual wavy boundary.

C2ca—22 to 35 inches; pale brown (10YR 6/3) loamy very fine sand; few fine faint dark yellowish brown (10YR 4/4) mottles; very weak very fine subangular blocky structure; very friable; few fine and medium dark reddish brown (5YR 3/2) concretions; violently effervescent; moderately alkaline; gradual wavy boundary.

C3—35 to 45 inches; light yellowish brown (2.5Y 6/3) very fine sand; common medium distinct yellowish brown (10YR 5/4 and 5/6), brownish yellow (10YR 6/6), and light gray (10YR 7/2) mottles and few medium prominent strong brown (7.5YR 5/8) mottles; single grained; loose; strongly effervescent; moderately alkaline; gradual wavy boundary.

C4—45 to 60 inches; light brownish gray (2.5Y 6/2) very fine sand; many medium prominent strong brown (7.5YR 5/8) and yellowish red (5YR 4/6) mottles and many medium distinct light yellowish brown (10YR 5/4, 5/6) mottles; single grained; loose; strongly effervescent, moderately alkaline.

The A horizon texture is very fine sandy loam, silt loam, or loam about 7 to 16 inches thick. It is black or very dark gray. It has weak to moderate, fine and very fine, granular or subangular blocky structure and is friable or very friable. The Cca horizon is silt loam, very fine sandy loam, and loamy very fine sand that is light brownish gray, grayish brown, dark grayish brown, and pale brown. Some pedons have a few faint mottles. The C horizon is typically very fine sand, but loamy very fine sand and coarse silt loam are also in the range. It is dark grayish brown, light brownish gray, light yellowish brown, and light olive brown in color. Mottling ranges from few to many and faint to prominent. In some pedons this horizon has hue of 5Y in the lower part.

Glyndon soils are associated with Bearden, Borup, Ulen, and Wheatville soils. They have less silt and clay than Bearden soils. Glyndon soils are better drained than Borup soils. They have more silt and very fine sand than Ulen soils. Glyndon soils lack a clayey IIC horizon within a depth of 40 inches that is characteristic of Wheatville soils.

60—Glyndon soils, 0 to 2 percent slopes. These soils are in areas that normally range in size from 15 to 130 acres. The surface is generally smooth or very slightly convex. The surface layer of this soil ranges from very fine sandy loam to silt loam and has a smooth mellow appearance when cultivated. Some variations of gray appear where the surface layer is shallow and tillage mixes underlying material with the surface.

Included with these soils in mapping, and making up as much as 20 percent of an individual mapped area, are Borup soils. Also included, and making up as much as 15 percent of an individual mapped area, are Ulen, Wheatville and Augsburg soils. A few areas of soils are included that have a thinner, more calcareous surface layer, and small areas of Glyndon soils where slopes are 2 to 6 percent. In some areas, soluble salts are present in varying concentrations.

The hazard of soil blowing limits the use of this soil. A nutrient imbalance in this soil resulting from its strongly calcareous condition also influences use and management.

Most areas of these soils are cultivated. Small grain, sugar beets, sunflowers, and potatoes are the most common crops. Legumes and grasses are included in the cropping sequence usually as green manure crops. A small acreage is used for hay and pasture. Capability unit IIe–2; Silty range site.

Grimstad series

The Grimstad series consists of nearly level, moderately well drained soils. These soils formed in loamy and sandy lacustrine sediment over loamy glacial till or lacustrine sediment. They commonly occupy very slightly convex areas. Native vegetation is tall grasses on prairies.

In a representative profile the surface layer is about 8 inches of black, strongly effervescent fine sandy loam underlain by about 9 inches of dark grayish brown, violently effervescent loamy fine sand. The underlying material is about 10 inches of strongly effervescent, pale brown fine sand, 11 inches of mottled, light brownish gray fine sand, and mottled, grayish brown loam.

Permeability is rapid in the upper part of the soils and moderate in the loamy material. Available water capacity is moderate to low. Inherent fertility is me-

dium. The seasonal high water table fluctuates from a depth of 2.5 to 6 feet.

Most areas of Grimstad soils are cultivated. Small grain, potatoes, and forage for livestock are the most common crops. A few areas support a growth of grasses and scattered trees. Droughtiness and soil movement by wind are the major limitations.

Representative profile of Grimstad fine sandy loam from an area of Grimstad soils, 0 to 2 percent slopes, in a cultivated field 65 feet north and 360 feet west of the southeast corner sec. 36, T. 160 N., R. 46 W.:

Ap—0 to 8 inches; black (10YR 2/1) fine sandy loam; weak fine granular structure; very friable; strongly effervescent; mildly alkaline; abrupt smooth boundary.

C1ca—8 to 17 inches; dark grayish brown (10YR 4/2) loamy fine sand; single grained; loose; violently effervescent; moderately alkaline; clear smooth boundary.

C2—17 to 27 inches; pale brown (10YR 6/3) fine sand; single grained; loose; strongly effervescent; moderately alkaline; clear smooth boundary.

C3—27 to 38 inches; light brownish gray (2.5Y 6/2) fine sand; common medium distinct dark yellowish brown (10YR 4/4) and yellowish brown (10YR 5/6) mottles; single grained; loose; strongly effervescent; moderately alkaline; abrupt smooth boundary.

IIc4g—38 to 60 inches; grayish brown (2.5Y 5/2) loam; common medium prominent strong brown (7.5YR 5/8) and dark yellowish brown (10YR 4/4) mottles; weak very fine subangular blocky structure; friable; about 24 percent coarse fragments; strongly effervescent; mildly alkaline.

Depth to the IIC horizon ranges from 20 to 40 inches. The A horizon is fine sandy loam, loamy fine sand, sandy loam, fine sandy loam, or loam. It is black, very dark gray, very dark grayish brown, and very dark brown in color. The A horizon is slightly to violently effervescent. Thickness of the A horizon ranges from 7 to 16 inches. The lower A horizon in some pedons is designated an Aca horizon. The Cca horizon is loamy sand, loamy fine sand, sandy loam, and fine sandy loam. It is dark gray, grayish brown, dark grayish brown, and brown in color. In some pedons the Cca horizon has a few masses of gypsum crystals. It is strongly to violently effervescent. The remaining C horizon is typically a fine sand, but sand, loamy sand, or loamy fine sand are also in the range. It is grayish brown, light brownish gray, pale brown, and light yellowish brown in color and has common, distinct or prominent mottles. The C horizon is slightly to strongly effervescent. The IIC horizon is typically loam, but fine sandy loam, silt loam, clay loam, and silty clay loam are also in the range. It is grayish brown, light yellowish brown, light brownish gray, and light olive brown. Mottling is common and distinct or prominent. The IIC horizon is slightly to strongly effervescent. In some pedons it is 5 to 25 percent coarse fragments.

Grimstad soils are associated with Foldahl, Rockwell, and Ulen soils. They are more calcareous in the A and upper C horizons than Foldahl soils. Grimstad soils are better drained than Rockwell soils. They have a loamy IIC horizon within a depth of 40 inches which is lacking in Ulen soils.

59—Grimstad soils, 0 to 2 percent slopes. These soils are commonly in a complex pattern of microrelief and soil material on slightly convex areas that range in size from 5 to 60 acres. The surface layer ranges in texture from fine sandy loam to loamy fine sand. Where cultivated, it has a smooth appearance and variations in color of black, very dark gray, and very dark grayish brown. A shallow surface layer and soil blowing influence surface color. In some places areas of soil accumulation occur along old fence lines and field boundaries.

Included with these soils in mapping, and making up as much as 20 percent of an individual mapped area, are Ulen soils and Rockwell soils. Also included, and making up as much as 15 percent of an individual mapped area, are Foldahl soils. Areas of soils with a shallower, more calcareous surface layer, spots of moderate to severe erosion, and areas where some short slopes are over 2 percent are included. In some areas soluble salts are present in varying degrees of concentration.

Moderate to low available water capacity limits the use of this soil. A susceptibility to soil blowing is a hazard. The strongly calcareous condition of this soil results in a nutrient imbalance and affects use and management.

Many areas of these soils are cultivated. Small grain, potatoes, and sunflowers are the most common crops. Some areas are used for hay and pasture. These soils are seeded to a grass or a grass-legume mixture. Scattered trees are on a few areas. Capability unit IIIs–1; Sandy range site.

Grygla series

The Grygla series consists of nearly level and slightly depressional, poorly drained soils. These soils formed in sandy sediment over loamy till or lacustrine material. They are in flat or slightly concave areas in the eastern part of the Glacial Lake Agassiz Basin. Native vegetation is mixed or alternating prairie and forest.

In a representative profile the surface layer is about 6 inches of very dark gray loamy fine sand. The subsurface layer is about 5 inches of mottled, light brownish gray fine sand. The subsoil is about 18 inches of prominently mottled, light brownish gray fine sand. The underlying material is strongly effervescent, mottled, light gray and light brownish gray loam.

Permeability is rapid in the upper part of the soil and moderate in the loamy material. Available water capacity is low to moderate. Inherent fertility is low. The seasonal high water table fluctuates from a depth of 0 to 3 feet.

Some areas of Grygla soils are cultivated. Small grain and forage for livestock are the most common crops. Other areas are not cultivated and support a growth of grasses or trees. Wetness is the major limitation.

Representative profile of Grygla loamy fine sand from an area of Grygla soils, in an open area with

mixed grasses 475 feet west and 325 feet south of the northeast corner of sec. 24, T. 163 N., R. 45 W.:

Ap—0 to 6 inches; very dark gray (10YR 3/1) loamy fine sand; single grained; loose; neutral; abrupt smooth boundary.

A2—6 to 11 inches; light brownish gray (2.5Y 6/2) fine sand; few fine distinct light yellowish brown (2.5Y 6/4) and olive yellow (2.5Y 6/6) mottles; single grained; loose; neutral; gradual wavy boundary.

B2—11 to 29 inches; light brownish gray (2.5Y 6/2) fine sand; many coarse prominent yellowish brown (10YR 5/6 and 5/8) and yellowish red (5YR 5/8) mottles; some mottles with dark reddish brown (2.5YR 3/4) centers; single grained; loose; about 5 percent gravel in lower part; neutral; abrupt smooth boundary.

IIC1g—29 to 42 inches; light gray (2.5Y 7/2) loam; common medium distinct olive yellow (2.5Y 6/8) and olive brown (2.5Y 4/4) mottles; weak thin platy structure parting to weak very fine subangular blocky; very friable; about 15 percent coarse fragments; strongly effervescent; moderately alkaline; gradual smooth boundary.

IIC2g—42 to 60 inches; light brownish gray (2.5Y 6/2) loam; many large prominent yellowish brown (10YR 5/8) mottles; weak thin platy structure parting to weak very fine subangular blocky; very friable; about 15 percent coarse fragments; strongly effervescent; moderately alkaline.

Thickness of the solum, depth to free carbonates, and depth to the IIC horizon range from 20 to 40 inches. The upper sandy soil typically lacks coarse fragments, but in some pedons the lower part has up to 35 percent of these fragments in the form of a lag line. The A1, or Ap, horizon is loamy fine sand, loamy sand, fine sand, or sandy loam. It is very dark gray, very dark grayish brown, and very dark brown in color. The A2 horizon is fine sand, sand, loamy sand, or loamy fine sand. It is light gray, light brownish gray, grayish brown, and dark grayish brown in color. In some pedons it has a weakly developed platy structure. The B horizon is fine sand, sand, loamy sand, or loamy fine sand and is grayish brown and light brownish gray in color. The IIC horizon is loam or fine sandy loam glacial till or silt loam and silty clay loam lacustrine sediment. It is light gray, grayish brown, and light brownish gray and has common distinct or prominent mottles. The IIC horizon is moderately to strongly effervescent.

Grygla soils are associated with Cormant, Enstrom, and Redby soils. Grygla soils have a loamy IIC horizon beginning at a depth of between 20 to 40 inches, but both Cormant and Redby soils lack this horizon in that depth. Grygla soils are more poorly drained than Enstrom and Redby soils.

482—Grygla soils. These soils are in areas of varied shapes. These areas are commonly between 4 and 70 acres in size. Slopes are 0 to 2 percent. Soil blowing has affected a few areas, and some erosion and accumulation is evident. The surface layer ranges in texture from fine sand to sandy loam, and it is dark to moderately dark colored and has clean, bleached sand grains that make colors appear grayer. These soils have the profile described as representative of the Grygla series.

Included with these soils in mapping and making up as much as 15 percent of an individual mapped area, are Cormant soils and Rockwell soils. Also included, and making up as much as 10 percent of an individual mapped area, are Redby soils and Poppleton soils. Small areas where soil blowing is moderate, some areas that have soils that have a thicker, darker colored surface layer, and a few areas that are up to 3 to 15 percent stones and boulders exposed at the surface are also included.

Wetness limits the use of these soils. Low to moderate available water capacity and low inherent fertility also influence use and management. Soil blowing can be a hazard. In places stones and boulders interfere with the operation of farm machines.

Some areas of these soils are cultivated. Small grain and potatoes are the most common crops. A more common use is for hay and pasture. Scattered quaking aspen and lowland brush also grow on this soil. Capability unit IVw–1; Subirrigated range site.

Hangaard series

The Hangaard series consists of nearly level and slightly depressional, poorly drained soils. These soils formed in a loamy layer and the underlying sandy and gravelly sediment commonly associated with shore lines of Glacial Lake Agassiz. They are on low flats and in shallow swales that have many areas affected by seep from adjoining gravelly ridges. Native vegetation is reeds, sedges, and tall grasses.

In a representative profile the surface layer is about 7 inches of black sandy loam. The next layer is about 7 inches of mottled, grayish brown gravelly coarse sand. The underlying material is mottled, light brownish gray gravelly coarse sand that grades with depth to light brownish gray gravelly sand.

Permeability is rapid, and available water capacity is low. Inherent fertility is low. The seasonal high water table commonly fluctuates from a depth of 1 to 3 feet.

A few areas of Hangaard soils are cultivated. Small grain and forage for livestock are the most common crops. The soils of other areas support a growth of grass and trees. Wetness is the major limitation.

Representative profile of Hangaard sandy loam, from an area of Hangaard soils in a cultivated field 1,470 feet west and 2,390 feet north of the southeast corner of sec. 28, T. 163 N., R. 45 W.:

Ap—0 to 7 inches; black (10YR 2/1) sandy loam; weak very fine granular structure; very friable; neutral; abrupt smooth boundary.

IIC1—7 to 14 inches; grayish brown (2.5Y 5/2) gravelly coarse sand; common medium distinct light brownish gray (2.5Y 6/2)

and olive yellow (2.5Y 6/6) mottles; single grained; loose; slightly effervescent; mildly alkaline; clear smooth boundary.

IIC2—14 to 24 inches; light brownish gray (2.5Y 6/2) gravelly coarse sand; many medium distinct olive yellow (2.5Y 6/6), light yellowish brown (2.5Y 6/4) and brownish yellow (10YR 6/6) mottles; single grained; loose; slightly effervescent; mildly alkaline; gradual smooth boundary.

IIC3—24 to 60 inches; light brownish gray (2.5Y 6/2) gravelly sand; common medium distinct yellow (2.5Y 7/6) and yellowish brown (10YR 5/6) mottles; single grained; loose; slightly effervescent; mildly alkaline.

Coarse fragments of gravel size make up from 10 to 35 percent of the material below the A horizon. Depth to the IIC horizon ranges from 7 to 20 inches. The A horizon is sandy loam, fine sandy loam, loamy sand, loamy fine sand, or loam. It is typically black, but in some pedons an A12 horizon is very dark gray or very dark grayish brown. In some pedons there is a thin loamy sand, or coarser B horizon that has a higher color value. The IIC horizon is gravelly sand, gravelly coarse sand, or stratified sand, coarse sand, and gravel. It is grayish brown, light brownish gray, olive gray, and light olive gray with distinct or prominent mottles, at least in the upper part.

Hangaard soils are associated with Karlstad, Lohnes, Strandquist, and Syrene soils. They are wetter than Karlstad and Lohnes soils. They lack the loamy IIC horizon within a depth of 40 inches which is characteristic of Strandquist soils. They lack a calcic horizon within a depth of 16 inches which is characteristic of Syrene soils.

111—Hangaard soils. These soils are in level to slightly concave areas that very considerably in shape and commonly range in size from 5 to 40 acres. Slopes are 0 to 2 percent. The surface layer ranges in texture from sandy loam to loam to loamy sand. These soils are near beach ridges or interbeach areas where soil material changes within short distances. Some areas are affected by seep from higher gravelly ridges.

Included with these soils in mapping, and making up as much as 15 percent of an individual mapped area, are Syrene soils, Strandquist soils, and Poppleton soils. Also included and making up as much as 10 percent of an individual mapped area, are Lohnes soils. Small areas where the surface is covered by stones and boulders, and a few areas of soils that have a thin subsoil horizon that is the accumulation of translocated clays are included.

Wetness limits the uses of this soil. Low available water capacity and low inherent fertility influence use and management. In places stones and boulders make operation of farm machines difficult.

Some areas of these soils are cultivated. Small grain is the most common crop. Many areas are used for hay and pasture. Scattered trees, mainly quaking aspen and some willow brush, also grow on these soils. Capability unit IVw–1; Subirrigated range site.

Haug series

The Haug series consists of level or depressional, very poorly drained soils. These soils formed in a thin layer of organic soil material over loamy glacial till. They commonly occupy low flats and broad depressions. Native vegetation is reeds, sedges, and other water-tolerant plants.

In a representative profile the surface is about 11 inches of black muck. Below this is about 3 inches of black, mucky sandy loam. The underlying material is mottled, dark gray over light brownish gray loam till.

Permeability is moderate, and available water capacity is very high. Inherent fertility is low. The seasonal high water table fluctuates from a depth of 0 to 3 feet.

Reeds, sedges, willow brush, and some trees, principally quaking aspen, grow on these soils. Some areas are used for hay and pasture, or they are cultivated for production of small grain. Wetness is the major limitation.

Representative profile of Haug muck, in a shallow depression with sedge vegetation 2,250 feet west and 300 feet north of the southeast corner of sec. 24, T. 163 N., R. 46 W.:

Oa—0 to 11 inches; black (10YR 2/1), broken face and rubbed, sapric material; a trace of fiber; weak very fine granular structure; very friable; herbaceous fiber; few thin hemic layers; neutral; clear smooth boundary.

IIA1b—11 to 14 inches; black (10YR 2/1) mucky sandy loam; weak very fine granular structure; about 5 percent coarse fragments; strongly effervescent; mildly alkaline; abrupt smooth boundary.

IIC1g—14 to 20 inches; dark gray (5Y 4/1) loam; common inclusions of gray (5Y 5/1) in lower part; weak very fine subangular blocky structure; very friable; about 5 percent coarse fragments; strongly effervescent; moderately alkaline; gradual smooth boundary.

IIC2g—20 to 60 inches; light brownish gray (2.5Y 6/2) loam; common medium distinct yellowish brown (10YR 5/6) mottles; weak very fine subangular blocky structure; very friable; a few layers and inclusions of sandy loam; about 5 percent coarse fragments; strongly effervescent; moderately alkaline.

The thickness of the O horizon ranges from 4 to 16 inches. Depth to free carbonates is between 10 and 20 inches. In some pedons a few cobblestones or larger fragments are on the mineral surface. The O horizon is typically sapric material, but in some pedons it has thin hemic layers. It is black, very dark gray, very dark grayish brown, or very dark brown when rubbed. The IIA1 horizon ranges in thickness from 2 to 6 inches. It is sandy loam, fine sandy loam, sandy clay loam, loam, and silt loam and is black and very dark gray. The IIC horizon is sandy loam, fine sandy loam, sandy clay loam, loam, and silt loam. It is dark gray, gray, light gray, olive gray, and light olive gray. The

IIA and IIC horizons are 0 to 20 percent coarse fragments.

Haug soils are associated with the Cathro and Percy soils. The Haug soils have a thinner O horizon than Cathro soils. They are wetter than Percy soils. They have an O horizon which Percy soils lack.

187—Haug muck. This soil occupies depressions, parts of old stream channels and low, broad, flat areas. These areas normally range from 10 to 300 acres in size. Slopes are 0 to 2 percent. The surface layer of this soil has a black, mellow, granular appearance when cultivated. Some surface material may be rootbound, so a lumpy condition occurs when it is first cultivated.

Included with this soil in mapping, and making up as much as 20 percent of an individual mapped area, are Percy soils, depressional. Also included, and making up as much as 15 percent of an individual mapped area, is Cathro muck. A few areas of soils that have a clay texture below the organic layer, spots with a calcareous surface layer, small marshy areas where soil materials have not been determined, and some areas with stones and boulders exposed to the surface are also included.

Wetness limits the uses of this soil. Low inherent fertility influences use and management. In places stones and boulders interfere with the operation of farm machines.

Reeds, sedges, phragmites, cattails, and scattered lowland brush grow on this soil. A few areas are wooded, primarily with quaking aspen. Some areas are used for hay and pasture. Reed canarygrass is grown on some of these areas. A few areas are cultivated, mainly with small grain. Capability unit IIIw–2; Grazeable Muck range site.

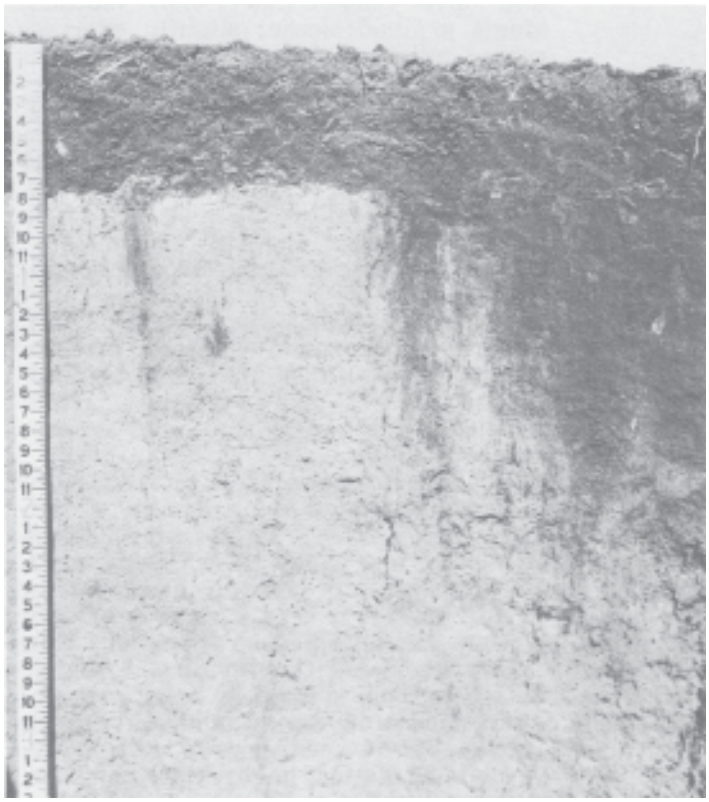

Figure 3.—**On the left is a Hegne silty clay. Its dark surface layer abruptly breaks to light gray. On the right is a Northcote clay that has a thicker surface layer and more extensive tonguing.**

Hegne series

The Hegne series consists of nearly level, poorly drained soils. These soils formed under a growth of tall grasses in calcareous lacustrine clay. They are on ridges and knolls. Hegne soils are mapped in a complex with Northcote soils which are in swales and depressions.

In a representative profile the surface layer is about 9 inches of black, strongly effervescent silty clay. The next layer is about 8 inches of dark gray, violently effervescent silty clay. The underlying material is mottled, dark grayish brown, strongly to slightly effervescent silty clay (fig. 3).

Permeability is slow, and available water capacity is moderate. Inherent fertility is medium. The seasonal high water table fluctuates from a depth of 0 to 4 feet.

Most areas of Hegne soils are cultivated. They are suited to nearly all crops grown in Kittson County. Small grain and sugar beets are the most common crops. Wetness is the major limitation.

Representative profile of Hegne silty clay, in an area of Hegne-Northcote complex, in a stubble field 1,470 feet north and 450 feet east of the southwest corner of sec. 13, T. 159 N., R. 50 W.:

Ap—0 to 9 inches; black (10YR 2/1) silty clay; dark gray (10YR 4/1) dry; weak very fine subangular blocky structure; sticky; few fine lime nodules; strongly effervescent; moderately alkaline; abrupt smooth boundary.

C1ca—9 to 17 inches; dark gray (2.5Y 4/1) silty clay; weak very fine subangular blocky structure; sticky; violently effervescent; moderately alkaline; gradual smooth boundary.

C2ca—17 to 26 inches; dark grayish brown (2.5Y 4/2) silty clay; few fine distinct light olive brown (2.5Y 5/4) mottles; weak very fine subangular blocky structure; sticky; strongly effervescent; moderately alkaline; gradual smooth boundary.

C3—26 to 43 inches; dark grayish brown (2.5Y 4/2) silty clay; common fine distinct dark yellowish brown (10YR 4/4), light olive brown (2.5Y 5/4), and brown (7.5YR 4/4) mottles; weak to moderate very fine angular blocky structure; sticky; few light gray (2.5Y 7/2) lime nodules; strongly effervescent; moderately alkaline; gradual smooth boundary.

C4—43 to 60 inches; dark grayish brown (2.5Y 4/2) silty clay; many medium and large prominent dark brown (7.5YR 3/4), strong brown (7.5YR 4/6), and yellowish red (5YR 4/6) mottles; weak thin platy structure parting to weak very fine

angular blocky; sticky; coating of very fine sand and silt particles on faces of plates; many masses of light gray (2.5Y 7/2) gypsum crystals; few fine black concretions; slightly effervescent; mildly alkaline.

The A horizon is black or very dark gray when moist. It is silty clay loam, silty clay, and, in a few profiles, clay. The A horizon ranges in thickness from 7 to 12 inches. In some places narrow tongues of A horizon extend to depths of 24 inches. In some places an Aca horizon is present. The Cca horizon is dark gray, gray, olive gray, light olive gray, and dark grayish brown in color and in some places it has distinct or prominent mottles. The Cca horizon ranges in thickness from 8 to 20 inches. The C horizon is grayish brown, olive gray, dark grayish brown, and dark gray in color and has faint to prominent mottles. It is silty clay or clay, and in some places it is over 60 percent clay in the lower part. Reaction ranges from mildly to moderately alkaline.

Hegne soils are associated with Bearden and Northcote soils. They are more poorly drained than Bearden soils. Hegne soils have a calcic horizon beginning at a depth of 16 inches, but the Northcote soils lack such a horizon at that depth.

937—Hegne-Northcote complex. This complex is in large areas that are commonly over 600 acres in size. Slopes are 0 to 2 percent. A relief of alternating ridges or knolls and draws or depressions generally is oriented in a northwest-southeast direction. Some higher knolls and deeper depressions vary in elevation from 6 inches to 2½ feet, and average 1 foot. The draws are elongated and generally joined.

Hegne silty clay is on the ridges and knolls. The concentration of carbonates is so near the surface layer in Hegne soils that tillage often mixes part of this layer with the original surface layer. A grayer surface color resulting from this mixing is most evident on the higher parts or ridges and knolls when the surface is dry.

Northcote clay is in the draws and depressions and has a deeper, darker, noncalcareous surface layer.

Hegne silty clay makes up 55 to 75 percent of this complex. Northcote clay makes up 25 to 45 percent. In some areas, Hegne soils are over 60 percent clay, and in a few areas, Northcote soils in this complex are slightly less than 60 percent clay.

Included with this soil in mapping, and making up as much as 15 percent of an individual mapped area, are Bearden soils and Colvin soils. Also included are a few areas where the higher areas in the soil complex have a noncalcareous surface. In some areas, soluble salts are present in varying concretions.

Wetness limits the uses of this complex. The alternating knolls and draws make drainage more difficult. Soil structural damage and compaction results if this complex is cultivated when wet. Soil blowing is a hazard where cultivated areas are smooth and have no protective cover. A nutrient imbalance in Hegne soils resulting from their strongly calcareous condition influences use and management.

Nearly all areas of this complex are cultivated. Small grain, sunflowers, and sugar beets are the most common crops. Legumes and grasses are included in cropping sequences as green manure crops. A few of these areas are used for hay or pasture before the soils are plowed and returned to cultivated cropland. Capability unit IIw–4; Clayey range site.

Karlstad series

The Karlstad series consists of nearly level, moderately well drained soils. These soils formed in sandy and gravelly material commonly near ridges along the shore lines of Glacial Lake Agassiz. Native vegetation is deciduous trees and grasses.

In a representative profile the surface layer is about 7 inches of very dark grayish brown loamy fine sand. The subsurface layer is about 3 inches of brown fine sand. The subsoil is about 2 inches of gravelly fine sandy loam with clay bridges between sand grains. The underlying material is light brownish gray gravelly loamy sand grading with depth to light gray fine sand.

Permeability is rapid, and available water capacity is low. Inherent fertility is low. The seasonal high water table commonly fluctuates from a depth of 2½ to 6 feet.

Some areas of Karlstad soils are cultivated. Small grain and forage for livestock are the most common crops. The soils in many areas support a growth of trees and grass. Droughtiness is the major limitation.

Representative profile of Karlstad loamy fine sand from an area of Karlstad soils, 0 to 2 percent slopes, in an open area with a growth of bluegrass, forbs, and weeds 745 feet west, 845 feet north of the southeast corner of sec. 12, T. 162 N., R. 45 W.:

Ap—0 to 7 inches; very dark grayish brown (10YR 3/2) loamy fine sand; single grained; loose; neutral; abrupt smooth boundary.

A2—7 to 10 inches; brown (10YR 5/3) fine sand; common medium distinct strong brown (7.5YR 5/8) mottles; single grained; loose; about 20 percent gravel; neutral; abrupt smooth boundary.

B2t—10 to 12 inches; brown (10YR 4/3) gravelly fine sandy loam; common fine distinct dark brown (7.5YR 4/4) mottles; weak very fine subangular blocky structure; friable; many clay bridges between sand grains; about 30 percent gravel; mildly alkaline; abrupt smooth boundary.

IIC1—12 to 18 inches; light brownish gray (2.5Y 6/2) gravelly loamy sand; single grained; loose; about 60 percent gravel; violently effervescent; moderately alkaline; abrupt smooth boundary.

IIIC2—18 to 38 inches; light gray (2.5Y 7/2) fine sand; common coarse distinct light yellowish brown (2.5Y 6/4) and olive brown (2.5Y 6/6) mottles; single grained; loose; strongly effervescent; moderately alkaline; gradual wavy boundary.

IIIC3—38 to 60 inches; light gray (2.5Y 7/3) fine sand; single grained; loose; slightly effervescent; mildly alkaline.

Thickness of the solum and depth to free carbonates

range from 8 to 20 inches. The content of gravel ranges from 15 to 30 percent in the solum to 60 percent in the IIC horizon. The A horizon is sand, fine sand, loamy sand, or loamy fine sand. The A1 horizon is very dark gray, very dark grayish brown, and very dark brown. The A2 horizon is grayish brown, light brownish gray, pale brown, and brown. The B2t horizon is coarse sandy loam, sandy loam, gravelly fine sandy loam, fine sandy loam, and sandy clay loam. It is brown, dark brown, yellowish brown, and dark yellowish brown. The IIC horizon is stratified coarse sand, sand, or fine sand with gravel in places. Typically, the upper part of the IIC horizon is gravelly loamy sand grading with depth to fine sand.

The Karlstad soils in this county have a thinner B2t horizon than the defined range for the series, but this difference does not alter their usefulness and behavior.

Karlstad soils are associated with Hangaard and Marquette soils. Karlstad soils are better drained than Hangaard soils. They are wetter than Marquette soils.

205—Karlstad soils, 0 to 2 percent slopes. These soils are in plane or slight convex areas that range from 5 to under 50 acres in size. They are near beach ridges or interbeach areas where water has sorted and deposited coarse textured materials. The surface layer ranges in texture from loamy fine sand to sand and has a brownish color and numerous clean, bleached sand grains. A few cobbles and stones are on the surface in some areas.

Included with these soils in mapping, and making up as much as 20 percent of an individual mapped area, are Pelan soils. Also included, and making up as much as 15 percent of an individual mapped area, are Poppleton soils. Some areas of soils that have more gravel in the underlying material than is typical for Karlstad soils and areas that are up to 10 percent Marquette and Lohnes soils are also included.

Low available water capacity and low inherent fertility limit the uses of this soil. The hazard of soil blowing is also a limitation.

A few areas of these soils are cultivated. Small grain is the most common crop. Other areas are in introduced grasses or grass-legume mixes. These are commonly used for hay and pasture. Trees, principally quaking aspen, bur oak, and ash, also grow on these soils. Capability unit IVs–1; Sands range site.

Lohnes series

The Lohnes series consists of nearly level to gently sloping, well drained to moderately well drained soils. These soils formed in sandy and gravelly sediment on ridges commonly located along the shore lines of Glacial Lake Agassiz. Native vegetation is tall grasses.

In a representative profile the surface layer is about 9 inches of black loamy sand, and the subsoil is about 4 inches of dark brown coarse sand. The underlying material is brown and pale brown coarse and medium sand mixed with some gravel (fig. 4).

Permeability is rapid, and available water capacity is low. Inherent fertility is low. The seasonal high water table commonly fluctuates from a depth of 4 to 6 feet.

Some areas of Lohnes soils are cultivated. Potatoes, rye, and legumes mixed with grasses are the most common crops. Other areas support a growth of native grasses and trees, principally bur oak and quaking aspen. Droughtiness is the major limitation.

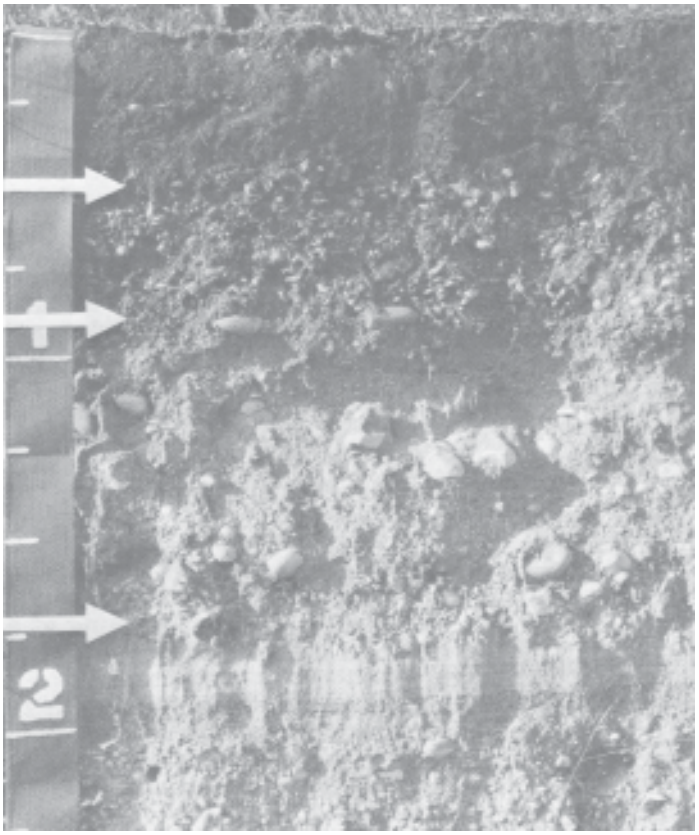

Figure 4.—**Profile of Lohnes soils. The dark surface layer is underlain by stratified sand and gravelly material.**

Representative profile of Lohnes loamy sand from an area of Lohnes soils, 0 to 6 percent slopes, in a field of alfalfa and bromegrass 50 feet south and 1,420 feet west of the northeast corner of sec. 23, T. 159 N., R. 46 W.:

A1—0 to 9 inches; black (10YR 2/1) loamy sand; weak very fine granular structure; very friable; neutral; clear smooth boundary.

B2—9 to 13 inches; dark brown (10YR 3/3) coarse sand; single grained; loose; about 30 percent gravel; slightly effervescent; mildly alkaline; clear smooth boundary.

C1—13 to 28 inches; brown (10YR 5/3) gravelly coarse sand; single grained; loose; about 50 percent gravel; slightly effervescent; mildly alkaline; gradual smooth boundary.

C2—28 to 44 inches; pale brown (10YR 6/3) sand; single grained; loose; about 1 percent gravel; slightly effervescent; moderately alkaline; gradual smooth boundary.

C3—44 to 60 inches; brown (10YR 5/3) gravelly coarse sand; single grained; loose; about 40 percent gravel; slightly effervescent; moderately alkaline.

The mollic epipedon ranges from 10 to 20 inches in thickness. The A horizon is loamy sand, loamy coarse sand, or coarse sandy loam, and is black and very dark gray. The B horizon is sand, coarse sand, and loamy sand. It is dark brown or very dark grayish brown. The C horizon is typically sand and coarse sand and some strata of gravelly coarse sand and gravelly sand. It is brown, dark brown, and pale brown. In some pedons the C horizon has few to common gray or yellowish brown mottles.

Lohnes soils are associated with Hangaard and Maddock soils. Lohnes soils are better drained than the poorly drained Hangaard soils. They have more coarse or very coarse sand and gravel than Maddock soils.

245—Lohnes soils, 0 to 6 percent slopes. These soils commonly are on beach ridges that formed along shore lines of Glacial Lake Agassiz. Areas generally are between 5 and 200 acres. The surface layer ranges in texture from coarse sandy loam to loamy sand and has a smooth appearance with variations of black and brown where cultivated. Clean, bleached sand grains and varying amounts of soil blowing influence surface color.

Included with these soils in mapping, and making up as much as 20 percent of an individual area, are more gravelly soils. Also included, and making up as much as 15 percent of an individual area, are Maddock soils. Small areas with moderate to severe erosion are also included.

Low available water capacity and low inherent fertility are limitations on this soil. The hazard of soil blowing is also a limitation.

Some areas of these soils are cultivated. Small grain and some potatoes are common crops. Many areas are in introduced and native grasses and scattered trees. Some of these areas are used for hay and pasture. Capability unit IVs–2; Sands range site.

Maddock series

The Maddock series consists of nearly level, well drained soils. These soils formed in fine sand on low ridges or knolls along shore lines of Glacial Lake Agassiz or on deltas of glacial streams. Native vegetation is tall grasses.

In a representative profile the surface layer is about 12 inches of black loamy fine sand. The next layer is about 4 inches of very dark grayish brown loamy fine sand. The subsoil is about 20 inches of yellowish brown fine sand. The underlying material is pale brown fine sand.

Permeability is rapid, and available water capacity is low. Inherent fertility is low. The seasonal high water table commonly fluctuates from a depth of 4 to 10 feet.

Some areas of Maddock soils are cultivated. Potatoes, small grain, mixed grasses and legumes, and corn for fodder are the most common crops. Other areas are in grasses and some trees, principally bur oak and quaking aspen. Droughtiness is the major limitation.

Representative profile of Maddock loamy fine sand from an area of Maddock soils, 0 to 2 percent slopes, in an idle area with grasses, weeds and forbs 1,180 feet east and 40 feet north of the southwest corner of sec. 16, T. 160 N., R. 46 W.:

A1—0 to 12 inches; black (10YR 2/1) loamy fine sand; single grained; loose; neutral; clear smooth boundary.

A3—12 to 16 inches; very dark grayish brown (10YR 3/2) loamy fine sand; single grained; loose; neutral; clear smooth boundary.

B2—16 to 36 inches; yellowish brown (10YR 5/4) fine sand; single grained; loose; neutral; clear smooth boundary.

C1—36 to 58 inches; pale brown (10YR 6/3) fine sand; single grained; loose; neutral; gradual smooth boundary.

C2—58 to 74 inches; pale brown (10YR 6/3) fine sand; single grained; loose; very slightly effervescent; mildly alkaline.

Thickness of the mollic epipedon ranges from 10 to 16 inches. The average texture between depths of 10 to 40 inches is fine sand, sand, or loamy fine sand. The A horizon is loamy fine sand, fine sandy loam, sandy loam, or loamy sand. It is black and very dark gray in color. In some pedons, an A3 horizon is very dark grayish brown. The B horizon is loamy fine sand, fine sand, loamy sand, and sand. It is brown, dark brown, yellowish brown, and dark yellowish brown. The C horizon is typically fine sand, but loamy fine sand, loamy sand, and sand are in the range. It is dark grayish brown, grayish brown, light brownish gray, pale brown, and brown. In some pedons a small amount of fine gravel is in the lower part of the C horizon.

Maddock soils are associated with Lohnes and Poppleton soils. They have finer sands and lack coarse fragments typical of Lohnes soils. They have a thicker, darker surface layer and are better drained than Poppleton soils.

45—Maddock soils, 0 to 2 percent slopes. These soils are in convex areas that normally range in size from 5 to 35 acres. They are commonly on low ridges along poorly defined shore lines of Glacial Lake Agassiz. The surface layer ranges from loamy fine sand to fine sandy loam. Where cultivated it has a smooth appearance and is black and gray in color. Clean, bleached sand grains and varying amounts of soil blowing influence surface color.

Included with these soils in mapping, and making up as much as 20 percent of an individual mapped area, are well drained sandy soils that have less than 10 inches of dark surface layer. Also included, and making up as much as 15 percent of an area, are Lohnes soils, and, making up as much as 10 percent of an area, are Poppleton soils. A few areas that have a sandy loam surface layer and some small areas of soils where slopes are over 2 percent are included.

Low available water capacity and low inherent fertility limit the use of this soil. The hazard of soil blowing is also a limitation.

Some areas of these soils are cultivated. Small grain and potatoes are the most common crops. Most areas are in introduced and native grasses and scattered trees. Some areas are used for hay and pasture. Capability unit IVs–2; Sands range site.

Markey series

The Markey series consists of level or depressional, very poorly drained soils. These soils formed in a

mantle of organic soil material underlain by sandy lacustrine sediment. They commonly are in broad, flat, slightly depressional areas. Native vegetation is reeds, sedges, and other water-tolerant plants.

In a representative profile the surface is about 6 inches of black muck. The next layer is about 10 inches of black, peaty muck. This layer has dark brown broken face colors. The next organic layer is black muck about 9 inches thick. The underlying mineral material is black mixed loam, sandy loam, and loamy sand that grades to grayish brown fine sand (fig. 5).

Permeability is moderate. Available water capacity is very high. Inherent fertility is low. The seasonal high water table commonly fluctuates from a depth of 0 to 3 feet.

Most areas of these soils are not cultivated. Reeds, sedges, willow brush, and some trees, mainly quaking aspen, grow on these soils. The soils in a few areas are used for hay and pasture or are cultivated for the production of small grain. Wetness is the major limitation.

Representative profile of Markey muck, in an area of sedges and grasses 150 feet east and 2,500 feet south of the northwest corner of sec. 20, T. 161 N., R. 45 W.:

Oa1—0 to 6 inches; black (10YR 2/1), broken face and rubbed, sapric material; about 30 percent fiber, about 5 percent rubbed; weak fine crumb structure; very friable; herbaceous fiber; about 15 percent mineral material; clear smooth boundary.

Oe1—6 to 16 inches; black (10YR 2/1), broken face and rubbed, matrix with dark brown (7.5YR 3/2) broken face, unrubbed, hemic material; about 60 percent fiber, about 20 percent rubbed; weak thin platy structure; nonsticky; herbaceous fiber; about 10 percent mineral material; gradual smooth boundary.

Oa2—16 to 25 inches; black (10YR 2/1), broken face and rubbed, sapric material; about 35 percent fiber, trace rubbed; weak medium platy structure; nonsticky; herbaceous fiber; about 25 percent mineral material; clear wavy boundary.

IIA1b—25 to 36 inches; black (N/2) mixed loam, sandy loam, and loamy sand; massive; slightly sticky; texture varies both horizontally and vertically; clear irregular boundary.

IIC1—36 to 60 inches; grayish brown (2.5Y 5/2) fine sand; massive.

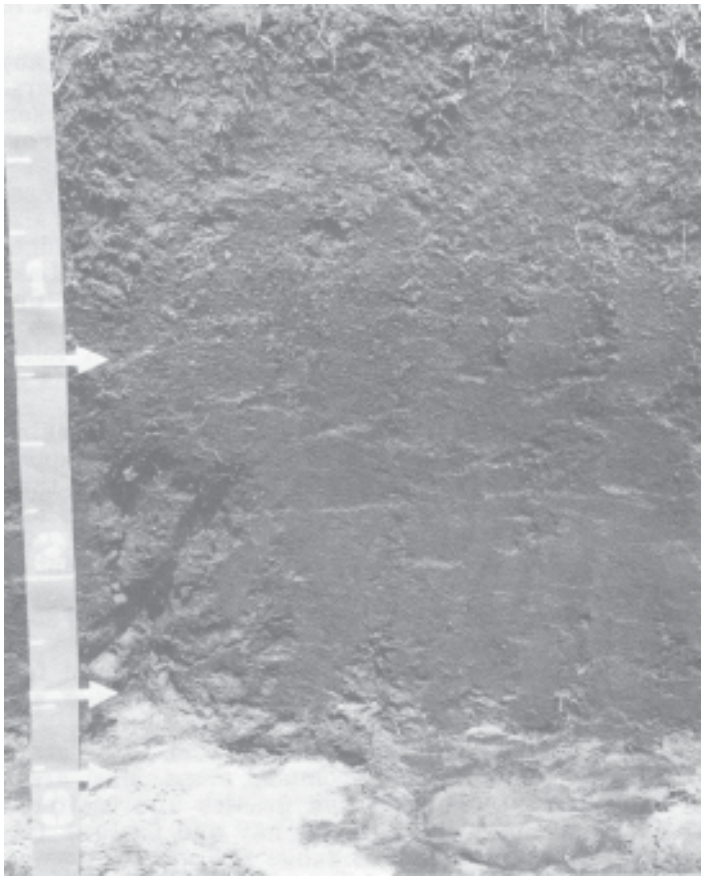

Figure 5.—**Profile of Markey muck. The organic layer is from 25 to 30 inches thick. The boundary of the dark top layer of mineral soil is irregular.**

Thickness of the O horizon ranges from 16 to 50 inches. The surface layer consists primarily of sapric material; however, in some pedons both sapric and hemic material are in various proportions. The underlying organic soil material is dominantly sapric; however, in some pedons hemic material is as much as 10 inches thick. The organic material is black, very dark gray, very dark grayish brown, and very dark brown in color. The IIA1b horizon is a black or very dark gray loam, sandy loam, or loamy sand. The IIC horizon is sand and loamy sand. It is gray, grayish brown, and light brownish gray.

Markey soils are associated with the Cormant, Deerwood, and Cathro soils. The Markey soils are wetter than Cormant soils. They have an O horizon which the Cormant soils lack. Markey soils have a thicker O horizon than Deerwood soils. They have a sandy IIC horizon whereas Cathro soils have a loamy IIC horizon.

543—Markey muck. This soil is in low, broad, flat areas that normally range in size from 10 to 500 acres. Slopes are 0 to 2 percent. The surface layer of this soil has a black, mellow, granular appearance where cultivated. Some surface materials may be rootbound, and a lumpy condition occurs when it is first cultivated.

Included with this soil in mapping, and making up as much as 15 percent of an individual mapped area, are soils where the organic soil material is deeper than 50 inches, and Cathro muck. Also included, and making up as much as 15 percent of an individual mapped area, are marshy areas where soil materials have not been determined. Areas where organic soil material is calcareous and areas where organic material is less highly decomposed are included. Some areas where stones and boulders are exposed at the surface are also included.

Wetness limits the uses of this soil. Low inherent fertility influences use and management. Fires are a hazard on this soil.

Many areas of this soil are not cultivated. Reeds, sedges, phragmites, cattails, and scattered lowland brush grow on this soil. A few areas are wooded, primarily with quaking aspen. Some areas are used for hay and pasture. Reed canarygrass is grown in some areas. Soils in a few areas have been cultivated, usually for the production of flax and small grain. Capability unit IVw–3; Grazeable Muck range site.

Marquette series

The Marquette series consists of nearly level, well drained to excessively drained soils. These soils formed in gravelly material commonly on ridges along the shore lines of Glacial Lake Agassiz. Native vegetation is deciduous trees. Oak and aspen are the most common trees.

