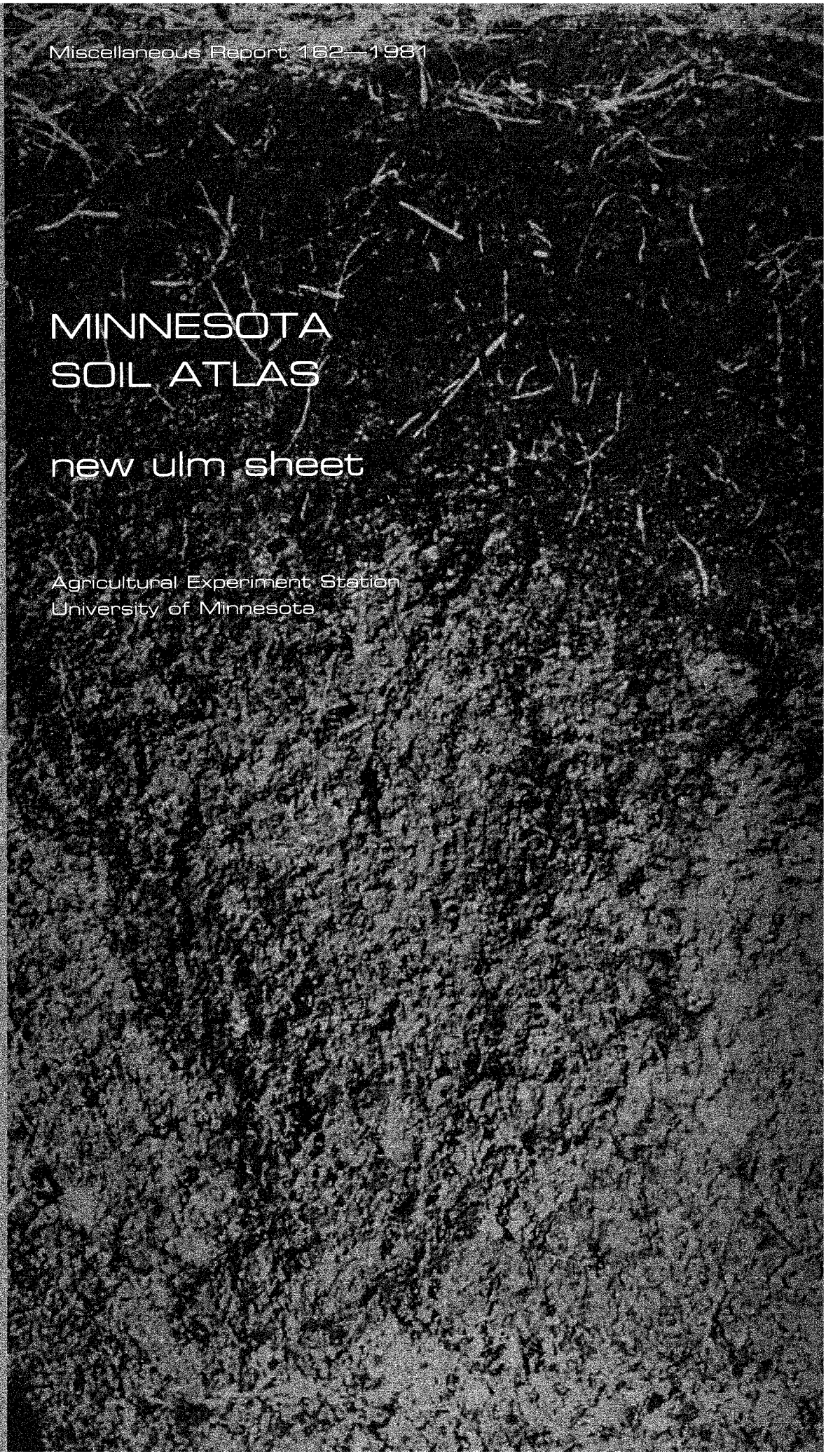
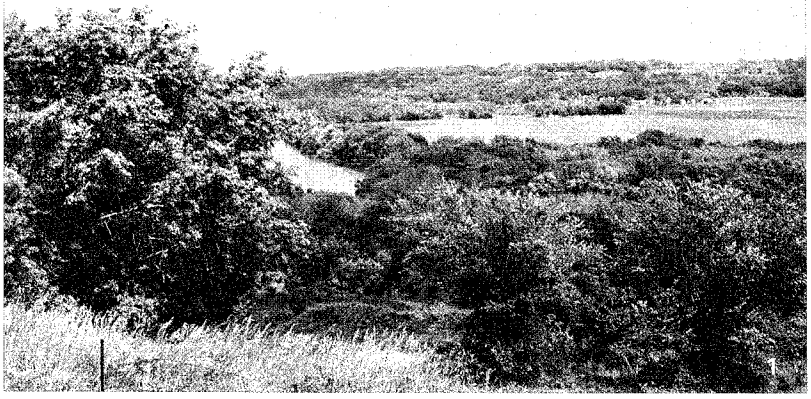
Miscellaneous Report 162—1981