In a representative profile the surface layer is about 6 inches of very dark brown loamy sand. The subsurface layer is about 3 inches of brown gravelly loamy fine sand. The subsoil is about 5 inches of dark yellowish brown gravelly fine sandy loam that has clay films and bridges and 6 inches of brown very gravelly loamy coarse sand. The next layer is strongly effervescent pale brown very gravelly loamy coarse sand. The underlying material is slightly effervescent, brown very gravelly sand and very gravelly coarse sand.

Permeability is rapid, and available water capacity is low. Inherent fertility is low. The seasonal high water table commonly fluctuates from a depth of 4 to 10 feet.

A few areas of these soils are cultivated. Small grain, or legumes and grasses for pasture are the most common crops. Many areas are in grasses and trees, mainly bur oak. Droughtiness is the major limitation.

Representative profile of Marquette loamy sand from an area of Marquette soils, 0 to 2 percent slopes, in an open area of quack grass 200 feet west and 2,840 feet north of the southeast corner of sec. 7, T. 161 N., R. 45 W.:

Ap—0 to 6 inches; very dark brown (10YR 2/2) loamy sand; weak very fine granular structure; very friable; neutral; abrupt smooth boundary.

A2—6 to 9 inches; brown (10YR 4/3) gravelly loamy fine sand; single grained; loose; about 40 percent coarse fragments; neutral; clear smooth boundary.

B2t—9 to 14 inches; dark yellowish brown (10YR 3/5) gravelly fine sandy loam; moderate fine subangular blocky structure; slightly sticky; thin clay film and clay bridging between peds and sand particles; about 55 percent coarse fragments; neutral; clear smooth boundary.

B3—14 to 20 inches; brown (10YR 4/3) very gravelly loamy coarse sand; single grained; loose; about 75 percent coarse fragments; slightly effervescent; mildly alkaline; gradual smooth boundary.

C1ca—20 to 29 inches; pale brown (10YR 6/3) very gravelly loamy coarse sand; single grained; loose; about 75 percent coarse fragments; strongly effervescent; moderately alkaline; gradual smooth boundary.

C2—29 to 36 inches; brown (10YR 5/3) very gravelly sand; single grained; loose; about 75 percent coarse fragments; slightly effervescent; moderately alkaline; gradual smooth boundary.

C3—36 to 60 inches; brown (10YR 5/3 and 4/3) very gravelly coarse sand; single grained; loose; about 80 percent coarse fragments; slightly effervescent; moderately alkaline.

Thickness of the solum and depth to free carbonates range from 8 to 24 inches. Undisturbed pedons either lack or have a thin O horizon. These pedons also either lack or have an A1 horizon up to 4 inches thick. The A horizon is sand, loamy sand, coarse sand, loamy coarse sand, or sandy loam. The A1 horizon is black, very dark gray, very dark grayish brown, and very dark brown in color. Where cultivated, the Ap horizon is black, very dark gray, dark gray, dark grayish brown, and very dark grayish brown. The A2 horizon is light brownish gray, dark grayish brown, brown, and pale brown. Coarse fragments of gravel size make up 50 to 80 percent of the material below the A1 horizon. The B horizon has a gravel content that ranges from 35 to 75 percent. The B2t horizon is coarse sandy loam, sandy loam, fine sandy loam, sandy clay loam, and loam. It is dark brown, brown, yellowish brown, and dark yellowish brown. In some pedons a B3 horizon is coarse sand, sand, loamy coarse sand, and loamy sand. The Cca horizon is gravelly or very gravelly loamy coarse sand or loamy sand. The C horizon is mostly gravelly or very gravelly coarse sand or sand. It is grayish brown, brown, light brownish gray, and pale brown. In some pedons the C horizon is stratified with layers of sand or coarse sand.

Marquette soils are associated with Karlstad, Pelan, and Lohnes soils. Marquette soils are drier than the Karlstad soils. They are drier and lack the loamy IIC horizon of Pelan soils. They have a B2t horizon which is lacking in Lohnes soils.

242—Marquette soils, 0 to 2 percent slopes. These soils are commonly on beach ridges that formed along the shore lines of Glacial Lake Agassiz. These areas generally range in size from 5 to 40 acres. The surface layer of these soils ranges in texture from coarse sand to sandy loam and has a smooth appearance where cultivated. The surface colors are brownish and are influenced by numerous clean, bleached sand grains.

Included with these soils in mapping, and making up as much as 20 percent of an individual mapped area, are Lohnes soils. Also included, and making up as much as 15 percent of an individual mapped area, are Maddock soils. Small eroded areas where gravel is exposed on the surface are also included.

Low available water capacity and low inherent fertility limit the uses of these soils. The hazard of soil blowing is also a limitation.

A few areas of these soils have been cultivated. Small grain is the most common crop. Many areas are in introduced and native grasses and scattered trees, primarily bur oak. Some of these areas are used for hay and pasture. Capability unit IVs–2; Sands range site.

Marsh

1053—Marsh. Marsh is in very wet depressions with predominantly marsh vegetation. These marshy depressions remain wet throughout most years. Soil material is not determined and classified in areas of marsh.

Included with Marsh in mapping, and making up as much as 10 percent of an individual mapped area, are intermittent water areas with little or no vegetative growth.

Wetness and difficulty in drainage are limitations on marsh areas.

Areas of marsh are not cultivated. Some are included in pasture areas, and some of the wetland vegetation may be grazed when conditions are dry and forage is short on higher ground. The most common vegetation in marsh areas is cattails and phragmites. Marsh areas are habitat for various species of wildlife such as muskrat and waterfowl. Capability unit—not classified; range site—not classified.

Mavie series

The Mavie series consists of nearly level or slightly depressional, poorly drained soils. These soils formed in sandy and gravelly sediment over loamy glacial till. They are in areas that are commonly associated with shore lines of Glacial Lake Agassiz. Native vegetation is wetland reeds and sedges, but there has been a conversion to tall grasses because of an improved drainage network.

In a representative profile the surface layer is about 7 inches of black sandy clay loam. Below this is violently effervescent, very dark gray sandy clay loam about 3 inches thick. The next layer is about 4 inches of violently effervescent, dark grayish brown fine sandy loam. The underlying material is about 8 inches of grayish brown gravelly coarse sand. Below this is light brownish gray fine sandy loam that grades with depth to light olive gray loam.

Permeability and available water capacity are moderate. Inherent fertility is medium. The seasonal high water table commonly fluctuates from a depth of 1 to 3 feet.

Some areas of Mavie soils are cultivated. Small grain and forage for livestock are the most common crops. Other areas are in reeds, sedges, grasses, brush, and trees. Wetness is the major limitation.

Representative profile of Mavie sandy clay loam from an area of Mavie soils, in an area of scattered quaking aspen and mixed grasses 100 feet west and 20 feet north of the southeast corner of sec. 36, T. 160 N., R. 45 W.:

A1—0 to 7 inches; black (10YR 2/1) sandy clay loam; weak very fine subangular blocky structure; very friable; strongly effervescent; abrupt smooth boundary.

A1ca—7 to 10 inches; very dark gray (2.5Y 3/1) sandy clay loam; very weak very fine subangular blocky structure; friable; violently effervescent; moderately alkaline; clear wavy boundary.

C1ca—10 to 14 inches; dark grayish brown (2.5Y 4/2) fine sandy loam; very weak very fine subangular blocky structure; very friable; about 5 percent coarse fragments; violently effervescent; moderately alkaline; abrupt smooth boundary.

IIC2—14 to 22 inches; grayish brown (2.5Y 5/2) very gravelly coarse sand; common medium distinct dark yellowish brown (10YR 4/4) and strong brown (7.5YR 5/8) mottles; single grained; loose; 70 percent coarse fragments; strongly effervescent; abrupt smooth boundary.

IIIC3—22 to 38 inches; light brownish gray (2.5Y 6/2) fine sandy loam; many medium distinct brownish yellow (10YR 6/8), yellowish brown (10YR 5/6), and light olive brown (2.5Y 5/6) mottles; weak very fine subangular blocky structure; very friable; about 30 percent coarse fragments; strongly effervescent; moderately alkaline; gradual wavy boundary.

IIIC4—38 to 60 inches; light olive gray (5Y 6/2) loam; many medium distinct yellowish brown (10YR 5/6), dark brown (7.5YR 4/4), and yellowish red (5YR 4/6) mottles; very weak very fine subangular blocky structure; friable; about 20 percent coarse fragments; strongly effervescent; moderately alkaline.

The A horizon ranges from 7 to 14 inches in thickness. Thickness of IIC horizon, that is 35 to 75 percent coarse fragments, ranges from 6 to 24 inches. Depth to IIIC horizon ranges from 20 to 40 inches. The A horizon is loam, silty loam, sandy loam, fine sandy loam, and sandy clay loam. It is black or very dark gray in color. The Aca horizon is not in all profiles. The C1ca horizon is sandy loam, gravelly sandy loam, and fine sandy loam that grades in the lower part to loamy sand, gravelly loamy sand, sand, and gravelly coarse sand. It is dark gray, gray, light brownish gray, and dark grayish brown and has distinct or prominent mottles in some pedons. The IIC horizon is gravelly sand or gravelly coarse sand. The IIC and IIIC horizons are grayish brown, light brownish gray, light olive gray, and olive gray and have common distinct or prominent mottles. The IIIC horizon is loam, clay loam, light silty clay loam, silt loam, and fine sandy loam.

Mavie soils are associated with Foxhome, Strandquist, and Syrene soils. Mavie soils are wetter than Foxhome soils. They have a calcic horizon within a depth of 16 inches which the Strandquist soils do not have. They have a loamy IIIC horizon which is lacking in the Syrene soils.

412—Mavie soils. These soils are in level to slightly concave areas that vary considerably in shape and commonly range in size from 5 to 40 acres. Slopes are 0 to 2 percent. The surface layer ranges in texture from sandy loam to silt loam. The Mavie soils are in interbeach areas where soil material is mixed and changes within short distances. Some areas of these soils have stones and cobbles scattered on the surface.

Included with these soils in mapping, and making up as much as 15 percent of an individual mapped area, are Syrene, Strandquist, and Rockwell soils. Also included, and making up as much as 10 percent of an

individual mapped area, are Foxhome and Percy soils. Small areas where the surface layer is very shallow and very strongly calcareous, a few spots where the surface is covered with stones and boulders, some areas that have less than 35 percent gravel in the coarse textured layer, and some areas where soluble salts are present in varying degrees of concentration are included.

Wetness limits the uses of these soils. Moderate available water capacity and medium inherent fertility also influence use and management. In places stones and boulders make operation of farm machines difficult.

Some areas of these soils are cultivated. Small grain is the most common crop. Many areas are used for hay and pasture. Scattered trees, principally quaking aspen and some willow brush, also grow on these soils. Capability unit IIIw–1; Subirrigated range site.

Nereson series

The Nereson series consists of nearly level, moderately well drained soils. These soils formed in loamy, calcareous till. They are in areas of lake washed glacial till. Native vegetation is tall grasses and an encroachment of trees, mainly oak and aspen.

In a representative profile the surface layer is about 6 inches of very dark brown fine sandy loam. The subsoil is about 3 inches of dark grayish brown fine sandy loam. The next layer is about 20 inches of mottled, grayish brown and light brownish gray loam that has a concentration of carbonates and is violently effervescent. The underlying material is mottled, grayish brown fine sandy loam that is strongly effervescent. Throughout this pedon content of coarse fragments ranges from 2 to 20 percent, and generally increases with depth.

Permeability is moderate, and available water capacity is high. Inherent fertility is high. The seasonal high water table fluctuates from a depth of 2.5 to 6 feet.

Many areas of Nereson soils are cultivated. Small grain and forage for livestock are the most common crops. A smaller acreage supports a growth of trees, mainly bur oak and quaking aspen. Climate is the major limitation.

Representative profile of Nereson fine sandy loam from an area of Nereson soils, 0 to 2 percent slopes, in a cultivated field 215 feet west and 1,848 feet north of the southeast corner of sec. 1, T. 159 N., R. 45 W.:

Ap—0 to 6 inches; very dark brown (10YR 2/2) fine sandy loam; weak to moderate very fine subangular blocky structure; friable; about 2 percent coarse fragments; mildly alkaline; abrupt smooth boundary.

B2t—6 to 9 inches; dark grayish brown (10YR 4/2) fine sandy loam; weak and moderate very fine angular blocky structure parting to single grained; friable; 8 percent coarse fragments; moderately alkaline; thin patchy dark brown (10YR 3/3) clay films on ped faces; bridges between sand grains; clear smooth boundary.

C1ca—9 to 18 inches; grayish brown (2.5Y 5/2) loam; few fine faint light yellowish brown (2.5Y 6/4) mottles; weak very fine subangular blocky structure; very friable; about 8 percent coarse fragments; violently effervescent; strongly alkaline; gradual smooth boundary.

C2ca—18 to 29 inches; light brownish gray (2.5Y 6/2) loam; common fine distinct yellowish brown (10YR 5/4) and light olive brown (2.5Y 5/6) mottles; weak very fine subangular blocky structure; about 5 percent coarse fragments; violently effervescent; strongly alkaline; gradual smooth boundary.

C3—29 to 60 inches; grayish brown (2.5Y 5/2) fine sandy loam; many medium distinct yellowish brown (10YR 5/6), brown (10YR 5/3), and strong brown (7.5YR 5/8) mottles; weak very fine subangular blocky structure; very friable; about 15 percent coarse fragments; strongly effervescent; strongly alkaline.

Thickness of solum and depth of free carbonates range from 9 to 22 inches. The A horizon is 6 to 14 inches of sandy loam, fine sandy loam, loam, and silt loam. It is black, very dark gray, very dark grayish brown, and very dark brown in color. In some pedons an A2 horizon is 2 inches of loam or sandy loam. It is dark grayish brown, grayish brown, and light brownish gray in color. The B horizon is 3 to 7 inches of sandy loam, loam, or sandy clay loam. It is very dark grayish brown, dark grayish brown, brown, dark brown, and olive brown. In some pedons, the lower part of the B horizon has a thin layer of up to 35 percent of coarse fragments. Clay films on ped faces in the B horizon are patchy to continuous and range in thickness from very thin to medium. The solum contains from 2 to 15 percent coarse fragments. The C horizon is sandy loam, fine sandy loam, loam, clay loam, and silt loam. It is dark grayish brown, grayish brown, and light brownish gray. Mottling is few to many, fine or medium, and faint or distinct. The IIC horizon contains from 5 to 20 percent coarse fragments. It is slightly to violently effervescent.

Nereson soils are associated with Fram, Garnes, and Percy soils. Nereson soils have a horizon of clay accumulation which Fram soils lack. They have a thicker A1 horizon or darker Ap horizon than Garnes soils. Nereson soils are better drained than Percy soils.

583—Nereson soils, 0 to 2 percent slopes. These soils are in generally slightly convex areas that vary considerably in shape and are commonly between 5 and 60 acres in size. They are in interbeach areas where soil material changes within short distances. The surface layer of these soils ranges in texture from sandy loam to silt loam and has a fine granular or blocky appearance. Where it is cultivated, some clean, bleached sand grains are visible. Cobbles and stones commonly occur on the surface of this soil. This soil has the profile described as representative of the Nereson series.

Included with these soils in mapping, and making up as much as 20 percent of an individual mapped area, are Fram soils. Also included, and making up as

much as 15 percent of an individual mapped area, are Pelan soils, Garnes soils, and Percy soils. Some soils that have more clay in the subsoil are also included.

Climate limits the selection of crops that will mature and provide an economic return. In places stones and cobbles make the operation of farm machines difficult.

Some areas of these soils are cultivated. Small grain is a common crop. Other areas are in introduced grasses or legumes and grasses. These areas are used for hay and pasture. Scattered trees, mainly bur oak and quaking aspen, also grow on these soils. Capability unit IIc–1; Silty range site.

Northcote series

The Northcote series consists of nearly level and gently sloping, poorly drained soils. These soils formed under a growth of reeds, sedges, and tall grasses in clayey lacustrine deposits. They are commonly nearly level with some slightly concave areas. The gently sloping soils are generally adjacent to natural draws and streams. All areas of these soils are in the western part of the Glacial Lake Agassiz Basin.

In a representative profile the surface layer is about 9 inches of black clay. The subsoil is about 9 inches of dark olive gray clay. The underlying material is dark gray and olive gray, slightly to strongly effervescent clay. Tongues of the black surface layer extend into the underlying material, and distinct mottles are below a depth of 38 inches (fig. 6).

Figure 6.—**Profile of Northcote clay. This soil has prismatic and blocky structure. The numerous cracks are characteristic of soils that have high shrink-swell rating. The cracks extend into the underlying material.**

Permeability is slow, and available water capacity is moderate. Inherent fertility is high. The seasonal high water table fluctuates from a depth of 0 to 5 feet.

Most areas of Northcote soils are cultivated. These soils are suited to nearly all crops commonly grown in the county. Small grain is the most common crop, but sugar beets and sunflowers are also grown. Wetness is the major limitation.

Representative profile of Northcote clay, 0 to 2 percent slopes, in a cultivated field 96 feet north and 94 feet east of the southwest corner of sec. 32, T. 162 N., R. 48 W.:

Ap—0 to 9 inches; black (10YR 2/1) clay; moderate very fine subangular blocky structure; sticky; neutral; clear smooth boundary broken by tongues of A horizon material.

B2g—9 to 18 inches; dark olive gray (5Y 3/2) clay; dark olive gray (5Y 3/1) coating on ped faces; weak coarse prismatic structure parting to strong very fine angular blocky; sticky; neutral; clear smooth boundary broken by a few tongues of A horizon material.

C1g—18 to 28 inches; dark gray (5Y 4/1) clay; very dark gray (5Y 3/1) coatings on ped faces; weak coarse prismatic structure parting to moderate very fine angular blocky; sticky; slightly effervescent; mildly alkaline; gradual smooth boundary broken by a few narrow tongues of A horizon material.

C2gca—28 to 38 inches; olive gray (5Y 4/2) clay; very dark gray (5Y 3/1) coatings on ped faces; moderate very fine subangular blocky structure; sticky; few gray (5Y 5/1) soft lime masses; few slickensides; strongly effervescent; moderately alkaline; gradual smooth boundary.

C3g—38 to 60 inches; olive gray (5Y 4/2) clay; common fine distinct olive brown (2.5Y 4/4), light olive brown (2.5Y 5/6), and yellowish brown (10YR 5/4) mottles; moderate very fine subangular blocky structure; sticky; few slickensides; strongly effervescent; moderately alkaline.

Thickness of the solum ranges from 16 to 36 inches. In places few to common tongues of A horizon material extend to a depth of 48 inches. Depth to free carbonates is 12 to 30 inches. The average clay content of these soils is between 60 and 85 percent. When this soil is dry structure in the A horizon is moderate or strong, subangular blocky. The soil material in this horizon is sticky or very sticky when wet. Reaction in the A horizon is neutral or mildly alkaline. The Bg horizon is very dark gray, very dark grayish brown, dark gray, dark grayish brown, dark olive gray, and olive gray. In places mottles are in this horizon. Reaction in the Bg horizon is neutral or mildly alkaline. The C horizon is dark gray, gray, and olive gray. It is mottled at a depth above 40 inches. Reaction in the C horizon is mildly or moderately alkaline. Masses of gypsum crystals, lime nodules, or both are in the C horizon of some profiles.

Northcote soils are associated with Cashel, Hegne, and Wahpeton soils. They contain more clay than these soils. Northcote soils are better developed than Cashel soils, and they have more clay and have free carbonates at a greater depth than Hegne soils. They are wetter and more slowly permeable than Wahpeton soils.

429—Northcote clay, 0 to 2 percent slopes. This soil is in areas commonly more than 80 acres in size. The surface is smooth or slightly undulating with alternating convex and concave slopes that are generally orientated in a northwest-southeast direction. This soil has the profile described as representative of the series.

Included with this soil in mapping, and making up as much as 25 percent of an individual mapped area, are Hegne soils. Also included, and making up as much as 15 percent of an individual mapped area, are Wahpeton and Colvin soils. In some areas soluble salts are present in varying degrees of concentration.

Wetness is the main limitation to use of this soil. Cultivating this soil when it is wet causes structural damage and compaction. Soil blowing is a hazard where cultivated areas have no protective cover.

Nearly all areas of this soil are cultivated. Wheat, barley, oats, sugar beets, and sunflowers are the most common crops. Grasses and legumes are included in the cropping system, usually for use as green manure. Capability unit IIw–1; Clayey range site.

429B—Northcote clay, 2 to 6 percent slopes. This soil is in oblong areas that parallel natural drainageways. Slopes are generally short and range from 50 to 250 feet in length. Areas are commonly 5 to 80 acres in size. Because of natural drainageways, the thickness of the surface layer varies, and some buried dark horizons are in evidence. Except for these characteristics, this soil has a profile similar to the one described as representative of the series.

Included with this soil in mapping, and making up as much as 20 percent of an individual mapped area, are Wahpeton soils. Also included, and making up as much as 20 percent of an individual mapped area, are areas where the surface layer is thin and often calcareous. Cashel and Bearden soils make up as much as 15 percent of some mapped areas, and in some areas along natural drainageways slope is as much as 12 percent. Soluble salts are present in various degrees of concentration in some areas.

Wetness limits the use of this soil. Cultivating this soil when wet causes structural damage and compaction. High water in adjacent natural water courses will occasionally flood areas of this soil. Soil blowing and water erosion are hazards when cultivated areas have no protective cover.

Nearly all areas of this soil are cultivated. Small grain is the most common crop. Some areas are in fields planted to sugar beets or sunflowers. Grasses and legumes are included in some cropping sequences. Occasionally areas are wooded. Elm and poplar are the most common trees. Capability unit IIw–1; Clayey range site.

438—Northcote clay, depressional. This soil is in nearly round to oblong depressions that are more than 3 acres and commonly less than 20 acres in size. Slopes are 0 to 2 percent. The depressions are bordered by higher areas of nearly level Northcote or Hegne soils. The surface layer of this soil is commonly rough and cloddy when plowed. Water often ponds in the depressions for short periods. When dry, the surface is commonly crusted and cracked. The thickness of the surface layer and the extent and depth of tonguing vary more from place to place in this soil than in the one described as representative of the series. Otherwise the profiles are similar.

Included with this soil in mapping, and making up as much as 10 percent of an individual mapped area, are Cashel soils. Also included, and making up as much as 10 percent of an individual mapped area, is Alluvial land.

Wetness limits the use of this soil. Some ponding occurs during heavy rainfall and spring runoff, even though field ditches have been constructed. This wetness often delays cultivation and seeding. Cultivating this soil when wet causes structural damage and compaction and makes seedbed preparation difficult. Some drowning of crops is common.

Most areas of this soil are cultivated. Small grain, sugar beets, and sunflowers are the most common crops. Grasses and legumes for use as green manure are included in most cropping sequences. Open field ditches have been constructed to remove excess surface water from most cultivated fields. Capability unit IIIw–2; Wetland range site.

991—Northcote and Wahpeton soils. These soils are on or near terraces of major streams. Slopes are 0 to 2 percent. A relief of alternating ridges and draws varies the surface elevation from 4 feet to 1 foot. Areas are oriented differently in the landscape, and no predictable directional pattern prevails.

Northcote soils are in draws and depressions, and Wahpeton soils are on ridges. Northcote soils have a thicker and generally blacker surface layer than Wahpeton soils. Other silty soils that have a clayey subsoil and soils that are clayey and deep occupy the ridges and knolls. In many places these other soils have a brown subsoil. In places in tilled areas, material of the subsoil has mixed with that of the surface layer to give it a very dark grayish brown cast.

Northcote and Wahpeton soils make up 45 to 60 percent of an individual mapped area. The percentage of other soils in this unit ranges from 30 to 50 percent. In places soils in this unit are browner and have less clay in the subsoil than is usual and have a silty substratum. Thickness of the surface layer in Northcote soils varies more than thickness of the surface layer in the soil described as representative of the Northcote series. Also, variation in the amount and depth of tonguing and in texture of the substratum is greater. Otherwise, the profile of the Northcote soils is similar to that described as representative of the Northcote series. The Wahpeton soils have the profile described as representative of the series.

Included with these soils in mapping, and making up as much as 15 percent of an individual mapped area, are Cashel and Fargo soils.

Wetness limits the use of these soils. It is difficult to drain excess water from the depressions because of the ridges and draws. Structural damage and compaction result if the soils of this unit are cultivated when they are wet. Soil blowing is a hazard in cultivated areas where there is no protective cover.

Nearly all areas of this complex are cultivated. Small grain is the most common crop, but sugar beets and sunflowers are also grown. Grasses and legumes are included in cropping sequences, generally for use as a green manure crop. A small area is wooded. Capability unit IIw–4; Clayey range site.

Noyes series

The Noyes series consists of nearly level, poorly drained to somewhat poorly drained soils. These soils formed in clayey material. They are on level areas on the eastern edge of the lacustrine clay sediment. Native vegetation was tall grasses and possibly trees during some stage in the development of this soil.

In a representative profile the surface layer is about 13 inches of black and very dark brown sandy clay loam, and the subsoil to about 35 inches is of dark grayish brown and grayish brown clay. The underlying material is mottled, dark and very dark grayish brown clay that has masses of gypsum crystals and is slightly effervescent.

Permeability is slow, and available water capacity is moderate. Inherent fertility is high. The seasonal high water table fluctuates from a depth of 1 to 5 feet.

Most areas of Noyes soils are cultivated. They are suited to all crops commonly grown in Kittson County. Small grain, sugar beets, and sunflowers are the most common crops. Wetness is the major limitation.

Representative profile of Noyes sandy clay loam from an area of Noyes soils in a cultivated field 2,540 feet south and 1,000 feet east of the northwest corner of sec. 24, T. 159 N., R. 48 W.:

Ap—0 to 9 inches; black (10YR 2/1) sandy clay loam; weak very fine subangular blocky structure; very friable; many clean quartz grains; mildly alkaline; abrupt smooth boundary.

A12—9 to 13 inches; very dark brown (10YR 2/2) and black (10YR 2/1) sandy clay loam; weak very fine subangular blocky structure; friable; common clean quartz grains; mildly alkaline; clear smooth boundary.

B2t—13 to 22 inches; dark grayish brown (2.5Y 4/2) clay; strong coarse prismatic structure parting to strong fine angular blocky; sticky; thin continuous very dark grayish brown (2.5Y 3/2) clay films on ped faces; many clean quartz grains on ped faces in upper part; moderately alkaline; gradual wavy boundary.

B3t—22 to 35 inches; grayish brown (2.5Y 5/2) clay; moderate coarse prismatic structure parting to moderate fine angular blocky; sticky; thin patchy very dark grayish brown (2.5Y 3/2) clay films on ped faces; slightly effervescent; moderately alkaline; gradual smooth boundary.

C1—35 to 44 inches; dark grayish brown (2.5Y 4/2) clay; many fine distinct olive brown (2.5Y 4/4) mottles; moderate very fine angular blocky structure; sticky; many masses of gypsum crystals; slightly effervescent; moderately alkaline; clear smooth boundary.

C2—44 to 60 inches; very dark grayish brown (2.5Y 3/2) clay; few ped coatings and inclusions of black (2.5Y 2/2) and olive brown (2.5Y 4/4); moderate very fine angular blocky structure; sticky; slightly effervescent; mildly alkaline.

The solum ranges from 15 to 40 inches in thickness. Depth to free carbonates ranges from 15 to 36 inches. Carbonate content may increase with depth. The A horizon is commonly subangular blocky or granular structure. The A1 horizon ranges from 7 to 15 inches in thickness. It is sandy clay loam, fine sandy loam, very fine sandy loam, loam, or silt loam and is mostly black, very dark brown, very dark gray, or very dark grayish brown in color. In places clean quartz grains from the A2 horizon modify the color. In some pedons an A2 horizon is as much as 4 inches thick. It is more grayish in color, is loam, sandy loam, very fine sandy loam, or loamy very fine sand in texture, and is platy in structure. The B horizon has clay content that ranges from 60 to 80 percent. The B horizon is dark grayish brown and very dark grayish brown that grades to dark gray and very dark gray. Mottling is faint and distinct in the lower part of the B horizon in some pedons. Reaction of the B horizon ranges from neutral to moderately alkaline. The C horizon has a clay content that ranges from 45 to 75 percent. It is dark grayish brown, very dark grayish brown, black, olive gray, and dark olive gray. Reaction of the C horizon is mildly to moderately alkaline.

Noyes soils are associated with Donaldson, Northcote, Viking, and Wheatville soils. Noyes soils are wetter than Donaldson soils. Although Noyes soils occupy positions on the landscape similar to Northcote and Viking soils, they have an argillic horizon which is lacking in these soils. They lack a calcic horizon within 16 inches of the surface which is characteristic of Wheatville soils.

430—Noyes soils. These soils are in smooth or very slightly convex areas that are commonly between 10 and 160 acres in size. Slopes are 0 to 2 percent. The surface layer of this soil ranges in texture from sandy clay loam to fine sandy loam and appears blocky in structure where it is cultivated. Many clean, bleached sand grains give a slightly grayish cast to the surface layer.

Included with these soils in mapping, and making up as much as 20 percent of an individual mapped area, are Donaldson, Northcote, or Viking soils. Also included, and making up as much as 15 percent of an individual mapped area, are Wheatville soils. Small areas that have thin sandy layers above the clay, or areas where the clay content of the B and C horizons is nearly the same are also included. In some areas soluble salts are present in varying degrees of concentration.

Wetness limits the use of this soil. Soil blowing is a hazard where cultivated areas have no protective cover.

Nearly all areas of these soils are cultivated. Small grain, sugar beets, and sunflowers are the most common crops. A smaller acreage is planted to potatoes. Legumes and grasses are included in cropping se-

quences generally for use as green manure crops. Capability unit IIw–2; Clayey range site.

Pelan series

The Pelan series consists of nearly level, moderately well drained soils. These soils formed in loamy sand and gravelly water-laid sediment over loamy glacial till. They are in areas of coarse textured deposits along shore lines of Glacial Lake Agassiz. Native vegetation is tall grasses and trees, mainly bur oak and quaking aspen.

In a representative profile the surface layer is about 6 inches of very dark brown loamy sand. The subsurface layer is about 3 inches of grayish brown sand. The subsoil is about 5 inches of brown gravelly sandy loam. The next layer is about 6 inches of brown very gravelly coarse sand. The underlying material is about 12 inches of light grayish brown gravelly fine sandy loam. Below this is light grayish brown fine sandy loam till (fig. 7).

Permeability is rapid in the upper part of the soil and moderate in the loamy till. Available water capacity is moderate. Inherent fertility is medium. The seasonal high water table commonly fluctuates from a depth of 2½ to 6 feet.

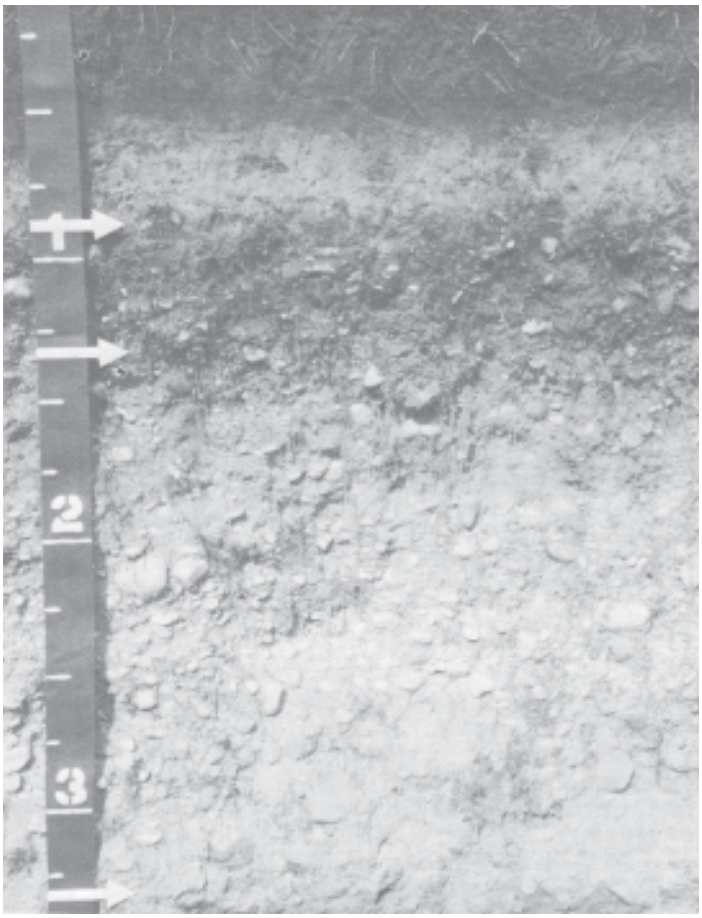

Figure 7.—**Profile of Pelan loamy sand. The dark colored surface layer is underlain at a depth of 6 to 7 inches by a thin, lighter colored subsurface layer. The subsoil is darker colored and about 5 inches thick. The gravelly underlying material extends to a depth of 32 to 38 inches and is underlain by fine sandy loam till.**

About half the areas of Pelan soils are cultivated. The most common crops are small grain and hay. The remaining areas are in grass and trees. A few of these areas are in pasture. Droughtiness is the major limitation.

Representative profile of Pelan loamy sand from an area of Pelan soils, 0 to 2 percent slopes, in a grass and legume field 2,475 feet north and 775 feet west of the southeast corner of sec. 36, T. 161 N., R. 46 W.:

Ap—0 to 6 inches; very dark brown (10YR 2/2) loamy sand; gray (10YR 5/1) dry; weak very fine subangular blocky structure; very friable; neutral; abrupt smooth boundary.

A2—6 to 9 inches; grayish brown (10YR 5/2) sand; light gray (10YR 7/2) dry; single grain; loose; about 15 percent gravel; neutral; abrupt wavy boundary.

B2t—9 to 14 inches; brown (10YR 4/3) gravelly sandy loam; moderate very fine angular blocky structure; very friable; thin continuous dark brown (10YR 3/3) clay coatings on faces of peds and in pores; about 40 percent gravel; mildly alkaline; clear wavy boundary.

C1—14 to 20 inches; brown (10YR 5/3) very gravelly coarse sand; single grain; loose; about 60 percent gravel; few masses of pale brown (10YR 6/3); slightly effervescent; moderately alkaline; gradual smooth boundary.

C2g—20 to 32 inches; light brownish gray (2.5Y 6/2) gravelly fine sandy loam; common fine and medium distinct light olive brown (2.5Y 5/4 and 5/6) mottles; weak very fine subangular blocky structure; very friable; about 40 percent gravel; strongly effervescent; moderately alkaline; gradual smooth boundary.

IIC3g—32 to 60 inches; light brownish gray (2.5Y 6/2) fine sandy loam; common medium and coarse prominent yellowish brown (10YR 5/6), strong brown (7.5YR 5/8), and light gray (10YR 7/1) mottles; weak very fine subangular blocky structure; friable; about 15 percent gravel; strongly effervescent; moderately alkaline.

Thickness of the solum and depth to free carbonates ranges from 10 to 24 inches. Content of gravel ranges from 0 to 25 percent in the A horizon, 35 to 65 percent in the B horizon, and 10 to 50 percent in the C horizon. The A1 horizon is loamy coarse sand, loamy sand, loamy fine sand, coarse sandy loam, sandy loam, and fine sandy loam. It is black, very dark gray, very dark grayish brown, and very dark brown. The A2 horizon is coarse sand, sand, fine sand, loamy coarse sand, loamy sand, and loamy fine sand. It is dark grayish brown, grayish brown, and brown. The B2t horizon is mostly coarse sandy loam, sandy loam, and sandy clay loam. It is very dark grayish brown, dark grayish brown, brown, and dark brown. The C horizon has a fine earth texture range of coarse sand, sand, fine sand,

loamy coarse sand, loamy sand, loamy fine sand, coarse sandy loam, and sandy loam. It is grayish brown, light brownish gray, pale brown, and brown. Mottling is throughout the C horizon in some pedons. The IIC horizon is sandy loam, fine sandy loam, and loam. It is grayish brown, light brownish gray, pale brown, and brown and has few to many mottles. The content of coarse fragments in the IIC horizon ranges from 5 to 20 percent.

Pelan soils are associated with Marquette, Lohnes, and Strandquist soils. Pelan soils are wetter than Marquette soils. They have a loamy IIC horizon beginning within a depth of 40 inches which is lacking in Marquette and Lohnes soils. They are drier than Strandquist soils, and have horizons of clay accumulation which is lacking in Strandquist soils.

280—Pelan soils, 0 to 2 percent slopes. These soils are in areas that vary considerably in shape and commonly range from 5 to 35 acres in size. The surface layer ranges in texture from loamy coarse sand to fine sandy loam. These soils are in interbeach areas where relief is variable and has some short, very gentle slopes. Soil material is very mixed across these areas. In most areas some cobbles and stones are scattered on the surface.

Included with these soils in mapping, and making up as much as 20 percent of an individual mapped area, are Nereson soils. Also included, and making up as much as 15 percent of an individual mapped area, are Strandquist, Marquette, and Garnes soils; and, making up as much as 10 percent of an area, Enstrom soils. A few areas where up to 3 to 15 percent stones and boulders are exposed at the surface are also included.

Moderate available water capacity and medium inherent fertility limit the use of this soil. Soil blowing can be a hazard. In places cobbles and stones make operation of farm machinery more difficult.

A few areas of these soils are cultivated, mainly for the production of small grain. More areas are used for hay and pasture. Scattered trees, mainly bur oak with some quaking aspen, also grow on these soils. Capability Unit IIIs–1; Sandy range site.

Percy series

The Percy series consists of nearly level, poorly drained soils. These soils formed in lake-washed, loamy glacial till. They are commonly in flat or slightly concave areas. Native vegetation is tall grasses. Trees, mainly quaking aspen, have recently invaded some areas.

In a representative profile the surface layer is about 11 inches of black and very dark brown sandy clay loam. The next layer is about 15 inches of violently effervescent, mottled light brownish gray loam. The underlying material is distinctly mottled, light brownish gray loam (fig. 8).

Permeability is moderate, and available water capacity is high. Inherent fertility is high. The seasonal high water table commonly fluctuates from a depth of 0 to 3 feet.

Many areas of Percy soils are cultivated. Small grain and forage for livestock are the most common crops. Other areas are in mixed grasses and some trees. Some of these areas are in pasture. Wetness is the major limitation.

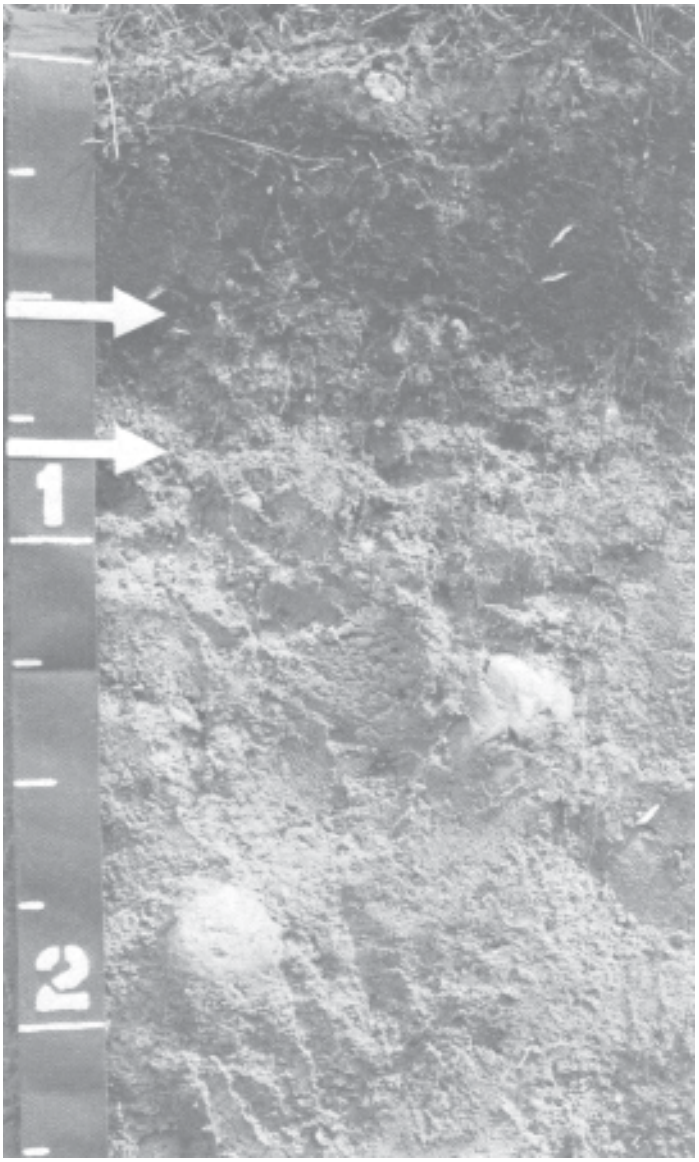

Figure 8.—**Profile of Percy sandy clay loam in an area of Percy soils. This soil has a dark surface layer. The underlying material is very calcareous, brownish gray loam till that has coarse fragments.**

Representative profile of Percy sandy clay loam from an area of Percy soils, in a native pasture 45 feet north and 2,580 feet west of the southeast corner of sec. 9, T. 163 N., R. 45 W.:

A11—0 to 8 inches; black (10YR 2/1) sandy clay loam; weak very fine subangular blocky structure; very friable; trace of coarse fragments; mildly alkaline; clear smooth boundary.

A12—8 to 11 inches; very dark brown (10YR 2/2) sandy clay loam; weak to moderate very fine subangular blocky structure; very

friable; about 5 percent coarse fragments; mildly alkaline; clear smooth boundary.

IIC1gca—11 to 26 inches; light brownish gray (2.5Y 6/2) loam; common fine distinct yellow (10YR 6/6) mottles; weak very fine subangular blocky structure; very friable; about 20 percent coarse fragments; violently effervescent; moderately alkaline; gradual wavy boundary.

IIC2g—26 to 60 inches; light brownish gray (2.5Y 6/2) loam; common fine distinct olive yellow (2.5Y 6/6) and brownish yellow (10YR 6/6) mottles; medium thin platy structure parting to weak very fine subangular blocky; friable; about 20 percent coarse fragments; strongly effervescent; moderately alkaline.

In the upper part of the profile the content of coarse fragments ranges from a trace to 25 percent, and in the IIC horizon it ranges from 10 to 25 percent. A lag line is present above the IIC horizon in some pedons and contains from 20 to 35 percent coarse fragments. The A horizon ranges from 7 to 14 inches in thickness. The A horizon is sandy loam, fine sandy loam, loam, and sandy clay loam. It is black, very dark brown, very dark grayish brown, and very dark gray. It contains 0 to 20 percent calcium carbonate. Reaction is neutral to moderately alkaline. The Cca and C horizons are light gray, light brownish gray, grayish brown, dark grayish brown, and olive gray. Mottling ranges from faint to prominent throughout. The Cca horizon is fine sandy loam, sandy loam, loam, sandy clay loam, and clay loam. The C horizon is sandy loam, fine sandy loam, and loam.

Percy soils are associated with Cathro, Fram, Haug, and Nereson soils. Percy soils are wetter than Fram soils. They lack the O horizon of the wetter Cathro and Haug soils. They lack the horizon of clay accumulation which is characteristic of Nereson soils.

379—Percy bouldery soils. These soils are in smooth or slightly concave areas that vary considerably in shape and range from 5 to about 120 acres in size. Slopes are 0 to 2 percent. The surface layer ranges in texture from sandy clay loam to sandy loam. Stones and boulders cover from 3 to 15 percent of the surface of this soil (fig. 9). Except for the number of stones and boulders and a calcareous surface layer, these soils have a profile similar to that described as representative of the series.

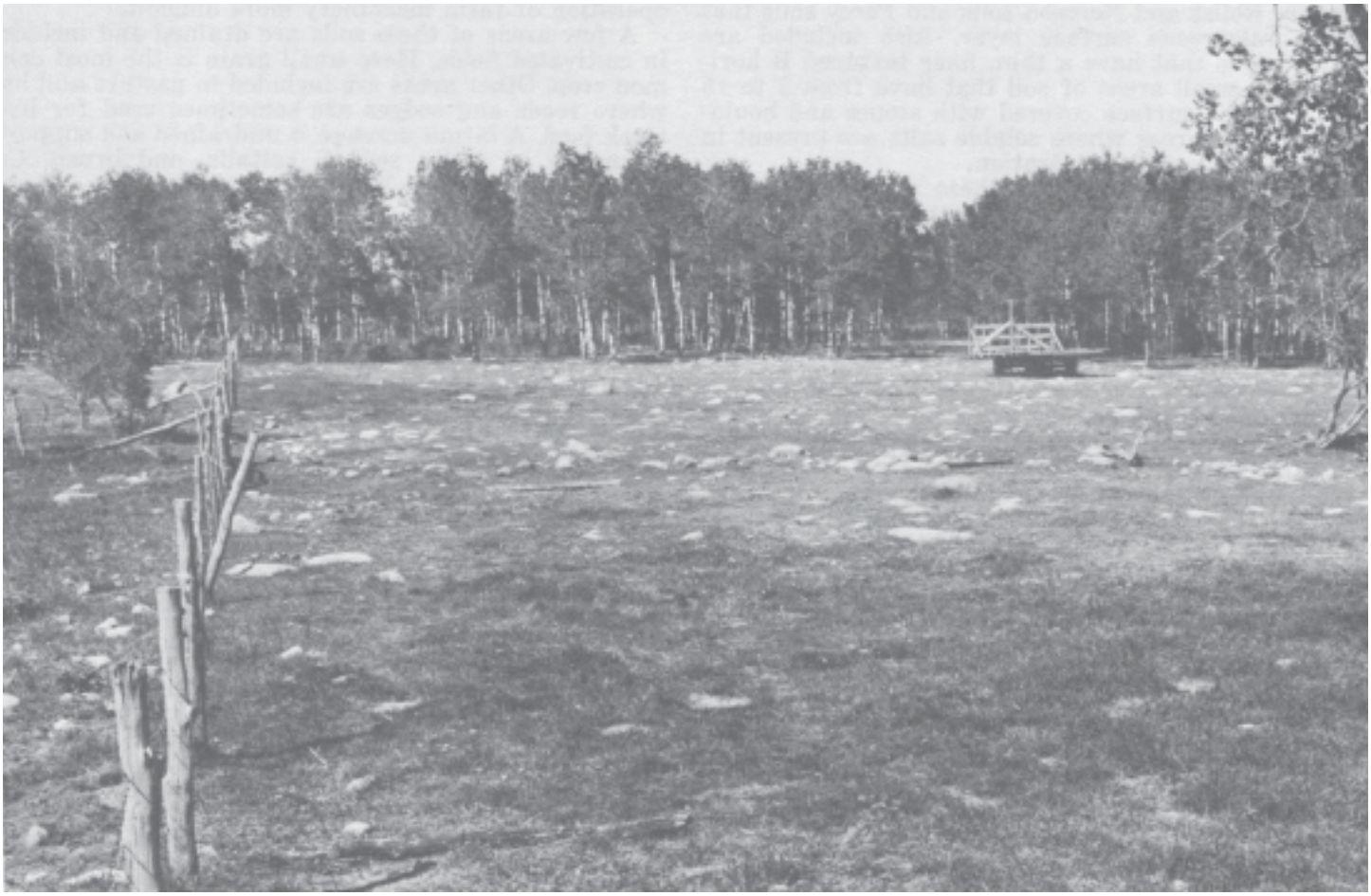

Figure 9.—**Typical Percy bouldery sandy clay loam, in an area of Percy bouldery soils.**

Included with these soils in mapping, and making up as much as 15 percent of an individual mapped area, are Rockwell and Foxhome soils. Also included are areas of Roliss soils, Percy depressional soils and Percy soils, and a soil that has a thin, finer textured subsoil.

Wetness limits the use of these soils. The numerous stones and boulders are also a limitation and greatly restrict the operation of farm machinery and tillage equipment. The calcareous condition of these soils influences its use and management.

Many areas of this soil support a variety of grasses which are used as pasture. Some areas also support scattered trees and brush. Capability unit VIw–1; Subirrigated range site.

581—Percy soils. These soils are in plane or slightly concave areas that vary considerably in shape and are commonly between 5 and 160 acres in size. Slopes are 0 to 2 percent. The surface layer ranges in texture from sandy clay loam to sandy loam and has a fine blocky appearance where it is cultivated. Stones, boulders and other coarse fragments are scattered on the surface but cover less than 3 percent. These soils have the profile described as representative of the series.

Included with these soils in mapping, and making up as much as 15 percent of an individual mapped area, are Roliss and Nereson soils and Percy soils that have a calcareous surface layer. Also included are areas of soils that have a thin, finer textured B horizon, a few small areas of soil that have from 3 to 15 percent of the surface covered with stones and boulders, and some areas where soluble salts are present in various degrees of concentration.

Wetness limits the use of these soils. Stones and boulders also influence use and management.

Many areas of these soils are cultivated. Small grain is the most common crop. Other areas are in introduced grasses or legumes and grasses. These areas are used for hay and pasture. Some areas of trees, primarily quaking aspen, are in pasture. Capability unit IIw–2; Subirrigated range site.

383—Percy soils, calcareous surface. These soils are in plane or slightly concave areas that vary considerably in shape and are commonly over 5 acres and under 160 acres in size. Slopes are 0 to 2 percent. The surface layer ranges in texture from sandy clay loam to sandy loam and has a fine blocky appearance where it is cultivated. Stones, boulders, and other coarse fragments are scattered on the surface but cover less than 3 percent. These soils have the profile described as representative of the series, but the surface layer is calcareous.

Included with these soils in mapping and making up as much as 15 percent of an individual mapped area, are Fram and Roliss soils. Also included are a few small areas of these soils that have from 3 to 15 percent of the surface covered with stones and boulders, and some areas where soluble salts are present in various degrees of concentration.

Wetness limits the use of these soils. The strongly calcareous condition of these soils and stones and boulders on the surface also influence use and management.

Many areas of these soils are cultivated. Small grain is the most common crop. Other areas are in introduced grasses or grasses and legumes. These areas are used for hay and pasture. In places some areas of trees, primarily quaking aspen, are included in pasture. Capability unit IIw–2; Subirrigated range site.

384—Percy soils, depressional. These soils are in depressions or the bottoms of natural draws. The size of the areas normally is between 3 and 20 acres. Slopes are 0 to 2 percent. The depressions and draws are bordered by higher areas of Roliss soils, other Percy soils, or associated soils. Stones and cobbles are scattered on the surface in some of the depressions. The surface layer ranges in texture from sandy clay loam to sandy loam. Except for more variation in thickness and color of the surface layer and for some finer textured soils in tills, these depressional soils have a profile similar to the one described as representative of the Percy series.

Included with these soils in mapping, and making up as much as 15 percent of an individual mapped area, are Rockwell and Grygla soils, depressional. Also included and making up as much as 10 percent of an individual mapped area, are Haug muck and marsh areas where soil material has not been determined.

Wetness limits the use of these soils. Ponded water in the depressions is not uncommon. In places, cobbles and stones on the surface and buried in the soil make operation of farm machinery more difficult.

A few areas of these soils are drained and included in cultivated fields. Here small grain is the most common crop. Other areas are included in pasture and hay where reeds and sedges are sometimes used for livestock feed. A larger acreage is undrained and supports a growth of reeds, sedges, cattails, and brush. Capability unit IIIw–2; Wetland range site.

Poppleton series

The Poppleton series consists of nearly level, moderately well drained soils. These soils formed in sandy lacustrine or outwash sediment. They are in slightly convex areas. Native vegetation is trees, mainly aspen. In places tall grasses have encroached.

In a representative profile the surface layer is about 6 inches of very dark brown loamy fine sand. The next layer is about 9 inches of very dark grayish brown loamy fine sand. The subsoil is about 15 inches of mottled, brown fine sand. The underlying material is mottled, grayish brown fine sand.

Permeability is rapid, and available water capacity is low. Inherent fertility is low. The seasonal high water table commonly fluctuates from a depth of 2½ to 6 feet.

Many areas of Poppleton soils are cultivated. Small grain, potatoes, and grasses or legumes are the most common crops. A few areas are in mixed grasses and trees, mainly aspen and oak. Droughtiness is the major limitation.

Representative profile of Poppleton loamy fine sand from an area of Poppleton soils, 0 to 2 percent slopes, in a pasture 167 feet north and 1,104 feet east of the southwest corner of sec. 22, T. 160 N., R. 46 W.:

Ap—0 to 6 inches; very dark brown (10YR 2/2) loamy fine sand; single grained; loose; slightly acid; abrupt smooth boundary.

A3—6 to 15 inches; very dark grayish brown (10YR 3/2) loamy fine sand; few fine faint dark yellowish brown (10YR 3/4) mottles; single grained; loose; medium acid; abrupt smooth boundary.

B21—15 to 21 inches; brown (10YR 5/3) fine sand; few fine faint dark brown (10YR 4/3) and dark yellowish brown (10YR 4/4) mottles; single grained; loose; medium acid; gradual wavy boundary.

B22—21 to 30 inches; brown (10YR 5/3) fine sand; few fine prominent yellowish red (5YR 4/8) mottles and common large distinct yellowish brown (10YR 5/6) mottles; single grained; loose; slightly acid; gradual wavy boundary.

C1—30 to 60 inches; grayish brown (2.5Y 5/2) fine sand; few large prominent dark yellowish brown (10YR 4/4) and yellowish brown (10YR 5/8) mottles; single grained; loose; slightly acid.

The solum ranges from 30 to 55 inches in thickness. Reaction in the solum is typically neutral but ranges from medium acid to mildly alkaline. The A1 or Ap horizon is 4 to 10 inches thick. It is fine sand, loamy fine sand, sand, and loamy sand. It is black, very dark gray, very dark grayish brown, and very dark brown in color. An A2 horizon is present in many pedons. It is fine sand or sand and is dark grayish brown and grayish brown. In some pedons an A3 horizon is similar in texture to the A1 horizon. It is very dark gray and very dark grayish brown. The A3 horizon contains less than 0.6 percent organic matter. The B horizon is brown, pale brown, light yellowish brown, and yellowish brown. Mottling in the B horizon and some subhorizons is distinct or prominent and has hue of 7.5YR or yellower in some places. Chroma of less than 2 occurs within 40 inches of the surface. The C horizon is grayish brown, light brownish gray, and light gray fine sand or sand. It commonly has mottles in the upper part.

Poppleton soils are associated with Enstrom, Grygla, and Redby soils. Poppleton soils lack the loamy IIC horizon within a depth of 40 inches which is characteristic of Enstrom soils. They are better drained than the poorly drained Grygla soils. They have fewer reddish mottles than Redby soils.

148—Poppleton soils, 0 to 2 percent slopes. These soils are in plane or slightly convex areas that generally are between 10 to 120 acres in size. The surface layer ranges in texture from loamy fine sand to sand. Where cultivated these soils have a varied pattern of black, grayish and brownish colors. Soil accumulation sometimes occurs along old fence lines, field boundaries, and the edge of wooded areas.

Included with these soils in mapping, and making up as much as 15 percent of an individual mapped area, are Enstrom soils. Also included, and making up as much as 10 percent of an area, are Maddock, Ulen, and Redby soils. Areas that are moderately and severely eroded and have slopes over 2 percent, and some areas that have a thicker, darker surface layer are included.

Low available water capacity and a low inherent fertility limit the use of this soil. The hazard of soil blowing is also a limitation.

Some areas of these soils are cultivated. Small grain and potatoes are the most common crops. A larger acreage is used for hay and pasture. Scattered trees, mainly quaking aspen and bur oak, and some hazel and other brush also grow on these soils. Capability unit IVs–1; Sands range site.

Redby series

The Redby series consists of nearly level, somewhat poorly drained soils. These soils formed in sandy lacustrine or outwash sediment. They are in flat or slightly convex areas. Some areas have alternating high and low spots. Most of these soils are in the eastern parts of the Glacial Lake Agassiz Basin. Native vegetation is deciduous forest.

In a representative profile the surface layer is about 4 inches of very dark gray loamy fine sand. The subsurface layer is about 4 inches of dark grayish brown fine sand. The subsoil is about 25 inches of mottled, brown fine sand. The underlying material is light brownish gray fine sand.

Permeability is rapid, and available water capacity is low. Inherent fertility is low. The seasonal high water table commonly fluctuates from a depth of 2 to 6 feet.

A few areas of Redby soils are cultivated. Small grain, potatoes, and forage for livestock are the most common crops. Many areas are in trees, mainly quaking aspen. Low available water capacity is the major limitation.

Representative profile of Redby loamy fine sand from an area of Redby soils, 0 to 2 percent slopes, in a wooded area 1,835 feet west and 275 feet south of the northeast corner of sec. 35, T. 162 N., R. 46 W.:

A1—0 to 4 inches; very dark gray (10YR 3/1) loamy fine sand; dark gray (10YR 4/1) dry; massive; loose; slightly acid; clear smooth boundary.

A2—4 to 8 inches; dark grayish brown (10YR 4/2) fine sand; single grained; loose; slightly acid; clear smooth boundary.

B21—8 to 19 inches; brown (10YR 5/3) fine sand; common medium distinct dark brown (7.5YR 4/4) mottles; single grained; loose; slightly acid; gradual wavy boundary.

B22—19 to 33 inches; brown (10YR 5/3) fine sand; common medium prominent yellowish red (5YR 4/6) mottles; single grained; loose in the matrix and friable to firm in the mottles; slightly acid; gradual wavy boundary.

C—33 to 60 inches; light brownish gray (2.5Y 6/2) fine sand; few fine faint light olive brown (2.5Y 5/4) mottles; single grained; loose; neutral.

The solum ranges from 18 to 40 inches in thickness. The depth to horizons with distinct or prominent mottles is less than 12 inches. Content of coarse and very coarse sand in the B and C horizons is less than 10 percent of the sand fraction. The A horizon is loamy fine sand, fine sand, loamy sand, and sand. The

A1 horizon is black, very dark gray, very dark grayish brown, and very dark brown in color. The A2 horizon is light brownish gray, grayish brown, and dark grayish brown and is mottled in places. The B horizon is fine sand or sand. It is brown, pale brown, light yellowish brown, and yellowish brown. Mottles are many or common, and some have a hue of 5YR or redder. The C horizon is fine sand or sand that is grayish brown, light brownish gray, and light gray.

Redby soils are associated with Cormant, Deerwood, Markey, and Poppleton soils. Redby soils are better drained than the poorly drained Cormant soils. They are better drained than Deerwood and Markey soils. They lack the O horizon of Deerwood and Markey soils. Redby soils have more mottles with redder hue than Poppleton soils.

116—Redby soils, 0 to 2 percent slopes. These soils are in plane or slightly convex areas. The relief is alternatingly slightly convex and concave. Soil blowing contributes to this uneven condition. These areas generally are between 5 and 80 acres in size. The surface layer ranges in texture from loamy fine sand to sand. Where cultivated this soil has a varied pattern of dark grayish and brownish color. Small, dark red iron oxide concentrations are on the surface of some areas.

Included with this soil in mapping, and making up as much as 20 percent of an individual mapped area, are Poppleton soils. Also included, and making up as much as 15 percent of an individual mapping area, are Enstrom and Cormant soils. Areas that are moderately and severely eroded are also included.

Low available water capacity and low inherent fertility limit the use of this soil. The hazard of soil blowing is also a limitation.

A few areas of these soils are cultivated. Small grain and potatoes are the most common crops. A larger acreage is used for hay and pasture. Trees, quaking aspen, bur oak, and some hazel, and other brush also grow on these soils. Capability unit IVs–1; Sands range site.

Rockwell series

The Rockwell series consists of nearly level and depressional, poorly drained soils. These soils formed in loamy material and the underlying sandy sediment over loamy glacial till. They are in flat or slightly concave areas in the east central part of the Glacial Lake Agassiz Basin. Native vegetation is tall grasses, reeds, and sedges.

In a representative profile the surface layer is about 9 inches of black fine sandy loam. The next layer is about 7 inches of violently effervescent, dark gray fine sandy loam. The underlying material is about 20 inches of distinctly mottled, grayish brown fine and medium sand. Below this is mottled, strongly effervescent grayish brown loam.

Permeability and available water capacity are moderate. Inherent fertility is medium. The seasonal high water table fluctuates from a depth of 0 to 3 feet.

Some areas of Rockwell soils are cultivated. Small grain and forage for livestock are the most common crops. Other areas are in grasses, reeds, sedges, and some trees. Wetness is the major limitation.

Representative profile of Rockwell fine sandy loam from an area of Rockwell soils, in a cultivated field 660 feet south and 75 feet east of the northwest corner of sec. 19, T. 160 N., R. 45 W.:

A1—0 to 9 inches; black (N/2) fine sandy loam; weak very fine granular structure; very friable; strongly effervescent; moderately alkaline; clear smooth boundary.

C1ca—9 to 16 inches; dark gray (5Y 4/1) fine sandy loam; weak very fine subangular blocky structure; very friable; violently effervescent; moderately alkaline; clear wavy boundary.

C2—16 to 28 inches; grayish brown (2.5Y 5/2) fine sand; common medium distinct light olive brown (2.5Y 5/4 and 5/6) mottles; single grained; loose; mildly alkaline; abrupt smooth boundary.

C3—28 to 36 inches; grayish brown (2.5Y 5/2) sand; many coarse distinct light olive brown (2.5Y 5/6) and olive yellow (2.5 6/6) mottles; single grained; loose; 5 to 10 percent coarse fragments; mildly alkaline; abrupt smooth boundary.

IIC4—36 to 60 inches; grayish brown (2.5Y 5/2) loam; common medium prominent yellowish brown (10YR 5/6) mottles; weak thin platy structure parting to weak very fine subangular blocky; very friable; 5 percent coarse fragments, strongly effervescent; moderately alkaline.

The IIC horizon ranges in depth from 20 to 40 inches. Depth to the lower boundary of the calcic horizon ranges from 14 to 20 inches. The A horizon is fine sandy loam and sandy loam, loam, or sandy clay loam. It is black or very dark gray in color. The Cca horizon is sandy loam, fine sandy loam, loamy fine sand, and loamy sand. It is dark gray, gray, grayish brown, and dark grayish brown. In some pedons mottles are distinct and prominent. The C horizon is typically fine sand, but sand, loamy fine sand, and loamy sand are in the range. It has distinct or prominent mottles. The C horizon is slightly to strongly effervescent. The IIC horizon is typically loam, but fine sandy loam, clay loam, and silty clay loam are within the range. It is grayish brown, dark grayish brown, and light brownish gray. Mottling is distinct or prominent. The IIC horizon is slightly to strongly effervescent.

Rockwell soils are associated with Grimstad, Ulen, and Arveson soils. Rockwell soils are more poorly drained than Grimstad and Ulen soils. They have a loamy IIC horizon beginning within a depth of 40 inches which is lacking in Arveson and Ulen soils.

63—Rockwell soils. These soils are in areas that vary considerably in shape and usually range from 10 to 50 acres in size. Slopes are 0 to 2 percent. Relief is variable, but often has a slightly concave slope. These soils are on water-worked till where soil material changes within short distances. The surface layer ranges in texture from sandy loam to sandy clay loam and has a smooth, fine granular appearance where it is cultivated. These soils have the profile described as representative of the series.

Included with this soil in mapping, and making up as much as 15 percent of an individual mapped area,

are Grimstad, Arveson, and Grygla soils. Also included, and making up as much as 10 percent of an area, are Augsburg, Percy, and Mavie soils. Soils that have a loam surface layer, small areas that are moderately eroded, and a few areas where stones and boulders are exposed at the surface are also included. In some areas soluble salts are present in various degrees of concentration.

Wetness limits the use of this soil. Susceptibility to soil blowing is a hazard. Moderate available water capacity and medium level of inherent fertility influence use and management of this soil.

Many areas of this soil are cultivated. Small grain and row crops such as potatoes and sunflowers are the most common crops. Many areas are also used for hay and pasture. Scattered trees, mainly quaking aspen, also grow on these soils. Capability unit IIw–3; Subirrigated range site.

994—Rockwell and Grygla soils, depressional. These soils are in depressions and draws that normally range in size from 3 to 20 acres. Slopes are 0 to 2 percent. They are bordered by nearly level, better drained, moderately coarse textured and coarse textured soils. The surface layer ranges in texture from sandy clay loam to loamy fine sand.

Rockwell soils make up 30 to 80 percent of this unit, and Grygla soils make up 20 to 70 percent. Any one depression may have all Rockwell soils or all Grygla soils or any combination of them. Where they are drained and cultivated, these soils have a black surface often mixed with blotches that have a grayish or brownish cast. The coloring of these blotches can be attributed to the presence of clean sand particles without organic staining and a strongly calcareous surface layer. Except for more variation in the thickness and color of the surface layer, these soils have profiles similar to those described as representative of the Rockwell and Grygla series.

Included with these soils in mapping, and making up as much as 20 percent of an individual mapped area, are depressional Arveson and Cormant soils. Also included, and making up as much as 10 percent of an area, are Deerwood muck, Haug muck, and small marsh areas. Some areas that have stones and boulders exposed at the surface and some areas with coarse sand and gravel above the IIC horizon are also included.

Wetness limits the use of these soils. Some ponding or flooding is likely even where ditches are installed to remove excess water. In places stones and boulders interfere with the operation of farm machinery.

Most areas of these soils are not cultivated. A few areas are drained and are included in fields seeded to small grain and other crops. Many areas of these soils support a growth of reeds, sedges, and lowland brush. They are sometimes included in areas used for hay or pasture. Capability unit IVw–2; Wetland range site.

Roliss series

The Roliss series consists of nearly level, poorly drained soils. These soils formed in lake-washed loam glacial till. They are commonly in areas that have flat or slightly concave slopes. Native vegetation is tall grasses with some invasion of trees, principally quaking aspen.

In a representative profile the surface layer is about 7 inches of black sandy clay loam. This grades to about 2 inches of very dark gray fine sandy loam. The subsoil is about 7 inches of distinctly mottled grayish brown fine sandy loam. The underlying material is mottled light brownish gray clay loam that is violently effervescent and grades with depth to a strongly effervescent, grayish brown loam.

Permeability is moderate, and available water capacity is high. Inherent fertility is high. The seasonal high water table commonly fluctuates from a depth of 0 to 3 feet.

Some areas of Roliss soils are cultivated. Small grain and forage for livestock are the most common crops. Many areas are in grasses and some trees and are used for pasture. Wetness is the major limitation.

Representative profile of Roliss sandy clay loam from an area of Roliss soils, in a pasture 1,920 feet south and 70 feet east of the northwest corner of sec. 7, T. 159 N., R. 45 W.:

A1—0 to 7 inches; black (N2/0) sandy clay loam; weak very fine subangular blocky structure; friable; about 5 percent coarse fragments; neutral; clear smooth boundary.

A3—7 to 9 inches; very dark gray (N/3) fine sandy loam; weak very fine subangular blocky structure; very friable; about 10 percent coarse fragments; neutral abrupt smooth boundary.

Bg—9 to 16 inches; grayish brown (2.5Y 5/2) fine sandy loam; common fine distinct yellowish brown (10YR 5/8) mottles; weak very fine subangular blocky structure; very friable; about 15 percent coarse fragments; slightly effervescent; moderately alkaline; clear smooth boundary.

C1gca—16 to 26 inches; light brownish gray (2.5Y 6/2) clay loam; common fine faint light gray (2.5Y 7/2) mottles and common fine distinct yellowish brown (10YR 5/6) and light olive brown (2.5Y 5/6) mottles; weak fine subangular blocky structure; very friable; about 10 percent coarse fragments; violently effervescent; moderately alkaline; diffused smooth boundary.

C2g—26 to 60 inches; grayish brown (2.5Y 5/2) loam; many medium prominent yellowish brown (10YR 5/8) and strong brown (7.5YR 5/8) mottles and few medium faint light olive gray (5Y 6/2) mottles; weak medium angular blocky structure with some horizontal cleavage; friable in upper part and firm in lower part; about 5 percent coarse fragments; strongly effervescent in upper part and slightly effervescent in lower part; moderately alkaline.

Thickness of the solum ranges from 12 to 20 inches. The content of coarse fragments in most pedons ranges from 2 to 8 percent. In some places the solum lacks

coarse fragments or has as much as 20 percent in parts of these horizons. In some pedons coarse fragments are concentrated in a lag line at the base of the A or B horizon. The A horizon is loam, sandy clay loam, clay loam, fine sandy loam, and sandy loam and is 7 to 18 inches thick. The A1 horizon is black. The A3 horizon is very dark gray and very dark grayish brown. It is lacking in some places. The Bg horizon is loam, sandy clay loam, clay loam, silty clay loam, silt loam, and fine sandy loam. It is dark grayish brown and grayish brown. It has distinct or prominent mottles. The C horizon is loam or clay loam. It is dark grayish brown, grayish brown, light brownish gray, olive gray, and light olive gray. It has common, distinct or prominent mottles, but in some places the lower part of the C horizon lacks mottles.

Roliss soils are associated with Rockwell and Viking soils. They lack the sandy layer over 6 inches thick that is present in Rockwell soils. They are coarser textured than the clayey Viking soils.

582—Roliss soils. These soils are generally in slightly concave areas that vary considerably in shape and are commonly between 5 and 160 acres in size. Slopes are 0 to 2 percent. They are commonly in interbeach areas where soil material changes within short distances. The surface layer of this soil ranges in texture from sandy loam to clay loam and has a fine granular or blocky appearance where it is cultivated. Cobbles, stones, and boulders are scattered on the surface and buried in the upper layers of this soil.

Included with these soils in mapping, and making up as much as 15 percent of an individual mapped area, are Percy soils. Also included, and making up as much as 15 percent of an individual mapped area, are Fram and Strandquist soils; and, making up as much as 10 percent of an area, Rockwell and Mavie soils.

Wetness limits the use of this soil. Cobbles, stones, and boulders on the surface and buried in the upper 2 feet of soil make operation of farm machinery more difficult.

Some areas of these soils are in small grain. Many areas are used for hay and pasture. Scattered trees, mainly quaking aspen, also grow on these soils. Capability unit IIw–2; Subirrigated range site.

Strandquist series

The Strandquist series consists of nearly level or slightly depressional, poorly drained soils. These soils formed in loam and the underlying sand and gravelly, water-laid deposits over loamy glacial till. They are commonly along shore lines of Glacial Lake Agassiz. Native vegetation is wetland reeds and sedges, some grasses, and an encroachment of trees, mainly quaking aspen.

In a representative profile the surface layer is about 10 inches of very dark brown fine sandy loam. The next layer is about 10 inches of mottled, light brownish gray very gravelly sand. The contrasting underlying material is mottled, grayish brown loam and silty clay loam and about 5 percent coarse fragments. This material is strongly effervescent.

Permeability is rapid in the upper part and moderate in the loamy till. Available water capacity is moderate. Inherent fertility is low. The seasonal high water table fluctuates from a depth of 1 to 3 feet.

About half of Strandquist soils are cultivated. Small grain and forage for livestock are the most common crops. Other areas are in grasses, sedges, and trees. Wetness is the major limitation.

Representative profile of Strandquist fine sandy loam from an area of Strandquist soils, in a cultivated field 2,710 feet north and 70 feet east of the southwest corner of sec. 24, T. 159 N., R. 45 W.:

Ap—0 to 10 inches; very dark brown (10YR 2/2) fine sandy loam; weak very fine subangular blocky structure; friable; trace of coarse fragments; neutral; abrupt smooth boundary.

C1—10 to 20 inches; light brownish gray (2.5Y 6/2) very gravelly sand; common medium distinct yellowish brown (10YR 5/6) mottles; single grained; loose; about 50 percent gravel; slightly effervescent; mildly alkaline; abrupt smooth boundary.

IIC2a—20 to 28 inches; grayish brown (2.5Y 5/2) loam; common fine and medium distinct yellowish brown (10YR 5/8) mottles; weak very fine subangular blocky structure; friable; about 5 percent coarse fragments; strongly effervescent; moderately alkaline; gradual smooth boundary.

IIC3—28 to 60 inches; grayish brown (2.5Y 5/2) light silty clay loam; many medium and coarse distinct olive yellow (2.5Y 6/7) and yellow (2.5Y 7/8) mottles; weak thin platy structure parting to weak very fine subangular blocky; friable; about 5 percent coarse fragments; strongly effervescent; mildly to moderately alkaline.

The IIC horizon ranges from 20 to 40 inches in depth. The A horizon ranges from 7 to 10 inches in thickness. It is sandy loam, fine sandy loam, silt loam, or loam; and it is black, very dark gray, very dark grayish brown and very dark brown. In some pedons a B horizon is as much as 6 inches thick. It is loamy fine sand, fine sand, sand, or gravelly sand and it is dark grayish brown and grayish brown. Mottling is distinct or prominent. The C horizon ranges in thickness from 8 to 24 inches. It is typically very gravelly sand, and in places is very gravelly coarse sand. A few pedons have thin layers of fine sand. Gravel content ranges from 35 to 70 percent in the C horizon. The C horizon is grayish, light brownish gray and light gray. It has distinct or prominent mottles. Reaction of the C horizon ranges from neutral to mildly alkaline. The IIC horizon is sandy loam, loam, clay loam, and silty clay loam. It is dark grayish brown, grayish brown, light brownish gray, olive gray, and light olive gray. Reaction of the IIC horizon ranges from mildly alkaline to moderately alkaline.

Strandquist soils are associated with Foxhome, Hangaard, Mavie, Pelan, and Lohnes soils. Strandquist soils are wetter than Foxhome soils. They have a loamy IIC horizon which is lacking in Hangaard soils. Strandquist soils lack a calcic horizon beginning within a depth of 16 inches which is characteristic

of the Mavie soils. They are more poorly drained than Pelan and Lohnes soils. Strandquist soils lack the horizon of clay accumulation which is characteristic of Pelan soils. They have a loamy IIC horizon that is lacking in Lohnes soils.

432—Strandquist soils. These soils are in level to slightly concave areas that vary considerably in shape and commonly range in size from 5 to 35 acres. Slopes are 0 to 2 percent. The soils are on beach ridges or in interbeach areas where soil material changes within short distances. The surface layer ranges in texture from fine sandy loam to loam. Some areas have stones and cobbles scattered on the surface.

Included with these soils in mapping and making up as much as 15 percent of an individual mapped area, are Hangaard, Mavie, and Grygla soils. Also included, and making up as much as 10 percent of an individual mapped area, are Percy and Foxhome soils.

Wetness limits the use of these soils. Moderate available water capacity and low inherent fertility also influence use and management. Stones and boulders make operation of farm machinery more difficult.

A few areas of these soils are cultivated. Small grain is the most common crop. Many areas are used for hay and pasture. Scattered trees, mainly quaking aspen and some brush, also grow on these soils. Capability unit IIIw–1; Subirrigated range site.

Syrene series

The Syrene series consists of nearly level and depressional, poorly drained and very poorly drained soils. These soils formed in loamy, sandy, and gravelly water-laid deposits commonly along shore lines of Glacial Lake Agassiz. They are on low flats and in swales and are affected by seep from adjoining gravelly ridges. Native vegetation is reeds, sedges, and tall grasses.

In a representative profile the surface layer is about 9 inches of black, strongly effervescent sandy loam. The next layer is about 7 inches of violently effervescent, mottled, grayish brown loamy fine sand. The underlying material is distinctly mottled, grayish brown gravelly coarse sand that grades with depth to light brownish gray stratified fine sand and gravel.

Permeability is rapid, and available water capacity is low. Inherent fertility is medium. The seasonal high water table commonly fluctuates from a depth of 0 to 3 feet.

A few areas of Syrene soils are cultivated. Small grain and forage crops for livestock are the most common crops. Other areas are in reeds, sedges, grasses, brush, and trees. Wetness is the major limitation.

Representative profile of Syrene sandy loam from an area of Syrene soils, in a cultivated field, 100 feet south and 1,650 feet west of the northeast corner of sec. 14, T. 159 N., R. 47 W.:

Ap—0 to 9 inches; black (10YR 2/1) sandy loam; weak very fine subangular blocky structure; very friable; strongly effervescent; moderately alkaline; abrupt smooth boundary.

C1ca—9 to 16 inches; grayish brown (2.5Y 5/2) loamy fine sand; light brownish gray (2.5Y 6/2) in lower part; few fine and medium distinct brownish yellow (10YR 6/6) mottles; massive; loose; violently effervescent; moderately alkaline; abrupt smooth boundary.

IIC2—16 to 32 inches; grayish brown (2.5Y 5/2) gravelly coarse sand; common large distinct light gray (2.5Y 7/2) mottles and common medium prominent dark brown (7.5YR 4/4) and yellowish brown (10YR 5/8) mottles; single grained; loose; about 70 percent gravel; strongly effervescent; moderately alkaline; abrupt smooth boundary.

IIC3—32 to 60 inches; light brownish gray (2.5Y 6/2) stratified fine sand and gravel; few medium prominent brownish yellow (10YR 6/6) and yellowish brown (10YR 5/6) mottles; single grained; loose; strongly effervescent; moderately alkaline.

Depth to the IIC horizon ranges from 14 to 24 inches. The IIC horizon contains from 15 to 70 percent coarse fragments. The A horizon is sandy loam, fine sandy loam, loam, silt loam, or sandy clay loam. It is typically black, but a very dark gray Aca horizon is in some pedons. The Cca horizon is loamy fine sand, sandy loam, fine sandy loam, and loam. In some pedons the Cca horizon grades into coarser materials, such as gravelly loamy sand, gravelly loamy coarse sand, and gravelly sand. It is dark gray, gray, light brownish gray, grayish brown, dark grayish brown, light olive gray, and olive gray. In some pedons, the Cca horizon has low chroma and no mottles; in other pedons mottles are faint to prominent. The IIC horizon typically is stratified sand and gravel and some layers of gravelly sand or gravelly coarse sand. It is gray, light olive gray, olive gray, grayish brown, and light brownish gray. Mottling ranges from faint to prominent.

Syrene soils are associated with Hangaard, Mavie, and Lohnes soils. Syrene soils have a calcic horizon at or near the surface which is lacking in Hangaard soils. They lack the loamy IIC horizon of Mavie soils. Syrene soils are more poorly drained than Lohnes soils.

435—Syrene soils. These soils are in scattered, elongated or irregularly shaped areas that normally range from over 5 to under 50 acres in size. Slopes are 0 to 2 percent. The soils are usually on beach ridges and are smooth or slightly concave. The surface layer ranges in texture from sandy loam to sandy clay loam and has a black or very dark gray color and a smooth, granular appearance where it is cultivated. In some places a very calcareous layer near the surface influences surface color. This soil has the profile described as representative of the Syrene series.

Included with this soil in mapping, and making up as much as 20 percent of an individual mapped area, are Arveson soils. Also included, and making up as much as 15 percent of an individual mapped area, are Hangaard and Mavie soils. Some areas where stones and cobbles are scattered on the surface and some small areas of depressional Syrene soils are also included.

Wetness limits the use of this soil. Low available water capacity and medium inherent fertility also influence use and management.

Some areas of this soil are cultivated. Small grain is the most common crop. Many areas are used for hay and pasture. A few scattered areas are in trees, mainly quaking aspen. Capability unit IVw–1; Subirrigated range site.

433—Syrene soils, very wet. This soil is in depressions or seep areas commonly associated with beach ridges. Many of these areas are elongated and parallel to the beach ridge. They commonly range in size from over 5 to under 50 acres. Slopes are 0 to 2 percent. The surface layer ranges in texture from sandy loam to sandy clay loam. Shell fragments are on the surface of some areas. Except for more variation in surface thickness and texture and more mixing of materials beneath the surface, this soil has a profile similar to the one described as representative of the series.

Included with this soil in mapping, and making up as much as 20 percent of an individual mapped area, are Arveson and Cormant soils, depressional. Also included, and making up as much as 10 percent of an area, are Rockwell and Grygla soils, depressional, and Deerwood muck.

Wetness limits the use of this soil. Seep from the base of adjoining ridges keeps these areas wet for long periods. Because of these seep conditions most areas are difficult to drain. The calcareous condition and medium inherent fertility of this soil influence its use and management.

Most areas support a growth of reeds, sedges, cattails, and lowland brush. Some areas are included in pasture. Capability unit Vw–1; Wetland range site.

Ulen series

The Ulen series consists of nearly level, somewhat poorly drained and moderately well drained soils. These soils formed in calcareous, loamy material over sandy lacustrine sediment. They are commonly on very slightly convex slopes. Native vegetation is tall grass prairie.

In a representative profile the surface layer is about 10 inches of black, strongly effervescent, fine sandy loam. The next layer is about 5 inches of dark grayish brown, violently effervescent sandy loam. The underlying material is 5 inches of dark brown loamy fine sand over mottled, pale brown to mottled, grayish brown fine sand.

Permeability is moderately rapid, and available water capacity is low. Inherent fertility is medium. The seasonal high water table commonly fluctuates from a depth of 2½ to 6 feet.

Many areas of Ulen soils are cultivated. Small grain, potatoes, and forage for livestock are the most common crops. A few areas are in mixed grasses and trees, principally quaking aspen. Droughtiness is the major limitation.

Representative profile of Ulen fine sandy loam from an area of Ulen soils, 0 to 2 percent slopes, in a cultivated field 1,440 feet south and 105 feet west of the northeast corner of sec. 15, T. 159 N., R. 46 W.:

Ap—0 to 10 inches; black (10YR 2/1) fine sandy loam; weak very fine subangular blocky structure; very friable; strongly effervescent; moderately alkaline; abrupt smooth boundary.

C1ca—10 to 15 inches; dark grayish brown (10YR 4/2) sandy loam; very weak very fine subangular blocky structure; very friable; violently effervescent; moderately alkaline; abrupt wavy boundary.

C2—15 to 20 inches; dark brown (10YR 4/3) loamy fine sand; single grained; loose; slightly effervescent; moderately alkaline; clear wavy boundary.

C3—20 to 30 inches; pale brown (10YR 6/3) fine sand; few fine distinct brownish yellow (10YR 6/6) and yellow (10YR 7/6) mottles; single grained; loose; slightly effervescent; moderately alkaline; gradual wavy boundary.

C4—30 to 60 inches; grayish brown (2.5Y 5/3) fine sand; few medium faint light brownish gray (2.5Y 6/2) mottles and many medium distinct brownish yellow (10YR 6/6) mottles; single grained; loose; few thin layers with some fine gravel; strongly effervescent; moderately alkaline.

The A horizon ranges from 10 to 16 inches in thickness. It is fine sandy loam, loamy fine sand, sandy loam, and very fine sandy loam. It is black, very dark gray, very dark grayish brown, and very dark brown. Structure is weak granular or subangular blocky. The Cca horizon is fine sandy loam, sandy loam, and loamy fine sand. It is dark gray, gray, grayish brown, and dark grayish brown. The lower part of the C horizon typically is fine sand or loamy fine sand, but in some pedons coarser strata occur below a depth of 40 inches. It is dark brown, brown, pale brown, light yellowish brown, and dark yellowish brown. In places dark grayish brown, grayish brown, and light brownish gray occur in the lower part. In some pedons faint to prominent mottles are in this horizon.

Ulen soils are associated with Arveson, Glyndon, and Grimstad soils. Ulen soils are better drained than the poorly drained Arveson soils. They have less silt and very fine sand than Glyndon soils. Ulen soils lack the loamy IIC horizon of Grimstad soils.

64—Ulen soils, 0 to 2 percent slopes. These soils are in a plane or slightly convex area. The surface layer ranges in texture from loamy fine sand to fine sandy loam, and has a smooth appearance where it is cultivated. It is black, very dark brown, or very dark gray. The presence of calcareous material mixed with soil material in the surface layer influences color. Areas of soil accumulation sometimes occur along old fence lines and field boundaries.

Included with these soils in mapping, and making up as much as 15 percent of an individual mapped area, are Arveson, Poppleton, and Grimstad soils. Also included and making up as much as 10 percent of an individual mapped area, are Glyndon and Wheatville soils. Small areas that have slopes over 2 percent and that are moderately to severely eroded, and some areas that have soluble salts in varying degrees of concentration are included.

Low available water capacity and medium inherent

fertility limit the use of this soil. Soil blowing is a hazard.

Many areas of these soils are cultivated. Small grain is the most common crop. Some potatoes and sunflowers are also planted. A considerable acreage is used for hay and pasture and is seeded to grass or a legume-grass mixture. Some scattered trees, mainly quaking aspen, also grow on these soils. Capability unit IIIs–1; Sandy range site.

Viking series

The Viking series consists of nearly level, poorly drained soils. These soils formed in lake-washed clayey till. They are in flat or slightly concave areas. Most areas have some sorting or thin lacustrine sediment on the surface. Native vegetation is tall grasses.

In a representative profile the surface layer is about 9 inches of black sandy clay loam. The subsoil is about 13 inches of olive gray to dark gray clay. The underlying material is dark gray and olive gray clay.

Permeability is very slow, and available water capacity is moderate. Inherent fertility is high. The seasonal high water table commonly fluctuates from a depth of 1 to 3 feet.

Many areas of Viking soils are cultivated. Small grain and forage for livestock are the most common crops. A few areas support a mixed growth of grasses and trees. Wetness is the major limitation.

Representative profile of Viking sandy clay loam from an area of Viking soils, in a cultivated field 100 feet south and 2,790 feet west of the northwest corner of sec. 36, T. 161 N., R. 48 W.:

A1—0 to 9 inches; black (10YR 2/1) sandy clay loam; moderate very fine subangular blocky structure; firm; about 3 percent coarse fragments; neutral; clear wavy boundary.

B2g—9 to 14 inches; olive gray (5Y 4/2) clay; moderate medium prismatic structure parting to moderate fine angular blocky; friable; about 2 percent coarse fragments; neutral in the upper part grading to mildly alkaline in the lower part; clear wavy boundary.

B3g—14 to 22 inches; dark gray (5Y 4/1) clay; few fine faint olive (5Y 5/3) mottles; weak coarse subangular blocky structure parting to weak very fine subangular blocky; very sticky; about 1 percent coarse fragments; strongly effervescent; mildly alkaline; gradual smooth boundary.

C1g—22 to 32 inches; mixed dark gray (5Y 4/1) and olive gray (5Y 4/2) clay; few fine distinct light olive brown (2.5Y 5/4) mottles; weak very fine subangular blocky structure; very sticky; few coarse fragments; strongly effervescent; mildly alkaline; gradual smooth boundary.

C2g—32 to 60 inches; layered dark gray (5Y 4/1) and olive (5Y 5/3) clay; few fine distinct light olive brown (2.5Y 5/4 and 5/6) mottles; massive; very sticky; few coarse fragments; slightly effervescent; mildly alkaline.

The solum ranges from 20 to 36 inches in thickness. Viking soils typically contain from 2 to 5 percent coarse fragments. In some pedons fewer coarse fragments are in the C horizon and more are in a lag line commonly located between the A and B horizons. A few cobbles and stones occur on the surface of most pedons. The A horizon ranges from 9 to 18 inches in thickness. It is sandy clay loam, clay loam, silty clay loam, clay, and silty clay. It is black that grades to very dark gray in some pedons. The main part of the B horizon is clay, but in some pedons the upper part is silty clay, silty clay loam, and clay loam. It is dark grayish brown, very dark gray, dark gray, dark olive gray, and olive gray. The clay C horizon is gray, olive gray, and light olive gray.

Viking soils are associated with Fram, Rockwell, Percy, and Roliss soils. Viking soils are wetter, more slowly permeable, and have more clay than Fram soils. They have more clay and less sand and silt than Rockwell, Percy, and Roliss soils.

403—Viking soils. These soils are in areas that vary considerably in shape and normally range in size from 10 to 80 acres. Slopes are 0 to 2 percent. The soils are nearly level and slightly concave or flat with scattered, shallow depressions. Where plowed the surface of these soils has a black, cloddy appearance. The surface layer ranges in texture from sandy clay loam to clay. Gravel, cobbles, and some stones and boulders are scattered on the surface and are in the upper 18 inches of this soil. The amount of these coarse fragments varies.

Included with these soils in mapping and making up as much as 15 percent of an individual mapped area, are Roliss and Northcote soils. Also included, and making up as much as 10 percent of an area, are Percy soils and small areas where over 6 inches of sandy, gravelly, or cobbly material is present.

Wetness limits the use of these soils. Structural damage and compaction results when these soils are cultivated when they are wet. Cobbles, stones, and boulders on the surface of these soils and buried in the upper 2 feet influence the efficiency of farm machine operations.

Many areas of these soils are cultivated. Small grain is the most common crop. Areas are also used for pasture and hay. Sometimes a grass-legume seeding is included in cropping sequences and returned to these soils as green manure. Some scattered trees, such as quaking aspen and cottonwood, and various kinds of brush grow on these soils. Capability unit IIw–1; Clayey range site.

Wahpeton series

The Wahpeton series consists of nearly level and gently sloping, moderately well drained soils. These soils formed in clayey alluvial material. They commonly are in slightly convex, high terrace positions adjacent to major streams in the western part of the Glacial Lake Agassiz Basin. Native vegetation is tall grasses mixed with trees, mainly oak, elm, boxelder, and cottonwood.

In a representative profile the surface layer is about

6 inches of black silty clay. It is dark gray when dry. The subsoil is about 36 inches of very dark gray and very dark grayish brown silty clay. The underlying material is very dark grayish brown silty clay. This material has white lime nodules.

Permeability is moderately slow to slow. Available water capacity is moderate. Inherent fertility is high. The seasonal high water table commonly fluctuates from a depth of 2 to 6 feet.

Most areas of Wahpeton soils are cultivated. Small grain and sugar beets are the most common crops. The other areas generally are in woodland, principally cottonwood and elm. Wetness is the major limitation.

Representative profile of Wahpeton silty clay, 0 to 2 percent slopes, in a grassy opening 1,340 feet west and 2,840 feet north of the southeast corner of sec. 8, T. 159 N., R. 50 W.:

A1—0 to 6 inches; black (10YR 2/1) silty clay; dark gray (10YR 4/1) dry; strong fine angular and subangular blocky structure; sticky; neutral; gradual smooth boundary.

B1—6 to 15 inches; very dark gray (10YR 3/1) silty clay; weak medium prismatic structure parting to moderate very fine subangular blocky; sticky; neutral; gradual smooth boundary.

B2—15 to 25 inches; very dark grayish brown (10YR 3/2) silty clay; moderate very fine subangular blocky structure; sticky; neutral; gradual smooth boundary.

B3—25 to 42 inches; very dark gray (2.5Y 3/1) silty clay; moderate very fine subangular blocky structure; sticky; few woody fragments; neutral; gradual smooth boundary.

C1—42 to 60 inches; very dark grayish brown (2.5Y 3/2) silty clay; weak and moderate very fine subangular blocky structure; sticky; few white (2.5Y 8/1) nodules of lime; slightly effervescent; mildly alkaline.

Depth to free carbonates ranges from 30 to 50 inches. The clay content of most pedons ranges from 40 to 60 percent. Extreme ranges are 40 to 65 percent clay. The mollic epipedon ranges from 24 to 60 inches in thickness. The A1 horizon is silty clay and clay. It is black and very dark gray when moist. The B and C horizons are silty clay and clay. They are very dark gray, dark gray, dark grayish brown, and very dark grayish brown when moist. In many places, woody fragments are absent.

Wahpeton soils are associated with Cashel and Northcote soils. Wahpeton soils exhibit more development and are less subject to flooding than Cashel soils. They contain less clay and are better drained than Northcote soils.

157—Wahpeton silty clay, 0 to 2 percent slopes. This soil commonly is in high levee positions near major streams. These areas have slightly convex slopes and commonly range in size from 5 to 160 acres. The surface layer is black, but is more grayish when the surface is dry. Where cultivated the surface soil exhibits a fine blocky appearance. If cultivated when wet the surface has a rougher, cloddy appearance. This soil has the profile described as representative of the Wahpeton series.

Included with this soil in mapping, and making up as much as 15 percent of an individual mapped area, are Northcote and Noyes soils. Also included, and making up as much as 10 percent of an area, are Bearden and Cashel soils.

Wetness limits the use of this soil. Some areas are flooded when adjoining streams are at very high water levels. Working this soil when wet causes compaction and damages structure.

Most areas of this soil are cultivated. Small grain and sugar beets are the most common crops. Legumes and grasses are often included in cropping sequences as green manure crops. Capability unit IIw–1; Clayey range site.

157B—Wahpeton silty clay, 2 to 6 percent slopes. This soil is in high positions on levees near major stream channels. These areas are usually between 3 and 25 acres in size. They are often long and narrow, paralleling the drainageways. The surface layer is black but is more grayish when the surface is dry. Where cultivated the surface layer has a fine blocky appearance. If cultivated when wet the surface layer has a rougher, cloddy appearance. Except for more variation in thickness of the surface layer, this soil has a profile similar to that described as representative of the Wahpeton series.

Included with this soil in mapping, and making up as much as 15 percent of an individual mapped area, are Northcote and Bearden soils. Also included, and making up as much as 10 percent of an area, are Cashel soils and small areas that are moderately to severely eroded. A few areas where slopes are over 6 percent are included.

Wetness limits the use of this soil. High water in adjoining streams will flood some areas. Cultivating this soil when wet causes compaction and structural damage. Soil blowing and water erosion are hazards.

Many areas of this soil are cultivated. Small grain is the most common crop, but some areas that are included in fields are planted to sugar beets and other row crops. A few areas are wooded and some wooded areas are used for pasture. Capability unit IIw–1; Clayey range site.

Wheatville series

The Wheatville series consists of nearly level, moderately well drained and somewhat poorly drained soils. These soils formed in a mantle of lacustrine sediment consisting mostly of very fine sand and silt over clayey lacustrine sediment. They are commonly in areas that have slightly convex slopes. Native vegetation is tall grasses.

In a representative profile the surface layer is about 8 inches of black sandy clay loam and grades to about 5 inches of strongly effervescent, very dark gray loam. The next layer is about 5 inches of violently effervescent, dark grayish brown very fine sandy loam. The underlying material is about 17 inches of light olive brown, loamy very fine sand that grades with depth to very fine sandy loam. Below this is olive gray clay.

Permeability is moderate in the upper part of the soil and slow in the clays. Available water capacity is

high. Inherent fertility is high. The seasonal high water table commonly fluctuates from a depth of 2½ to 6 feet.

Nearly all areas of Wheatville soils are cultivated. They are suited to all crops commonly grown in Kittson County. Small grain and sugar beets are the most common crops. Soil blowing is the major limitation.

Representative profile of Wheatville sandy clay loam from an area of Wheatville soils, 0 to 2 percent slopes, in a windbreak of golden willow and Russian-olive 465 feet south and 45 feet east of the northwest corner of sec. 15, T. 159 N., R. 47 W.:

A1—0 to 8 inches; black (10YR 2/1) sandy clay loam; weak fine subangular blocky structure; friable; strongly effervescent; mildly alkaline; clear smooth boundary.

A3ca—8 to 13 inches; very dark gray (10YR 3/1) loam; weak very fine subangular blocky structure; very friable; strongly effervescent; moderately alkaline; gradual wavy boundary.

C1ca—13 to 18 inches; dark grayish brown (10YR 4/2) very fine sandy loam; very weak very fine subangular blocky structure; very friable; violently effervescent; moderately alkaline; clear wavy boundary.

C2—18 to 26 inches; light olive brown (2.5Y 5/3) loamy very fine sand; few fine faint light brownish yellow (2.5Y 6/4) mottles; single grained; loose; slightly effervescent; moderately alkaline; clear smooth boundary.

C3—26 to 35 inches; light olive brown (2.5Y 5/4) very fine sandy loam; few fine faint olive yellow (2.5Y 6/6) and light brownish gray (2.5Y 6/2) mottles; weak very fine subangular blocky structure; very friable; strongly effervescent; moderately alkaline; abrupt smooth boundary.

IIC4—35 to 60 inches; olive gray (5Y 4/2) clay; many fine distinct light olive brown (2.5Y 5/4), very dark grayish brown (2.5Y 3/2), and olive brown (2.5Y 4/4) mottles; moderate and strong very fine angular blocky structure; very sticky; slightly effervescent; mildly alkaline.

The A horizon is sandy clay loam, loam, silt loam, or very fine sandy loam. It is black or very dark gray and has weak granular or subangular blocky structure. The Cca horizon is very fine sandy loam, loam, silt loam, loamy very fine sand, and sandy clay loam. It is dark grayish brown and grayish brown. Some pedons have faint mottles in this horizon. The C horizon below is typically loamy very fine sand, but very fine sandy loam, silt loam, and loam are also in the range. It has faint to prominent mottles. The IIC horizon is typically clay, but silty clay is also in the range. The IIC horizon ranges from 20 to 40 inches in thickness. It is dark grayish brown, grayish brown, light brownish gray, olive gray, olive, dark gray, gray, light olive gray, and pale olive. Mottling ranges from faint to prominent.

Wheatville soils are associated with Augsburg, Bearden, Fram, and Glyndon soils. They are better drained than the Augsburg soils. They have more very fine sand and silt and less clay in the upper part than Bearden soils. Wheatville soils formed in lacustrine sediment whereas Fram soils formed in glacial till. They have a clayey IIC horizon which is lacking in Glyndon soils.

343—Wheatville soils, 0 to 2 percent slopes. These soils are in generally smooth or slightly convex areas that normally range in size from 15 to 120 acres. The surface layer of these soils ranges in texture from sandy clay loam to very fine sandy loam and has a smooth, mellow appearance where it is cultivated. It is grayer where shallow and tillage mixes underlying material with it.

Included with this soil in mapping, and making up as much as 20 percent of an individual mapped area, are Augsburg soils. Also included, and making up as much as 15 percent of an individual mapped area, are Glyndon and Borup soils. Small areas of Bearden soils, small areas of Wheatville soils that have 2 to 6 percent slopes, and some areas where soluble salts are present in varying degrees of concentration are also included.

The hazard of soil blowing limits the use of this soil. A nutrient imbalance in these soils that results from its strongly calcareous condition also influences use and management.

Most areas of these soils are cultivated. Small grain, sugar beets, sunflowers, and potatoes are the most common crops (fig. 10). Legumes and grasses are included in cropping sequences usually as green manure crops. A small acreage is used for hay and pasture. Capability unit IIe–2; Silty range site.

Planning the use and management of the soils

The soil survey is a detailed analysis and evaluation of the most basic resource of the survey area—the soil. It may be used to adjust land management, including urbanization, to the limitations and potentials of the natural resources and the environment. Also, it can help avoid soil-related failures in uses of the land.

During a soil survey soil scientists, conservationists, engineers, and others keep extensive notes, not only about the nature of the soils, but also about unique aspects of behavior of these soils in the field and at construction sites. These notes include observations of erosion, drought damage to specific crops, yield estimates, flooding, the functioning of septic systems, and other factors relating to the kinds of soil and their productivity, potentials, and limitations under various uses and management. In this way field experience incorporated with measured data on soil properties and performance is used as a basis for predicting soil behavior.

Information in this section will be useful in applying basic facts about the soils to plans and decisions for use and management of soils for crops and pasture, range, woodland, and many nonfarm uses, including building sites, highways, sanitary facilities, parks and other recreational developments, and wildlife habitat. From the data presented, the potential of each soil

Figure 10.—Potatoes on nearly level Wheatville loam.

for specified land uses may be determined, soil limitations to these land uses may be identified, and costly failures in homes and other structures, because of unfavorable soil properties, may be avoided. A site can be selected where the soil properties are favorable, or practices can be planned that will overcome the soil limitations.

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

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

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

Crop production

This subsection describes the capability classification of soils used by the Soil Conservation Service, and the capability units in which the soils in Kittson County are placed. It also includes a table of predicted yields for the more common crops on the different soils of the county (Table 2).

Most of the farmland is used for the production of wheat, barley, and oats. Sugar beets are an important crop on the medium to fine textured soils in the western half of Kittson County. Some potatoes are grown, and an increasing interest in that crop is being shown by farmers. Legumes and grasses are used for livestock feed or plowed under as green manure.

Sandy soils are more subject to soil blowing than other soils. All soils, however, will have soil movement due to wind action if they are not protected. Vegetative cover, crop residue, rough tillage, and field windbreaks aid in controlling soil blowing.

Improved drainage is needed on the wetland and

depressional soils. Open field ditches are used to remove excess surface water from these soils.

All cultivated areas in Kittson County respond to fertilizer. The amount and kind of fertilizer needed varies with the kind of soil, past and present management, and the kind of crop grown. Application of fertilizer should be based on analyses received from soil tests and field trials.

Irrigation

Some interest has developed during the past few years in irrigation. Potatoes are being irrigated on some of the sandy soils in Kittson County.

There are many items to consider before deciding on supplemental irrigation: (1) kind of crops to grow; (2) kind of soils to irrigate; (3) availability of water; (4) kind of irrigation systems; (5) cost of equipment; and (6) economic returns.

The sprinkler irrigation system is presently being used on the few irrigated soils in Kittson County. The farmer must provide for excess water in the event of a heavy rain after irrigation. He must also know when and how much water to apply to satisfy the needs of the growing crop. Because of the intensive cropping that comes with irrigation, the soils must be protected from soil blowing. This is particularly true on sandy soils.

A study was made of an aquifer as a source of water in the Halma-Lake Bronson area *(18)*.[2] The information gathered included kinds of material in well logs, ground water, surface water, water quality, and quantity.

In general the limits of the aquifer are as follows: straight south of the town of Lake Bronson is the western limit, and the eastern limit is a north-south line about one mile west of Karlstad. It is open-ended on the north and south sides.

A large amount of water is stored in the principal aquifer area. The coarsest and most permeable part of the aquifer is about 130 feet thick and underlies an area of about 24 square miles. Precipitation is the main source of recharge, and evapotranspiration accounts for most of the natural discharge. A conservative estimate is that 10 percent of the mean annual precipitation is net recharge. Pumping and utilizing these aquifer waters for crop production would increase the recharge.

The majority of the present irrigation in Kittson County is in this aquifer area.

Capability grouping

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

[2] Italic numbers in parentheses refer to References, p. 133.

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

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

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

- Class I soils have few limitations that restrict their use. (Because of climatic limitations, there is no Class I soil in Kittson County.)
- Class II soils have moderate limitations that reduce the choice of plants or that require moderate conservation practices.
- Class III soils have severe limitations that reduce the choice of plants, require special conservation practices, or both.
- Class IV soils have very severe limitations that reduce the choice of plants, require very careful management, or both.
- Class V soils are not likely to erode but have other limitations impractical to remove, that limit their use largely to pasture, range, woodland, or wildlife.
- Class VI soils have severe limitations that make them generally unsuited to cultivation and limit their use largely to pasture or range, woodland, or wildlife.
- Class VII soils have very severe limitations that make them unsuited to cultivation and that restrict their use largely to pasture or range, woodland, or wildlife. (There are no Class VII soils in Kittson County.)
- Class VIII soils and landforms have limitations that preclude their use for commercial plants and restrict their use to recreation, wildlife, water supply, or to esthetic purposes. (There are no class VIII soils in Kittson County.)

CAPABILITY SUBCLASSES are soil groups within one class; they are designated by adding a small letter, *e*, *w*, *s*, or *c*, to the class numeral, for example, IIe. The letter *e* shows that the main limitation is risk of erosion unless close-growing plant cover is maintained; *w* shows that water in or on the soil interferes with plant growth or cultivation (in some soils the wetness can be partly corrected by artificial drainage); *s* shows that the soil is limited mainly because it is shallow, droughty, or stony, and *c*, used in only some parts of the United States, shows that the chief limitation is climate that is too cold or too dry.

In class I there are no subclasses, because the soils of this class have few limitations. Class V can contain, at the most, only the subclasses indicated by *w*, *s*, and *c*, because the soils in class V are subject to little or no erosion, though they have other limitations that restrict their use largely to pasture, range, woodland, wildlife, or recreation.

CAPABILITY UNITS are soil groups within the sub-

classes. The soils in one capability unit are enough alike to be suited to the same crops and pasture plants, to require similar management, and to have similar productivity and other responses to management. Thus, the capability unit is a convenient grouping for making many statements about management of soils. Capability units are generally designated by adding an Arabic numeral to the subclass symbol, for example, IIe–1 or IIIw–2. Thus, in one symbol, the Roman numeral designates the capability class, or degrees of limitation, and the small letter indicates the subclass, or kind of limitation, as defined in the foregoing paragraph. The Arabic numeral specifically identifies the capability unit within each subclass.

In the following pages the capability units in Kittson County are described and suggestions for the use and management of the soils are given. To find the names of all the soils in any given capability unit, refer to the "Guide to Mapping Units" at the back of this survey.

Capability unit IIe–1

This unit consists of medium to moderately fine textured, somewhat poorly drained soils. These soils formed in silty deposits. They are in level and gently sloping landscape. Reaction in the surface layer of these soils is mildly alkaline to moderately alkaline. Soil blowing and water erosion are hazards. The alkaline condition of most of these soils results in a fertility imbalance.

Small grain, sugar beets, potatoes, and sunflowers are the most common crops on the silty soils. A few areas of these soils are wooded, primarily with quaking aspen and bur oak.

Practices including rough tillage, stubble mulching and cover cropping help to control soil blowing and water erosion. Field shelterbelts also help control soil blowing. Returning crop residue to the soil and growing green manure crops help to maintain organic-matter content and maintain or improve soil structure. The application of fertilizers helps to improve nutrient status.

Capability unit IIe–2

This unit consists of moderately coarse to moderately fine textured, somewhat poorly drained to moderately well drained soils. These soils are in nearly level areas. A few soils are in the interbeach areas. Reaction in the surface layer of these soils is neutral to moderately alkaline. Soil blowing is a hazard on these soils. The alkaline condition results in a fertility imbalance.

Small grain, sugar beets, potatoes, and sunflowers are the most common crops. Small grain, potatoes, and grass and legume crops are more common in the eastern areas. A few areas are wooded primarily with quaking aspen.

Practices including rough tillage, stubble mulching, and cover-cropping help to control soil blowing. Field shelterbelts also help to control soil blowing and other effects of wind action. Returning crop residue to the soil and growing green manure crops help to maintain organic-matter content. The application of commercial fertilizers helps to improve nutrient status.

Capability unit IIw–1

This unit consists of fine and moderately fine textured, poorly drained and moderately well drained soils. Most of these soils are in nearly level areas. A few soils adjacent to rivers and streams are gently sloping. Some soils are on water-modified clay till in more eastern areas. Reaction in the surface layer is neutral to mildly alkaline. Wetness is the main limitation to use of soils in this unit. Cultivating these soils when they are wet causes structural damage and compacting. Soil blowing is a hazard on smooth fields with no protective cover. Water erodes soils in gently sloping areas. Stones and boulders interfere with the operation of farm machinery on soils in eastern areas.

Small grain and sugar beets are the most common crops in western areas. Small grain, hay, and pasture crops are more common in eastern areas (fig. 11). Some areas of soils in western areas are gently sloping and are wooded.

Open field ditches are needed to reduce the wetness limitation on most areas. Growing deep rooted legumes helps internal drainage. Returning crop residue to the soil, growing green manure crops, and applying barnyard manure help to maintain organic matter and maintain or improve soil structure. Practices including rough tillage, stubble mulching, and cover-cropping help to control soil blowing and water erosion.

Capability unit IIw–2

This unit consists of moderately fine textured, poorly drained and somewhat poorly drained soils. These soils formed in water-worked till and lacustrine clay. They are in nearly level areas. Reaction in the surface layer of these soils is neutral to moderately alkaline. Wetness is the principal limitation on the soils in this unit. The alkaline condition of some of these soils results in a fertility imbalance. In places, cobbles, stones, and boulders on these soils interfere with the operation of farm machines. Soil blowing is a hazard on smooth fields that have no protective cover.

Small grain, sugar beets, hay, and pasture are the most common crops. Some areas are wooded, primarily with quaking aspen.

Open field ditches are needed to reduce the limitation caused by wetness on soils in this unit. Returning crop residue to the soil and applying barnyard manure help to maintain organic matter and maintain or improve soil structure. Application of commercial fertilizers helps to improve nutrient status. Practices including rough tillage, stubble mulching, and cover-cropping help to control soil blowing. Removing stones, boulders, and cobbles facilitates operation of farm machinery.

Capability unit IIw–3

This unit consists of moderately coarse to moderately fine textured, poorly drained soils. These soils formed in lacustrine silt and very fine and fine sand underlain in some places by lacustrine clay and clay loam or loam till. Reaction in the surface layer is mildly alkaline to moderately alkaline. Wetness is the main limitation to use of soils in this unit. Their alkaline condition results in a fertility imbalance. Soil blowing is a hazard.

Figure 11.—**Freshly dug livestock watering pit on Northcote soils.**

Small grain, potatoes, sunflowers, and sugar beets are the most common crops on soils in this unit. In more eastern areas of the county, hay and pasture crops are also common. A few areas are wooded, primarily with quaking aspen.

Open field ditches are needed to reduce the limitation caused by wetness. Application of commercial fertilizers help to improve fertility. Practices including rough tillage, stubble mulching, cover-cropping, and planting field windbreaks help to control soil blowing. Returning crop residue to the soil and applying barnyard manure help to maintain organic-matter content.

Capability unit IIw–4

This unit consists of moderately fine and fine textured, poorly drained to moderately well drained soils. These soils formed in clay and silt in the western part of the county. Reaction in the surface layer is neutral to moderately alkaline. Wetness is the main limitation to use of soils in this unit. The microrelief condition on complexes makes removing water from wet soils more difficult. Tilling these soils when wet will cause compaction and damage structure. The alkaline condition of some soils results in a fertility imbalance. Soil blowing is a hazard where fields are smooth and have no protective cover.

Small grain and sugar beets are the most common crops on complexes in this unit. A few areas near rivers are wooded and are used for pasture.

Open field ditches are needed to reduce the limitation caused by wetness. Application of commercial fertilizers helps to improve the fertility. Practices including rough tillage, stubble mulching, and cover-cropping help to control soil blowing. Returning crop residue to the soil and growing green manure crops help to maintain or increase organic-matter content.

Capability unit IIc–1

This unit consists of medium to moderately coarse textured, somewhat poorly drained and moderately well drained soils. These soils formed in lacustrine sediment and water-worked till. They are in nearly level areas. Reaction on the surface layer is slightly acid to mildly alkaline. Climate limits the crops that will mature and provide an economic return on these soils. The presence of cobbles, stones, and boulders influence farming operations on some soils in this unit.

Small grain, sugar beets, potatoes, and sunflowers are common crops on the west-central areas. Small grain and hay or pasture crops are the most common on the water-worked tills further east. A few wooded areas include quaking aspen and bur oak.

Planting or seeding adapted varieties helps to assure a mature, harvestable crop. Returning crop residue to the soil and growing green manure crops help to maintain organic-matter content. The application of fertilizers helps to maintain or improve fertility. Removing stones and boulders from some areas facilitates the operation of farm machinery.

Capability unit IIIw–1

This unit consists of moderately fine textured to moderately coarse textured, poorly drained soils. These soils formed in lacustrine sand and gravel and a few depressions of silt. The sand and gravel are underlain by sandy loam, loam, and clay loam till in some areas. Reaction in the surface layer is neutral to moderately alkaline. Wetness is the main limitation to use of the soils in this unit. Soil blowing is a hazard. Moderate to high available water capacity and low to medium inherent fertility is a limitation on many of these soils. The alkaline condition on many of these soils also affects fertility. Stones and boulders in some areas interfere with the operation of farm machines.

Small grain, potatoes, and hay or pasture are the most common crops on soils in this unit. Some areas are wooded to quaking aspen and lowland brush.

Open field ditches are needed to reduce the limitation caused by wetness. Practices including rough tillage, stubble mulching, and cover-cropping help to control soil blowing. Application of commercial fertilizers helps to improve fertility. Returning crop residue to the soil and applying barnyard manure help to maintain organic-matter content. Removing stones and boulders facilitates efficient operation of farm machinery.

Capability unit IIIw–2

This unit consists of moderately fine textured and fine textured, very poorly drained and poorly drained soils. Some soils in this unit have a shallow organic accumulation on the surface. These soils formed in water-worked till depressional areas in the east and east-central part of the county, and they formed in fine textured, depressional areas subject to flooding in western parts. Reaction in the surface layer of these soils is neutral to moderately alkaline. Wetness is the main limitation to use of soils in this unit. Some ponding or flooding is likely even when drainage ditches are constructed. Some drowning of crops occurs during most seasons. Some stones and boulders are on soils in eastern parts of the county.

Soils in this unit in the western part of the county are commonly planted to small grain and sugar beets. Some areas subject to flooding are wooded or used for pasture. Depressional areas in eastern parts of the county are less commonly drained. They are often included in pasture and support a growth of wetland vegetation.

Open field ditches are needed to reduce limitation caused by wetness. Some flooding or ponding occurs on many areas even though drainage has been provided. Stones and boulders must be removed from some areas before farm machinery can operate efficiently.

Capability unit IIIs–1

This unit consists of moderately coarse and coarse textured, moderately well drained and somewhat poorly drained soils. These soils formed in lacustrine sand and gravel in nearly level and a few gently sloping areas. In some areas the sandy and gravelly materials are underlain by finer textured till. Reaction in the surface layer is neutral to moderately alkaline. Low to moderate available water capacity and medium inherent fertility limit use of these soils. Soil blowing is a hazard. Stones and boulders on some areas interfere with the operation of farm machinery.

Some areas of these soils are cultivated. Small grain, potatoes, and sunflowers are the most common crops. Other areas support introduced grasses or are seeded to grasses and legumes and used for hay and pasture. A few areas are in mixed grasses and trees.

Application of commercial fertilizers helps to improve fertility. Practices including rough tillage, stubble mulching, and cover-cropping help to control soil blowing. Returning crop residue to the soil, growing green manure crops, and adding barnyard manure help to maintain organic-matter content. Removing stones and boulders facilitates efficient operation of farm machinery.

Capability unit IVw–1

This unit consists of coarse and moderately coarse textured, poorly drained soils. These soils formed in lacustrine sand and gravel that, in some areas, are over loam and clay loam till. They are in nearly level areas. Reaction in the surface layer of these soils is slightly acid to moderately alkaline. Wetness is the main limitation to use of these soils. Soil blowing can be a hazard. Low to moderate available water capacity and low to medium inherent fertility are also limitations. The alkaline condition in a few soils affects nutrient status. Stones and boulders on some areas interfere with the operation of farm machines.

Small grain and hay or pasture are the most common crops on soils in this unit. Some areas are wooded with quaking aspen and lowland brush. Some areas of these soils are not cultivated.

Open field ditches are needed to reduce limitation of wetness. Practices including rough tillage, stubble mulching, and cover-cropping help to control soil blowing. Application of commercial fertilizers helps to improve nutrient status. Returning crop residue to the soil and applying barnyard manure help to maintain organic-matter content. Removing stone and boulders from some areas facilitates efficient operation of farm machinery.

Capability unit IVw–2

This unit consists of coarse textured to moderately fine textured, poorly drained soils. These soils formed in lacustrine sand or sand underlain by till. They are in depressions. Reaction in the surface layer of these soils is slightly acid to moderately alkaline. Wetness

is the main limitation to use of soils in this unit. Some drowning of crops will occur during most seasons. Low to medium inherent fertility is also a limitation. In some places stones and boulders interfere with the operation of farm machines.

Where drained, soils in some depressional areas in fields produce small grain. These soils are more often included in pasture and support a growth of wetland vegetation.

Open field ditches are needed to reduce wetness. Some ponding or drowning of crops commonly occurs even though drainage has been provided. Application of commercial fertilizers helps to improve fertility. Stones and boulders should be removed from some areas so farm machinery can operate efficiently.

Capability unit IVw–3

The soils of this unit consist of very poorly drained muck that formed in highly decomposed reed and sedge organic materials. These soils are in depressions and low, flat areas. Deep or moderately deep organic deposits are over sand or loam and clay loam, and shallow organic deposits are over sand. Reaction in the surface layer is slightly acid to mildly alkaline. Wetness is the main limitation to use of soils in this unit. A low inherent fertility is also a limitation. Some ponding is common in depressions, even where ditches are present. The possibility of muck fires is a hazard on these soils. In some areas, stones and boulders interfere with the operation of farm machines.

Where drained, a few areas of soils in this capability unit are cultivated. Small grain is grown in these areas. In places hay is harvested on these soils. Many areas are not cultivated and support reeds, sedges, and cattails, and lowland brush.

Open field ditches help to reduce the limitation caused by wetness. Commercial fertilizers improve the fertility.

Capability unit IVs–1

This unit consists of coarse textured, somewhat poorly drained and moderately well drained soils. These soils formed in lacustrine sand and gravel in nearly level landscape. In some areas sandy materials are underlain by fine textured till. Reaction in the surface layer is medium acid to mildly alkaline. The low to moderate available water capacity and a low inherent fertility limits the use of these soils. Soil blowing is a hazard.

In some areas these soils are cultivated. Small grain and potatoes are the most common crops. Introduced grasses used for hay and pasture are in other areas. Some areas of grasses, brush, and trees are used for pasture.

Irrigation reduces or eliminates the limitation caused by insufficient water in these soils. Commercial fertilizers increase fertility. Rough tilling, stubble mulching, and cover-cropping help to control soil blowing. Returning crop residue to the soil, growing green manure crops, and adding barnyard manure help to maintain organic-matter content.

Capability unit IVs–2

This unit consists of coarse textured, moderately well drained to excessively drained soils. These soils formed in lacustrine sandy and gravelly deposits. They are in level areas and on convex ridges. Slopes are as much as 6 percent. Reaction in the surface layer of these soils is slightly acid to neutral. Low available water capacity and low inherent fertility limit the use of these soils. Soil blowing is a hazard.

Some areas of soils in this unit are cultivated. Small grain is the most common crop. Other areas are in introduced grasses and are used for hay and pasture. Some areas in grasses and trees are not cultivated.

Irrigation of crops may be needed on soils in this unit. Application of commercial fertilizers helps to improve fertility. Practices including rough tillage, stubble mulching, and cover-cropping help to control soil blowing. Returning crop residue to the soil, growing green manure crops, and adding barnyard manure help to maintain organic-matter content.

Capability unit Vw–1

The only soil in this unit is Syrene soils, very wet. This moderately coarse textured, very poorly drained soil formed in gravelly lacustrine deposits. It is in depressional and seep areas. Reaction in the surface layer is moderately alkaline. Wetness is the main limitation to use of soils in this unit. Low available water capacity and medium inherent fertility are also limitations.

Some areas in this unit are used for pasture. Most areas are in wetland herbaceous vegetation and lowland brush.

Ditches are needed to reduce the limitation of wetness where this soil is being improved for hayland or pasture. Application of commercial fertilizer will improve fertility.

Capability unit VIe–1

This unit consists of Breaks and Alluvial land. Slopes are moderately steep or steep on breaks, and nearly level in areas of alluvium. These areas are commonly adjacent to the Red River of the North and its tributaries. The soil material is mostly fine textured, but it is moderately fine and medium textured in areas of alluvium. Erosion is a hazard. Inaccessibility and steepness of slopes are also limitations. Flooding during high water levels of streams is a hazard in some areas.

Trees are the most common vegetative cover. A few areas are in grass. Basswood, elm, ash, and cottonwood are the most common trees. Some areas are used for pasture.

Control of grazing is needed to maintain a vegetative cover that helps prevent erosion. Care must be exercised to prevent gullies from forming when directing water flow over steep slopes. These areas are well suited to limited grazing. They also can be maintained or improved for use as wildlife habitat.

Capability unit VIw–1

This unit consists of moderately fine textured, poorly drained soils, and soils subject to frequent flooding. Some soils, in east-central and eastern parts of the county that formed in water-worked till, may have a shallow organic accumulation and have from 3 to 15

percent of their surface covered with stones and boulders. The areas that are subject to frequent flooding are along major streams and near the bottom of natural draws. Reaction in the surface layer of soils in this capability unit is neutral to moderately alkaline. Wetness and flooding limit the use of soils in this unit. On some soils the numerous stones and boulders make the operation of farm machines impractical. Alkaline conditions and the presence of organic materials affect fertility.

Some areas of soils in this unit are used for pasture. Most areas are not cultivated and are in grasses and scattered trees.

Open field ditches help to reduce the limitation caused by wetness. Stones and boulders must be removed from some areas before farm machinery can operate efficiently. Application of commercial fertilizer helps improve fertility for pasture use.

Capability unit VIs–1

This unit consists of coarse textured Dune land that is affected by severe soil blowing. These commonly well drained to excessively drained soils are nearly level to moderately steep. Reaction in the surface layer is slightly acid to neutral. Low available water capacity and low inherent fertility limit the use of these soils. A high susceptibility to soil blowing is a hazard.

Some areas of lands in this unit are in pasture. Many areas are not cultivated and are in native and introduced grasses and scattered trees.

Grazing on these lands must be limited to prevent soil blowing that forms active dune areas.

Yields per acre

The per acre average yields that can be expected of the principal crops under a high level of management are shown in table 2. In any given year, yields may be higher or lower than those indicated in table 2 because of seasonal variations in rainfall and other climatic factors. Absence of a yield estimate indicates that the crop is not suited to or not commonly grown on the soil or that irrigation of a given crop is not commonly practiced on the soil.

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

The latest soil and crop management practices used by many farmers in the county are assumed in predicting the yields. Hay and pasture yields are predicted for varieties of grasses and legumes suited to the soil. A few farmers may be using more advanced practices and are obtaining average yields higher than those shown in table 2.

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

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

Crops other than those shown in table 2 are grown in the survey area, but because their acreage is small, predicted yields for these crops are not included. The local offices of the Soil Conservation Service and the Cooperative Extension Service can provide information about the productivity and management concerns of the soils for these crops.

Range[3]

The original vegetation in Kittson County consisted of tall and short prairie grasses, sedges, broadleaved plants (forbs), and numerous kinds of legumes. The shorter grasses occurred more frequently on the droughtier soils. The tall grasses were common in places where the moisture supply was favorable, generally in areas subject to flooding, or subirrigation.

Most of the present native grassland exists in the eastern two-thirds of the county. It is intermingled with the woods and brush. Areas vary from several sections to long narrow fingers or irregularly shaped squares and circles.

When fire destroys the woody cover, native prairie grasses and forbs quickly take over.

The acreage of range in Kittson County is small compared with the acreage that is under cultivation. Range, however, is a resource and should be managed in a way that permits the best possible sustained forage yields. Basic to successful management is proper stocking of the range in relation to the forage producing capacity of the site.

Where climate and topography are about the same, differences in the kind and amount of vegetation that range can produce are related closely to the kind of soil. Effective management is based on the relationships among soils, vegetation, and water.

A range site supports a distinctive potential plant community, or combination of plants, that can grow on a site that has not undergone major disturbance. Soils that produce the same kind, amount, and proportion of range plants are grouped into range sites. Range sites can be interpreted directly from the soil map where the relationships between soils and vegetation have been correlated. Properties that determine the capacity of the soil to supply moisture and plant nutrients have the greatest influence on range plants and their productivity. Soil reaction, salt content, and a seasonal high water table are also important.

Potential production refers to the amount of herbage that can be expected to grow on well managed range that is supporting the potential plant community. It is expressed in pounds per acre of air-dry herbage for

[3] ELDOR MUELLER, conservation agronomist, Soil Conservation Service, helped prepare this section.

TABLE 2.—*Yields per acre of crops and pasture*

[All yields were estimated for a high level of management in 1974. Absence of a yield figure indicates the crop is seldom grown or is not suited]

Soil name and map symbol	Oats	Wheat, spring	Barley	Sugar beets	Potatoes, Irish	Grass-legume hay	Reed canarygrass
	Bu	*Bu*	*Bu*	*Ton*	*Cwt*	*Ton*	*AUM* [1]
Maddock:							
[2]45	34	17	23			2.0	
Borup:							
46	75	40	55	15	150	3.5	
Colvin:							
47	75	40	46	16		2.6	
Cashel:							
50	70	38	61			3.3	
Augsburg:							
[2]52	78	45	55	16	160	3.5	
Grimstad:							
[2]59	70	35	50		160	3.0	
Glyndon:							
[2]60	80	45	55	16	160	3.8	
Arveson:							
[2]61	65	35	45		125	2.5	6.0
Rockwell:							
[2]63	75	40	50		135	3.5	6.0
Ulen:							
[2]64	70	35	45		135	2.5	
Foxhome:							
[2]65	65	35	45			3.0	
Bearden:							
67	80	45	55	16	170	3.8	
Garnes:							
[2]77	80	45	55		160	4.0	
Bearden:							
93, 93B	80	45	55	16	170	3.8	
Hangaard:							
[2]111	55	25	30			2.5	
Redby:							
[2]116	45	20	30		100	2.5	
Cormant:							
[2]117	55	30	35		110	2.5	6.0
Enstrom:							
145	60	25	35		115	3.0	
Poppleton:							
[2]148	45	20	25		120	2.3	
Wahpeton:							
157, 157B	75	40	55	14		3.5	
Haug:							
187	50	25	40				6.0
Karlstad:							
[2]205	50	20	30			2.5	
Marquette:							
[2]242	35	15	25			2.0	

TABLE 2.—*Yields per acre of crops and pasture*—Continued

Soil name and map symbol	Oats	Wheat, spring	Barley	Sugar beets	Potatoes, Irish	Grass-legume hay	Reed canarygrass
	Bu	*Bu*	*Bu*	*Ton*	*Cwt*	*Ton*	*AUM* [1]
Lohnes:							
[2] 245	45	20	25			2.0	
Pelan:							
[2] 280	60	30	35			2.5	
Fram:							
[2] 296	75	40	55			4.0	
Wheatville:							
[2] 343	75	40	55	16	170	4.0	
Percy:							
[2] 379							
[2] 383	70	40	50			3.5	6.0
[2] 384	55	25	30			3.5	6.0
Viking:							
[2] 403	75	40	50			3.5	
Mavie:							
[2] 412	60	30	40			2.5	5.0
Augsburg:							
[2] 424	70	40	55	14	160	3.5	
Donaldson:							
[2] 425	85	48	58	16	165	4.0	
Foldahl:							
[2] 426	75	40	50		140	4.0	
Fram:							
[2] 427	75	40	55			4.0	
Northcote:							
429	75	40	55	15		3.5	
429B	70	40	50	14		3.3	
Noyes:							
[2] 430	80	40	55	15		3.7	
Strandquist:							
[2] 432	55	25	30			2.5	5.0
Syrene:							
[2] 433							4.5
[2] 435	50	20	25			2.0	6.0
Northcote:							
438	55	30	45	13			
Grygla:							
[2] 482	60	30	40		120	2.5	6.0
Markey:							
543							6.0
Cathro:							
544							6.0
Deerwood:							
547							5.0
Percy:							
[2] 581	70	40	50			3.5	6.0
Roliss:							
[2] 582	70	40	50			3.5	6.0
Nereson:							
[2] 583	75	40	50			4.0	

TABLE 2.—*Yields per acre of crops and pasture*—Continued

Soil name and map symbol	Oats	Wheat, spring	Barley	Sugar beets	Potatoes, Irish	Grass-legume hay	Reed canarygrass
	Bu	*Bu*	*Bu*	*Ton*	*Cwt*	*Ton*	*AUM*[1]
Bearden: [2]908	75	45	55	16		3.8	
Hegne: [2]937	70	40	50	14		3.8	
Northcote: [2]991	70	40	50	15		3.5	
Arveson: [2]993	50	20	30				6.0
Rockwell: [2]994	50	25	35				6.0
Alluvial land: 1002							4.5
Breaks and Alluvial land: 1006							
Dune land: 1025							
Marsh: 1053							

[1] Animal-unit-month: The amount of forage or feed required to feed one animal unit (one cow, one horse, one mule, five sheep, or five goats) for 30 days.

[2] This mapping unit is made up of two or more dominant kinds of soil. See description of the mapping unit for composition and behavior characteristics of the whole mapping unit.

favorable, normal, and unfavorable years. A favorable year is one in which the amount and distribution of precipitation and the temperatures result in growing conditions substantially better than average; a normal year is one in which these conditions are about average for the area; an unfavorable year is one in which growing conditions are well below average, generally because of low available soil moisture.

Dry weight refers to the total air-dry herbage produced per acre each year by the potential plant community. All herbage, both that which is highly palatable and that which is unpalatable to livestock, is included. Some of the herbage also may be grazed extensively by wildlife. Plant species that have special value for livestock forage are mentioned in the description of each soil mapping unit.

Range management requires, in addition to knowledge of the kinds of soil and the potential plant community, an evaluation of the present condition of the range vegetation in relation to its potential. Range condition is determined by comparing the present plant community with the potential natural plant community on a particular range site. The more nearly alike the present kinds and amounts of plants are to the potential plant community, the better the range condition. The objective in range management is to manage grazing so that the plants growing on a site are about the same in kind and amount as the potential native plant community for that site. Such management generally results in the maximum production of herbage, conservation of water, and control of erosion. Sometimes, however, a range condition somewhat below the potential fits grazing needs, provides wildlife habitat, or provides other benefits, as well as protecting soil and water resources.

The major management concern on most of the rangeland is control of grazing so that the kinds and amounts of plants that make up the potential plant community are reestablished. Controlling brush and minimizing soil blowing are also important management concerns. If sound range management based on the soil survey information and rangeland inventories is applied, the potential is good for increasing the productivity of range in the area.

Wetland range site

This site consists of soils that vary in texture from clay to loamy sand. These soils are in depressions. They have a seasonal high water table and unless drained, are ponded part of the growing season. They are not too wet, however, to grow good stands of grasses and sedges. The vegetation is characterized by an abundance of such water-tolerant plants as broadleaf and narrowleaf sedges, rushes, reed canarygrass, and some lesser amounts of tufted hairgrass, native redtop, and prairie cordgrass. This site differs from the subirrigated site in that little, if any, big bluestem grows on it.

Among the decreaser plants on this site are reedgrass, reed canarygrass, prairie cordgrass, and broad-

leaf sedge. Among the increaser plants are rushes and narrowleaf sedges. In places, woody increasers such as willows may become overabundant and need to be controlled.

If this range site is in excellent condition, the average estimated total yield per acre is 4,500 pounds, dry weight.

Grazeable Muck range site

This site consists of organic soils in broad depressional areas. The state of decomposition is variable. Excluded from the range site are areas where water at or near the surface during a major portion of the growing season seriously restricts grazing and produces a plant community of narrowleaf sedge, phragmites, and cattails. The vegetation of this site is characterized by reedgrass, reed canarygrass, broadleaf sedges, native redtop, and prairie cordgrass.

Among the decreaser plants are reedgrass, reed canarygrass, and broadleaf sedges. Among the increaser plants are tufted hairgrass, rushes, and narrowleaf sedges. If drainage is installed, a nongrazeable muck can be changed to a grazeable condition.

If this range site is in excellent condition, the average estimated total yield per acre is 4,500 pounds, dry weight.

Subirrigated range site

This site consists of soils that vary in texture from loamy sands to silty clay loams. The water table is high, but it is rarely at the surface during the growing season. Distinct mottling can be observed in absence of an actual water table. Moisture is usually within reach of most plants. Production of forage is not affected much by dry weather. The vegetation is characterized by big bluestem, prairie cordgrass, indiangrass, reedgrasses, and switchgrass. This site differs from drier sites in that porcupinegrass and prairie sandreed are absent, and relatively small amounts of little bluestem grow on it.

Among the decreaser plants are big bluestem, indiangrass, switchgrass, white and purple prairie clover, tall gayfeather, and reedgrass. Among the increaser plants are mat muhly, narrowleaf sedge, foxtail, and redtop. In places, poplar and willows may become overabundant and need to be controlled.

If this range site is in excellent condition, the average estimated total yield per acre is 3,700 pounds, dry weight.

Clayey range site

This site consists of soils that vary in surface texture from sandy clay loam to clay. When it is dry and has a good vegetative cover, this soil has a good water intake rate. There is a rapid decline in the water intake rate when the surface is bare and becomes puddled. The water table is high in the spring of the year, but is rarely at the surface during the growing season. Moisture is usually within reach of most plants.

Most of these soils are cropland in the western half of the county. Some areas support native vegetation. The vegetation is characterized by big bluestem, prairie cordgrass, indiangrass, and switchgrass. This site differs from the subirrigated site in that drying out of these soils and the limitation of shrink-swell cause lower yield.

Among the decreaser plants are big bluestem, indiangrass, switchgrass, and white and purple prairie clover. Among the increaser plants are foxtail and redtop.

If this range site is in excellent condition, the average total estimated yield per acre is 3,400 pounds, dry weight.

Silty range site

This site consists of soils with a surface layer that ranges from fine sandy loam, very fine sandy loam, loam, silt loam, and sandy clay loam to silty clay loam. These soils are moderately well drained and somewhat poorly drained. The water intake ranges from moderately rapid to moderately slow. The vegetation is characterized by big bluestem, little bluestem, porcupinegrass, prairie dropseed, and indiangrass. This site differs from sandier sites in that prairie sandreed is generally absent.

Among the decreaser plants are big bluestem, little bluestem, indiangrass, porcupinegrass, white and purple prairie clover, tall gayfeather, and prairie leadplant. Among the increaser plants are sand dropseed, prairie dropseed, muhlys, blue grama and side-oats grama. As the range condition declines, Kentucky bluegrass, redtop, quackgrass, white clover, and Canada thistle invade the site.

If this range site is in excellent condition, the average estimated total yield per acre is 3,000 pounds, dry weight.

Sandy range site

This site consists of loamy sand, sandy loam, and fine sandy loam. These soils are moderately well drained to somewhat poorly drained. In places fine textured material is at a depth usually below 30 inches. The water table is generally below the effective root zone. Water intake rate is moderately rapid to rapid. The vegetation is characterized by big bluestem, little bluestem, and porcupinegrass. This site differs from the Sands range site in that less prairie sandreed and the grama grasses grow here.

Among the decreaser plants are big bluestem, little bluestem, indiangrass, Canada wildrye, procupinegrass, white and purple prairie clover, tall gayfeather, and prairie leadplant. Among the increaser plants are prairie sandreed, grama grasses, sand dropseed, prairie dropseed, and prairie junegrass. As the range condition declines, Kentucky bluegrass, redtop, quackgrass, Canada thistle, annuals, and numerous shrubs invade the site. This site deteriorates quickly if it is overused.

If this range site is in excellent condition, the average estimated total yield per acre is 2,500 pounds, dry weight.

Sands range site

This site consists of eroded sandy soils that are excessively drained to somewhat poorly drained on sand ridges. These soils range in texture from loamy

fine sand to sand. In places fine textured material is at a depth usually below 30 inches. Water intake rate is rapid. Big bluestem is dominant on this range site. Little bluestem and porcupinegrass are next in importance. Some prairie sandreed, blue grama, and site-oats grama grow in minor amounts.

Among the decreaser plants are big bluestem, little bluestem, indiangrass, porcupinegrass, Canada wildrye, and prairie leadplant. Among the increaser plants are prairie sandreed, blue grama, prairie dropseed, and sand dropseed. As the range condition declines, annuals, Canada thistle, quackgrass, bluegrass, and numerous shrubs invade the site. This site deteriorates rapidly if it is overused.

If this range site is in excellent condition, the average estimated total yield per acre is 2,000 pounds, dry weight.

Saline soils [4]

Some areas in Kittson County have toxic concentrations of soluble salts in association with high water tables. Specifically, the saline areas occur in the western half of the county. Some deep wells were dug years ago. Many were flowing wells that delivered saline water. Most, if not all, have since been plugged or capped. Natural internal drainage is poor because of artesian pressure and the fine texture of the soil materials present in most of the area. The only positive way of identifying the various salt affected soils is laboratory analysis. Field observations, however, are fairly reliable if done during specific times of the year.

Extensive research on problems of saline and saline-alkali soils has been conducted and has application for Kittson County (*13*).

Field observations

1. *Growing Crops.*—Appearance is a useful clue to saline soil conditions. Stands generally appear spotty. This spotty condition varies according to crop species and intensity of the salinity. The presence of excessive salts becomes apparent at early stages when seedlings emerge. In other cases, early growth can look good but deteriorates as the season progresses. In severely affected areas, crop growth is very uneven and may be completely eliminated where the salinity

[4] R. H. RUST and J. M. MACGREGOR, Department of Soil Science, University of Minnesota, helped prepare this section.

TABLE 3.—*Chemical properties of selected soils*

[Dashes indicate data were not determined. The symbol > means greater than]

Soils and locations	Soil depth	Conductivity	pH	Carbonate	Sodium	Chloride	Sulphates
	Ins	*Mmhos*		*Pct*	*Meq/l*	*Ppm*	*Ppm*
Good Wheat Growth:							
Northcote clay, 0 to 2 percent slopes:	0–6	4.0	7.1	4	8	570	54
	6–12	5.8	7.6	4	22	820	113
4.5 miles southeast of Kennedy.	12–24	13.4	7.5	14	49	1,320	540
	24–36	14.0	7.7	10	43	2,220	698
Augsburg soils (0 to 2 percent slopes):	0–8	3.2	8.0				
	8–11	4.9	8.3				
sec. 7, T. 159 N., R. 47 W.	11–18	6.5	8.4				
	18–33	8.1	8.4				
	33–62	8.1	7.9				
Northcote clay, 0 to 2 percent slopes:	0–6	4.2	7.4				
	6–12	>10	7.7				
sec. 29, T. 159 N., R. 48 W.							
Poor Wheat Growth (bare spot):							
Northcote clay, 0 to 2 percent slopes:	0–6	21.0	7.1	5	66.3	3,960	383
	6–12	27.0	7.2	6	65.0	3,960	270
4.5 miles southeast of Kennedy.	12–24	21.0	7.6	11	65.0	3,000	675
	24–36	18.0	7.5	14	62.3	2,760	216
No Growth:							
Hegne-Northcote complex (0 to 2 percent slopes):	0–7	>10	7.4			3,028	
	7–9	>10	7.7			1,372	
sec. 8, T. 162 N., R. 49 W.	9–13	>10	7.8			4,773	
Augsburg soils (0 to 2 percent slopes):	0–7	>10	7.6			155	
	7–11	8.0	8.1			3,095	
sec. 17, T. 159 N., R. 47 W.	11–16	7.0	8.1			1,535	
	16–27	>10	7.9			2,947	
Northcote clay, 0 to 2 percent slopes:	0–7	>10	7.0				
	7–12	>10	7.0				
sec. 29, T. 159 N., R. 48 W.	12–18	>10	7.1				

is most severe. Such effects are most noticeable in dry years.

2. *Weed Growth.*—Certain tolerant species, or those having a wider range of tolerance, are also useful indicators. These species include saltgrass, sea flite, wild barley, and kochia. Care must be exercised when weed growth is used as a salt indicator. Other salt indicators, such as the presence of surface salts, often help to confirm the conclusion.

3. *The Appearance of the Soil.*—Strongly saline soils are often devoid of all vegetation. The surface may be slightly crusted, and light gray or white salt crystals may be visible, especially when the soil is dry.

Less strongly saline soils may lack salt precipitation at the surface, but this may be present ¼ inch to 1 inch below the surface as gray or white concentrations.

High-lime soil surfaces commonly are grayer than noncalcareous or nonlimy soil surfaces. Soils high in lime usually form the border of slight depressions and will effervesce (bubble) when treated with 0.1 N hydrochloric acid. High lime concentration limits the availability of both phosphate and potash. Caution must be exercised in determining if a salt or high-lime condition exists (a high electrical conductivity will indicate the former).

Laboratory observations

Soil scientists have defined and listed the saline-alkali soils as follows: (1) A normal soil has less than 4 mmhos of conductance and less than 15 percent exchangeable sodium. (2) A saline soil has more than 4 mmhos of conductance and less than 15 percent exchangeable sodium. (3) A saline-alkali soil has more than 4 mmhos of conductance and more than 15 percent exchangeable sodium. (4) A nonsaline-alkali soil has less than 4 mmhos of conductance and more than 15 percent exchangeable sodium (*16*). In general, the severity of the problem increases in the same order as the conditions listed above.

Chemical tests made on some Kittson County soils are shown in Table 3 (*10*).

Field observations, aerial photographic interpretations, and laboratory data from Kittson County areas suggest the following conclusions:

1. There are areas where soluble salts are a problem. The most troublesome salts are those in combina-

Figure 12.—**Growth of small grain crop affected by soluble salts on Northcote soils.**

tion with Sodium (Na), Chloride (Cl) and Sulphates (SO_4).

2. The water from the deep wells is often brackish.

3. Saline soils in Kittson County occur on nearly level areas that have a high water table or where ground water seepage or artesian pressure occurs. Water rises above the water table as free water by capillary action (a wick-like process) and carries dissolved salts upward into the rooting zone. Likewise, soluble salts move downward in the soil when water percolates through the soil in the form of rain or snowmelt. This tends to reduce or dilute the salt content in the upper part of the soil. If a high water table is present, water and soluble salts will begin to move upward again, after percolation has stopped. This will occur as evaporation and transpiration by the plants remove water from the soils.

4. The prevention of a high water table and reduction of artesian pressure are likely factors to be considered in correcting saline soil conditions and in preventing the development of soil salinity.

Agronomic considerations

Effects on plant growth.—During the seed germination process, the embryo uses food stored within the seed. During germination and later growth stages, both water and oxygen are needed. The rate of water absorption by seeds is dependent in part on the salt content of the water. A small quantity of salt assists in the germination process, but large concentrations increase the osmotic pressure and reduce the rate of water intake and consequently reduce seed germination. With each day into the growing season, the tillage layer of a saline soil frequently accumulates an increasing concentration of soluble salts. This makes it less likely that late seedings will be able to grow. It is imperative that germination be early and uniform because the salt tolerance of the seedling is at a minimum. The soil salinity is lowest late in winter and in spring, because of seasonal leaching of the salts out of the tillage layer.

The harmful effects of high concentrations of salt on plant growth are: (1) reduction of water intake by plant roots because of the high osmotic pressure of the solution; (2) the toxicity of some salts in high concentrations; (3) water removed from root cells by osmotic pressure; (4) lack of availability of certain plant nutrients.

Soluble salts increase the osmotic concentration of nutrients in the soil solution. Plants take up less water from solutions of high osmotic concentrations. As soil and air temperatures increase, plants transpire more water. Equal concentrations of salt would be more harmful to plants growing in hot rather than cool climate. Plants growing in saline soils are subject to physiological drought. The degree of drought will vary with the concentration and kind of salts present (*11*).

The physical appearance of the crop varies with the stage of growth of the plant at the time of stress brought on by the saline condition and the degree of that stress. If stress occurs early in the growing season, the plants become spindly, yellow, and soon die (fig. 12). If stress occurs later in the growing season, crops develop a bluish green color in the basal leaves, and firing on the leaf tips and edges. This bluish color is the result of an unusually heavy waxy coating on the surface of the leaves, while the darker color is due to an increase in the chlorophyll content on the surface areas.

A word of caution should be noted concerning the physical appearance. Plants may also appear stunted and yellowish because of low fertility, a high lime condition, or excess soil moisture.

Trees planted for field windbreaks or for farmstead shelter belts are affected by soluble salt concentrations. Select only the most tolerant trees for planting in known areas of soluble salt concentrations.

Relative tolerance of crops to saline conditions

The following arrangement is in general order of tolerance of crops to saline conditions. Crops are grouped by high tolerance, moderate tolerance, and low tolerance. Under each heading, the most tolerant crop is at the top of each list and the amount of tolerance declines in descending order (*7*):

Field crops		
High tolerance	Moderate tolerance	Low tolerance
No crops have high tolerance. (In occasional years, particularly those with favorable moisture and cool temperatures, the most tolerant crops may do well on soils usually unsuitable for good yields of field crops.)	Sugar Beets (after emergence) Rape Safflower Barley Rye Oats Wheat (Hard Red Spring) Wheat (Durum) Sorghum	Corn Flax Sunflowers Soybeans Peas Field Beans Potatoes

Forage crops		
High tolerance	Moderate tolerance	Low tolerance
Tall wheatgrass Slender wheatgrass Russian wild rye Western wheatgrass Birdsfoot trefoil	Sweet clover Sudan grass Millet Sorghum Alfalfa (established) Crested wheatgrass Bromegrass Canada wild rye Reed canarygrass	Alfalfa (seedling) White Dutch clover Alsike clover Red clover

Management of saline areas.—A permanent correction of the saline condition requires the removal of the excess salts from the soil:

1. When artesian conditions exist, a logical consideration is pump drainage. This pumping will provide a sustained reduction of the artesian pressure, which will cause the water table to be reestablished at a lower elevation. The Agricultural Research Service has conducted some studies in the Grand Forks, North Dakota, area on this kind of system (*6*).

2. Another consideration is the installation of an

effective deep drainage system that permits flushing the soluble salts out of the plant rooting zone.

Because of the lack of water for flushing and the difficulties of organizing, planning, and implementing a pump drainage system, these two permanent solutions appear quite remote.

Temporary improvements could be accomplished by some of the following practices:

1. Planting crops that are tolerant of saline conditions.
2. Using straw mulch or managing crop residue during a fallow year (with weeds controlled) to reduce evaporation, maximize infiltration, and reduce salt concentration within the plant rooting zone (*4, 14*).
3. Seeding when soil is well supplied with moisture.
4. Seeding as early as possible using amounts that are about 20–30 percent greater than in nonsaline areas.
5. Presoaking seed in a saline or nutrient-rich solution to assure a quick, uniform germination (*9*).
6. Utilizing as much organic matter as possible to reduce the harmful effects of the salts.
7. Fertilizing to provide adequate amounts of nutrients for the growing crop.
8. Growing alfalfa or sweetclover to deplete water, to provide organic-matter content, and to improve the tilth, which improves permeability (*7*).

The salt regime is directly related to the water-balance system. Anything that is done to reduce the evapotranspiration, maintain surface infiltration, and increase soil drainage, should reduce the salt concentration in the plant rooting zone.

Areas of saline soils are known to change in degree of salinity, size, and productivity from year to year. This occurs because of the variability in rainfall, both in quantity and frequency of distribution. The infiltration of the surface and permeability of the substrata determine the extent of the flushing action of any moisture moving into and downward through the soil.

The texture and structure of the soil material greatly influence this water movement. Usually the finer the texture, the slower the water movement.

Capillary water movement is toward the surface when it is dryer than the substratum. At such times, some soil moisture moves upward, and with it whatever salts that are in solution. The quantity of salts depends upon their degree of solubility and the amount of moisture present.

As moisture is removed from the soil by plant roots or from the soil surface by evaporation, the remaining water still contains most of the salts, and the salt concentration in the soil solution increases.

Probably the best method of recognizing the saline areas is examination of the growth of the crops having low or moderate salt tolerance. Using air photos of areas of these crops in early August is presently a useful procedure.

Wildlife [5]

Soils directly affect the kind and amount of vegetation that is available to wildlife as food and cover, and they affect the development of water impoundments. The kind and abundance of wildlife that populate an area depend largely on the amount and distribution of food, cover, and water. If any one of these elements is missing, inadequate, or inaccessible, wildlife will either be scarce or will not inhabit the area. Manipulation of the types of cover usually causes changes in wildlife species composition and population levels. Although there are several elements that affect the presence and numbers of animals, land use is one of the more important factors. Conversely, the presence of good habitat does not necessarily insure the presence of high wildlife population. The Northcote map unit in its original condition produced prime waterfowl and prairie grouse habitat consisting of marshes, sedge meadows, and wet prairie grass areas. Elk were native before the settling of the area. The majority of this map unit, representative of the western part of the county, presently is used for production of small grains, sunflowers and sugar beets. Wildlife species associated with this land use pattern are primarily Hungarian partridge, jackrabbits, and songbirds. Waterfowl still migrate through the area, but population is very low. However, there is high potential to create or restore waterfowl-producing wetlands.

In contrast, the Cormant-Poppleton-Redby map unit is representative of the eastern part of the county. It supports extensive stands of poplar species and scattered areas of bur oak. Herbaceous cover consists mainly of such native species as big blue stem and prairie sandreedgrass. The farming in this area is diversified with an abundance of wildlife food and cover.

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

In table 4 the soils in the survey area are rated according to their potential to support the main kinds of wildlife habitat in the area. This information can be used in—

1. Planning the use of parks, wildlife refuges, nature study areas, and other developments for wildlife.
2. Selecting soils that are suitable for creating, improving, or maintaining specific elements of wildlife habitat.
3. Determining the intensity of management needed for each element of the habitat.
4. Determining areas that are suitable for acquisition to manage for wildlife.

The potential of the soil is rated good, fair, poor, or very poor. A rating of *good* means that the element of wildlife habitat or the kind of habitat is easily created, improved, or maintained. Few or no limitations affect management, and satisfactory results can be expected if the soil is used for the designated purpose. A rating of *fair* means that the element of wildlife habitat or kind of habitat can be created, improved, or maintained in most places. Moderate intensity of management and fairly frequent attention are required for satisfactory results. A rating of *poor* means that limitations are severe for the designated element or kind of wildlife habitat. Habitat can be created,

[5] JOHN W. BEDISH and ALLEN VAUGHN, biologists, Soil Conservation Service, helped prepare this section.

improved, or maintained in most places, but management is difficult and requires intensive effort. A rating of *very poor* means that restrictions for the element of wildlife habitat or kind of wildlife are very severe, and that unsatisfactory results can be expected. Wildlife habitat is impractical or even impossible to create, improve, or maintain in soils having such a rating.

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

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

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

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

Hardwood trees and the associated woody understory provide cover for wildlife and produce nuts or other fruits, buds, catkins, twigs, bark, or foliage that wildlife eat. Examples of native plants are oak, aspen, birch, hawthorn, dogwood, plum, maple, sumac, basswood, blackberry, grape, viburnum, blueberry, and willow. Examples of fruit-producing shrubs that are commercially available and suitable for planting on soils rated good are Russian-olive, honeysuckle, cherry, and crabapple. Major soil properties that affect growth of hardwood trees and shrubs are depth of the root zone, available water capacity, and wetness.

Coniferous plants are cone-bearing trees, shrubs, or ground cover that furnish habitat or supply food in the form of browse, seeds, or fruitlike cones. Examples are pine, spruce, cedar, and juniper. Major soil properties that affect the growth of coniferous plants are depth of the root zone, available water capacity, and wetness.

Shrubs are bushy woody plants that produce fruits, buds, twigs, bark, or foliage used by wildlife or that provide cover and shade for some species of wildlife. Examples are willow, indigo bush, snowberry, and wild plum. Major soil properties that affect the growth of shrubs are depth of the root zone, available water capacity, salinity, and moisture.

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

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

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

Openland wildlife habitat consists of croplands, pastures, meadows, and areas that are overgrown with grasses, herbs, shrubs, and vines. These areas produce grain and seed crops, grasses and legumes, and wild herbaceous plants. The kinds of wildlife attracted to these areas include sharptailed grouse, meadowlark, field sparrow, killdeer, rabbits, fox, and Hungarian partridge.

Woodland wildlife habitat consists of hardwoods or conifers or a mixture of both, with associated grasses, legumes, and wild herbaceous plants. Examples of wildlife attracted to this habitat are ruffed grouse, woodcock, thrushes, vireos, woodpeckers, tree squirrels, fox, raccoon, moose, deer, wolf, and black bear.

Wetland wildlife habitat consists of water-tolerant plants in open, marshy, or swampy shallow water areas. Examples of wildlife attracted to this habitat are ducks, geese, herons, shore birds, rails, kingfishers, muskrat, mink, and beaver.

Rangeland wildlife habitat consists of wild herbaceous plants and shrubs on range. Examples of wildlife attracted to this habitat are white-tailed deer, sharptailed grouse, and meadowlark.

Windbreak and environmental plantings [6]

The western half of Kittson County was originally prairie except for a narrow wooded band along the major drainageways. The eastern half of the county was covered by quaking aspen, balsam, poplar, dogwood, and bur oak, or open spaces that supported prairie vegetation. Some areas along drainageways in the eastern half had stands of cottonwood, box elder, green ash, American elm, and basswood.

Since woodland for use in commercial forest products is not important in Kittson County, this section deals with trees and shrubs for other purposes. Field windbreaks and farmstead windbreaks have been extensively planted since the early 1950's.

Windbreaks are established to protect livestock, buildings, and yards from wind and snow. Windbreaks also help protect fruit trees and gardens, and they furnish habitat for wildlife. Several rows of both

[6] JOHN HULTGREN, woodland conservationist, Soil Conservation Service, helped prepare this section.

TABLE 4.—*Wildlife*

[See text for definitions of "good," "fair," "poor," and "very

Soil name and map symbol	Potential for habitat elements				
	Grain and seed crops	Grasses and legumes	Wild herbaceous plants	Hardwood trees	Coniferous plants
Maddock: [1] 45	Poor	Fair	Fair	Fair	Poor
Borup: 46	Good	Good	Good	Fair	Poor
Colvin: 47	Good	Good	Good	Fair	Poor
Cashel: 50	Good	Good	Good	Fair	Poor
Augsburg: [1] 52	Good	Good	Good	Fair	Poor
Grimstad: [1] 59	Fair	Good	Good	Fair	Poor
Glyndon: [1] 60	Good	Good	Good	Fair	Poor
Arveson: [1] 61	Fair	Good	Good	Fair	Poor
Rockwell: [1] 63	Fair	Good	Good	Fair	Poor
Ulen: [1] 64	Fair	Good	Good	Fair	Poor
Foxhome: [1] 65	Fair	Good	Good	Fair	Poor
Bearden: 67	Good	Good	Good	Fair	Poor
Garnes: [1] 77	Good	Good	Good	Good	Fair
Bearden: 93, 93B	Good	Good	Good	Fair	Poor
Hangaard: [1] 111	Poor	Fair	Fair	Fair	Poor
Redby: [1] 116	Poor	Fair	Fair	Good	Fair
Cormant: [1] 117	Poor	Fair	Fair	Good	Fair
Enstrom: 145	Poor	Fair	Fair	Fair	Fair
Poppleton: [1] 148	Poor	Fair	Fair	Fair	Fair
Wahpeton: 157	Good	Good	Good	Fair	Poor
157B	Good	Good	Good	Fair	Poor
Haug: 187	Poor	Poor	Poor	Poor	Poor
Karlstad: [1] 205	Poor	Fair	Fair	Good	Fair

habitat potentials

poor." Absence of an entry indicates that the soil was not rated]

Potential for habitat elements—continued			Potential as habitat for—			
Shrubs	Wetland plants	Shallow water areas	Openland wildlife	Woodland wildlife	Wetland wildlife	Rangeland wildlife
Fair	Poor	Very poor	Fair	Fair	Very poor	Fair.
Fair	Good	Good	Good	Fair	Good	
	Good	Good	Good	Fair	Good	
Good	Fair	Fair	Good	Fair	Fair	Fair.
	Good	Good	Good	Fair	Good	
	Poor	Poor	Good	Fair	Poor	
	Poor	Poor	Good	Fair	Poor	
Fair	Good	Good	Good	Fair	Good	
	Good	Good	Good	Fair	Poor	
	Poor	Poor	Good	Fair	Poor	
	Poor	Poor	Good	Fair	Poor	
Fair	Poor	Poor	Good	Fair	Poor	Fair.
	Poor	Poor	Good	Good	Poor	
Fair	Poor	Poor	Good	Fair	Poor	Fair.
	Good	Good	Fair	Fair	Good	
	Fair	Fair	Fair	Good	Fair	
	Good	Good	Fair	Good	Good	
	Poor	Poor	Fair	Good	Poor	
	Poor	Poor	Fair	Good	Poor	
Poor	Poor	Poor	Good	Fair	Poor	Poor.
Poor	Poor	Very poor	Good	Fair	Very poor	Poor.
Poor	Good	Fair	Poor	Poor	Good	
	Poor	Very poor	Fair	Good	Very poor	

TABLE 4.—*Wildlife habitat*

Soil name and map symbol	Potential for habitat elements				
	Grain and seed crops	Grasses and legumes	Wild herbaceous plants	Hardwood trees	Coniferous plants
Marquette:					
[1] 242	Poor	Fair	Fair	Good	Fair
Lohnes:					
[1] 245	Poor	Fair	Fair	Fair	Poor
Pelan:					
[1] 280	Fair	Good	Good	Good	Fair
Fram:					
[1] 296	Good	Good	Good	Fair	Poor
Wheatville:					
[1] 343	Good	Good	Good	Fair	Poor
Percy:					
[1] 379	Poor	Fair	Good	Fair	Poor
[1] 383	Good	Good	Fair	Fair	Poor
[1] 384	Fair	Fair	Fair	Poor	Poor
Viking:					
[1] 403	Good	Good	Good	Fair	Poor
Mavie:					
[1] 412	Fair	Good	Good	Fair	Poor
Augsburg:					
[1] 424	Fair	Fair	Fair	Poor	Poor
Donaldson:					
[1] 425	Good	Good	Good	Fair	Poor
Foldahl:					
[1] 426	Fair	Good	Good	Fair	Poor
Fram:					
[1] 427	Good	Good	Good	Fair	Poor
Northcote:					
429, 429B	Good	Good	Good	Fair	Poor
Noyes:					
[1] 430	Good	Good	Good	Fair	Poor
Strandquist:					
[1] 432	Fair	Good	Good	Fair	Poor
Syrene:					
[1] 433	Poor	Fair	Good	Poor	Poor
[1] 435	Fair	Good	Good	Fair	Poor
Northcote:					
438	Fair	Fair	Fair	Poor	Poor
Grygla:					
[1] 482	Poor	Fair	Fair	Good	Fair
Markey:					
543	Poor	Poor	Poor	Poor	Poor
Cathro:					
544	Poor	Poor	Poor	Poor	Poor
Deerwood:					
547	Poor	Poor	Poor	Poor	Poor
Percy:					
[1] 581	Good	Good	Good	Fair	Poor

potentials—Continued

Potential for habitat elements—continued			Potential as habitat for—			
Shrubs	Wetland plants	Shallow water areas	Openland wildlife	Woodland wildlife	Wetland wildlife	Rangeland wildlife
	Very poor	Very poor	Fair	Good	Very poor	
Fair	Poor	Very poor	Fair	Fair	Very poor	Fair.
Fair	Poor	Poor	Fair	Good	Poor	
Fair	Poor	Poor	Good	Fair	Poor	Fair.
	Poor	Poor	Good	Fair	Poor	
	Good	Good	Poor	Poor	Good	
	Good	Good	Fair	Fair	Good	
	Good	Good	Fair	Poor	Good	
	Good	Good	Good	Fair	Good	
Fair	Good	Good	Good	Fair	Good	
	Good	Good	Fair	Poor	Good	
	Poor	Poor	Good	Fair	Poor	
	Poor	Poor	Good	Fair	Poor	
Fair	Poor	Poor	Good	Fair	Poor	Fair.
	Good	Good	Good	Fair	Good	
Fair	Good	Good	Good	Fair	Good	
Fair	Good	Good	Good	Fair	Good	
	Good	Good	Fair	Poor	Good	
	Good	Good	Fair	Fair	Good	
	Good	Good	Fair	Poor	Good	
	Good	Good	Fair	Good	Good	
	Good	Good	Very poor	Poor	Good	
	Good	Good	Poor	Poor	Good	
	Good	Good	Poor	Poor	Good	
	Good	Good	Good	Fair	Good	

TABLE 4.—*Wildlife habitat*

Soil name and map symbol	Potential for habitat elements				
	Grain and seed crops	Grasses and legumes	Wild herbaceous plants	Hardwood trees	Coniferous plants
Roliss:					
[1] 582	Good	Good	Good	Fair	Poor
Nereson:					
[1] 583	Good	Good	Good	Good	Fair
Bearden:					
[1] 908:					
Bearden part	Good	Good	Good	Fair	Poor
Fargo part	Good	Good	Good	Fair	Poor
Hegne:					
[1] 937:					
Hegne part	Good	Good	Good	Fair	Poor
Northcote part	Good	Good	Good	Fair	Poor
Northcote:					
[1] 991:					
Northcote part	Good	Good	Good	Fair	Poor
Wahpeton part	Good	Good	Good	Fair	Poor
Arveson:					
[1] 993:					
Arveson part	Poor	Fair	Fair	Poor	Poor
Cormant part	Poor	Fair	Fair	Poor	Poor
Rockwell:					
[1] 994:					
Rockwell part	Poor	Fair	Fair	Poor	Poor
Grygla part	Poor	Fair	Fair	Poor	Poor

[1] This mapping unit is made up of two or more dominant kinds of soil. See mapping unit description for the composition and behavior characteristics of the whole mapping unit.

broadleaved and coniferons species provide the most protection (fig. 13).

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

Environmental plantings help to beautify and screen homes and other buildings and to abate noise around them. The plants, shrubs, and trees are closely spaced. Healthy planting stock of suitable species planted properly on a well prepared site and maintained in good condition can insure a high degree of plant survival.

Table 5 shows the height that locally adapted trees and shrubs are expected to reach on various kinds of soils in 20 years. The estimates in table 5, based on measurements and observation of established plantings that have been given adequate care, can be used as a guide in planning windbreaks and screens. Additional information about planning windbreaks and screens and the planting and care of trees can be obtained from the local office of the Soil Conservation Service, Extension Service, or local nurserymen.

Recreation

Kittson County is primarily agricultural and lacks the lakes, landscape, and associated vegetation that would increase recreation potential. There is a potential for more overnight camping areas and wayside rests along the major highways.

Lake Bronson was created when the Army Corps of Engineers and the Public Works Administration, in 1939, constructed a dam across the south branch of the Two Rivers just south and east of the town of Lake Bronson. This facility is used extensively during the summer by tourists and in the fall by hunters.

The four water impoundment areas—Skull Lake, Lake Bronson, Joe River Wildlife Structure and Twin Lakes—are populated by waterfowl.

The soils of Kittson County are rated in table 6 according to limitations that affect their suitability for camp areas, picnic areas, playgrounds, and paths and trails. The ratings are based on such restrictive soil features as flooding, wetness, slopes, and texture of the surface layer. Not considered in these ratings, but important in evaluating a site, are location and accessibility of the area, size and shape of the area and its scenic quality, the ability of the soil to support vegetation, access to water, potential water impoundment

potentials—Continued

Potential for habitat elements—continued			Potential as habitat for—			
Shrubs	Wetland plants	Shallow water areas	Openland wildlife	Woodland wildlife	Wetland wildlife	Rangeland wildlife
Fair	Good	Good	Good	Fair	Good	
	Poor	Poor	Good	Good	Poor	
Fair	Poor	Fair	Good	Fair	Poor	Fair.
Poor	Good	Good	Good	Fair	Good	Poor.
	Good	Good	Good	Fair	Good	
	Good	Good	Good	Fair	Good	
	Good	Good	Good	Fair	Good	
Poor	Poor	Poor	Good	Fair	Poor	Poor.
Fair	Good	Good	Fair	Poor	Good	
	Good	Good	Fair	Poor	Good	
	Good	Good	Fair	Poor	Good	
	Good	Good	Fair	Poor	Good	

sites available, and either access to public sewer lines or capacity of the soil to absorb septic tank effluent. Soils subject to flooding are limited, in varying degree, for recreational use by the duration of flooding and the season when it occurs. Onsite assessment of height, duration, and frequency of flooding is essential in planning recreational facilities.

In table 6 the limitations of soils are rated as slight, moderate, or severe. *Slight* means that the soil properties are generally favorable and that the limitations are minor and easily overcome. *Moderate* means that the limitations can be overcome or alleviated by planning, design, or special maintenance. *Severe* means that soil properties are unfavorable and that limitations can be offset only by costly soil reclamation, special design, intensive maintenance, limited use, or by a combination of these measures.

The information in table 6 can be supplemented by additional information in other parts of this survey. Especially helpful are interpretations for septic tank absorption fields, given in table 9, and interpretations for dwellings without basements and for local roads and streets, given in table 7.

Camp areas require such site preparation as shaping and leveling tent and parking areas, stabilizing roads and intensively used areas, and installing sanitary facilities and utility lines. Camp areas are subject to intensive foot traffic and some vehicular traffic. The best soils for this use have nearly level 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. Steep slopes and stones or boulders can greatly increase the cost of constructing camping sites.

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

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

Paths and trails need a design and layout for walking, horseback riding, and bicycling that requires little

Figure 13.—One row field windbreak planted on Northcote soils.

or no cutting and filling. The soils suitable for this use are those that are not wet, are firm after rains, are not dusty when dry, and are not subject to flooding more than once during the period of use. They should have moderate slopes and few or no stones or boulders on the surface.

Engineering[7]

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

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

[7] RICHARD CULLEN, engineer, Soil Conservation Service, assisted in preparation of this section.

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

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

These factors of soil behavior affect construction and maintenance of roads, airport runways, pipelines, foundations for small buildings, ponds and small dams, irrigation projects, drainage systems, sewage and refuse disposal systems, and other engineering works.

TABLE 5.—*Windbreaks and environmental plantings*

[The symbol < means less than; the symbol > means more than. Absence of an entry indicates that trees generally do not grow to the given height on that soil]

Soil name and map symbol	Trees having predicted 20-year average heights, in feet, of—				
	<8	8–15	16–25	26–35	>35
Maddock: [1]45		Eastern redcedar, northern white-cedar, Russian-olive, Siberian crabapple, Tartarian honeysuckle, Siberian peashrub.	Siberian elm, hackberry, American elm, green ash, ponderosa pine.		
Borup: 46		Redosier dogwood, Tartarian honeysuckle, Siberian peashrub, tall purple willow.	Russian-olive, eastern redcedar, northern white-cedar.	American elm, green ash.	Eastern cottonwood, golden willow, Siberian elm.
Colvin: 47		Tartarian honeysuckle, Siberian peashrub, American plum, redosier dogwood, common chokecherry, tall purple willow.	Blue spruce, eastern redcedar, Russian-olive, northern white-cedar.	Green ash, American elm.	Eastern cottonwood, golden willow, Siberian elm.
Cashel: 50		Eastern redcedar, common chokecherry, Siberian peashrub, Tartarian honeysuckle, American plum.	Ponderosa pine, Black Hills spruce, blue spruce.	Siberian elm, American elm, green ash.	Eastern cottonwood.
Augsburg: [1]52		Medium purple willow, redosier dogwood, Tartarian honeysuckle, Siberian peashrub.	Russian-olive	Green ash, American elm.	Eastern cottonwood, golden willow, Siberian elm.
Grimstad: [1]59		Tartarian honeysuckle, Siberian peashrub.	Eastern redcedar, white spruce, blue spruce.	Green ash, Russian-olive.	Eastern cottonwood, Siberian elm.
Glyndon: [1]60		Tall purple willow, northern white-cedar, silver buffaloberry, Tartarian honeysuckle.	Eastern redcedar, white spruce.	Green ash, Russian-olive, golden willow, American elm.	Eastern cottonwood, Siberian elm.
Arveson: [1]61		Tall purple willow, redosier dogwood, Tartarian honeysuckle, Siberian peashrub.	Russian-olive, eastern redcedar, northern white-cedar.	Green ash, American elm.	Eastern cottonwood, golden willow, Siberian elm.
Rockwell: [1]63		Tall purple willow, redosier dogwood, Tartarian honeysuckle, Siberian peashrub.	Russian-olive, eastern redcedar, northern white-cedar.	Green ash, American elm.	Eastern cottonwood, golden willow, Siberian elm.
Ulen: [1]64		Eastern redcedar, Russian-olive, Siberian crabapple, silver buffaloberry, Tartarian honeysuckle, Siberian peashrub.	Red pine, jack pine, ponderosa pine, Austrian pine, hackberry.	Siberian elm, eastern cottonwood.	

TABLE 5.—*Windbreaks and environmental plantings*—Continued

Soil name and map symbol	Trees having predicted 20-year average heights, in feet, of—				
	<8	8–15	16–25	26–35	>35
Foxhome: [1]65		Lilac, Tartarian honeysuckle.	Black Hills spruce, northern white-cedar, Amur maple, western redcedar, Siberian crabapple.	Hackberry, ponderosa pine, green ash.	Eastern cottonwood.
Bearden: 67		Eastern redcedar, common chokecherry, Siberian peashrub, Tartarian honeysuckle, American plum.	Ponderosa pine, Black Hills spruce.	Siberian elm, American elm, green ash.	Eastern cottonwood.
Garnes: [1]77		Lilac, redosier dogwood, Tartarian honeysuckle.	Northern white-cedar, Amur maple, Black Hills spruce, Siberian crabapple, medium purple willow.	Green ash, hackberry, jack pine.	Silver maple, Siberian elm, American elm.
Bearden: 93, 93B		Eastern redcedar, common chokecherry, Siberian peashrub, Tartarian honeysuckle, American plum.	Ponderosa pine, Black Hills spruce.	Siberian elm, American elm, green ash.	Eastern cottonwood.
Hangaard: [1]111		Tartarian honeysuckle, lilac, northern white-cedar, redosier dogwood, medium purple willow.	Amur maple, white spruce.	Green ash, silver maple, golden willow.	Siberian elm, eastern cottonwood.
Redby: [1]116		Eastern redcedar, Russian-olive, Siberian crabapple, silver buffaloberry, Tartarian honeysuckle, Siberian peashrub.	Red pine, jack pine, ponderosa pine, Austrian pine, hackberry.	Silver maple, Siberian elm.	
Cormant: [1]117		Northern white-cedar, tall purple willow, redosier dogwood, Tartarian honeysuckle, lilac, eastern redcedar.	White spruce, Amur maple.	Golden willow, green ash, silver maple.	Eastern cottonwood.
Enstrom: 145		Eastern redcedar, lilac, silver buffaloberry, Tartarian honeysuckle.	Ponderosa pine, green ash, Russian-olive, Siberian crabapple.	Eastern white pine, jack pine, golden willow.	Eastern cottonwood.
Poppleton: [1]148		Eastern redcedar, northern white-cedar, Russian-olive, Siberian crabapple, Tartarian honeysuckle, Siberian peashrub.	Red pine, hackberry, green ash.	Silver maple, Siberian elm.	

TABLE 5.—*Windbreaks and environmental plantings*—Continued

Soil name and map symbol	Trees having predicted 20-year average heights, in feet, of—				
	<8	8–15	16–25	26–35	>35
Wahpeton: 157, 157B		Eastern redcedar, common chokecherry, Siberian peashrub, Tartarian honeysuckle, American plum.	Ponderosa pine, Black Hills spruce, blue spruce.	Siberian elm, American elm, green ash.	Eastern cottonwood.
Haug: 187.					
Karlstad: [1] 205		Eastern redcedar, Russian-olive, Siberian crabapple, silver buffaloberry, Tartarian honeysuckle, Siberian peashrub.	Red pine, jack pine, Austrian pine, hackberry, green ash.	Siberian elm	
Marquette: [1] 242		Eastern redcedar, Russian-olive, Siberian crabapple, silver buffaloberry, Tartarian honeysuckle, Siberian peashrub.	Red pine, jack pine, Austrian pine, hackberry, green ash.	Siberian elm	
Lohnes: [1] 245		Rocky Mountain juniper, eastern redcedar, Russian-olive, Tartarian honeysuckle, Siberian peashrub.	Siberian elm, hackberry, green ash, ponderosa pine.		
Pelan: [1] 280		Lilac, redosier dogwood, Tartarian honeysuckle.	Black Hills spruce, northern white-cedar, Amur maple, western redcedar, Siberian crabapple.	Hackberry, jack pine, green ash.	Eastern cottonwood.
Fram: [1] 296		Rocky Mountain juniper, common chokecherry, Siberian peashrub.	Ponderosa pine, Black Hills spruce, blue spruce, Russian-olive, eastern redcedar.	American elm, green ash.	Eastern cottonwood, Siberian elm.
Wheatville: [1] 343		Tall purple willow, northern white-cedar, Siberian peashrub, silver buffaloberry, Tartarian honeysuckle.	Eastern redcedar, white spruce.	Green ash, Russian-olive, golden willow.	Eastern cottonwood, Siberian elm.
Percy: [1] 379, [1,2] 384		Tartarian honeysuckle, tall purple willow, Siberian peashrub, redosier dogwood.	Siberian crabapple, Russian-olive.	Green ash	Golden willow, Siberian elm, eastern cottonwood.
[1] 383		Tartarian honeysuckle, tall purple willow, Siberian peashrub, redosier dogwood.	Siberian crabapple, Russian-olive.	Green ash	Golden willow, Siberian elm, eastern cottonwood.

TABLE 5.—*Windbreaks and environmental plantings*—Continued

Soil name and map symbol	Trees having predicted 20-year average heights, in feet, of—				
	< 8	8–15	16–25	26–35	> 35
Viking: [1]403		Tall purple willow, redosier dogwood, Tartarian honeysuckle, Siberian peashrub.	Russian-olive, eastern redcedar, northern white-cedar.	Green ash, American elm.	Eastern cottonwood, golden willow, Siberian elm.
Mavie: [1]412		Redosier dogwood, lilac, Tartarian honeysuckle.	Medium purple willow, northern white-cedar, Black Hills spruce, Siberian crabapple.	Green ash, hackberry, ponderosa pine.	Eastern cottonwood, silver maple.
[2]Augsburg: [1]424		Medium purple willow, redosier dogwood, Tartarian honeysuckle, Siberian peashrub.	Russian-olive, northern white-cedar, eastern redcedar.	Green ash, American elm.	Eastern cottonwood, golden willow, Siberian elm.
Donaldson: [1]425		Tartarian honeysuckle, lilac, redosier dogwood.	Siberian crabapple, Black Hills spruce, Amur maple, northern white-cedar.	Green ash, ponderosa pine, hackberry.	Eastern cottonwood, silver maple.
Foldahl: [1]426		Siberian crabapple, Tartarian honeysuckle, lilac, Siberian peashrub, redosier dogwood.	Eastern redcedar, Black Hills spruce, ponderosa pine, northern white-cedar, hackberry.	Green ash, Siberian elm.	Eastern cottonwood.
Fram: [1]427		Eastern redcedar, Rocky Mountain juniper, common chokecherry, Siberian peashrub.	Ponderosa pine, Black Hills spruce, blue spruce, Russian-olive.	American elm, green ash.	Eastern cottonwood, Siberian elm.
Northcote: 429, 429B		Northern white-cedar, medium purple willow, redosier dogwood, Tartarian honeysuckle, lilac.	Blue spruce, Amur maple.	Golden willow, green ash.	Eastern cottonwood, Siberian elm.
Noyes: [1]430		Redosier dogwood, Tartarian honeysuckle, northern white-cedar, lilac, medium purple willow.	Black Hills spruce, Amur maple.	Green ash, golden willow, silver maple.	Eastern cottonwood, Siberian elm.
Strandquist: [1]432		Northern white-cedar, medium purple willow, redosier dogwood, Tartarian honeysuckle, lilac.	White spruce, Amur maple.	Green ash, golden willow, silver maple.	Eastern cottonwood, Siberian elm.
[2]Syrene: [1]433, [1]435		Northern white-cedar, redosier dogwood, Tartarian honeysuckle, medium purple willow, lilac.	Black Hills spruce, Amur maple, Russian-olive.	Golden willow, green ash.	Eastern cottonwood, Siberian elm.

TABLE 5.—*Windbreaks and environmental plantings*—Continued

Soil name and map symbol	Trees having predicted 20-year average heights, in feet, of—				
	<8	8–15	16–25	26–35	>35
[2]Northcote: 438		Northern white-cedar, medium purple willow, redosier dogwood, Tartarian honeysuckle, lilac.	Blue spruce, Amur maple.	Golden willow, green ash.	Eastern cottonwood.
Grygla: [1]482		Northern white-cedar, medium purple willow, redosier dogwood, Tartarian honeysuckle, lilac.	White spruce, Amur maple.	Golden willow, green ash.	Eastern cottonwood.
Markey: 543					
Cathro: 544					
Deerwood: 547					
Percy: [1]581		Amur honeysuckle, tall purple willow, Siberian peashrub, redosier dogwood.	Siberian crabapple, Russian-olive.	Green ash	Golden willow, Siberian elm, eastern cottonwood.
Roliss: [1]582		Northern white-cedar, Tartarian honeysuckle, lilac, eastern redcedar.	Blue spruce, hackberry, Amur maple, Russian-olive.	Green ash, silver maple, American elm.	Siberian elm.
Nereson: [1]583		Redosier dogwood, Tartarian honeysuckle, lilac.	White spruce, Amur maple, northern white-cedar, Siberian crabapple, medium purple willow.	Jack pine, hackberry, green ash.	Silver maple.
Bearden: [1]908:					
Bearden part		Eastern redcedar, common chokecherry, Siberian peashrub, Tartarian honeysuckle, American plum.	Ponderosa pine, Black Hills spruce.	Siberian elm, American elm, green ash.	Eastern cottonwood.
Fargo part		Common chokecherry, Rocky Mountain juniper, Siberian peashrub, Tartarian honeysuckle.	Ponderosa pine, Black Hills spruce, blue spruce.	Siberian elm, American elm, green ash.	Eastern cottonwood.
Hegne: [1]937:					
Hegne part		Redosier dogwood, Tartarian honeysuckle, Siberian peashrub, tall purple willow.	Russian-olive, eastern redcedar, northern white-cedar.	American elm, green ash.	Eastern cottonwood, golden willow, Siberian elm.
Northcote part		Northern white-cedar, medium purple willow, redosier dogwood, Tartarian honeysuckle, lilac.	Blue spruce, Amur maple.	Golden willow, green ash.	Eastern cottonwood, Siberian elm.

TABLE 5.—*Windbreaks and environmental plantings*—Continued

Soil name and map symbol	Trees having predicted 20-year average heights, in feet, of—				
	< 8	8–15	16–25	26–35	> 35
Northcote: [1] 991:					
Northcote part		Northern white-cedar, medium purple willow, redosier dogwood, Tartarian honeysuckle, lilac.	Blue spruce, Amur maple.	Golden willow, green ash.	Eastern cottonwood, Siberian elm.
Wahpeton part		Eastern redcedar, common chokecherry, Siberian peashrub, Tartarian honeysuckle, American plum.	Ponderosa pine, Black Hills spruce, blue spruce.	Siberian elm, American elm, green ash.	Eastern cottonwood.
Arveson: [1] 993:					
[2] Arveson part		Tall purple willow, redosier dogwood, Tartarian honeysuckle, Siberian peashrub.	Russian-olive, eastern redcedar, northern white-cedar.	Green ash, American elm.	Eastern cottonwood, golden willow, Siberian elm.
[2] Cormant part		Northern white-cedar, tall purple willow, redosier dogwood, Tartarian honeysuckle, lilac, eastern redcedar.	White spruce, Amur maple.	Golden willow, green ash, silver maple.	Eastern cottonwood.
Rockwell: [1] 994:					
[2] Rockwell part		Tall purple willow, redosier dogwood, Tartarian honeysuckle, Siberian peashrub.	Russian-olive, eastern redcedar, northern white-cedar.	Green ash, American elm.	Eastern cottonwood, golden willow, Siberian elm.
[2] Grygla part		Northern white-cedar, medium purple willow, redosier dogwood, Tartarian honeysuckle, lilac.	White spruce, Amur maple.	Golden willow, green ash.	Eastern cottonwood.

[1] This mapping unit is made up of two or more dominant kinds of soil. See description of the mapping unit for composition and behavior characteristics of the whole mapping unit.

[2] This is a depressional soil and is suitable for trees only if adequately drained.

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

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

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

The information in the tables, along with the soil map, the soil descriptions, and other data provided in

TABLE 6.—*Recreational development*

["Percs slowly" and some of the other terms that describe restrictive soil features are defined in the Glossary. See text for definitions of "slight," "moderate," and "severe"]

Soil name and map symbol	Camp areas	Picnic areas	Playgrounds	Paths and trails
Maddock: [1]45	Moderate: too sandy	Moderate: too sandy	Moderate: too sandy	Moderate: too sandy.
Borup: 46	Severe: wetness	Severe: wetness	Severe: wetness	Severe: wetness.
Colvin: 47	Severe: wetness	Severe: wetness	Severe: wetness	Severe: wetness.
Cashel: 50	Severe: floods, too clayey, wetness.	Severe: too clayey, floods, wetness.	Severe: too clayey, floods, wetness.	Severe: too clayey, floods, wetness.
Augsburg: [1]52	Severe: wetness	Severe: wetness	Severe: wetness	Severe: wetness.
Grimstad: [1]59	Slight	Slight	Slight	Slight.
Glyndon: [1]60	Slight	Slight	Slight	Slight.
Arveson: [1]61	Severe: wetness	Severe: wetness	Severe: wetness	Severe: wetness.
Rockwell: [1]63	Severe: wetness	Severe: wetness	Severe: wetness	Severe: wetness.
Ulen: [1]64	Slight	Slight	Slight	Slight.
Foxhome: [1]65	Slight	Slight	Slight	Slight.
Bearden: 67	Slight	Slight	Slight	Slight.
Garnes: [1]77	Slight	Slight	Slight	Slight.
Bearden: 93, 93B	Moderate: too clayey.	Moderate: too clayey	Moderate: too clayey	Moderate: too clayey.
Hangaard: [1]111	Severe: wetness	Severe: wetness	Severe: wetness	Severe: wetness.
Redby: [1]116	Moderate: too sandy, wetness.	Moderate: too sandy, wetness.	Moderate: too sandy, wetness.	Moderate: too sandy, wetness.
Cormant: [1]117	Severe: wetness, too sandy.	Severe: wetness, too sandy.	Severe: wetness, too sandy.	Severe: wetness, too sandy.
Enstrom: 145	Moderate: too sandy	Moderate: too sandy	Moderate: too sandy	Moderate: too sandy.
Poppleton: [1]148	Moderate: too sandy	Moderate: too sandy	Moderate: too sandy	Moderate: too sandy.
Wahpeton: 157, 157B	Severe: too clayey	Severe: too clayey	Severe: too clayey	Severe: too clayey.
Haug: 187	Severe: wetness, floods, excess humus.	Severe: wetness, floods, excess humus.	Severe: wetness, floods, excess humus.	Severe: wetness, floods, excess humus.
Karlstad: [1]205	Moderate: too sandy	Moderate: too sandy	Moderate: too sandy	Moderate: too sandy.

TABLE 6.—*Recreational development*—Continued

Soil name and map symbol	Camp areas	Picnic areas	Playgrounds	Paths and trails
Marquette: [1] 242	Moderate: too sandy	Moderate: too sandy	Moderate: too sandy	Moderate: too sandy.
Lohnes: [1] 245	Moderate: too sandy	Moderate: too sandy	Moderate: too sandy	Moderate: too sandy.
Pelan: [1] 280	Moderate: too sandy	Moderate: too sandy	Moderate: too sandy	Moderate: too sandy.
Fram: [1] 296	Slight	Slight	Slight	Slight.
Wheatville: [1] 343	Slight	Slight	Slight	Slight.
Percy: [1] 379	Severe: wetness, large stones.	Severe: wetness, large stones.	Severe: wetness, large stones.	Severe: wetness, large stones.
[1] 383	Severe: wetness	Severe: wetness	Severe: wetness	Severe: wetness.
[1] 384	Severe: wetness, floods.	Severe: wetness	Severe: wetness, floods.	Severe: wetness.
Viking: [1] 403	Severe: too clayey, wetness.	Severe: too clayey, wetness.	Severe: too clayey, wetness.	Severe: too clayey, wetness.
Mavie: [1] 412	Severe: wetness	Severe: wetness	Severe: wetness	Severe: wetness.
Augsburg: [1] 424	Severe: wetness, floods.	Severe: wetness	Severe: wetness, floods.	Severe: wetness.
Donaldson: [1] 425	Slight	Slight	Slight	Slight.
Foldahl: [1] 426	Slight	Slight	Slight	Slight.
Fram: [1] 427	Slight	Slight	Slight	Slight.
Northcote: 429, 429B	Severe: wetness, percs slowly, too clayey.	Severe: wetness, too clayey.	Severe: wetness, too clayey, percs slowly.	Severe: wetness, too clayey.
Noyes: [1] 430	Severe: wetness	Severe: wetness	Severe: wetness	Severe: wetness.
Strandquist: [1] 432	Severe: wetness	Severe: wetness	Severe: wetness	Severe: wetness.
Syrene: [1] 433, [1] 435	Severe: wetness	Severe: wetness	Severe: wetness	Severe: wetness.
Northcote: 438	Severe: wetness, percs slowly, too clayey.	Severe: wetness, too clayey.	Severe: wetness, too clayey, percs slowly.	Severe: wetness, too clayey.
Grygla: [1] 482	Severe: wetness, too sandy.	Severe: wetness, too sandy.	Severe: wetness, too sandy.	Severe: wetness, too sandy.
Markey: 543	Severe: wetness, floods, excess humus.	Severe: wetness, floods, excess humus.	Severe: wetness, floods, excess humus.	Severe: wetness, floods, excess humus.
Cathro: 544	Severe: wetness, floods, excess humus.	Severe: wetness, floods, excess humus.	Severe: wetness, floods, excess humus.	Severe: wetness, floods, excess humus.

TABLE 6.—*Recreational development*—Continued

Soil name and map symbol	Camp areas	Picnic areas	Playgrounds	Paths and trails
Deerwood: 547	Severe: wetness, floods, excess humus.	Severe: wetness, floods, excess humus.	Severe: wetness, floods, excess humus.	Severe: wetness, floods, excess humus.
Percy: [1] 581	Severe: wetness	Severe: wetness	Severe: wetness	Severe: wetness.
Roliss: [1] 582	Severe: wetness	Severe: wetness	Severe: wetness	Severe: wetness.
Nereson: [1] 583	Slight	Slight	Slight	Slight.
Bearden: [1] 908:				
Bearden part	Slight	Slight	Slight	Slight.
Fargo part	Severe: wetness	Severe: wetness	Severe: wetness	Severe: wetness.
Hegne: [1] 937:				
Hegne part	Severe: wetness, too clayey.	Severe: wetness, too clayey.	Severe: wetness, too clayey.	Severe: wetness, too clayey.
Northcote part	Severe: wetness, percs slowly, too clayey.	Severe: wetness, too clayey.	Severe: wetness, too clayey, percs slowly.	Severe: wetness, too clayey.
Northcote: [1] 991:				
Northcote part	Severe: wetness, percs slowly, too clayey.	Severe: wetness, too clayey.	Severe: wetness, too clayey, percs slowly.	Severe: wetness, too clayey.
Wahpeton part	Severe: too clayey	Severe: too clayey	Severe: too clayey	Severe: too clayey.
Arveson: [1] 993:				
Arveson part	Severe: wetness, floods.	Severe: wetness	Severe: wetness, floods.	Severe: wetness.
Cormant part	Severe: wetness, too sandy, floods.	Severe: wetness, too sandy.	Severe: wetness, too sandy, floods.	Severe: wetness, too sandy.
Rockwell: [1] 994:				
Rockwell part	Severe: wetness, floods.	Severe: wetness	Severe: wetness, floods.	Severe: wetness.
Grygla part	Severe: wetness, too sandy, floods.	Severe: wetness, too sandy.	Severe: wetness, too sandy, floods.	Severe: wetness, too sandy.

[1] This mapping unit is made up of two or more dominant kinds of soil. See description of the mapping unit for composition and behavior characteristics of the whole mapping unit.

this survey can be used to make additional interpretations and to construct interpretive maps for specific uses of land.

Some of the terms used in this soil survey have different meanings in soil science and in engineering; the Glossary defines many of these terms.

Building site development

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

Shallow excavations are used for pipelines, sewerlines, telephone and power transmission lines, basements, open ditches, and cemeteries. Such digging or

TABLE 7.—*Building site development*

["Shrink-swell" and some of the other terms that describe restrictive soil features are defined in the Glossary. See text for definitions of "slight," "moderate," and "severe"]

Soil name and map symbol	Shallow excavations	Dwellings without basements	Dwellings with basements	Small commercial buildings	Local roads and streets
Maddock: [1] 45	Severe: cutbanks cave.	Slight	Slight	Slight	Slight.
Borup: 46	Severe: wetness, cutbanks cave.	Severe: wetness, frost action.	Severe: wetness	Severe: wetness, frost action.	Severe: wetness, frost action.
Colvin: 47	Severe: wetness	Severe: wetness, frost action.	Severe: wetness	Severe: wetness, frost action.	Severe: wetness, frost action.
Cashel: 50	Severe: floods, too clayey.	Severe: floods, shrink-swell, frost action.	Severe: floods, shrink-swell.	Severe: floods, shrink-swell, frost action.	Severe: floods, shrink-swell, frost action.
Augsburg: [1] 52	Severe: wetness	Severe: wetness, frost action, shrink-swell.	Severe: wetness, shrink-swell.	Severe: wetness, frost action, shrink-swell.	Severe: wetness, frost action, shrink-swell.
Grimstad: [1] 59	Moderate: wetness.	Severe: frost action.	Moderate: wetness, shrink-swell.	Severe: frost action.	Severe: frost action.
Glyndon: [1] 60	Severe: cutbanks cave.	Severe: frost action.	Moderate: wetness.	Severe: frost action.	Severe: frost action.
Arveson: [1] 61	Severe: wetness, cutbanks cave.	Severe: wetness, frost action.	Severe: wetness	Severe: wetness, frost action.	Severe: wetness, frost action.
Rockwell: [1] 63	Severe: wetness	Severe: wetness, frost action.	Severe: wetness	Severe: wetness, frost action.	Severe: wetness, frost action.
Ulen: [1] 64	Severe: cutbanks cave.	Moderate: frost action.	Moderate: wetness.	Moderate: frost action.	Moderate: frost action.
Foxhome: [1] 65	Moderate: wetness.	Severe: frost action.	Moderate: wetness, shrink-swell.	Severe: frost action.	Severe: frost action.
Bearden: 67	Moderate: wetness.	Severe: frost action.	Moderate: wetness, shrink-swell.	Severe: frost action.	Severe: frost action.
Garnes: [1] 77	Moderate: wetness.	Severe: frost action.	Moderate: wetness.	Severe: frost action.	Severe: frost action.
Bearden: 93, 93B	Moderate: wetness.	Severe: frost action.	Moderate: wetness, shrink-swell.	Severe: frost action.	Severe: frost action.
Hangaard: [1] 111	Severe: wetness, cutbanks cave.	Severe: wetness	Severe: wetness	Severe: wetness	Severe: wetness.
Redby: [1] 116	Severe: wetness, cutbanks cave.	Moderate: wetness, frost action.	Severe: wetness	Moderate: wetness, frost action.	Moderate: wetness, frost action.

TABLE 7.—*Building site development*—Continued

Soil name and map symbol	Shallow excavations	Dwellings without basements	Dwellings with basements	Small commercial buildings	Local roads and streets
Cormant: [1] 117	Severe: wetness, cutbanks cave.	Severe: wetness	Severe: wetness	Severe: wetness	Severe: wetness.
Enstrom: 145	Moderate: wetness.	Severe: frost action.	Moderate: wetness, shrink-swell.	Severe: frost action.	Severe: frost action.
Poppleton: [1] 148	Severe: cutbanks cave.	Moderate: frost action.	Moderate: wetness.	Moderate: frost action.	Moderate: frost action.
Wahpeton: 157, 157B	Severe: too clayey, floods.	Severe: shrink-swell, floods, frost action.	Severe: shrink-swell, floods.	Severe: shrink-swell, floods, frost action.	Severe: shrink-swell, floods, frost action.
Haug: 187	Severe: wetness, floods.	Severe: wetness, frost action, floods.	Severe: wetness, floods.	Severe: wetness, frost action, floods.	Severe: wetness, floods, frost action.
Karlstad: [1] 205	Severe: cutbanks cave.	Moderate: frost action.	Moderate: wetness.	Moderate: frost action.	Slight.
Marquette: [1] 242	Severe: cutbanks cave.	Slight	Slight	Slight	Slight.
Lohnes: [1] 245	Severe: cutbanks cave.	Slight	Slight	Slight	Slight.
Pelan: [1] 280	Moderate: wetness.	Severe: frost action.	Moderate: wetness.	Severe: frost action.	Severe: frost action.
Fram: [1] 296	Moderate: wetness.	Severe: frost action.	Moderate: wetness.	Severe: frost action.	Severe: frost action.
Wheatville: [1] 343	Moderate: wetness.	Severe: frost action, shrink-swell.	Severe: shrink-swell.	Severe: frost action, shrink-swell.	Severe: frost action, shrink-swell.
Percy: [1] 379	Severe: wetness, large stones.	Severe: weness, frost action, large stones.	Severe: wetness, large stones.	Severe: wetness, frost action, large stones.	Severe: wetness, frost action, large stones.
[1] 383	Severe: wetness	Severe: wetness, frost action.	Severe: wetness	Severe: wetness, frost action.	Severe: wetness, frost action.
[1] 384	Severe: wetness, floods.	Severe: wetness, frost action, floods.	Severe: wetness, floods.	Severe: wetness, frost action, floods.	Severe: wetness, frost action, floods.
Viking: [1] 403	Severe: too clayey, wetness.	Severe: shrink-swell, wetness.	Severe: shrink-swell, wetness.	Severe: shrink-swell, wetness.	Severe: shrink-swell, wetness.
Mavie: [1] 412	Severe: wetness	Severe: wetness, frost action.	Severe: wetness	Severe: wetness, frost action.	Severe: wetness, frost action.
Augsburg: [1] 424	Severe: wetness, floods.	Severe: wetness, frost action, floods.	Severe: wetness, floods.	Severe: wetness, frost action, floods.	Severe: wetness, frost action, floods.

TABLE 7.—*Building site development*—Continued

Soil name and map symbol	Shallow excavations	Dwellings without basements	Dwellings with basements	Small commercial buildings	Local roads and streets
Donaldson: [1]425	Moderate: too clayey, wetness.	Severe: shrink-swell, frost action.	Severe: shrink-swell.	Severe: shrink-swell, frost action.	Severe: shrink-swell, frost action.
Foldahl: [1]426	Moderate: wetness.	Severe: frost action.	Moderate: wetness.	Severe: frost action.	Severe: frost action.
Fram: [1]427	Moderate: wetness.	Severe: frost action.	Moderate: wetness.	Severe: frost action.	Severe: frost action.
Northcote: 429, 429B	Severe: wetness, too clayey.	Severe: wetness, shrink-swell, frost action.	Severe: wetness, shrink-swell.	Severe: wetness, shrink-swell, frost action.	Severe: wetness, shrink-swell, frost action.
Noyes: [1]430	Severe: too clayey, wetness.	Severe: shrink-swell, wetness, low strength.	Severe: shrink-swell, wetness, low strength.	Severe: shrink-swell, wetness, low strength.	Severe: shrink-swell, wetness, low strength.
Strandquist: [1]432	Severe: wetness	Severe: wetness, frost action	Severe: wetness	Severe: wetness, frost action.	Severe: wetness, frost action.
Syrene: [1]433, [1]435	Severe: wetness, cutbanks cave.	Severe: wetness	Severe: wetness	Severe: wetness	Severe: wetness.
Northcote: 438	Severe: wetness, too clayey, floods.	Severe: wetness, shrink-swell, frost action.	Severe: wetness, shrink-swell.	Severe: wetness, shrink-swell, frost action.	Severe: wetness, shrink-swell, frost action.
Grygla: [1]482	Severe: wetness	Severe: wetness, frost action.	Severe: wetness	Severe: wetness, frost action.	Severe: wetness, frost action.
Markey: 543	Severe: wetness, floods, cutbanks cave.	Severe: wetness, floods, frost action.	Severe: wetness, floods.	Severe: wetness, floods, frost action.	Severe: wetness, frost action, floods.
Cathro: 544	Severe: wetness, floods.	Severe: wetness, floods, frost action.	Severe: wetness, floods.	Severe: wetness, floods, frost action.	Severe: wetness, frost action, floods.
Deerwood: 547	Severe: excess humus, floods, wetness.	Severe: excess humus, floods, wetness.	Severe: excess humus, floods, wetness.	Severe: excess humus, floods, wetness.	Severe: excess humus, floods, wetness.
Percy: [1]581	Severe: wetness	Severe: wetness, frost action.	Severe: wetness	Severe: wetness, frost action.	Severe: wetness, frost action.
Roliss: [1]582	Severe: wetness	Severe: wetness, frost action.	Severe: wetness	Severe: wetness, frost action.	Severe: wetness, frost action.
Nereson: [1]583	Moderate: wetness.	Severe: frost action.	Moderate: wetness.	Severe: frost action.	Severe: frost action.
Bearden: [1]908: Bearden part	Moderate: wetness.	Severe: frost action.	Moderate: wetness, shrink-swell.	Severe: frost action.	Severe: frost action.

TABLE 7.—*Building site development*—Continued

Soil name and map symbol	Shallow excavations	Dwellings without basements	Dwellings with basements	Small commercial buildings	Local roads and streets
Bearden, cont.: Fargo part	Severe: too clayey, wetness.	Severe: shrink-swell, frost action, wetness.	Severe: shrink-swell, wetness.	Severe: shrink-swell, frost action, wetness.	Severe: shrink-swell, frost action, wetness.
Hegne: [1] 937: Hegne part	Severe: wetness, too clayey.	Severe: wetness, shrink-swell, frost action.	Severe: wetness, shrink-swell.	Severe: wetness, shrink-swell, frost action.	Severe: wetness, shrink-swell, frost action.
Northcote part	Severe: wetness, too clayey.	Severe: wetness, shrink-swell, frost action.	Severe: wetness, shrink-swell.	Severe: wetness, shrink-swell, frost action.	Severe: wetness, shrink-swell, frost action.
Northcote: [1] 991: Northcote part	Severe: wetness, too clayey.	Severe: wetness, shrink-swell, frost action.	Severe: wetness, shrink-swell.	Severe: wetness, shrink-swell, frost action.	Severe: wetness, shrink-swell, frost action.
Wahpeton part	Severe: too clayey, floods.	Severe: shrink-swell, floods, frost action.	Severe: shrink-swell, floods.	Severe: shrink-swell, floods, frost action.	Severe: shrink-swell, floods, frost action.
Arveson: [1] 993: Arveson part	Severe: wetness, cutbanks cave, floods.	Severe: wetness, frost action, floods.	Severe: wetness, floods.	Severe: wetness, frost action, floods.	Severe: floods, wetness, frost action.
Cormant part	Severe: wetness, cutbanks cave, floods.	Severe: wetness, floods.	Severe: wetness, floods.	Severe: wetness, floods.	Severe: wetness, floods.
Rockwell: [1] 994: Rockwell part	Severe: wetness, floods.	Severe: wetness, frost action, floods.	Severe: wetness, floods.	Severe: wetness, frost action, floods.	Severe: wetness, frost action, floods.
Grygla part	Severe: wetness, floods.	Severe: wetness, frost action, floods.	Severe: wetness, floods.	Severe: wetness, frost action, floods.	Severe: wetness, frost action, floods.

[1] This mapping unit is made up of two or more dominant kinds of soil. See description of the mapping unit for composition and behavior characteristics of the whole mapping unit.

trenching is influenced by the soil wetness of a high seasonal water table, the texture and consistence of soils, the tendency of soils to cave in or slough, and the presence of very firm, dense soil layers, bedrock, or large stones. In addition, excavations are affected by slope of the soil and the probability of flooding. Ratings do not apply to soil horizons below a depth of 6 feet unless otherwise noted.

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

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

material at hand, and most cuts and fills are less than 6 feet deep.

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

Construction materials

The suitability of each soil as a source of road fill, sand, gravel, and topsoil is indicated in table 8 by ratings of good, fair, or poor. The texture, thickness, and organic-matter content of each soil horizon are important factors in rating soils for use as construction materials. Each soil is evaluated to the depth observed, generally about 6 feet.

Road fill is soil material used in embankments for roads. The ratings reflect the ease of excavating and working the material and the expected performance of the material after it has been compacted and adequately drained. The performance of soil after it is stabilized with lime or cement is not considered in the ratings, but information about soil properties that determine such performance is given in the descriptions of soil series.

The ratings apply to the soil profile between the A horizon and a depth of 5 to 6 feet. It is assumed that soil horizons will be mixed during excavation and spreading. Many soils have horizons of contrasting suitability within the profile. The estimated engineering properties in table 11 provide more specific information about the nature of each horizon that can help determine its suitability for road fill.

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

Sand and gravel are used in great quantities in many kinds of construction. The ratings in table 8 provide guidance as to where to look for probable sources and are based on the probability that soils in a given area contain sizable quantities of sand or gravel. A soil rated *good* or *fair* has a layer of suitable material at least 3 feet thick, the top of which is within a depth of 6 feet. Coarse fragments of soft bedrock material, such as shale and siltstone, are not considered to be sand and gravel. Fine-grained soils are not suitable sources of sand and gravel.

The ratings do not take into account depth to the water table or other factors that affect excavation of the material. Descriptions of grain size, kinds of minerals, reaction, and stratification are given in the soil series descriptions and in table 11.

Topsoil is used in areas where vegetation is to be established and maintained. Suitability is affected mainly by the ease of working and spreading the soil material in preparing a seedbed and by the ability of the soil material to sustain the growth of plants. Also considered is the damage that would result to the area from which the topsoil is taken.

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

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

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

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

Sanitary facilities

Favorable soil properties and site features are needed for proper functioning of septic tank absorption fields, sewage lagoons, and sanitary landfills. The nature of the soil is important in selecting sites for these facilities and in identifying limiting soil properties and site features to be considered in design and installation. Also, those soil properties that deal with the ease of excavation or installation of these facilities will be of interest to contractors and local officials. Table 9 shows the degree and kind of limitations of each soil for sanitary facilities and for use of the soil as daily cover for landfills.

If the degree of soil limitation is indicated by the rating *slight,* soils are favorable for the specified use and limitations are minor and easily overcome; if *moderate,* soil properties or site features are unfavorable for the specified use, but limitations can be overcome by special planning and design; and if *severe,* soil properties or site features are so unfavorable or difficult to overcome that major soil reclamation, special designs, or intensive maintenance are required. Sanitary landfill is rated by the terms *good, fair,* or *poor,* which have, respectively, meanings approximately parallel to the terms *slight, moderate,* and *severe.*

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

TABLE 8.—*Construction materials*

["Shrink-swell" and some of the other terms that describe restrictive soil features are defined in the Glossary. See text for definitions of "good," "fair," and "poor."]

Soil name and map symbol	Roadfill	Sand	Gravel	Topsoil
Maddock: [1]45	Good	Fair: excess fines	Unsuited	Poor: too sandy.
Borup: 46	Poor: wetness, frost action.	Poor: excess fines	Unsuited	Poor: wetness.
Colvin: 47	Poor: wetness, frost action.	Unsuited	Unsuited	Poor: wetness.
Cashel: 50	Poor: shrink-swell, frost action.	Unsuited	Unsuited	Poor: too clayey.
Augsburg: [1]52	Poor: frost action, wetness.	Unsuited	Unsuited	Poor: wetness.
Grimstad: [1]59	Fair: frost action	Poor: excess fines	Unsuited	Fair: excess lime.
Glyndon: [1]60	Poor: frost action	Poor: excess fines	Unsuited	Fair: excess lime.
Arveson: [1]61	Poor: wetness, frost action.	Fair: excess fines	Unsuited	Poor: wetness.
Rockwell: [1]63	Poor: frost action, wetness.	Poor: excess fines	Unsuited	Poor: wetness.
Ulen: [1]64	Good	Fair: excess fines	Unsuited	Fair: too sandy, excess lime.
Foxhome: [1]65	Fair: frost action	Unsuited	Poor: excess fines	Fair: thin layer.
Bearden: 67	Poor: frost action	Unsuited	Unsuited	Fair: excess lime.
Garnes: [1]77	Poor: frost action	Unsuited	Unsuited	Poor: thin layer.
Bearden: 93, 93B	Poor: frost action	Unsuited	Unsuited	Fair: excess lime.
Hangaard: [1]111	Poor: wetness	Good	Fair: excess fines	Poor: wetness.
Redby: [1]116	Fair: wetness, frost action.	Fair: excess fines	Unsuited	Poor: thin layer, too sandy.
Cormant: [1]117	Poor: wetness	Fair: excess fines	Unsuited	Poor: wetness, too sandy.
Enstrom: 145	Fair: frost action	Poor: excess fines	Unsuited	Poor: too sandy.
Poppleton: [1]148	Fair: frost action	Fair: excess fines	Unsuited	Poor: too sandy.
Wahpeton: 157, 157B	Poor: shrink-swell, frost action.	Unsuited	Unsuited	Poor: too clayey.

TABLE 8.—*Construction materials*—Continued

Soil name and map symbol	Roadfill	Sand	Gravel	Topsoil
Haug: 187	Poor: excess humus, wetness, frost action.	Unsuited	Unsuited	Poor: wetness.
Karlstad: [1]205	Good	Good	Poor: excess fines	Poor: too sandy, thin layer.
Marquette: [1]242	Good	Good	Good	Poor: too sandy, thin layer.
Lohnes: [1]245	Good	Good	Fair: excess fines	Poor: too sandy.
Pelan: [1]280	Fair: frost action	Unsuited	Poor: excess fines	Poor: thin layer, too sandy.
Fram: [1]296	Poor: frost action	Unsuited	Unsuited	Fair: excess lime.
Wheatville: [1]343	Poor: frost action	Unsuited	Unsuited	Fair: excess lime.
Percy: [1]379, [1]383, [1]384	Poor: frost action, wetness.	Unsuited	Unsuited	Poor: wetness.
Viking: [1]403	Poor: shrink-swell, wetness.	Unsuited	Unsuited	Poor: too clayey, wetness.
Mavie: [1]412	Poor: wetness, frost action.	Unsuited	Poor: excess fines	Poor: wetness.
Augsburg: [1]424	Poor: frost action, wetness, low strength.	Unsuited	Unsuited	Poor: wetness.
Donaldson: [1]425	Poor: shrink-swell, frost action.	Unsuited	Unsuited	Good.
Foldahl: [1]426	Fair: frost action	Poor: excess fines	Unsuited	Fair: thin layer.
Fram: [1]427	Poor: frost action	Unsuited	Unsuited	Good.
Northcote: 429, 429B	Poor: shrink-swell, wetness, frost action.	Unsuited	Unsuited	Poor: too clayey, wetness.
Noyes: [1]430	Poor: shrink-swell, frost action, wetness.	Unsuited	Unsuited	Fair: too clayey, wetness.
Strandquist: [1]432	Poor: wetness, frost action.	Unsuited	Poor: excess fines	Poor: wetness.
Syrene: [1]433, [1]435	Poor: wetness	Good	Fair: excess fines	Poor: wetness.
Northcote: 438	Poor: shrink-swell, frost action, wetness.	Unsuited	Unsuited	Poor: too clayey, wetness.

TABLE 8.—*Construction materials*—Continued

Soil name and map symbol	Roadfill	Sand	Gravel	Topsoil
Grygla: [1]482	Poor: wetness, frost action.	Poor: excess fines	Unsuited	Poor: wetness, thin layer, too sandy.
Markey: 543	Poor: excess humus, wetness.	Poor: excess fines	Unsuited	Poor: wetness.
Cathro: 544	Poor: excess humus, frost action, wetness.	Unsuited	Unsuited	Poor: wetness.
Deerwood: 547	Poor: excess humus, wetness.	Poor: excess fines	Unsuited	Poor: wetness.
Percy: [1]581	Poor: frost action, wetness.	Unsuited	Unsuited	Poor: wetness.
Roliss: [1]582	Poor: wetness, frost action.	Unsuited	Unsuited	Poor: wetness.
Nereson: [1]583	Poor: frost action	Unsuited	Unsuited	Fair: thin layer.
Bearden: [1]908:				
Bearden part	Poor: frost action	Unsuited	Unsuited	Fair: excess lime.
Fargo part	Poor: shrink-swell, frost action.	Unsuited	Unsuited	Poor: wetness, too clayey.
Hegne: [1]937:				
Hegne part	Poor: shrink-swell, wetness, frost action.	Unsuited	Unsuited	Poor: too clayey, wetness.
Northcote part	Poor: shrink-swell, frost action, wetness.	Unsuited	Unsuited	Poor: too clayey, wetness.
Northcote: [1]991:				
Northcote part	Poor: shrink-swell, frost action, wetness.	Unsuited	Unsuited	Poor: too clayey, wetness.
Wahpeton part	Poor: shrink-swell, frost action.	Unsuited	Unsuited	Poor: too clayey.
Arveson: [1]993:				
Arveson part	Poor: wetness, frost action.	Fair: excess fines	Unsuited	Poor: wetness.
Cormant part	Poor: wetness	Fair: excess fines	Unsuited	Poor: wetness, too sandy.
Rockwell: [1]994:				
Rockwell part	Poor: frost action, wetness.	Unsuited	Unsuited	Poor: wetness.
Grygla part	Poor: wetness, frost action.	Poor: excess fines	Unsuited	Poor: wetness, thin layer, too sandy.

[1] This mapping unit is made up of two or more dominant kinds of soil. See description of the mapping unit for composition and behavior characteristics of the whole mapping unit.

TABLE 9.—*Sanitary facilities*

["Percs slowly" and some of the other terms that describe restrictive soil features are defined in the Glossary. See text for definitions of "slight," "moderate," "severe," and other terms used to rate soils]

Soil name and map symbol	Septic tank absorption fields	Sewage lagoon areas	Trench sanitary landfill	Area sanitary landfill	Daily cover for landfill
[2] Maddock: [1] 45	Slight	Severe: seepage	Severe: seepage, too sandy.	Severe: seepage	Poor: too sandy.
Borup: 46	Severe: wetness.	Severe: wetness, seepage.	Severe: wetness, seepage.	Severe: wetness, seepage.	Poor: wetness.
Colvin: 47	Severe: wetness.	Severe: wetness	Severe: wetness	Severe: wetness	Poor: wetness.
Cashel: 50	Severe: floods, percs slowly, wetness.	Severe: floods	Severe: floods, too clayey, wetness.	Severe: floods, wetness.	Poor: too clayey.
Augsburg: [1] 52	Severe: wetness.	Severe: wetness	Severe: wetness	Severe: wetness	Poor: wetness.
Grimstad: [1] 59	Moderate: wetness.	Moderate: seepage, wetness.	Severe: wetness	Moderate: wetness.	Fair: too sandy.
Glyndon: [1] 60	Moderate: wetness.	Severe: seepage	Severe: seepage, wetness.	Severe: seepage	Good.
Arveson: [1] 61	Severe: wetness.	Severe: wetness, seepage.	Severe: wetness, seepage.	Severe: wetness, seepage.	Poor: wetness.
Rockwell: [1] 63	Severe: wetness.	Severe: wetness	Severe: wetness	Severe: wetness	Poor: wetness.
[2] Ulen: [1] 64	Moderate: wetness.	Severe: seepage	Severe: wetness, seepage.	Severe: wetness, seepage.	Poor: too sandy.
Foxhome: [1] 65	Moderate: wetness.	Moderate: wetness, seepage.	Severe: wetness	Moderate: wetness.	Fair: too sandy.
Bearden: 67	Moderate: wetness, percs slowly.	Moderate: wetness, seepage.	Severe: wetness	Moderate: wetness.	Good.
Garnes: [1] 77	Moderate wetness.	Moderate: wetness, seepage.	Severe: wetness	Moderate: wetness.	Good.
Bearden: 93, 93B	Moderate: wetness, percs slowly.	Moderate: wetness, seepage.	Severe: wetness	Moderate: wetness.	Good.
Hangaard: [1] 111	Severe: wetness.	Severe: wetness, seepage.	Severe: wetness, too sandy, seepage.	Severe: wetness, seepage.	Poor: wetness, too sandy.
[2] Redby: [1] 116	Moderate: wetness.	Severe: seepage, wetness.	Severe: seepage, too sandy, wetness.	Severe: seepage, too sandy.	Poor: too sandy.

TABLE 9.—*Sanitary facilities*—Continued

Soil name and map symbol	Septic tank absorption fields	Sewage lagoon areas	Trench sanitary landfill	Area sanitary landfill	Daily cover for landfill
Cormant: [1] 117	Severe: wetness.	Severe: wetness, seepage.	Severe: wetness, seepage, too sandy.	Severe: wetness, seepage.	Poor: wetness, too sandy.
Enstrom: 145	Moderate: wetness.	Moderate: wetness, seepage.	Severe: wetness	Moderate: wetness.	Fair: too sandy.
[2] Poppleton: [1] 148	Moderate: wetness.	Severe: seepage	Severe: seepage, too sandy, wetness.	Severe: seepage	Poor: too sandy.
Wahpeton: 157, 1578	Severe: floods	Severe: floods	Severe: too clayey, floods.	Severe: floods	Poor: too clayey.
Haug: 187	Severe: wetness, floods.	Severe: wetness, excess humus, floods.	Severe: wetness, floods, excess humus.	Severe: wetness, floods.	Poor: wetness, excess humus.
[2] Karlstad: [1] 205	Moderate: wetness.	Severe: seepage	Severe: seepage, wetness.	Severe: seepage	Poor: too sandy.
[2] Marquette: [1] 242	Slight	Severe: seepage	Severe: too sandy, seepage.	Severe: seepage	Poor: too sandy.
[2] Lohnes: [1] 245	Slight	Severe: seepage	Severe: seepage, too sandy.	Severe: seepage	Poor: too sandy.
Pelan: [1] 280	Moderate: wetness.	Moderate: seepage, wetness.	Severe: wetness	Moderate: wetness.	Fair: too sandy.
Fram: [1] 296	Moderate: wetness.	Moderate: wetness, seepage.	Severe: wetness	Moderate: wetness.	Good.
Wheatville: [1] 343	Severe: percs slowly.	Moderate: seepage.	Severe: wetness	Moderate: wetness.	Fair: thin layer.
Percy: [1] 379	Severe: wetness, large stones.	Severe: wetness, large stones.	Severe: wetness, large stones.	Severe: wetness	Poor: wetness, large stones.
[1] 383	Severe: wetness.	Severe: wetness	Severe: wetness	Severe: wetness	Poor: wetness.
[1] 384	Severe: wetness, floods.	Severe: wetness	Severe: wetness, floods.	Severe: wetness, floods.	Poor: wetness.
Viking: [1] 403	Severe: percs slowly, wetness.	Slight	Severe: wetness, too clayey.	Severe: wetness, too clayey.	Poor: too clayey, wetness.
Mavie: [1] 412	Severe: wetness.	Severe: wetness	Severe: wetness	Severe: wetness	Poor: wetness.
Augsburg: [1] 424	Severe: wetness, floods.	Severe: wetness	Severe: wetness, floods.	Severe: wetness, floods.	Poor: wetness.

TABLE 9.—*Sanitary facilities*—Continued

Soil name and map symbol	Septic tank absorption fields	Sewage lagoon areas	Trench sanitary landfill	Area sanitary landfill	Daily cover for landfill
Donaldson: [1]425	Severe: percs slowly.	Moderate: seepage, wetness.	Severe: wetness	Moderate: wetness.	Fair: thin layer.
Foldahl: [1]426	Severe: wetness, percs slowly.	Moderate: wetness, seepage.	Severe: wetness	Moderate: wetness.	Fair: too sandy.
Fram: [1]427	Moderate: wetness.	Moderate: wetness, seepage.	Severe: wetness	Moderate: wetness.	Good.
Northcote: 429	Severe: percs slowly, wetness.	Slight	Severe: wetness, too clayey.	Severe: wetness	Poor: wetness, too clayey.
429B	Severe: percs slowly, wetness.	Moderate: slope	Severe: wetness, too clayey.	Severe: wetness	Poor: wetness, too clayey.
Noyes: [1]430	Severe: percs slowly, wetness.	Slight	Severe: wetness, too clayey.	Severe: wetness	Poor: too clayey, wetness.
Strandquist: [1]432	Severe: wetness	Severe: wetness	Severe: wetness	Severe: wetness	Poor: wetness.
Syrene: [1]433, [1]435	Severe: wetness	Severe: wetness, seepage.	Severe: wetness, seepage.	Severe: wetness, seepage.	Poor: wetness, too sandy.
Northcote: 438	Severe: percs slowly, wetness, floods.	Slight	Severe: wetness, too clayey, floods.	Severe: wetness, floods.	Poor: wetness, too clayey.
Grygla: [1]482	Severe: wetness	Severe: wetness	Severe: wetness	Severe: wetness	Poor: wetness.
Markey: 543	Severe: wetness, floods.	Severe: wetness, excess humus, seepage.	Severe: wetness, floods, seepage.	Severe: wetness, floods, seepage.	Poor: excess humus, hard to pack, wetness.
Cathro: 544	Severe: wetness, floods.	Severe: wetness, excess humus, seepage.	Severe: wetness, floods, seepage.	Severe: wetness, floods, seepage.	Poor: excess humus, hard to pack, wetness.
Deerwood: 547	Severe: wetness, floods.	Severe: wetness, excess humus, seepage.	Severe: wetness, excess humus, seepage.	Severe: wetness, seepage, floods.	Poor: excess humus, wetness.
Percy: [1]581	Severe: wetness	Severe: wetness	Severe: wetness	Severe: wetness	Poor: wetness.
Roliss: [1]582	Severe: wetness, percs slowly.	Severe: wetness	Severe: wetness	Severe: wetness	Poor: wetness.
Nereson: [1]583	Moderate: wetness.	Moderate: wetness, seepage.	Severe: wetness, seepage.	Moderate: wetness.	Good.
Bearden: [1]908:					
Bearden part	Moderate: wetness, percs slowly.	Moderate: wetness, seepage.	Severe: wetness	Moderate: wetness.	Good.
Fargo part	Severe: percs slowly, wetness.	Slight	Severe: too clayey, wetness.	Severe: wetness	Poor: wetness, too clayey.

TABLE 9.—*Sanitary facilities*—Continued

Soil name and map symbol	Septic tank absorption fields	Sewage lagoon areas	Trench sanitary landfill	Area sanitary landfill	Daily cover for landfill
Hegne: [1] 937:					
Hegne part	Severe: wetness, percs slowly.	Slight	Severe: wetness, too clayey.	Severe: wetness	Poor: too clayey, wetness.
Northcote part	Severe: percs slowly, wetness.	Slight	Severe: wetness, too clayey.	Severe: wetness	Poor: wetness, too clayey.
Northcote: [1] 991:					
Northcote part	Severe: percs slowly, wetness.	Slight	Severe: wetness, too clayey.	Severe: wetness	Poor: wetness, too clayey.
Wahpeton part	Severe: floods	Slight	Severe: too clayey, floods.	Severe: floods	Poor: too clayey.
Arveson: [1] 993:					
Arveson part	Severe: wetness, floods.	Severe: wetness, seepage.	Severe: wetness, seepage, floods.	Severe: wetness, floods.	Poor: wetness, too sandy.
Cormant part	Severe: wetness, floods.	Severe: wetness, seepage.	Severe: wetness, seepage, floods.	Severe: wetness, seepage, floods.	Poor: wetness, too sandy.
Rockwell: [1] 994:					
Rockwell part	Severe: wetness, floods.	Severe: wetness	Severe: wetness, floods.	Severe: wetness, floods.	Poor: wetness.
Grygla part	Severe: wetness, floods.	Severe: wetness	Severe: wetness, floods.	Severe: wetness, floods.	Poor: wetness.

[1] This mapping unit is made up of two or more dominant kinds of soil. See description of the mapping unit for composition and behavior characteristics of the whole mapping unit.
[2] This mapping unit has a potential hazard of inadequate filtration.

effluent and those that affect the construction of the system.

Properties and features that affect the absorption of the effluent are permeability, depth to seasonal high water table, depth to bedrock, and susceptibility to flooding. Stones, boulders, and a shallow depth to bedrock interfere with installation. Excessive slope may cause lateral seepage and surfacing of the effluent in downslope areas. Also, soil erosion and soil slippage are hazards where absorption fields are installed in sloping soils.

Some soils are underlain by loose sand and gravel or fractured bedrock at a depth less than 4 feet below the tile lines. In these soils the absorption field does not adequately filter the effluent, and as a result ground water supplies in the area may be contaminated. Soils having a hazard of inadequate filtration are indicated by footnotes in table 9.

Percolation tests are performed to determine the absorptive capacity of the soil and its suitability for septic tank absorption fields. These tests should be performed during the season when the water table is highest and the soil is at minimum absorptive capacity.

In many of the soils that have moderate or severe limitations for septic tank absorption fields, it may be possible to install special systems that lower the seasonal water table or to increase the size of the absorption field so that satisfactory performance is achieved.

Sewage lagoons are shallow ponds constructed to hold sewage while bacteria decompose the solid and liquid wastes. Lagoons have a nearly level flow area surrounded by slopes or embankments of compacted, nearly impervious soil material. They generally are designed so that depth of the sewage is 2 to 5 feet. Impervious soil for the lagoon floor and sides is required to minimize seepage and contamination of local ground water. Soils that are very high in organic matter and those that have stones and boulders are undesirable. Unless the soil has very slow permeability, contamination of local ground water is a hazard in areas where the seasonal high water table is above the level of the lagoon floor. In soils where the water table is seasonally high, seepage of ground water into the lagoon can seriously reduce its capacity for liquid waste. Slope, depth to bedrock, and susceptibility to flooding also affect the location of sites for sewage lagoons or the cost of construction. Shear strength and permeability of compacted soils affect the performance of embankments.

Sanitary landfill is a method of disposing of solid waste, either in excavated trenches or on the surface of the soil. The waste is spread compacted in layers and covered with thin layers of soil. Landfill areas are

subject to heavy vehicular traffic. Ease of excavation, risk of polluting ground water, and trafficability affect the suitability of a soil for this purpose. The best soils have a loamy or silty texture, have moderate or slow permeability, are deep to bedrock and a seasonal water table, are free of large stones and boulders, and are not subject to flooding. In areas where the seasonal water table is high, water seeps into the trenches and causes problems in excavating and filling them. Also, seepage into the refuse increases the risk of pollution of ground water. Clayey soils are likely to be sticky and difficult to spread. Sandy or gravelly soils generally have rapid permeability that might allow noxious liquids to contaminate local ground water.

Unless otherwise stated, the ratings in table 9 apply only to soil properties and features within a depth of about 6 feet. If the trench is deeper, ratings of slight or moderate may not be valid. Site investigation is needed before a site is selected.

In the area type of sanitary landfill, refuse is placed on the surface of the soil in successive layers. The limitations caused by soil texture, depth to bedrock, and stone content do not apply to this type of landfill. Soil wetness, however, may be a limitation because of difficulty in operating equipment.

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

In addition to these features, the soils selected for final cover of landfills should be suitable for growing plants. In comparison with other horizons, the A horizon in most soils has the best workability, most organic matter, and the best potential for growing plants. Thus, for either the area- or trench-type landfill, stockpiling material from the A horizon for use as the surface layer of the final cover is desirable.

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

Water management

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

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

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

An *aquifer-fed excavated pond* is a body of water created by excavating a pit or dugout into a groundwater aquifer. Excluded are ponds that are fed by surface runoff and embankment ponds that impound water 3 feet or more above the original surface. Ratings in table 10 are for ponds that are properly designed, located, and constructed. Soil properties and site features that affect aquifer-fed ponds are depth to a permanent water table, permeability of the aquifer, quality of the water, and ease of excavation.

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

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

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

Soil properties

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

When making soil borings during field mapping, the soil scientist can identify several important soil properties. He notes the seasonal soil moisture condition, or the presence of free water and its depth in the profile. For each horizon, he notes the thickness of the soil and its color; the texture, or the amount of clay, silt, sand, and gravel or other coarse fragments; the structure, or natural pattern of cracks and pores in the undisturbed soil; and the consistence of soil in place under the existing soil moisture conditions. He records the root depth of existing plants, determines soil reaction, and identifies any free carbonates.

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

Based on summaries of available field and laboratory data, and listed in tables in this section, are estimated ranges in engineering properties and classifications and in physical and chemical properties for each major horizon of each soil in the survey area. Also presented are pertinent soil and water features and engineering test data.

TABLE 10.—*Water management*

["Seepage," and some of the other terms that describe restrictive soil features are defined in the Glossary]

Soil name and map symbol	Pond reservoir areas	Embankments, dikes, and levees	Aquifer-fed excavated ponds	Drainage	Irrigation	Grassed waterways
Maddock: [1]45	Seepage	Seepage	No water	Not needed	Seepage, soil blowing, fast intake.	Soil blowing.
Borup: 46	Seepage	Seepage, piping.	Favorable	Cutbanks cave	Wetness	Not needed.
Colvin: 47	Favorable	Low strength, compressible, piping.	Favorable	Percs slowly	Wetness, percs slowly.	Not needed.
Cashel: 50	Favorable	Compressible, shrink-swell, low strength.	Slow refill	Floods, percs slowly.	Floods, percs slowly, slow intake.	Not needed.
Augsburg: [1]52	Seepage	Low strength, compressible, piping.	Slow refill	Favorable	Wetness	Not needed.
Grimstad: [1]59	Seepage	Seepage	Deep to water	Not needed	Fast intake	Erodes easily.
Glyndon: [1]60	Seepage	Seepage, piping, low strength.	Deep to water	Not needed	Favorable	Not needed.
Arveson: [1]61	Seepage	Seepage	Favorable	Cutbanks cave	Wetness	Not needed.
Rockwell: [1]63	Seepage	Seepage	Favorable	Favorable	Wetness	Not needed.
Ulen: [1]64	Seepage	Seepage	Deep to water	Not needed	Fast intake, seepage.	Not needed.
Foxhome: [1]65	Seepage	Seepage	Deep to water	Not needed	Fast intake	Erodes easily.
Bearden: 67	Favorable	Low strength, shrink-swell, piping.	Deep to water	Not needed	Favorable	Not needed.
Garnes: [1]77	Favorable	Favorable	Deep to water	Not needed	Favorable	Favorable.
Bearden: 93, 93B	Favorable	Low strength, shrink-swell, piping.	Deep to water	Not needed	Favorable	Not needed.
Hangaard: [1]111	Seepage	Seepage	Favorable	Cutbanks cave	Wetness	Not needed.
Redby: [1]116	Seepage	Seepage	Deep to water	Not needed	Fast intake, seepage.	Erodes easily.
Cormant: [1]117	Seepage	Seepage	Favorable	Cutbanks cave	Wetness	Not needed.
Enstrom: 145	Seepage	Seepage	Deep to water	Not needed	Fast intake	Erodes easily.

TABLE 10.—*Water management*—Continued

Soil name and map symbol	Pond reservoir areas	Embankments, dikes, and levees	Aquifer-fed excavated ponds	Drainage	Irrigation	Grassed waterways
Poppleton: [1] 148	Seepage	Seepage	Deep to water	Not needed	Seepage, fast intake.	Not needed.
Wahpeton: 157, 1578	Favorable	Hard to pack, shrink-swell, low strength.	Deep to water, slow refill.	Not needed	Slow intake, percs slowly.	Not needed.
Haug: 187	Favorable	Piping, compressible.	Favorable	Floods	Wetness, floods.	Not needed.
Karlstad: [1] 205	Seepage	Seepage	Deep to water	Not needed	Droughty, fast intake, seepage.	Droughty, erodes easily.
Marquette: [1] 242	Seepage	Seepage	No water	Not needed	Droughty, fast intake, seepage.	Droughty, erodes easily.
Lohnes: [1] 245	Seepage	Seepage	No water	Not needed	Droughty, soil blowing, fast intake.	Droughty, erodes easily.
Pelan: [1] 280	Seepage	Seepage	Deep to water	Not needed	Fast intake	Not needed.
Fram: [1] 296	Seepage	Piping, low strength.	Deep to water	Not needed	Wetness	Favorable.
Wheatville: [1] 343	Seepage	Compressible, low strength, piping.	Slow refill, deep to water.	Not needed	Favorable	Not needed.
Percy: [1] 379	Favorable	Piping, large stones.	Large stones	Favorable	Wetness	Not needed.
[1] 383	Favorable	Piping	Favorable	Favorable	Wetness	Not needed.
[1] 384	Favorable	Piping	Favorable	Floods	Wetness, floods.	Not needed.
Viking: [1] 403	Favorable	Compressible, hard to pack.	Slow refill	Percs slowly	Slow intake, wetness, percs slowly.	Percs slowly, wetness.
Mavie: [1] 412	Seepage	Compressible, seepage.	Favorable	Favorable	Wetness	Not needed.
Augsburg: [1] 424	Seepage	Low strength, compressible, piping.	Slow refill	Favorable	Wetness	Not needed.
Donaldson: [1] 425	Seepage	Compressible, low strength, piping.	Deep to water, slow refill.	Not needed	Favorable	Not needed.
Foldahl: [1] 426	Seepage	Seepage, low strength.	Deep to water	Not needed	Fast intake	Erodes easily.

TABLE 10.—*Water management*—Continued

Soil name and map symbol	Pond reservoir areas	Embankments, dikes, and levees	Aquifer-fed excavated ponds	Drainage	Irrigation	Grassed waterways
Fram: [1]427	Seepage	Piping, low strength.	Deep to water	Not needed	Favorable	Favorable.
Northcote: 429, 429B	Favorable	Compressible, low strength, shrink-swell.	Slow refill	Percs slowly	Slow intake, wetness, percs slowly.	Not needed.
Noyes: [1]430	Favorable	Low strength, compressible, shrink-swell.	Slow refill	Percs slowly	Slow intake, wetness, percs slowly.	Not needed.
Strandquist: [1]432	Seepage	Seepage	Favorable	Favorable	Wetness	Not needed.
Syrene: [1]433, [1]435	Seepage	Seepage	Favorable	Cutbanks cave	Wetness	Wetness.
Northcote: 438	Favorable	Compressible, low strength, shrink-swell.	Slow refill	Percs slowly	Slow intake, wetness, percs slowly.	Not needed.
Grygla: [1]482	Seepage	Seepage	Favorable	Favorable	Wetness	Not needed.
Markey: 543	Seepage	Compressible, seepage, hard to pack.	Favorable	Floods	Wetness, floods.	Not needed.
Cathro: 544	Seepage	Compressible, hard to pack, low strength.	Favorable	Floods	Wetness, floods.	Not needed.
Deerwood: 547	Seepage	Seepage, piping.	Favorable	Floods	Wetness, floods.	Not needed.
Percy: [1]581	Favorable	Piping	Favorable	Favorable	Wetness	Not needed.
Roliss: [1]582	Favorable	Favorable	Favorable	Wetness	Wetness	Wetness.
Nereson: [1]583	Seepage	Piping	Deep to water	Not needed	Favorable	Favorable.
Bearden: [1]908:						
Bearden part	Favorable	Low strength, shrink-swell, piping.	Deep to water	Not needed	Favorable	Not needed.
Fargo part	Favorable	Hard to pack, low strength, shrink-swell.	Slow refill	Percs slowly	Slow intake, wetness, percs slowly.	Not needed.
Hegne: [1]937:						
Hegne part	Favorable	Compressible, low strength, shrink-swell.	Slow refill	Percs slowly	Wetness, slow intake, percs slowly.	Wetness, percs slowly.
Northcote part	Favorable	Compressible, low strength, shrink-swell.	Slow refill	Percs slowly	Slow intake, wetness, percs slowly.	Not needed.

TABLE 10.—*Water management*—Continued

Soil name and map symbol	Pond reservoir areas	Embankments, dikes, and levees	Aquifer-fed excavated ponds	Drainage	Irrigation	Grassed waterways
Northcote: [1] 991:						
Northcote part	Favorable	Compressible, low strength, shrink-swell.	Slow refill	Percs slowly	Slow intake, wetness, percs slowly.	Not needed.
Wahpeton part	Favorable	Hard to pack, shrink-swell, low strength.	Deep to water, slow refill.	Not needed	Slow intake, percs slowly.	Not needed.
Arveson: [1] 993:						
Arveson part	Seepage	Seepage	Favorable	Cutbanks cave	Wetness, floods.	Not needed.
Cormant part	Seepage	Seepage	Favorable	Cutbanks cave	Wetness, floods.	Not needed.
Rockwell: [1] 994:						
Rockwell part	Seepage	Seepage	Favorable	Favorable	Wetness, floods.	Not needed.
Grygla part	Seepage	Seepage	Favorable	Favorable	Wetness, floods.	Not needed.

[1] This mapping unit is made up of two or more dominant kinds of soil. See description of the mapping unit for composition and behavior characteristics of the whole mapping unit.

Engineering properties

Table 11 gives estimates of engineering properties and classifications for the major horizons of each soil in the survey area. These estimates are presented as ranges in values most likely to exist in areas where the soil is mapped.

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

Texture is described in table 11 in standard terms used by the United States Department of Agriculture. These terms are defined according to percentages of sand, silt, and clay in soil material that is less than 2 millimeters in diameter. "Loam," for example, is soil material that is 7 to 27 percent clay, 28 to 50 percent silt, and less than 52 percent sand. If a soil contains gravel or other particles coarser than sand, an appropriate modifier is added, for example, "gravelly loam." Other texture terms used by USDA are defined in the Glossary.

The two systems commonly used in classification of soils for engineering use are the Unified Soil Classification System (USCS) (*3*) and the American Association of State Highway and Transportation Officials Soil Classification System (AASHTO) (*2*). In table 11 soils in the survey area are classified according to both systems.

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

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

When laboratory data are available, the A–1, A–2, and A–7 groups are further classified as follows: A–1–a, A–1–b, A–2–4, A–2–5, A–2–6, A–2–7, A–7–5, and A–7–6. As an additional refinement, the desirability of soils as subgrade material can be indicated by a group index number. These numbers range from 0 for the best subgrade material to 20 or more for the poorest. The AASHTO classification for soils tested in the survey area, with group index numbers in parentheses, is given in table 14. The estimated classification, without group index numbers, is given in table 11. Also in table 11 the percentage, by weight, of cobbles or the rock fragments more than 3 inches in diameter

are estimated for each major horizon. These estimates are determined largely by observing volume percentage in the field and then converting it, by formula, to weight percentage.

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

Liquid limit and plasticity index indicate the effect of water on the strength and consistency of soil. These indexes are used in both the unified and the AASHTO soil classification systems. They are also used as indicators in making general predictions of soil behavior.

Range in liquid limit and plasticity index are estimated on the basis of test data from the survey area or from nearby areas and on observations of the many soil borings made during the survey. Definitions for liquid limit, plastic limit, and plasticity index are in the Glossary.

Physical and chemical properties

Table 12 shows estimated values for several soil characteristics and features that affect behavior of soils in engineering uses. These estimates are given for each major horizon, at the depths indicated, in the representative profile of each soil. The estimates are based on field observations and on test data for these and similar soils.

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

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

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

Salinity is expressed as the electrical conductivity of the saturation extract, in millimhos per centimeter at 25° C. Estimates are based on field and laboratory measurements at representative sites of the nonirrigated soils. The salinity of individual irrigated fields is largely affected by the quality of the irrigation water and the irrigation practices. Hence, the salinity of individual fields can differ greatly from the value given in table 12. Salinity affects the suitability of a soil for crop production, its stability when used as a construction material, and its potential to corrode metal and concrete.

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

Risk of corrosion, as used in table 12, pertains to potential soil-induced chemical action that dissolves or weakens uncoated steel or concrete. The rate of corrosion of uncoated steel is related to soil moisture, particle-size distribution, total acidity, and electrical conductivity of the soil material. The rating of soils for corrosivity to concrete is based mainly on the sulfate content, soil texture, and acidity. Protective measures for steel or more resistant concrete help to avoid or minimize damage resulting from the corrosion. Installations of steel that intersect soil boundaries or soil horizons are more susceptible to corrosion than installations entirely within one kind of soil or within one soil horizon.

Erosion factors are used to predict the amount of erosion that will result from specific kinds of land treatment. The soil erodibility factor (K) is a measure of the susceptibility of the soil to erosion by water. Soils having the highest K values are the most erodible. The soil-loss tolerance factor (T) is the maximum rate of soil erosion, measured in tons per acre per year, whether from rainfall or wind, that may occur without reducing crop production or environmental quality.

Wind erodibility groups are used to predict the susceptibility of soils to blowing and to predict the amount of soil lost by blowing. The groups consist of soils that have similar properties that affect soil blowing, principally those that determine the stability of aggregates that resist breakdown by tillage and abrasion by wind. Among properties of soils that affect their placement in wind erodibility groups are texture, organic-matter content, content of calcium carbonate, soil moisture, mineralogical composition, susceptibility to frost action, and size and stability of aggregates. The wind erodibility group number indicates the relative susceptibility of soils to soil blowing. Soils that are most subject to soil blowing are in group 1; those progressively less subject to soil blowing are in groups 2 through 7; and soils in group 8 are usually not subject to soil blowing.

TABLE 11.—*Engineering*

[The symbol < means less than; > means greater than.

Soil name and map symbol	Depth	USDA texture	Classification	
			Unified	AASHTO
	In			
Maddock:				
[1]45	0–16	Loamy fine sand	SM	A–2
	16–60	Loamy sand, loamy fine sand, fine sand.	SM, SP–SM	A–2, A–3
Borup:				
46	0–10	Loam	OL, ML, CL–ML	A–4
	10–19	Very fine sandy loam, loamy very fine sand, silt loam.	ML, CL–ML	A–4
	19–60	Loamy very fine sand, very fine sand, very fine sandy loam.	ML, CL–ML	A–4
Colvin:				
47	0–60	Silty clay loam	CL, ML	A–6, A–7
Cashel:				
50	0–12	Clay	CH	A–7
	12–60	Silty clay, clay	CH	A–7
Augsburg:				
[1]52	0–11	Very fine sandy loam	ML, CL, OL	A–4, A–6
	11–18	Loam, very fine sandy loam, silt loam.	ML	A–4
	18–33	Loamy very fine sand, very fine sandy loam, loam.	ML	A–4
	33–62	Silty clay, clay, silty clay loam	CH	A–7
Grimstad:				
[1]59	0–8	Fine sandy loam	SM, SM–SC	A–4, A–2
	8–38	Loamy sand, loamy fine sand, fine sand.	SM, SP–SM	A–2, A–3
	38–60	Sandy loam, fine sandy loam, loam	SC, CL, SM–SC, CL–ML	A–4, A–6
Glyndon:				
[1]60	0–22	Very fine sandy loam	OL, ML	A–4
	22–35	Silt loam, very fine sandy loam	ML, CL–ML	A–4
	35–60	Loamy very fine sand, very fine sand	ML, SM	A–4
Arveson:				
[1]61	0–8	Loam	OL, ML, CL–ML	A–4
	8–15	Fine sandy loam, sandy loam, loam	SM	A–4
	15–60	Fine sand, loamy sand, sandy loam	SP–SM, SM	A–3, A–2, A–4
Rockwell:				
[1]63	0–9	Fine sandy loam	ML, SM, SM–SC	A–4
	9–16	Fine sandy loam, sandy loam, loam	SM, ML, SM–SC	A–4
	16–28	Fine sand, sand, loamy fine sand	SM	A–2
	28–60	Silt loam, loam, clay loam	CL, ML	A–6
Ulen:				
[1]64	0–15	Fine sandy loam	SM	A–4, A–2
	15–20	Loamy fine sand, fine sand	SM	A–2
	20–60	Fine sand	SP–SM, SM	A–3
Foxhome:				
[1]65	0–11	Sandy loam	SM, ML	A–4, A–6
	11–15	Loamy sand, sandy loam, loam	SM, SP–SM	A–2, A–4
	15–36	Gravelly sand, gravelly coarse sand, gravelly loamy sand.	SP, SP–SM	A–1, A–3
	36–60	Loam, clay loam, silt loam	SM, ML, CL	A–4, A–6
Bearden:				
67	0–10	Silt loam	CL–ML, CL	A–4, A–6
	10–14	Silt loam, silty clay loam	CL	A–6, A–7
	14–60	Silt loam, silty clay loam	CL	A–6, A–7

properties and classifications

Absence of an entry means data were not estimated]

Fragments > 3 inches	Percentage passing sieve number—				Liquid limit	Plasticity index
	4	10	40	200		
Pct					*Pct*	
0	100	100	50–80	15–35		NP
0	100	95–100	60–95	5–35		NP
0	100	100	95–100	70–95	20–40	NP–10
0	100	100	90–100	60–95	<30	NP–10
0	100	100	85–100	50–90	<30	NP–10
0	100	100	90–100	80–95	20–50	11–30
0	100	100	95–100	90–95	50–70	25–45
0	100	100	95–100	90–95	50–70	25–45
0	100	100	95–100	50–90	15–40	NP–15
0	100	100	95–100	50–90	15–40	NP–10
0	100	100	95–100	50–85	15–40	NP–10
0	100	100	95–100	95–100	50–80	35–55
0	100	100	80–100	15–50	15–30	2–7
0	100	90–100	80–90	5–35	<25	NP–4
0–3	95–100	90–100	70–90	40–60	15–40	5–25
0	100	100	95–100	70–95	20–40	NP–10
0	100	100	90–100	60–95	20–30	NP–10
0	100	100	85–100	35–75	10–30	NP–4
0	100	95–100	85–90	50–65	20–40	NP–10
0	100	95–100	60–85	35–50	<20	NP–5
0	100	95–100	50–80	5–45	<20	NP–5
0	100	95–100	70–85	40–55	15–25	1–7
0	100	95–100	70–85	40–55	15–25	1–7
0	100	95–100	65–80	20–35		NP
0–1	95–100	90–100	85–90	70–90	25–40	11–20
0	100	100	80–100	20–50	<20	NP–5
0	100	95–100	70–95	12–35		NP
0	100	95–100	80–100	5–35		NP
0–2	95–100	90–100	75–90	35–60	15–40	NP–15
0–2	95–100	85–100	55–80	10–50	15–30	NP–5
2–5	60–85	40–65	20–50	0–10		NP
1–5	40–85	20–60	75–90	50–80	15–40	1–15
0	100	100	90–100	70–90	20–40	5–20
0	100	100	90–100	70–95	30–50	10–25
0	100	100	90–100	70–95	30–50	10–25

TABLE 11.—*Engineering properties*

Soil name and map symbol	Depth	USDA texture	Classification	
			Unified	AASHTO
	In			
Garnes:				
[1]77	0–6	Loam	ML	A–4
	6–10	Clay loam, sandy clay loam, silty clay loam.	CL, SC	A–6, A–4
	10–60	Sandy loam, loam, fine sandy loam	SM, ML, CL	A–4, A–6
Bearden:				
93, 93B	0–10	Silty clay loam	CL	A–6, A–7
	10–14	Silt loam, silty clay loam	CL	A–6, A–7
	14–60	Silt loam, silty clay loam	CL	A–6, A–7
Hangaard:				
[1]111	0–7	Sandy loam	SM	A–2, A–4
	7–60	Gravelly coarse sand, sand and gravel	SP–SM, SP	A–3, A–1
Redby:				
[1]116	0–4	Loamy fine sand	SM, SP–SM	A–2, A–3
	4–33	Fine sand, sand	SM, SP–SM	A–3, A–2
	33–60	Fine sand, sand	SP, SP–SM	A–3, A–2
Cormant:				
[1]117	0–6	Loamy fine sand	SM, SP–SM	A–2, A–4
	6–60	Fine sand, sand, loamy fine sand	SP, SP–SM, SM	A–2, A–3
Enstrom:				
145	0–8	Loamy fine sand	SM	A–2
	8–33	Fine sand, sand	SP–SM, SM	A–2, A–3
	33–60	Fine sandy loam, loam, silt loam	CL–ML, CL, SC, SM–SC	A–4, A–6
Poppleton:				
[1]148	0–6	Loamy fine sand	SP–SM, SM	A–3, A–2
	6–60	Fine sand	SM, SP	A–3, A–2
Wahpeton:				
157, 157B	0–15	Silty clay	CH	A–7
	15–60	Clay, silty clay	CH	A–7
Haug:				
187	0–11	Muck	Pt	A–8
	11–14	Mucky sandy loam, fine sandy loam, loam.	OL, ML, CL, SM	A–4, A–6
	14–60	Loam, sandy loam, fine sandy loam	ML, CL, SM	A–4, A–6
Karlstad:				
[1]205	0–10	Loamy fine sand	SM, SP–SM	A–2, A–3
	10–12	Gravelly sandy clay loam, gravelly sandy loam.	SM–SC, SC	A–2, A–4
	12–18	Very gravelly sand, gravelly sand	SP, GP	A–1
	18–60	Stratified loamy sand to coarse sand	SP, SP–SM	A–1, A–3
Marquette:				
[1]242	0–9	Loamy sand	SP–SM, SM	A–2, A–3
	9–14	Gravelly fine sandy loam, gravelly loam, gravelly sandy clay loam.	SM, SC	A–2, A–1
	14–60	Stratified gravelly sand to coarse sand.	SP, SP–SM	A–1, A–3
Lohnes:				
[1]245	0–9	Loamy sand	SM	A–2
	9–60	Coarse sand, loamy coarse sand, loamy sand.	SM, SP–SM, SP	A–2, A–1, A–3
Pelan:				
[1]280	0–9	Loamy sand	SM	A–2, A–4
	9–14	Gravelly sandy loam, gravelly sandy clay loam.	SM, GM, SC	A–2
	14–32	Stratified gravelly coarse sand to fine sandy loam.	SP–SM, SP, GP	A–1, A–3
	32–60	Fine sandy loam, sandy loam, loam	SM, ML, CL	A–4, A–6

and classifications—Continued

Fragments >3 inches	Percentage passing sieve number—				Liquid limit	Plasticity index
	4	10	40	200		
Pct					*Pct*	
0–3	95–100	90–100	60–90	50–65	10–40	1–10
2–5	95–100	85–100	70–100	45–80	20–40	7–20
1–5	95–100	75–95	75–95	35–60	15–40	1–15
0	100	100	95–100	80–95	30–50	10–25
0	100	100	90–100	70–95	30–50	10–25
0	100	100	90–100	70–95	30–50	10–25
0–3	95–100	80–100	50–75	20–45	----------	NP
2–5	70–95	55–90	30–60	0–10	----------	NP
0	100	100	85–95	5–25	----------	NP
0	100	100	80–95	5–20	----------	NP
0	100	100	80–95	2–12	----------	NP
0	100	100	80–100	5–40	----------	NP
0	100	100	70–100	1–20	----------	NP
0	100	100	80–95	10–25	----------	NP
0–3	95–100	75–100	60–95	5–15	----------	NP
0–2	90–100	80–95	65–90	35–80	15–40	5–15
0	100	100	80–100	5–30	----------	NP
0	100	100	80–95	3–15	----------	NP
0	100	100	95–100	80–95	50–75	25–50
0	100	100	95–100	80–95	50–75	25–50
0–3	95–100	90–100	70–85	35–65	15–40	1–15
0–3	95–100	70–100	60–95	35–65	15–40	1–15
0–2	95–100	85–100	50–75	5–20	----------	NP
0–2	85–95	60–85	40–70	20–45	<20	5–10
0–2	40–90	15–80	10–50	0–5	----------	NP
0	90–100	80–100	40–80	0–10	----------	NP
0	90–100	85–100	50–75	10–35	----------	NP
0	50–85	20–55	10–45	10–35	<30	NP–10
0	50–95	20–85	15–70	0–10	----------	NP
0	100	100	45–65	10–25	----------	NP
0	80–100	65–100	35–60	2–20	----------	NP
2–4	95–100	65–100	60–90	15–40	<20	NP–5
2–4	45–85	25–55	20–45	10–35	10–30	NP–10
2–4	50–85	25–65	20–60	1–10	----------	NP
1–5	90–100	75–95	60–90	40–65	10–30	1–15

TABLE 11.—*Engineering properties*

Soil name and map symbol	Depth	USDA texture	Classification	
			Unified	AASHTO
	In			
Fram:				
[1] 296	0–9	Fine sandy loam	SM, SC	A–2, A–4
	9–60	Sandy loam, fine sandy loam, loam	SM, SC	A–2, A–4
Wheatville:				
[1] 343	0–13	Loam	OL, ML, CL–ML	A–4
	13–35	Very fine sandy loam, silt loam, loamy very fine sand.	ML, CL–ML	A–4
	35–60	Clay, silty clay, silty clay loam	CH, CL	A–7, A–6
Percy:				
[1] 379, [1] 383, [1] 384	0–6	Sandy clay loam	SC, SM–SC	A–4, A–6
	6–15	Loam, clay loam, fine sandy loam	CL, CL–ML	A–4, A–6
	15–60	Loam, fine sandy loam, sandy loam	SM–SC, SC, CL–ML, CL	A–4, A–6
Viking:				
[1] 403	0–9	Sandy clay loam	CL	A–6, A–7
	9–22	Clay	CH	A–7
	22–60	Clay	CH	A–7
Mavie:				
[1] 412	0–10	Sandy clay loam	ML, SM, OL	A–4, A–6, A–7
	10–14	Gravelly loamy sand, gravelly sandy loam.	SM, SP–SM	A–1, A–2
	14–22	Gravelly coarse sand, gravelly sand	SP–SM, SP, GP	A–1
	22–60	Loam, silt loam, clay loam	ML, CL, SM, SC	A–4, A–6
Augsburg:				
[1] 424	0–11	Very fine sandy loam	ML, CL, OL	A–4, A–6
	11–18	Loam, very fine sandy loam, silt loam	ML	A–4
	18–33	Loamy very fine sand, very fine sandy loam, loam.	ML	A–4
	33–62	Silty clay, clay, silty clay loam	CH	A–7
Donaldson:				
[1] 425	0–9	Very fine sandy loam	SM,ML	A–4
	9–14	Loamy very fine sand, very fine sandy loam, loam.	SM,ML	A–4
	14–24	Loamy very fine sand, very fine sandy loam, very fine sand.	SM	A–4, A–2
	24–60	Clay, silty clay	CH	A–7
Foldahl:				
[1] 426	0–9	Sandy loam	SM	A–4
	9–28	Fine sand, loamy fine sand, sand	SP–SM, SM	A–2, A–3
	28–60	Loam, clay loam, sandy loam	CL–ML, CL, SM–SC	A–4, A–6
Fram:				
[1] 427	0–9	Fine sandy loam	SM, SC	A–2, A–4
	9–60	Sandy loam, fine sandy loam, loam	SM, SC	A–2, A–4
Northcote:				
429, 429B	0–9	Clay	OH, CH	A–7
	9–18	Clay	CH	A–7
	18–60	Clay	CH	A–7
Noyes:				
[1] 430	0–13	Sandy clay loam	CL, SC	A–6
	13–60	Clay	CH	A–7
Strandquist:				
[1] 432	0–10	Sandy loam	SM	A–2, A–4
	10–20	Gravelly sand, gravelly coarse sand	SP, GP	A–1
	20–60	Silty clay loam, loam, sandy loam	CL, SC, CL–ML, SM–SC	A–4, A–6

and classifications—Continued

Fragments >3 inches	Percentage passing sieve number—				Liquid limit	Plasticity index
	4	10	40	200		
Pct					*Pct*	
0–1	90–100	70–100	45–65	25–45	<30	NP–10
0–1	90–100	70–95	45–70	25–50	<30	NP–10
0	100	100	90–100	50–95	15–40	NP–10
0	100	100	85–100	50–95	15–40	NP–10
0	100	100	95–100	90–100	35–65	15–45
0–1	90–100	75–100	60–90	40–50	20–30	5–15
1–5	85–100	80–95	60–90	50–70	15–40	5–20
1–5	85–100	65–85	55–80	40–60	20–40	5–20
0–5	90–97	90–97	85–95	50–90	20–40	10–20
0–5	90–97	90–97	90–95	80–95	50–75	25–45
0–5	90–97	90–97	90–95	80–95	50–75	25–45
0–3	95–100	85–100	70–95	35–65	20–45	5–15
2–5	70–90	45–70	30–50	5–30	15–30	NP–5
2–5	60–85	40–55	20–50	3–10	----------	NP
1–5	95–100	75–90	70–85	45–75	15–40	2–15
0	100	100	95–100	50–90	15–40	NP–15
0	100	100	95–100	50–90	15–40	NP–10
0	100	100	95–100	50–85	15–40	NP–10
0	100	100	95–100	95–100	50–80	35–55
0	100	100	95–100	35–60	15–35	1–5
0	100	100	95–100	35–60	15–40	1–10
0	100	100	95–100	20–50	<30	NP–5
0	100	95–100	90–100	85–100	60–80	30–50
0	100	95–100	70–85	35–50	<20	NP–5
0–3	95–100	90–100	70–85	5–35	----------	NP
1–5	95–100	80–95	80–90	45–75	20–40	5–20
0–1	90–100	70–100	45–65	25–45	<30	NP–10
0–1	90–100	70–95	45–70	25–50	<30	NP–10
0	100	100	95–100	95–100	65–80	35–45
0	100	100	95–100	90–100	70–85	30–50
0	100	100	95–100	90–100	70–85	40–60
0	100	100	60–85	40–75	25–40	10–20
0	100	100	75–100	75–100	60–85	30–60
0	95–100	90–100	70–80	25–50	10–30	1–5
2–5	40–75	20–55	15–50	0–5	----------	NP
1–2	95–100	75–98	65–90	35–80	20–40	5–20

TABLE 11.—*Engineering properties*

Soil name and map symbol	Depth	USDA texture	Classification	
			Unified	AASHTO
	In			
Syrene:				
[1]433, [1]435	0–16	Sandy loam	SM, SC	A–4
	16–60	Stratified loamy fine sand to gravelly coarse sand.	SP–SM, SP	A–3, A–1
Northcote:				
438	0–9	Clay	OH, CH	A–7
	9–18	Clay	CH	A–7
	18–60	Clay	CH	A–7
Grygla:				
[1]482	0–11	Loamy fine sand	SM, SP–SM	A–2, A–3
	11–29	Sand, fine sand, loamy fine sand	SP–SM, SM	A–2, A–3
	29–60	Loam, fine sandy loam, silt loam	CL–ML, CL	A–4, A–6
Markey:				
543	0–25	Sapric material	Pt	A–8
	25–60	Sand, loamy sand	SP, SM	A–2, A–3
Cathro:				
544	0–15	Hemic material	Pt	A–8
	15–34	Sapric material	Pt	A–8
	34–60	Sandy loam	SM, ML, SC	A–4
Deerwood:				
547	0–10	Sapric material	Pt	A–8
	10–12	Fine sand, loamy sand, fine sandy loam.	OL, ML, SM	A–2, A–4
	12–60	Sand and gravel	SM, SP	A–2, A–3, A–1
Percy:				
[1]581	0–6	Sandy clay loam	SC, SM–SC	A–4, A–6
	6–15	Loam, clay loam, fine sandy loam	CL, CL–ML	A–4, A–6
	15–60	Loam, fine sandy loam, sandy loam	SM–SC, SC, CL–ML, CL	A–4, A–6
Roliss:				
[1]582	0–16	Sandy clay loam	SC, CL	A–6
	16–26	Loam, clay loam, silty clay loam	ML, CL	A–6, A–7
	26–60	Loam, clay loam	CL	A–6, A–7
Nereson:				
[1]583	0–9	Fine sandy loam	SM	A–4
	9–60	Sandy loam, loam, fine sandy loam	SM, ML, CL	A–4, A–6
Bearden:				
[1]908:				
Bearden part	0–10	Silty clay loam	CL	A–6, A–7
	10–14	Silt loam, silty clay loam	CL	A–6, A–7
	14–60	Silt loam, silty clay loam	CL	A–6, A–7
Fargo part	0–18	Silty clay	CH	A–7
	18–41	Silty clay, clay	CH	A–7
	41–60	Silty clay, clay	CH	A–7
Hegne:				
[1]937:				
Hegne part	0–9	Silty clay	OH, CH	A–7
	9–26	Silty clay, clay	CH	A–7
	26–60	Clay, silty clay	CH	A–7
Northcote part	0–9	Clay	OH, CH	A–7
	9–18	Clay	CH	A–7
	18–60	Clay	CH	A–7
Northcote:				
[1]991:				
Northcote part	0–9	Clay	OH, CH	A–7
	9–18	Clay	CH	A–7
	18–60	Clay	CH	A–7

and classifications—Continued

Fragments >3 inches	Percentage passing sieve number—				Liquid limit	Plasticity index
	4	10	40	200		
Pct					*Pct*	
0–3	95–100	85–95	55–70	35–50	15–35	NP–10
2–5	75–95	55–80	30–60	0–10		NP
0	100	100	95–100	95–100	65–80	35–45
0	100	100	95–100	90–100	70–85	30–50
0	100	100	95–100	90–100	70–85	40–60
0	95–100	90–100	85–95	5–35		NP
0	95–100	90–100	70–95	5–35		NP
0–3	95–100	80–98	70–85	50–70	20–40	5–20
0	100	90–100	60–75	0–20		NP
0						
0						
0	100	95–100	60–85	35–60	15–26	3–10
0						
0–5	95–100	90–100	50–75	12–60	<20	NP–10
0–5	75–100	55–100	35–70	1–35		NP
0–1	90–100	75–100	60–90	40–50	20–30	5–15
1–5	85–100	80–95	60–90	50–70	15–40	5–20
1–5	85–100	65–85	55–80	40–60	20–40	5–20
0	90–100	85–100	70–90	40–60	20–40	10–25
0	95–100	90–100	80–90	60–80	20–50	11–30
0	95–100	90–100	80–90	60–80	20–50	11–30
0–5	90–100	75–100	50–70	35–50	<20	NP–5
1–5	90–100	75–95	60–95	45–75	<30	1–15
0	100	100	95–100	80–95	30–50	10–25
0	100	100	90–100	70–95	30–50	10–25
0	100	100	90–100	70–95	30–50	10–25
0	100	100	95–100	85–100	50–75	25–45
0	100	100	95–100	85–100	50–75	25–45
0	100	100	95–100	85–100	50–75	25–45
0	100	100	95–100	90–98	50–70	11–30
0	100	100	95–100	95–98	50–70	22–40
0	100	100	95–100	95–100	50–70	22–45
0	100	100	95–100	95–100	65–80	35–45
0	100	100	95–100	90–100	70–85	30–50
0	100	100	95–100	90–100	70–85	40–60
0	100	100	95–100	95–100	65–80	35–45
0	100	100	95–100	90–100	70–85	30–50
0	100	100	95–100	90–100	70–85	40–60

TABLE 11.—*Engineering properties*

Soil name and map symbol	Depth	USDA texture	Classification	
			Unified	AASHTO
	In			
Northcote, cont.:				
Wahpeton part	0–15	Silty clay	CH	A–7
	15–60	Clay, silty clay	CH	A–7
Arveson: [1]993:				
Arveson part	0–8	Loam	OL, ML, CL–ML	A–4
	8–15	Fine sandy loam, sandy loam, loam	SM	A–4
	15–60	Fine sand, loamy sand, sandy loam	SP–SM, SM	A–3, A–2, A–4
Cormant part	0–6	Loamy fine sand	SM, SP–SM	A–2, A–4
	6–60	Fine sand, sand, loamy fine sand	SP, SP–SM, SM	A–2, A–3
Rockwell: [1]994:				
Rockwell part	0–9	Fine sandy loam	ML, SM, SM–SC	A–4
	9–16	Fine sandy loam, sandy loam, loam	SM, ML, SM–SC	A–4
	16–28	Fine sand, sand, loamy fine sand	SM	A–2
	28–60	Silt loam, loam, clay loam	CL, ML	A–6
Grygla part	0–11	Loamy fine sand	SM, SP–SM	A–2, A–3
	11–29	Sand, fine sand, loamy fine sand	SP–SM, SM	A–2, A–3
	29–60	Loam, fine sandy loam, silt loam	CL–ML, CL	A–4, A–6

[1] This mapping unit is made up of two or more dominant kinds of soil. See description of the mapping unit for composition and

Soil and water features

Features that relate to runoff or infiltration of water, to flooding, to grading and excavation, and to subsidence and frost action of each soil are indicated in table 13. This information is helpful in planning land uses and engineering projects that are likely to be affected by the amount of runoff from watersheds, by flooding and a seasonal high water table, by the presence of a cemented pan in the upper 5 or 6 feet of the soil, by subsidence, or by frost action.

Hydrologic groups are used to estimate runoff caused by precipitation. Soil properties that influence the minimum rate of infiltration into the bare soil after prolonged wetting are depth to a water table, water intake rate and permeability after prolonged wetting, and depth to layers of slowly or very slowly permeable soil. Soils are assigned to four groups. In group A are soils that have a high infiltation rate when thoroughly wet and that have a low runoff potential. They are mainly deep, well drained, and sandy or gravelly. In group D, at the other extreme, are soils that have 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.

Flooding is rated in general terms that describe the frequency, duration, and period of the year when flooding is most likely. The ratings are based on evidences in the soil profile of the effects of flooding, namely thin strata of gravel, sand, silt, or, in places, clay deposited by floodwater; irregular decrease in organic-matter content with increasing depth; absence of distinctive soil horizons that form in soils of the areas that are not subject to flooding; local information about floodwater heights and the extent of flooding; and local knowledge that relates the unique landscape position of each soil to historic floods. Most soils in low positions on the landscape where flooding is likely to occur are classified as fluvents at the suborder level or as fluventic subgroups. See the section "Formation and Classification of the Soils."

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

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

Information about the seasonal high water table helps in assessing the need for specially designed foundations, the need for specific kinds of drainage systems, and the need for footing drains to insure dry basements. Such information is also needed to decide whether or not to construct basements and to deter-

and classifications—Continued

Fragments >3 inches	Percentage passing sieve number—				Liquid limit	Plasticity index
	4	10	40	200		
Pct					*Pct*	
0	100	100	95–100	80–95	50–75	25–50
0	100	100	95–100	80–95	50–75	25–50
0	100	95–100	85–90	50–65	20–40	NP–10
0	100	95–100	60–85	35–50	<20	NP–5
0	100	95–100	50–80	5–45	<20	NP–5
0	100	100	80–100	5–40	----------	NP
0	100	100	70–100	1–20	----------	NP
0	100	95–100	70–85	40–55	15–25	1–7
0	100	95–100	70–85	40–55	15–25	1–7
0	100	95–100	65–80	20–35	----------	NP
0–1	95–100	90–100	85–90	70–90	25–40	11–20
0	95–100	90–100	85–95	5–35	----------	NP
0	95–100	90–100	70–95	5–35	----------	NP
0–3	95–100	80–98	70–85	50–70	20–40	5–20

behavior characteristics of the whole mapping unit.

mine how septic tank absorption fields and other underground installations will function. Also, a seasonal high water table affects ease of excavation.

Depth to bedrock is shown as greater than 60 inches in depth for all soils in the county. In fact, bedrock is generally at depths of 200 feet or more.

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

Test data

Table 14 contains the results of engineering tests performed by the Minnesota Department of Highways on several important soils in Kittson County, Minnesota. The table shows the specific location where samples were taken, the depth to which sampling was done, and the results of tests to determine particle-size distribution and other properties significant in soil engineering.

Moisture density tests were not made for the soils in Kittson County.

Mechanical analysis shows the percentages of soil particles that would pass sieves of specified sizes. When classifying soils in the AASHTO and Unified systems, sand and other coarser materials do not pass through the No. 200 sieve (0.074 mm.) while silt and clay-size particles do. In a further separation of particle sizes, the clay fraction was determined by the hydrometer method rather than the pipette method used by most soil scientists.

Liquid limit and plasticity index indicate the effect of water on the strength and consistence of soil material. As the moisture content of a clayey soil is increased from a dry state, the material changes from a solid to a plastic state. If the moisture content is further increased, the material changes from a plastic to a liquid state. The plastic limit is the moisture content at which the soil material passes from solid to plastic. The liquid limit is the moisture content at which the material changes from plastic to liquid. The plasticity index is the numerical difference between the liquid limit and the plastic limit. It indicates the range of moisture content within which a soil material is plastic.

The AASHTO and Unified classifications have been explained earlier in the engineering classification of soils.

Formation and classification of the soils

This section consists of two main parts. The first part tells how the factors of soil formation have affected the development of soils in Kittson County. The second explains the system of soil classification currently used and places each soil series in the classes of that system.

TABLE 12.—*Physical and chemical*

[The symbol <means less than; >means more than. Entries under Erosion factors—(T) apply to the entire profile. Entries under not

Soil name and map symbol	Depth	Permeability	Available water capacity	Soil reaction	Salinity
	In	*In/hr*	*In/in*	*pH*	*Mmhos/cm*
Maddock:					
[1]45	0–16	6.0–20	0.08–0.12	6.6–7.3	<2
	16–60	6.0–20	0.05–0.13	6.6–8.4	<2
[2] Borup:					
46	0–10	2.0–6.0	0.20–0.23	7.4–8.4	<2
	10–19	2.0–6.0	0.17–0.20	7.4–8.4	<2
	19–60	2.0–20	0.15–0.19	7.9–8.4	<2
[2] Colvin:					
47	0–60	0.2–2.0	0.16–0.22	7.4–8.4	<2
Cashel:					
50	0–12	0.06–0.2	0.15–0.18	6.6–7.8	<2
	12–60	0.06–0.2	0.13–0.17	7.4–8.4	<2
[2] Augsburg:					
[1]52	0–11	0.6–6.0	0.20–0.23	7.9–8.4	<2
	11–18	2.0–6.0	0.20–0.23	7.9–8.4	<2
	18–33	2.0–6.0	0.17–0.22	7.9–8.4	<2
	33–62	<0.2	0.10–0.14	7.4–8.4	<2
[2] Grimstad:					
[1]59	0–8	2.0–6.0	0.13–0.18	7.4–8.4	<2
	8–38	6.0–20	0.09–0.19	7.4–8.4	<2
	38–60	0.6–2.0	0.11–0.19	7.4–8.4	<2
[2] Glyndon:					
[1]60	0–22	0.6–2.0	0.20–0.23	7.9–8.4	<2
	22–35	2.0–6.0	0.17–0.20	7.9–9.0	<2
	35–60	2.0–20	0.15–0.19	7.9–8.4	<2
[2] Arveson:					
[1]61	0–8	2.0–6.0	0.16–0.18	7.9–8.4	<2
	8–15	0.6–6.0	0.15–0.17	7.9–8.4	<2
	15–60	2.0–20	0.05–0.15	7.4–8.4	<2
[2] Rockwell:					
[1]63	0–9	2.0–6.0	0.16–0.18	7.4–8.4	<2
	9–16	2.0–6.0	0.15–0.17	7.9–8.4	<2
	16–28	6.0–20	0.05–0.07	7.4–7.8	<2
	28–60	0.2–2.0	0.18–0.22	7.4–7.8	<2
[2] Ulen:					
[1]64	0–15	6.0–20	0.16–0.18	7.4–8.4	<2
	15–20	6.0–20	0.10–0.12	7.9–8.4	<2
	20–60	6.0–20	0.06–0.08	7.9–8.4	<2
Foxhome:					
[1]65	0–11	0.6–6.0	0.14–0.18	6.6–7.3	<2
	11–15	2.0–20	0.10–0.15	6.6–7.3	<2
	15–36	6.0–20	0.03–0.05	7.4–7.8	<2
	36–60	0.6–2.0	0.15–0.21	7.4–8.4	<2
[2] Bearden:					
67	0–10	0.6–2.0	0.20–0.24	7.4–8.4	<2–4
	10–14	0.6–2.0	0.16–0.22	7.4–8.4	<2–8
	14–60	0.6–2.0	0.16–0.22	7.4–8.4	<2–8
Garnes:					
[1]77	0–6	0.6–2.0	0.18–0.20	6.1–7.3	<2
	6–10	0.6–2.0	0.17–0.20	6.6–7.8	<2
	10–60	0.6–2.0	0.14–0.19	7.4–8.4	<2
[2] Bearden:					
93, 93B	0–10	0.2–0.6	0.17–0.23	7.4–8.4	<2–4
	10–14	0.6–2.0	0.16–0.22	7.4–8.4	<2–8
	14–60	0.6–2.0	0.16–0.22	7.4–8.4	<2–8

properties of soils

"Wind erodibility group" applies only to the surface layer. Absence of an entry indicates that data were not available or were estimated]

Shrink-swell potential	Risk of corrosion		Erosion factors		Wind erodibility groups
	Uncoated steel	Concrete	K	T	
Low	Moderate	Low	0.17	5–4	2
Low	Moderate	Low	0.17		
Low	High	Low			4L
Low	High	Low			
Low	High	Low			
High	High	Low			4L
High	High	Low	0.28	5–4	4
High	High	Low	0.28		
Low	High	Low			4L
Low	High	Low			
Low	High	Low			
High	High	Low			
Low	Low	Low	0.20	4–3	3
Low	Low	Low	0.17		
Low	Moderate	Low	0.37		
Low	High	Low	0.32	4	4L
Low	High	Low	0.32		
Low	High	Low	0.32		
Low	High	Low			4L
Low	High	Low			
Low	High	Low			
Low	High	Low			3
Low	High	Low			
Low	High	Low			
Low	High	Low			
Low	Low	Low	0.17	4	2
Low	Low	Low	0.17		
Low	Low	Low	0.17		
Low	Low	Low	0.20	4	3
Low	Low	Low	0.20		
Low	Low	Low	0.20		
Moderate	Moderate	Low	0.37		
Moderate	High	Low			4L
Moderate	High	Low			
Moderate	High	Low			
Low	Moderate	Low	0.32	4–3	6
Moderate	Moderate	Low	0.32		
Low	Moderate	Low	0.32		
Moderate	High	Low			4L
Moderate	High	Low			
Moderate	High	Low			

TABLE 12.—*Physical and chemical*

Soil name and map symbol	Depth	Permeability	Available water capacity	Soil reaction	Salinity
	In	*In/hr*	*In/in*	*pH*	*Mmhos/cm*
Hangaard:					
[1] 111	0–7	2.0–20	0.10–0.14	6.6–7.8	<2
	7–60	6.0–20	0.02–0.04	7.4–8.4	<2
Redby:					
[1] 116	0–4	6.0–20	0.08–0.12	5.6–7.3	<2
	4–33	6.0–20	0.07–0.09	6.1–7.3	<2
	33–60	6.0–20	0.06–0.08	6.6–7.8	<2
Cormant:					
[1] 117	0–6	6.0–20	0.08–0.12	6.1–7.3	<2
	6–60	6.0–20	0.06–0.10	6.1–7.8	<2
Enstrom:					
145	0–8	6.0–20	0.10–0.12	6.6–7.8	<2
	8–33	6.0–20	0.06–0.08	6.6–8.4	<2
	33–60	0.2–2.0	0.17–0.20	7.4–8.4	<2
Poppleton:					
[1] 148	0–6	6.0–20	0.10–0.13	6.1–7.3	<2
	6–60	6.0–20	0.07–0.09	5.6–7.8	<2
Wahpeton:					
157, 157B	0–15	0.2–2.0	0.14–0.18	6.6–7.8	<2
	15–60	0.2–2.0	0.13–0.17	7.4–7.8	<2
Haug:					
187	0–11	0.6–6.0	0.35–0.48	6.6–7.3	<2
	11–14	0.6–6.0	0.12–0.24	7.4–8.4	<2
	14–60	0.6–2.0	0.11–0.19	7.4–8.4	<2
Karlstad:					
[1] 205	0–10	6.0–20	0.09–0.12	6.6–7.3	<2
	10–12	2.0–6.0	0.12–0.16	6.6–7.8	<2
	12–18	>20	0.02–0.04	7.4–8.4	<2
	18–60	>6.0	0.02–0.08	7.4–8.4	<2
Marquette:					
[1] 242	0–9	6.0–20	0.10–0.14	6.1–7.3	<2
	9–14	2.0–6.0	0.10–0.16	7.4–7.8	<2
	14–60	>20	0.02–0.04	7.4–9.0	<2
Lohnes:					
[1] 245	0–9	6.0–20	0.08–0.10	6.6–7.3	<2
	9–60	6.0–20	0.03–0.07	6.6–8.4	<2
Pelan:					
[1] 280	0–9	6.0–20	0.10–0.12	6.6–7.3	<2
	9–14	6.0–20	0.10–0.16	6.6–7.8	<2
	14–32	6.0–20	0.03–0.05	7.4–8.4	<2
	32–60	0.6–6.0	0.15–0.16	7.9–9.0	<2
[2] Fram:					
[1] 296	0–9	2.0–6.0	0.13–0.18	7.4–8.4	<2
	9–60	0.6–6.0	0.13–0.20	7.4–8.4	<2
[2] Wheatville:					
[1] 343	0–13	2.0–6.0	0.18–0.22	7.9–8.4	<2
	13–35	2.0–6.0	0.15–0.21	7.4–8.4	<2
	35–60	0.06–0.2	0.10–0.14	7.4–7.8	<2
[2] Percy:					
[1] 379, [1] 383, [1] 384	0–6	0.6–2.0	0.18–0.20	6.6–8.4	<2
	6–15	0.6–6.0	0.15–0.19	7.4–8.4	<2
	15–60	0.6–6.0	0.12–0.19	7.4–8.4	<2
Viking:					
[1] 403	0–9	0.6–2.0	0.18–0.20	6.6–7.8	<2
	9–22	<0.06	0.10–0.14	7.4–7.8	<2
	22–60	<0.06	0.09–0.13	7.4–8.4	<2

properties of soils—Continued

Shrink-swell potential	Risk of corrosion		Erosion factors		Wind erodibility groups
	Uncoated steel	Concrete	K	T	
Low	High	Low			3
Low	High	Low			
Low	Low	Moderate	0.17	5	2
Low	Low	Low	0.17		
Low	Low	Low	0.17		
Low	High	Low			2
Low	High	Low			
Low	Moderate	Low	0.17	4–3	2
Low	Moderate	Low	0.17		
Moderate	Moderate	Low	0.37		
Low	Low	Low			2
Low	Low	Low			
High	High	Low	0.32	5	4
High	High	Low	0.32		
	High	Low			8
Low	High	Low			
Low	High	Low			
Low	Low	Low			2
Low	Low	Low			
Low	Low	Low			
Low	Low	Low			
Low	Low	Low	0.20	3	2
Low	Low	Low	0.20		
Low	Low	Low	0.20		
Low	Moderate	Low	0.15	5	2
Low	Moderate	Low	0.15		
Low	Moderate	Low	0.20	3	2
Low	Moderate	Low	0.20		
Low	Moderate	Low	0.20		
Low	Moderate	Low	0.20		
Low	High	Low	0.20	4–3	3
Low	High	Low	0.43		
Low	High	Low	0.32	4–3	4L
Low	High	Low	0.32		
High	High	Low	0.32		
Moderate	High	Low			5
Moderate	High	Low			
Moderate	High	Low			
Moderate	High	Low	0.32	5	5
High	High	Low	0.32		
High	High	Low	0.32		

TABLE 12.—*Physical and chemical*

Soil name and map symbol	Depth	Permeability	Available water capacity	Soil reaction	Salinity
	In	*In/hr*	*In/in*	*pH*	*Mmhos/cm*
[2] Mavie:					
[1] 412	0–10	0.6–2.0	0.18–0.22	7.9–8.4	<2
	10–14	2.0–20	0.08–0.13	7.9–8.4	<2
	14–22	6.0–20	0.03–0.05	7.4–8.4	<2
	22–60	0.2–2.0	0.15–0.21	7.9–8.4	<2
[2] Augsburg:					
[1] 424	0–11	0.6–6.0	0.20–0.23	7.9–8.4	<2
	11–18	2.0–6.0	0.20–0.23	7.9–8.4	<2
	18–33	2.0–6.0	0.17–0.22	7.9–8.4	<2
	33–62	<0.2	0.10–0.14	7.4–8.4	<2
[2] Donaldson:					
[1] 425	0–9	2.0–6.0	0.20–0.23	6.6–7.3	<2
	9–14	2.0–6.0	0.17–0.21	6.6–7.8	<2
	14–24	2.0–6.0	0.16–0.19	7.4–8.4	<2
	24–60	0.06–0.2	0.09–0.13	7.4–8.4	<2
Foldahl:					
[1] 426	0–9	2.0–6.0	0.14–0.18	6.6–7.3	<2
	9–28	6.0–20	0.07–0.12	6.6–7.8	<2
	28–60	0.2–2.0	0.14–0.19	7.4–8.4	<2
Fram:					
[1] 427	0–9	2.0–6.0	0.13–0.18	6.6–7.3	<2
	9–60	0.6–6.0	0.13–0.20	7.4–8.4	<2
[2] Northcote:					
429, 429B	0–9	0.06–0.2	0.13–0.16	6.6–7.3	<2
	9–18	0.06–0.2	0.10–0.14	6.6–7.8	<2
	18–60	0.06–0.2	0.10–0.14	7.4–8.4	<2
[2] Noyes:					
[1] 430	0–13	0.6–2.0	0.18–0.22	6.6–7.3	<2
	13–60	0.06–0.2	0.10–0.16	6.6–8.4	<2
Strandquist:					
[1] 432	0–10	0.6–6.0	0.16–0.20	6.6–7.3	<2
	10–20	6.0–20	0.03–0.05	7.4–8.4	<2
	20–60	0.6–2.0	0.12–0.19	7.4–8.4	<2
Syrene:					
[1] 433, [1] 435	0–16	2.0–6.0	0.13–0.18	7.4–8.4	<2
	16–60	6.0–20	0.02–0.04	7.4–8.4	<2
Northcote:					
438	0–9	0.06–0.2	0.13–0.16	6.6–7.3	<2
	9–18	0.06–0.2	0.10–0.14	6.6–7.8	<2
	18–60	0.06–0.2	0.10–0.14	7.4–8.4	<2
Grygla:					
[1] 482	0–11	6.0–20	0.13–0.15	6.6–7.3	<2
	11–29	6.0–20	0.06–0.11	6.6–7.3	<2
	29–60	0.2–2.0	0.17–0.19	7.4–8.4	<2
Markey:					
543	0–25	0.2–6.0	0.35–0.45	6.1–7.3	<2
	25–60	6.0–20	0.03–0.08	6.1–8.4	<2
Cathro:					
544	0–15	0.6–6.0	0.45–0.55	6.1–7.3	<2
	15–34	0.2–6.0	0.35–0.45	5.6–7.8	<2
	34–60	0.2–2.0	0.12–0.16	6.6–8.4	<2
Deerwood:					
547	0–10	0.6–6.0	0.35–0.45	6.6–7.8	<2
	10–12	2.0–20	0.09–0.17	6.6–7.8	<2
	12–60	6.0–20	0.02–0.17	7.4–8.4	<2

properties of soils—Continued

Shrink-swell potential	Risk of corrosion		Erosion factors		Wind erodibility groups
	Uncoated steel	Concrete	K	T	
Low	High	Low			4L
Low	High	Low			
Low	High	Low			
Moderate	High	Low			
Low	High	Low			4L
Low	High	Low			
Low	High	Low			
High	High	Low			
Low	High	Low			3
Low	High	Low			
Low	High	Low			
High	High	Low			
Low	Moderate	Low	0.20	4	3
Low	Moderate	Low	0.17		
Moderate	Moderate	Low	0.37		
Low	High	Low	0.20	4–3	3
Low	High	Low	0.43		
High	High	Low	0.28	5	4
High	High	Low	0.28		
High	High	Low	0.28		
Moderate	High	Low			5
High	High	Low			
Low	High	Low			3
Low	High	Low			
Moderate	High	Low			
Low	High	Low			3
Low	High	Low			
High	High	Low	0.28	5	4
High	High	Low	0.28		
High	High	Low	0.28		
Low	High	Low			2
Low	High	Low			
Moderate	High	Low			
	High	Low			8
Low	High	Low			
	High	Low			8
	High	Low			
Low	High	Low			
	High	Low			
Low	High	Low			
Low	High	Low			

TABLE 12.—*Physical and chemical*

Soil name and map symbol	Depth	Permeability	Available water capacity	Soil reaction	Salinity
	In	*In/hr*	*In/in*	*pH*	*Mmhos/cm*
[2] Percy:					
[1] 581	0–6	0.6–2.0	0.18–0.20	6.6–7.8	<2
	6–15	0.6–6.0	0.15–0.19	7.4–8.4	<2
	15–60	0.6–6.0	0.12–0.19	7.4–8.4	<2
Roliss:					
[1] 582	0–16	0.6–2.0	0.18–0.20	6.6–7.8	<2
	16–26	0.2–0.6	0.15–0.19	6.6–7.8	<2
	26–60	0.2–2.0	0.15–0.19	7.9–8.4	<2
Nereson:					
[1] 583	0–9	2.0–6.0	0.14–0.17	6.6–7.8	<2
	9–60	0.6–6.0	0.16–0.18	7.4–8.4	<2
Bearden:					
[1] 908:					
[2] Bearden part	0–10	0.2–0.6	0.17–0.23	7.4–8.4	<2
	10–14	0.6–2.0	0.16–0.22	7.4–8.4	<2
	14–60	0.6–2.0	0.16–0.22	7.4–8.4	<2
[2] Fargo part	0–18	0.06–0.2	0.15–0.18	6.6–7.8	<2
	18–41	0.06–0.2	0.14–0.17	6.6–7.8	<2
	41–60	0.06–0.2	0.14–0.17	7.9–8.4	<2
Hegne:					
[1] 937:					
[2] Hegne part	0–9	<0.2	0.14–0.17	7.8–8.4	<2
	9–26	<0.2	0.13–0.16	7.4–8.4	<2
	26–60	<0.06	0.09–0.13	7.4–8.4	<2
[2] Northcote part	0–9	0.06–0.2	0.13–0.16	6.6–7.3	<2
	9–18	0.06–0.2	0.10–0.14	6.6–7.8	<2
	18–60	0.06–0.2	0.10–0.14	7.4–8.4	<2
Northcote:					
[1] 991:					
Northcote part	0–9	0.06–0.2	0.13–0.16	6.6–7.3	<2
	9–18	0.06–0.2	0.10–0.14	6.6–7.8	<2
	18–60	0.06–0.2	0.10–0.14	7.4–8.4	<2
Wahpeton part	0–15	0.2–2.0	0.14–0.18	6.6–7.8	<2
	15–60	0.2–2.0	0.13–0.17	7.4–7.8	<2
Arveson:					
[1] 993:					
Arveson part	0–8	2.0–6.0	0.16–0.18	7.9–8.4	<2
	8–15	0.6–6.0	0.15–0.17	7.9–8.4	<2
	15–60	2.0–20	0.05–0.15	7.4–8.4	<2
Cormant part	0–6	6.0–20	0.08–0.12	6.1–7.3	<2
	6–60	6.0–20	0.06–0.10	6.1–7.8	<2
Rockwell:					
[1] 994:					
Rockwell part	0–9	2.0–6.0	0.16–0.18	7.4–8.4	<2
	9–16	2.0–6.0	0.15–0.17	7.9–8.4	<2
	16–28	6.0–20	0.05–0.07	7.4–7.8	<2
	28–60	0.2–2.0	0.18–0.22	7.4–7.8	<2
Grygla part	0–11	6.0–20	0.13–0.15	6.1–7.3	<2
	11–29	6.0–20	0.06–0.11	6.6–7.3	<2
	29–60	0.2–2.0	0.17–0.19	7.4–8.4	<2

[1] This mapping unit is made up of two or more dominant kinds of soil. See description of the mapping unit for composition and behavior characteristics of the whole mapping unit.

properties of soils—Continued

Shrink-swell potential	Risk of corrosion		Erosion factors		Wind erodibility groups
	Uncoated steel	Concrete	K	T	
Moderate	High	Low			5
Moderate	High	Low			
Moderate	High	Low			
Moderate	High	Low			5
Moderate	High	Low			
Moderate	High	Low			
Low	Moderate	Low	0.28	4–3	3
Low	Moderate	Low	0.28		
Moderate	High	Low			4L
Moderate	High	Low			
Moderate	High	Low			
High	High	Low	0.32	5	4
High	High	Low	0.32		
High	High	Low	0.32		
High	High	Low			4
High	High	Low			
High	High	Low			
High	High	Low	0.28	5	4
High	High	Low	0.28		
High	High	Low	0.28		
High	High	Low	0.28	5	4
High	High	Low	0.28		
High	High	Low	0.28		
High	High	Low	0.32	5	4
High	High	Low	0.32		
Low	High	Low			4L
Low	High	Low			
Low	High	Low			
Low	High	Low			2
Low	High	Low			
Low	High	Low			3
Low	High	Low			
Low	High	Low			
Low	High	Low			
Low	High	Low			2
Low	High	Low			
Moderate	High	Low			

[a] This mapping unit may have areas that have more salinity than is indicated. See section on "Saline Areas" for more information.

TABLE 13.—*Soil and*

[The definitions of "flooding" and "water table" in the Glossary explain such terms as "rare," "brief," "apparent," and

Soil name and map symbol	Hydrologic group	Flooding		
		Frequency	Duration	Months
Maddock: [1] 45	A	None		
Borup: 46	B/D	Rare		
Colvin: 47	C/D	Rare		
Cashel: 50	C	Occasional	Brief	Mar-Jun
Augsburg: [1] 52	B/D	Rare		
Grimstad: [1] 59	C	None		
Glyndon: [1] 60	B	None		
Arveson: [1] 61	A/D	Rare		
Rockwell: [1] 63	C	Rare		
Ulen: [1] 64	B	None		
Foxhome: [1] 65	B	None		
Bearden: 67	C	None		
Garnes: [1] 77	B	None		
Bearden: 93, 93B	C	None		
Hangaard: [1] 111	D	Rare		
Redby: [1] 116	B	None		
Cormant: [1] 117	A/D	Rare		
Enstrom: 145	B	None		
Poppleton: [1] 148	A	None		
Wahpeton: 157, 157B	C	Occasional	Brief	Apr-Jun
Haug: 187	C/D	Frequent	Very long	Apr-Jun
Karlstad: [1] 205	A	None		
Marquette: [1] 242	A	None		

water features

"perched." The symbol < means less than; > means more than. Absence of an entry indicates that the feature is not a concern]

High water table			Bedrock		Potential frost action
Depth	Kind	Months	Depth	Hardness	
Ft			*In*		
>6.0			>60		Low.
1.0–3.0	Apparent	Apr-Jul	>60		High.
0–3.0	Apparent	Apr-Jun	>60		High.
1.0–6.0	Apparent	Apr-Jul	>60		High.
1.0–3.0	Apparent	Apr-Jul	>60		High.
2.5–6.0	Apparent	Apr-Jul	>60		High.
2.5–6.0	Apparent	Apr-Jul	>60		High.
1.0–3.0	Apparent	Apr-Jul	>60		High.
1.0–3.0	Apparent	Apr-Jul	>60		High.
2.5–6.0	Apparent	Apr-Jul	>60		Moderate.
2.5–6.0	Apparent	Nov-Jun	>60		High.
3.0–5.0	Apparent	Sep-Jun	>60		High.
2.5–6.0	Apparent	Nov-Jul	>60		High.
3.0–5.0	Apparent	Sep-Jun	>60		High.
1.0–3.0	Apparent	Apr-Jul	>60		Moderate.
2.0–6.0	Apparent	Apr-Jul	>60		Moderate.
1.0–3.0	Apparent	Apr-Jul	>60		Moderate.
2.5–6.0	Apparent	Apr-Jul	>60		High.
2.5–6.0	Apparent	Apr-Jul	>60		Moderate.
2.0–6.0			>60		High.
0–3.0	Apparent	Jan-Dec	>60		High.
2.5–6.0	Apparent	Apr-Jul	>60		Low.
>6.0			>60		Low.

TABLE 13.—*Soil and*

Soil name and map symbol	Hydrologic group	Flooding		
		Frequency	Duration	Months
Lohnes: [1]245	A	None		
Pelan: [1]280	B	None		
Fram: [1]296	B	None		
Wheatville: [1]343	B	None		
Percy: [1]379, [1]383	B/D	Rare		
[1]384	B/D	Common	Brief	Apr-Jun
Viking: [1]403	D	Rare		
Mavie: [1]412	B/D	Rare		
Augsburg: [1]424	B/D	Common	Brief	Apr-Jun
Donaldson: [1]425	B	None		
Foldahl: [1]426	B	None		
Fram: [1]427	B	None		
Northcote: 429, 429B	D	Rare		
Noyes: [1]430	C	Rare		
Strandquist: [1]432	C	Rare		
Syrene: [1]433, [1]435	A/D	Rare		
Northcote: 438	D	Common	Brief	Apr-Jun
Grygla: [1]482	B/D	Rare		
Markey: 543	D	Frequent	Long	Nov-May
Cathro: 544	D	Frequent	Long	Nov-May
Deerwood: 547	B/D	Frequent	Very long	Apr-Jul
Percy: [1]581	B/D	Rare		
Roliss: [1]582	B/D	Rare		
Nereson: [1]583	B	None		

water features—Continued

High water table			Bedrock		Potential frost action
Depth	Kind	Months	Depth	Hardness	
Ft			*In*		
4.0–6.0	Apparent	Mar-Jul	>60		Low.
2.5–6.0	Apparent	Apr-Jul	>60		High.
2.5–5.0	Apparent	Sep-Jun	>60		High.
2.5–6.0	Apparent	Apr-Jul	>60		High.
1.0–3.0	Apparent	Apr-Jul	>60		High.
0–3.0	Apparent	Apr-Jul	>60		High.
1.0–3.0	Apparent	Apr-Jul	>60		Moderate.
1.0–5.0	Apparent	Apr-Jul	>60		High.
0–3.0	Apparent	Apr-Jul	>60		High.
2.5–6.0	Apparent	Apr-Jul	>60		High.
2.5–6.0	Apparent	Nov-Jun	>60		High.
2.5–5.0	Apparent	Sep-Jun	>60		High.
1.0–5.0	Apparent	Apr-Jul	>60		High.
1.0–5.0	Apparent	Apr-Jul	>60		High.
1.0–3.0	Apparent	Nov-Jun	>60		High.
0–3.0	Apparent	Apr-Jul	>60		Moderate.
0–5.0	Apparent	Apr-Jul	>60		High.
1.0–3.0	Apparent	Nov-Jul	>60		High.
0–1.0	Apparent	Nov-Jun	>60		High.
0–1.0	Apparent	Nov-Jun	>60		High.
0–3.0	Apparent	Jan-Dec	>60		Moderate.
1.0–3.0	Apparent	Apr-Jul	>60		High.
1.0–3.0	Apparent	Apr-Jul	>60		High.
2.5–6.0	Apparent	Nov-Jun	>60		High.

TABLE 13.—*Soil and*

Soil name and map symbol	Hydrologic group	Flooding		
		Frequency	Duration	Months
Bearden: [1]908:				
Bearden part	C	None		
Fargo part	D	Rare	Brief	Apr-Jun
Hegne: [1]937:				
Hegne part	D	Rare		
Northcote part	D	Rare		
Northcote: [1]991:				
Northcote part	D	Rare		
Wahpeton part	C	Occasional	Brief	Apr-Jun
Arveson: [1]993:				
Arveson part	A/D	Common	Brief	Apr-Jun
Cormant part	A/D	Common	Brief	Apr-Jun
Rockwell: [1]994:				
Rockwell part	C	Common	Brief	Apr-Nov
Grygla part	B/D	Common	Brief	Apr-Jul

[1] This mapping unit is made up of two or more dominant kinds of soil. See description of the mapping unit for composition and

Formation of soils

Soil is the result of the action of soil-forming processes on materials deposited or accumulated by geologic agencies. The characteristics of the soil at any given point are determined by (1) the physical and mineralogical composition of the parent material; (2) the climate under which the soil material accumulated and which has existed since its accumulation; (3) the plant and animal life on and in the soil; (4) the relief or lay of the land, and the resulting moisture regime; and (5) the length of time the forces of soil formation have acted on the soil material. These factors of soil formation are interdependent, and few generalizations can be made regarding any one factor unless the effects of the others are known.

Man has also influenced the development of soils by disturbing the natural balance of certain factors or altering related conditions. In removing natural vegetation and tilling the soil he has accelerated erosion. Changes in drainage condition or relief, or the effects of relief as induced by man may also influence soil development. Modification of natural differences by adding fertilizers or organic residues, or cropping without replacing nutrients also modify the soil forming processes and resulting characteristics.

Parent material

Kittson County soils formed in calcareous lacustrine deposits in the basin of Glacial Lake Agassiz. In the west of the county, nearly level, calcareous lacustrine deposits are very fine textured (clays) and generally become progressively coarser toward the east. The clayey sediment grades into silty, sandy, and finally gravel sediment. Areas of lake-modified glacial till and related sediment also occur throughout the eastern half of the county. Several small areas of sand dunes are in southern St. Joseph Township and on the north and south side of Lake Bronson.

The lake-modified glacial sediment primarily is calcareous, olive brown glacial till. This is mainly loam or fine sandy loam. In places this till is very firm when dry. Stones and boulders are scattered on the surface and throughout the till. There is a lag line beneath the surface of the soil that is supportive evidence of the lake-modified concept.

There are several relatively large areas of organic soils in the eastern third of the county. These soils accumulated over the years from the remains of plants in areas where there was an abundance of water.

Climate

As a soil forming factor, climate affects the physical, chemical, and biological relationships of the soil. Rainfall, humidity, and frost influence the availability of moisture and rate of percolation. This movement of water in turn dissolves minerals and transports them in the soil mass. Temperature influences formation as it regulates the growth of organisms and the speed of chemical reactions.

water features—Continued

High water table			Bedrock		Potential frost action
Depth	Kind	Months	Depth	Hardness	
Ft			*In*		
3.0–5.0	Apparent	Sep-Jun	>60		High.
1.0–5.0	Apparent	Sep-Jun	>60		High.
0–4.0	Apparent	Apr-Jul	>60		High.
0–5.0	Apparent	Apr-Jul	>60		High.
0–5.0	Apparent	Apr-Jul	>60		High.
>6.0			>60		High.
0–3.0	Apparent	Apr-Jul	>60		High.
0–3.0	Apparent	Apr-Jul	>60		Moderate.
0–3.0	Apparent	Apr-Jul	>60		High.
0–3.0	Apparent	Nov-Jul	>60		High.

behavior characteristics of the whole mapping unit.

Kittson County has a subhumid, continental climate characterized by wide variations in temperature from summer to winter. The winters are quite long, and the soils commonly are frozen to a depth of from 3 to 5 feet for approximately 6 months of the year. During this time, the soil forming processes are largely dormant, except for effects of frost action. The growing season averages 110 days, and during this time approximately 65 percent of the annual precipitation is received. It is during this season of the year that the soil forming processes as influenced by climate are most active. The climate is essentially uniform throughout Kittson County. However, the eastern part of the county receives slightly more precipitation than the western part. This has influenced the native vegetation and the kind of soils formed (refer to next section).

Plant and animal life

All forms of life, both in and on the soil, influence its chemical and biological processes. Bacteria, earthworms, and other forms of animal life aid in the weathering of materials and the decomposition of organic matter. Vegetation and fungi influence soil formation by returning residues to the soil and aiding in decomposition. They also affect formation of soil by influencing the transfer of elements in the soil mass, by influencing soil pH value and, by existing in a close interrelationship with climate and relief.

The native vegetation of Kittson County was mainly tall prairie grasses mixed with areas of wetland reeds and sedges. Fire control had some effect on limiting tree growth in this area. The eastern part of the county had a mixture of prairie and forest, a savannah, at the time of settlement. These trees have left their influence on some of the soils in the eastern part of the county. Bottom-land hardwoods such as ash, elm, and poplar, line the banks and narrow terraces of the major streams in the county. These trees aid in stabilizing these areas, but other affects on soil formation have been minimal.

The activities of animals on formation of soils in Kittson County is of minor importance as compared to the influence of plants. Earthworms and rodents, however, do perform an important function in the transportation and translocation of organic materials. Snails and other marine life also influence formation in that their shells or other skeletal structures increase the carbonate content of the soils. The action of bacteria on soil materials and organic matter is also an important factor in the formation of soil.

Environmental factors such as climate, parent material, relief, and age influence the kinds of plants and animals present so there is a very close interrelationship of these factors.

Relief

Relief influences soil formation by affecting the relationships among temperature, water, erosion, and vegetation.

TABLE 14.—*Engineering*

[Tests performed by the Minnesota Department of Highways, in cooperation with U.S. Department of Commerce, Bureau of Public (AASHTO)

Soil name and map symbol	Parent material	Minnesota report number SS72–	Depth	Moisture density	
				Maximum dry	Optimum moisture
			In	*Lb/cu ft* [3]	*Pct*
Arveson sandy clay loam: NW¼, NW¼, NE¼, sec. 19, T. 159 N., R. 47 W. (Modal.)	Lacustrine sand	291	0–6		
		292	6–12		
		293	12–27		
		295	33–40		
Lohnes loamy sand: NE¼, NW¼, NE¼, sec. 23, T. 159 N., R. 46 W. (Modal.)	Beach ridge sands	280	0–10		
		282	13–17		
		284	23–42		
Mavie sandy clay loam: SE¼, SE¼, SE¼, sec. 36, T. 160 N., R. 45 W. (Modal.)	Locally sorted water-laid cap over till.	316	0–6		
		317	6–14		
		318	14–25		
		319	25–42		
Northcote clay: SW¼, SW¼, SW¼, sec. 32, T. 162 N., R. 48 W. (Modal.)	Lacustrine clay	304	0–9		
		305	9–18		
		308	38–48		
Percy sandy clay loam: SW¼, SW¼, SE¼, sec. 9, T. 163 N., R. 45 W.	Water sorted glacial till	300	0–8		
		302	11–26		
		303	26–50		
Redby loamy fine sand: NE¼, NW¼, NE¼, sec. 35, T. 162 N., R. 46 W. (Modal.)	Lacustrine clay	320	0–6		
		322	13–18		
		324	32–50		
Roliss sandy clay loam: SW¼, NW¼, NW¼, sec. 7, T. 159 N., R. 45 W. (Modal.)	Water sorted glacial till	296	0–10		
		297	10–17		
		299	24–40		

[1] Mechanical analysis according to AASHTO Designation T–88–70 (*2*). Results by this procedure frequently may differ somewhat from results that would have been obtained by the soil survey procedure of the Soil Conservation Service (SCS). In the AASHTO procedure, the fine material is analyzed by the hydrometer method and the various grain-size fractions are calculated on the basis of all the material, including that coarser than 2 millimeters in diameter. In the SCS soil survey procedure, the fine

Kittson County is level to nearly level throughout with the exception of the beach ridges and breaks or slopes along drainageways and streams. This nearly level condition results in many poorly drained soils that have a high organic-matter content, a gleyed condition, a high concentration of carbonates, and mottling of varying intensity in the soil profiles.

Time

Long periods of time are required for the factors of soil formation to develop a profile; however, the length of time to reach a level of development is quite variable. Much less time is required for soil to form in humid regions with dense vegetation than in very cold regions with little vegetation. Drainage also influences how rapidly a soil develops; well drained sites usually develop more rapidly. The nature of parent materials also determines how quickly development takes place. Materials such as glacial till or lacustrine sediment develop profiles and soil much more rapidly than hard bedrock. Geologically the soils of Kittson County are young. Most of the parent materials were deposited about 9,000 to 12,000 years ago.

Classification of soils

The system of soil classification currently used was adopted by the National Cooperative Soil Survey in 1965. Readers interested in further details about the system should refer to the latest literature available (*17*).

test data

Roads, in accordance with standard procedures of the American Association of State Highway and Transportation Officials (*2*)]

Mechanical analysis [1]							Liquid limit	Plasticity index	Classification	
Percentage passing sieve—			Percentage smaller than—						AASHTO [2]	Unified [3]
No. 10	No. 40	No. 200	0.05 mm	0.02 mm	0.005 mm	0.002 mm				
							Pct			
100	99	53	48	43	30	22	42	8	A–5(4)	OL
100	98	37	35	31	24	16	25	2	A–4(0)	SM
100	99	20	12	12	8	6	NP	NP	A–2–4(0)	SM
97	90	10	9	8	6	5	NP	NP	A–3(0)	SP–SM
96	62	13	12	10	6	6	NP	NP	A–2–4(0)	SM
89	43	4	3	3	3	3	NP	NP	A–1–6(0)	SP
93	45	4	3	3	3	3	NP	NP	A–1–6(0)	SP
99	91	61	56	46	37	30	41	14	A–7–6(7)	OL
99	86	47	43	37	29	25	28	13	A–6(3)	SC
64	47	7	7	6	5	5	NP	NP	A–1–6(0)	SP–SM
84	75	47	42	30	21	15	19	6	A–4(2)	SM–SC
97	96	93	89	83	71	63	77	43	A–7–6(20)	CH
97	96	94	92	89	84	77	80	48	A–7–5(20)	CH
100	100	98	98	98	96	89	79	50	A–7–6(20)	CH
99	89	59	53	38	28	23	47	18	A–7–6(9)	OL
90	83	60	55	43	28	19	23	6	A–4(5)	CL–ML
89	81	59	55	45	28	20	20	6	A–4(5)	CL–ML
100	86	13	12	9	7	5	NP	NP	A–2–4(0)	SM
99	84	18	10	8	8	7	NP	NP	A–2–4(0)	SM
100	95	7	6	6	5	5	NP	NP	A–3(0)	SP–SM
97	84	51	48	38	24	23	40	25	A–6(9)	CL
79	67	45	42	33	24	18	28	13	A–6(3)	CL
93	87	65	59	48	36	27	29	14	A–6(8)	CL

material is analyzed by the pipette method and the material coarser than 2 millimeters is excluded from calculations of grain-size fractions. The mechanical analyses used in this table are not suitable for use in naming textural classes for soils.

[2] Based on AASHTO Designation M 145–66 (*2*).

[3] Based on the Unified Soil Classification System (*3,12*).

The system of classification has six categories. Beginning with the broadest, these categories are order, suborder, great group, subgroup, family, and series. In this system the bases for classification are the different soil properties that can be observed in the field or those that can be inferred either from other properties that are observable in the field or from the combined data of soil science and other disciplines. The properties selected for the higher categories are the result of soil genesis or of factors that affect soil genesis. In table 15 the soils of the survey area are classified according to the system. Classes of the system are briefly discussed in the following paragraphs.

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

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

GREAT GROUP.—Each suborder is divided into great groups on the basis of close similarities in kind, arrangement, and degree of expression of pedogenic horizons; soil moisture and temperature regimes; and base status. The name of a great group ends with the name of a suborder. A prefix added to the same suggests something about the properties of the soil. An

TABLE 15.—*Classification of the soils*

[An asterisk in the first column indicates a taxadjunct to the series. See text for a description of those characteristics of this taxadjunct that are outside the range of the series]

Soil name	Family or higher taxonomic class
*Arveson	Coarse-loamy, frigid Typic Calciaquolls
Augsburg	Coarse-silty over clayey, frigid Typic Calciaquolls
Bearden	Fine-silty, frigid Aeric Calciaquolls
Borup	Coarse-silty, frigid Typic Calciaquolls
Cashel	Fine, montmorillonitic, frigid Mollic Udifluvents
Cathro	Loamy, mixed, euic Terric Borosaprists
Colvin	Fine-silty, frigid Typic Calciaquolls
Cormant	Mixed, frigid Mollic Psammaquents
Deerwood	Sandy, mixed (calcareous), frigid Histic Humaquepts
Donaldson	Coarse-loamy over clayey, mixed Aquic Haploborolls
Enstrom	Sandy over loamy, mixed, nonacid, frigid Aquic Udorthents
*Fargo	Fine, montmorillonitic, frigid Vertic Haplaquolls
Foldahl	Sandy over loamy, mixed Aquic Haploborolls
Foxhome	Sandy-skeletal over loamy, mixed Aquic Haploborolls
Fram	Coarse-loamy, frigid Aeric Calciaquolls
Garnes	Fine-loamy, mixed Aquic Eutroboralfs
Glyndon	Coarse-silty, frigid Aeric Calciaquolls
Grimstad	Sandy over loamy, frigid Aeric Calciaquolls
Grygla	Sandy over loamy, mixed, nonacid, frigid Mollic Haplaquents
Hangaard	Sandy, mixed, frigid Typic Haplaquolls
Haug	Coarse-loamy, mixed (calcareous), frigid Histic Humaquepts
Hegne	Fine, frigid Typic Calciaquolls
*Karlstad	Coarse-loamy, mixed Aquic Eutroboralfs
Lohnes	Sandy, mixed Udorthentic Haploborolls
Maddock	Sandy, mixed Udorthentic Haploborolls
Markey	Sandy or sandy-skeletal, mixed, euic Terric Borosaprists
Marquette	Loamy-skeletal, mixed Psammentic Eutroboralfs
Mavie	Sandy-skeletal over loamy, frigid Typic Calciaquolls
Nereson	Coarse-loamy, mixed Aquic Argiborolls
Northcote	Very-fine, montmorillonitic, frigid Vertic Haplaquolls
Noyes	Very-fine, montmorillonitic, frigid Typic Argiaquolls
Pelan	Loamy-skeletal, mixed Psammentic Eutroboralfs
Percy	Coarse-loamy, frigid Typic Calciaquolls
Poppleton	Mixed, frigid Aquic Udipsamments
Redby	Mixed, frigid Aquic Udipsamments
Rockwell	Coarse-loamy, frigid Typic Calciaquolls
Roliss	Fine-loamy, mixed (calcareous), frigid Typic Haplaquolls
Strandquist	Sandy-skeletal over loamy, mixed (calcareous), frigid Typic Haplaquolls
Syrene	Sandy, frigid Typic Calciaquolls
Ulen	Sandy, frigid Aeric Calciaquolls
Viking	Very-fine, montmorillonitic (calcareous), frigid Typic Haplaquolls
Wahpeton	Fine, montmorillonitic Udertic Haploborolls
Wheatville	Coarse-silty over clayey, frigid Aeric Calciaquolls

example is Haplaquoll (*Hapl*, meaning simple horizons, plus *aquoll*, the suborder of Mollisols that have an aquic moisture regime).

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

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

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

There are five soil orders recognized in Kittson County. Table 15 shows that these orders are Alfisols, Entisols, Histosols, Inceptisols, and Mollisols.

Alfisols are moderately dark to light colored soils that formed primarily where forest has encroached upon the prairie. They have a clay enriched horizon. They have no mollic epipedon unless it is associated with an Ap horizon in a cultivated area.

Entisols are moderately dark to light colored soils that do not have natural genetic horizons or that have

only very weakly expressed beginnings of such horizons. These soils do not have traits or characteristics that reflect soil mixing caused by shrinking and swelling.

Histosols are soils with a layer of organic soil material that is 16 inches or more thick. These soils differ in kind of fiber, amount of decomposition, reaction, and the kind of underlying mineral soil material.

Inceptisols are soils that have some horizon development but not sufficient to qualify for the other orders. They may have a light to dark colored surface that is not thick enough to be a mollic epipedon.

Mollisols have formed under prairie and have a thick, dark colored surface horizon containing many bases dominated by calcium or magnesium. This horizon is called a mollic epipedon.

General nature of the county

This section is primarily for readers not familiar with Kittson County. It tells about the physiography, relief, drainage, and climate of the county. The history and development, transportation, and markets are also discussed. The farming of the county is summarized, and a short discussion on recreation is also given.

Physiography, relief, and drainage

The highest land, approximately 1,060 feet above sea level, in southeastern Kittson County is the gravel ridge in the vicinity of the town of Karlstad. The lowest point is about 785 feet above sea level, and occurs in the northwestern corner where the Red River of the North leaves the county. The maximum difference in elevation from southeast to northwest is 290 feet. The elevation in the southwestern corner is about 800 feet above sea level and in the northeastern corner is 1,035 feet. The slope in the western part of the county is commonly 1 to 3 feet per mile (*1*).

The whole county has been influenced by the water of Glacial Lake Agassiz. In the western part, where the glacial water was deep, the clay soils now occur. As one moves east, progressively coarser particles settled out, grading from clay, silt, very fine sand, and sand to gravel. This is complicated by successive beach ridges which indicate changing water level. In parts of the lake basin the water was shallow and covered the area for a relatively short period of time. The deposited sediment is very thin, and the evidence of the sorting action is the concentration of boulders and stones at or near the surface on much of the glacial till soils.

The Red River of the North receives all of the drainage from Kittson County. A part of it goes into Canada via the Roseau River in the eastern part of the county. The other tributaries are the Joe River in the northwest and the Two Rivers in the central part of the county. Numerous natural draws and creeks also drain the county. An extensive system of ditches has been constructed to aid in draining excess water from agricultural land.

Three watershed projects have been completed which emphasize flood control, conservation and protection of soil and water, and improvement of wildlife habitat.

Related information about the physiography, relief, and drainage of Kittson County is given in the "Formation of soils" section.

Climate [8]

Kittson County is in the extreme northwest corner of Minnesota, in the heart of the rich Red River Valley. The county, near the center of the North American Continent, is well within the great interior climate region, and has a very strong continental climate. Outside of mountain regions, the northwest portion of the county is the coldest location in the United States. Winters are very cold, but summers are mild and pleasant. Daily or weekly extremes of temperature may be great in any season. In Kittson County, the winter temperature averages 6° F. (–14° C), and the average daily minimum in winter is –5° F (–21° C). The lowest temperature, 2 years out of 10, is –45° F (–43° C). The absolutely lowest temperature observed during the period of record is –51° F (–46° C), at Hallock on February 11, 1914. In summer, the temperature averages 66° F (19° C), and the average daily maximum is 77° F (25° C). The highest summer temperature, 2 years out of 10, is 99° F (37° C). The absolutely highest temperature observed was 109° F (43° C) at Hallock on July 11, 1936.

Of the total annual precipitation of 20 inches, 15 inches, or 75 percent, falls during the 6 warm months, April through September. Thus, only 5 inches falls during the colder months.

The heaviest one-day rainfall of record was 5.50 inches at Hallock on September 4, 1900. The average number of thunderstorm days per year is 18 days, the greatest number of which, 5 days, come in August. Average seasonal snowfall is 32 inches, and the greatest depth on record is 42 inches. The average number of days during the year with one inch or more of snow on the ground is 126 days. January has the most snow, with 6.6 inches, followed by March with 6.0 inches.

Relative humidity is at its annual minimum during May at midafternoon, when it averages around 45 percent. It is at its maximum at dawn in the summer and fall, when it averages nearly 85 percent. November is the most humid month, averaging 77 percent; May is the least humid at 60 percent. The prevailing wind is out of the south-southeast. However, the wind blows from the southeast quadrant slightly over 25 percent of the time, and from the northwest quadrant one-third of the time.

The average annual windspeed is 13 miles per hour. April is the windiest month when the average windspeed is 15 miles per hour. July is the least windy when it is 11 miles per hour. Strongest winds are usually from the northwest quadrant, the lightest from the northeast quadrant. Southwesterly winds are also usually light. Except in the summer months, Kittson County is subject to daylong windstorms of gale velocity that may result in extensive blowing dust, and very occasionally may lower visibility to a mile or less. Dust limits visibility to 6 miles or less 0.6 percent of the time over the year as a whole, which is not a small

[8] This section was prepared by BRUCE WATSON, consulting climatalogist.

amount of time relative to most of the United States and most other parts of Minnesota. In April, the figure rises to 4 percent of the time. Dust reaches minimum impact in August and again in December. In summer, high winds are generally brief, and limited to occasional high velocities (over 50 mph) from thunderstorms. Dust occasionally blows prior to the beginning of rain from such a storm. Such winds produce damage of a localized nature, in a spotty pattern. Hail falls at times in the warmer part of the year, but such storms occur in an irregular pattern and affect relatively small areas.

Sunshine is a vital part of the Kittson County climate, since it is so far north. At the summer solstice, day length is 16 hours, 20 minutes, while at the winter solstice, it is 8 hours, 6 minutes. Possible sunshine varies from 70 percent in July (when the days are also long) to 38 percent in November (when the days are also short). On a seasonal basis, winter averages 59 percent, spring 58 percent, summer 63 percent, and autumn 47 percent.

Additional information on temperature and precipitation can be found in table 16.

Table 17 gives information on occurrence dates of freezing, 32° F, 28° F, 24° F, 20° F, and 16° F temperatures.

Data for the climate section are from Hallock and are felt to be representative of the county as a whole. Temperature and precipitation were based on records for 75 years from 1899 through 1974.

History and development

Kittson County was established by legislative act on February 25, 1879. The act separated Kittson County from Pembina County which had been created in 1858. (*5*)

Among the first to pass through the area were the French explorers. After the explorers came the fur trappers.

The American Fur Company was very active in buying furs. Mr. Norman W. Kittson, for whom the county was named, was their agent at Pembina. He was instrumental in the development of the Red River ox carts which carried these furs to St. Paul.

Steamboat traffic on the Red River lasted from about 1859 to 1877. The railroad brought into the area by Mr. James J. Hill and Mr. Kittson ended the steamboat era. The Canadian Pacific and St. Paul, Minneapolis and Manitoba Railroads joined at the Canadian border December 2, 1878.

The population of Kittson County in 1940 was 10,717. In 1960 the population was 8,343.

The city of Hallock is the county seat.

Transportation and markets

Two railroads cross the county. The Great Northern serves Donaldson, Kennedy, Hallock, Northcote, Humbolt, and St. Vincent. The Soo Line serves Karlstad, Halma, Lake Bronson, Lancaster, and Orleans. Both cross the county generally in a south to north direction.

The major highways are either paved or blacktopped. U.S. Highway No. 75 crosses the county from north to south. U.S. Highway No. 59 crosses the county approximately diagonally from Karlstad to Lancaster and then north into Canada. Minnesota Highway No. 11 crosses the county from east to west through Karlstad and Donaldson. Minnesota Highway No. 175 crosses the county from U.S. Highway No. 59 west through Hallock into North Dakota.

The north-south highways carry predominantly through-traffic and trucks that haul fuel, manufactured products, and agricultural commodities.

TABLE 16.—*Temperature and precipitation data*

[Data are from Hallock, Minnesota, for the period 1899 through 1974]

Month	Temperature				Precipitation				
	Average daily maximum	Average daily minimum	Two years in 10 will have—		Average	Precipitation Two years in 10 will have—		Average number of days with 0.10 inch or more	Average snowfall
			Maximum temperature higher than—	Minimum temperature lower than—		Less than—	More than—		
	°F	°F	°F	°F	In	In	In		In
January	12.0	−10.0	38	−42	.59	.18	.98	3	6.6
February	16.2	−6.0	42	−40	.55	.15	1.00	2	5.5
March	30.9	9.5	61	−28	.88	.24	1.26	2	6.0
April	51.9	28.3	83	2	1.40	.47	2.07	3	2.0
May	67.3	39.3	95	16	2.27	1.06	3.67	7	0.1
June	75.5	50.2	96	29	3.26	1.87	4.70	7	T
July	81.2	54.4	96	35	2.95	1.41	3.92	6	0
August	79.3	52.1	96	33	2.87	1.19	3.85	5	0
September	68.7	43.1	92	22	2.61	.82	3.70	4	T
October	55.0	32.0	79	3	1.38	.55	2.13	4	1.1
November	33.6	15.6	62	−20	.86	.30	1.11	3	5.3
December	18.3	−0.9	43	−36	.56	.28	.87	2	5.7
Year	49.2	25.6	99	−45	20.18	15.47	24.19	48	32.3

TABLE 17.—*Probabilities of last freezing temperature in spring and first in fall*

[Data are from Hallock, Kittson County, Minnesota]

Probability	Dates for given probability and temperature				
	16°F. or lower	20°F. or lower	24°F. or lower	28°F. or lower	32°F. or lower
Spring:					
1 year in 10 later than	Apr. 26	May 10	May 22	May 28	June 10
2 years in 10 later than	Apr. 22	May 6	May 18	May 25	June 8
5 years in 10 later than	Apr. 15	Apr. 30	May 10	May 16	May 28
Fall:					
1 year in 10 earlier than	Oct. 16	Oct. 7	Sep. 21	Sep. 16	Sep. 8
2 years in 10 earlier than	Oct. 20	Oct. 9	Sep. 24	Sep. 19	Sep. 7
5 years in 10 earlier than	Oct. 27	Oct. 17	Oct. 2	Sep. 26	Sep. 15

The east-west roads carry agricultural products in the fall and tourist traffic that moves to Lake Bronson and Lake of the Woods.

Many of the county roads are paved or blacktopped. Minor roads are on most section lines in the county and are maintained under the jurisdiction of the townships. They function primarily as collectors for the major road systems.

Grain elevators are located in the villages of the county. Grain crops are transported by truck and railroad primarily to Duluth and Minneapolis-St. Paul. More onfarm grain storage has been built in recent years and provides the farmer greater freedom in marketing his crops. Sugar beets are transported by truck to Drayton, North Dakota, for processing. Potatoes are stored on the farm or hauled to storage facilities mostly at Kennedy, Donaldson, or Karlstad.

Slaughter or feeder animals are generally taken by truck to markets in West Fargo or South St. Paul. Dairy products are usually collected by truck and transported for processing to creameries and plants in the county or to markets in adjacent counties.

Farming

Wheat, oats, barley, potatoes, and hay cut from the native prairie grasses were the principal crops produced by the first settlers.

Wheat is presently the most important cash crop, of which 5,855,600 bushels were produced in Kittson County in 1968. (*15*) Barley and oats are also important grain crops. Sugar beets are important, but their production is restricted to farmers who have allotted acreage. They are grown largely on the medium and fine textured soils in the western half of the county. Potatoes are grown on the coarser textured soils. Some irrigation is being tried with good success to date.

Since the 1940's livestock in Kittson County has decreased. Beef numbers have increased, however, in the past several years. Livestock farming is most common in the eastern half of the county.

Sheep production has fallen quite drastically since 1940. Predation is one reason, another is the increased cost of labor.

Dairy cow numbers also have fallen. The required labor relative to the return is a major factor. In the last few years, those who have stayed in dairy farming have increased their herd size to be more economical.

Hay for livestock feed is an important crop, of which 62,100 tons were harvested in 1972. (*15*)

In 1945 there were 1,430 farms that had an average size of 333 acres. (*8*) In 1959 there were 1,036 farms that had an average size of 495 acres. By 1969 there were 655 farms that had an average size of 793 acres.

This trend to fewer and larger farms will continue until the economic relationship changes and there is a greater demand for food and fiber throughout the world. Currently both of these factors have changed. This is likely to stabilize the decline in numbers of farmers at least for the time being.

References

(1) Allison, Ira S. 1932. Geology and water resources of northwestern Minnesota. Univ. Minn., pp. 98-105.

(2) American Association of State Highway [and Transportation] Officials. 1970. Standard specifications for highway materials and methods of sampling and testing. Ed. 10, 2 vol., illus.

(3) American Society for Testing and Materials. 1974. Method for classification of soils for engineering purposes. ASTM Stand. D 2487–69. *In* 1974 Annual Book of ASTM Standards, Part 19, 464 pp., illus.

(4) Benz, L. C., F. M. Sandaval and W. O. Willis. 1966. Soil-salinity changes with fallow and a straw mulch on fallow. Soil Sci. vol. 104, no. 1, pp. 66–68.

(5) Bouvette, J. E. and Sons. 1935. Fiftieth Anniversary Number Kittson County Enterprise.
(6) Doering, E. J. and L. C. Benz. 1972. Pumping, an artesian source for water table control. J. of the Irrigation and Drainage Div. ASCE, vol. 98, no. IR 2, June 1972, pp. 275–287.
(7) Johnsgard, G. A. 1965. Salt affected problem soils in North Dakota. N. D. State Univ. Agric. Exp. Stn. Bull. 453, June 1965. 15 pp.
(8) Kittson County Planning Committee. 1963. A study of Kittson County resources and its people. 31 pp.
(9) Kovda, V. A. 1947. Origin of saline soils and their regime, vol. 2. Translated from Russian, Israel program for scientific translation, Jerusalem 1972. Academy of Science of the USSR. Dokuchaev Soil Science Institute. 311 pp.
(10) MacGregor, J. M. and R. C. Munter. 1967. Soil-salinity and crop growth in western Minnesota. U. of Minn., Dep. Soil Science. A Report on Field Research in Soils, February 1967, pp. 32–58.
(11) Magistad, O. C. and J. E. Christiansen. 1944. Saline soils, their nature and management. U.S. Dep. of Agric. Circular 707, September 1944. 32 pp.
(12) Portland Cement Association. 1962. PCA soil primer. 52 pp. illus.
(13) Rust, R. H., Gerbit, Bruce. 1974. Remote Sensing Application to Management of Agriculture, Forestry and Water Resources in Minnesota. Rep. of Inst. of Agric. Remote Sensing Lab. Res. Rep. 74–2, Ch. 4.
(14) Sandoval, F. M. and L. C. Benz. 1966. Effect of bare fallow, barley, and grass on salinity of a soil over a saline water table. Soil Sci. Soc. Am. Proc., vol. 30, no. 3, June 1966, pp. 392–396.
(15) United States Department of Agriculture and Minnesota Department of Agriculture. 1973. Minnesota agricultural statistics, 1973. Crop and Livestock Reporting Service, March 1973, 100 pp.
(16) United States Department of Agriculture. 1954. Diagnosis and improvement of saline and alkali soils. U.S. Dep. Agric. Handb. 60, 160 pp., illus.
(17) United States Department of Agriculture. 1975. Soil Taxonomy; a basic system of soil classification for making and interpreting soil surveys. Soil Conserv. Serv., 754 pp., illus.
(18) United States Department of the Interior and Minnesota Department of Conservation and Department of Iron Range Resources and Rehabilitation. 1963. Ground-water exploration and test pumping in the Halma-Lake Bronson area, Kittson County. Geological Survey Water Supply Paper 1619–BB.

Glossary

Alkali (sodic) soil. A 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.

Animal unit. In range of pasture management; one cow, one horse, one mule, five sheep, or five goats.

Aquifer. A porous soil or geological formation that yields ground water to wells and springs.

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

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

Calcareous soil. A soil containing enough calcium carbonate (commonly with magnesium carbonate) to effervesce (fizz) visibly when treated with cold, dilute hydrochloric acid. A soil having measurable amounts of calcium carbonate or magnesium carbonate.

Capillary. Very slender, small bare, tubelike openings where the phenomena of surface tensions, acts through the contact of the surface of a liquid and the solid surface, elevates or depresses the liquid.

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

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

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. Mineral or rock particles up to 3 inches (2 millimeters to 7.5 centimeters) in diameter. Coarse textured (light textured) soil. Sand or loamy sand.

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

Compressible. Excessive decrease in volume of soft soil under load.

Conductance. A physical quantity that measures the readiness with which a medium transmits electricity. Commonly used for expressing the salinity of irrigation water and soil extracts because it can be directly related to salt concentration.

Conifer (botany). Any tree of the pine family bearing true cones and any of the yew family having a berrylike fruit. The wood of conifers is commercially known as "softwood."

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.

Continental climate. The climate in areas distant from the ocean; characterized by considerable variation in temperature and in other weather conditions.

Cultivation. A mechanical stirring of the soil in place, as for preparation of a seedbed or control of weeds.

Deciduous. Refers to plants that lose their leaves at maturity or at certain seasons. Contrasts with evergreen.

Decreasers. The most heavily grazed climax range plants. Because they are the most palatable, they are the first to be destroyed by overgrazing.

Drainage, surface. Runoff, or surface flow of water, from an area.

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

Erosion (geologic). Erosion caused by geologic processes acting over long geologic periods and resulting in the wearing away of mountains and the building up of such landscape features as flood plains and coastal plains. Synonym: natural erosion.
Erosion (accelerated). Erosion much more rapid than geologic erosion, mainly as a result of the activities of man or other animals or of a castastrophe in nature, for example, fire, that exposes a bare surface.

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

Flooding. The temporary covering of soil with water from overflowing streams, runoff from adjacent slopes, and tides. Frequency, duration, and probable dates of occurrence are

estimated. Frequency is expressed as none, rare, occasional, and frequent. None means that flooding is not probable; rare that it is unlikely but possible under unusual weather conditions; occasional that it occurs on an average of once or less in 2 years; and frequent that it occurs on an average of 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; November-May, for example, means that flooding can occur during the period November through May. Water standing for short periods after rainfall or commonly covering swamps and marshes is not considered flooding.

Friability. A friable soil is one that crumbles easily.

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

Gleyed soil. A soil having one or more neutral gray horizons as a result of waterlogging and lack of oxygen. The term "gleyed" also designates gray horizons and horizons having yellow and gray mottles as a result of intermittent waterlogging.

Granule. A single mass, or cluster, of many individual soil particles.

Gravelly soil material. Material from 15 to 50 percent, by volume, rounded or angular rock fragments, not prominently flattened, up to 3 inches (7.5 centimeters) in diameter.

Grazing capacity. The maximum number of animals or animal units per acre, or acres per animal unit, that a grazing area can support adequately without deterioration; sometimes called carrying capacity.

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

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

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

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

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

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

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

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

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 less palatable to livestock.

Infiltration. The downward entry of water into the immediate surface of soil or other material, as contrasted with percolation, which is movement of water through soil layers or material.

Invaders. On range, plants that encroach into an area and grow after the climax vegetation has been reduced by grazing. Generally, invader plants are those that follow disturbance of the surface.

Lacustrine deposit (geology). Material deposited in lake water and exposed when the water level is lowered or the elevation of the land is raised.

Lag line. A thin soil layer composed of coarse fragments underlain by finer textured material. This accumulation of coarse fragments is the result of sorting action of water at some time in the geological past.

Land classification. The classification of units of land for the purpose of showing their realtive suitabilities for some specific use.

Leaching. The removal of soluble material from soil or other material by percolating water.

Lime. Chemically, lime is calcium oxide (CaO), but its meaning has been extended to include all limestone-derived materials applied to neutralize acid soils. Agricultural lime can be obtained as ground limestone, hydrated lime, or burned lime, with or without magnesium minerals. Basic slag, oystershells, and marl also contain calcium.

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

Marsh. Periodically wet or continually flooded areas. Surface not deeply submerged. Covered dominantly with sedges, cattails, rushes, or other water-tolerant plants.

Mechanical analysis (soils). The percentage of the various sizes of individual mineral particles, or separates, in the soil. Also, a laboratory method of determining soil texture.

Medium textured soil. Very fine sandy loam, loam, silt loam, or silt.

Microclimate. Local climatic conditions, brought about by the changes in the general climate resulting from local differences in elevation and exposure.

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).

Muck. Dark colored, finely divided, well decomposed organic soil material mixed with mineral soil material. The content of organic matter is more than 20 percent.

Mulch. A natural or artificially applied layer of plant residue or other material on the surface of the soil. Mulches are generally used to help conserve moisture, control temperature, prevent surface compaction or crusting, reduce runoff and erosion, improve soil structure, or control weeds. Common mulching materials are wood chips, plant residue, sawdust, and compost.

Neutral soil. A soil having a pH value between 6.6 and 7.3.

Organic soil. A soil or soil horizon that consists primarily of organic matter, such as peat soils, muck soils, and peaty soil layers. In chemistry, organic refers to the compounds of carbon.

Overgrazing. Grazing so heavy as to impair future forage production and to deteriorate plants, soil, or both. Contrasts with undergrazing.

Peat. Unconsolidated material, largely undecomposed organic matter, that has accumulated under excess moisture.

Percolation. The downward movement of water through the soil.

Percs slowly. The slow movement of water through the soil adversely affecting the specified use.

Permanent pasture. Pasture that is on the soil for a long time, in contrast to rotation pasture, which is on the soil only a year or two because it is grown in rotation with other crops.

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

pH value. (See Reaction, soil). A numerical designation of acidity and alkalinity in soil.

Piping. Moving water forms subsurface tunnels or pipelike cavities in 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 a semisolid to a plastic state.

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

Range (or rangeland). Land that, for the most part, produces native plants suitable for grazing by livestock; includes land supporting some forest trees.

Range condition. The health or productivity of forage plants on a given range, in terms of the potential productivity under normal climate and the best practical management. Condition classes generally recognized are—excellent, good, fair, and poor. The classification is based on the percentage of original, or assumed climax vegetation on a site, as compared to what has been observed to grow on it when well managed.

Range site. An area of range where climate, soil, and relief are sufficiently uniform to produce a distinct kind and amount of native vegetation.

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

	pH		pH
Extremely acid	Below 4.5	Neutral	6.6 to 7.3
Very strongly acid	4.5 to 5.0	Mildly alkaline	7.4 to 7.8
Strongly acid	5.1 to 5.5	Moderately alkaline	7.9 to 8.4
Medium acid	5.6 to 6.0	Strongly alkaline	8.5 to 9.0
Slightly acid	6.1 to 6.5	Very strongly alkaline	9.1 and higher

Saline-alkali soil. A soil that contains a harmful concentration of salts and exchngeable sodium; contains harmful salts and is strongly alkaline; or contains harmful salts and exchangeable sodium and is very strongly alkaline. The salts, exchangeable sodium, and alkaline reaction are in the soil in such location that growth of most crop plants is less than normal.

Saline soil. A soil containing soluble salts in an amount that impairs 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.

Sandy soils. A broad term for soils of the sand and loamy sand classes; soil material with more than 70 percent sand and less than 15 percent clay.

Seepage. The rapid movement of water through the soil. Seepage adversely affects the specified use.

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

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

Silt. As a soil separate, individual mineral particles that range in diameter from the upper limit of clay (0.002 millimeter) to the lower limit of very fine sand (0.05 millimeter). As a soil textural class, soil that is 80 percent or more silt and less than 12 percent clay.

Soil survey. A systematic examination, description, classification, and mapping of soils in an area. Soil surveys are classified according to intensity of field examination as exploratory, reconnaissance, or detailed.

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

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

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

Subsurface layer. Technically, the A2 horizon. Generally refers to a leached horizon lighter in color and lower in content of organic matter than the overlying surface layer.

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

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

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

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

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

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

Windbreak. Any shelter that protects from the wind. A vegetative windbreak is a strip of closely spaced trees or shrubs that is planted primarily to deflect wind currents and thereby reduce soil blowing, control snow drifting, conserve moisture, and protect crops, orchards, livestock, and buildings.

GUIDE TO MAP UNITS

For a full description of a map unit, read both the description of the map unit and the soil to which the map unit belongs.

Map symbol	Map unit	Page	Capability unit		Range site	
			Symbol	Page	Name	Page
45	Maddock soils, 0 to 2 percent slopes	33	IVs-2	59	Sands	64
46	Borup loam	13	IIw-3	56	Subirrigated	64
47	Colvin silty clay loam	16	IIw-3	56	Subirrigated	64
50	Cashel clay	14	IIIw-2	58	Clayey	64
52	Augsburg soils	10	IIw-3	56	Subirrigated	64
59	Grimstad soils, 0 to 2 percent slopes	27	IIIs-1	58	Sandy	64
60	Glyndon soils, 0 to 2 percent slopes	26	IIe-2	56	Silty	64
61	Arveson soils	9	IIIw-1	58	Subirrigated	64
63	Rockwell soils	46	IIw-3	56	Subirrigated	64
64	Ulen soils, 0 to 2 percent slopes	50	IIIs-1	58	Sandy	64
65	Foxhome soils, 0 to 2 percent slopes	23	IIIs-1	58	Sandy	64
67	Bearden silt loam, 0 to 2 percent slopes	12	IIe-1	56	Silty	64
77	Garnes soils, 0 to 2 percent slopes	25	IIc-1	57	Silty	64
93	Bearden silty clay loam, 0 to 2 percent slopes	12	IIe-1	56	Silty	64
93B	Bearden silty clay loam, 2 to 6 percent slopes	12	IIe-1	56	Silty	64
111	Hangaard soils	29	IVw-1	58	Subirrigated	64
116	Redby soils, 0 to 2 percent slopes	46	IVs-1	59	Sands	64
117	Cormant soils	17	IVw-1	58	Subirrigated	64
145	Enstrom loamy fine sand, 0 to 2 percent slopes	20	IVs-1	59	Sands	64
148	Poppleton soils, 0 to 2 percent slopes	45	IVs-1	59	Sands	64
157	Wahpeton silty clay, 0 to 2 percent slopes	52	IIw-1	56	Clayey	64
157B	Wahpeton silty clay, 2 to 6 percent slopes	52	IIw-1	56	Clayey	64
187	Haug muck	30	IIIw-2	58	Grazeable Muck	64
205	Karlstad soils, 0 to 2 percent slopes	32	IVs-1	59	Sands	64
242	Marquette soils, 0 to 2 percent slopes	35	IVs-2	59	Sands	64
245	Lohnes soils, 0 to 6 percent slopes	33	IVs-2	59	Sands	64
280	Pelan soils, 0 to 2 percent slopes	42	IIIs-1	58	Sandy	64
296	Fram soils, 0 to 2 percent slopes	24	IIe-2	56	Silty	64
343	Wheatville soils, 0 to 2 percent slopes	53	IIe-2	56	Silty	64
379	Percy bouldery soils	43	VIw-1	59	Subirrigated	64
383	Percy soils, calcareous surface	44	IIw-2	56	Subirrigated	64
384	Percy soils, depressional	44	IIIw-2	58	Wetland	63
403	Viking soils	51	IIw-1	56	Clayey	64
412	Mavie soils	36	IIIw-1	58	Subirrigated	64
424	Augsburg soils, depressional	10	IIIw-1	58	Wetland	63
425	Donaldson soils, 0 to 2 percent slopes	18	IIc-1	57	Silty	64
426	Foldahl soils, 0 to 2 percent slopes	22	IIIs-1	58	Sandy	64
427	Fram soils, leached, 0 to 3 percent slopes	24	IIe-2	56	Silty	64
429	Northcote clay, 0 to 2 percent slopes	39	IIw-1	56	Clayey	64
429B	Northcote clay, 2 to 6 percent slopes	39	IIw-1	56	Clayey	64
430	Noyes soils	40	IIw-2	56	Clayey	64
432	Strandquist soils	49	IIIw-1	58	Subirrigated	64
433	Syrene soils, very wet	50	Vw-1	59	Wetland	63
435	Syrene soils	49	IVw-1	58	Subirrigated	64
438	Northcote clay, depressional	39	IIIw-2	58	Wetland	63
482	Grygla soils	28	IVw-1	58	Subirrigated	64
543	Markey muck	34	IVw-3	59	Grazeable Muck	64
544	Cathro muck	15	IVw-3	59	Grazeable Muck	64
547	Deerwood muck	17	IVw-3	59	Grazeable Muck	64
581	Percy soils	44	IIw-2	56	Subirrigated	64
582	Roliss soils	48	IIw-2	56	Subirrigated	64
583	Nereson soils, 0 to 2 percent slopes	37	IIc-1	57	Silty	64
908	Bearden-Fargo complex	12	IIw-4	57	Not Classified	--
937	Hegne-Northcote complex	31	IIw-4	57	Clayey[1/]	64
991	Northcote and Wahpeton soils	39	IIw-4	57	Clayey[1/]	64
993	Arveson and Cormant soils, depressional	9	IVw-2	58	Wetland	63
994	Rockwell and Grygla soils, depressional	47	IVw-2	58	Wetland	63

Map symbol	Map unit	Page	Capability unit		Range site	
			Symbol	Page	Name	Page
1002	Alluvial land, frequently flooded	7	VIw-1	59	Not classified	--
1006	Breaks and Alluvial land	13	VIe-1	59	Not classified	--
1025	Dune land	19	VIs-1	60	Sands	64
1053	Marsh	36	Not classified		Not classified	--

1/ These are soil complexes; refer to each component for proper interpretation.

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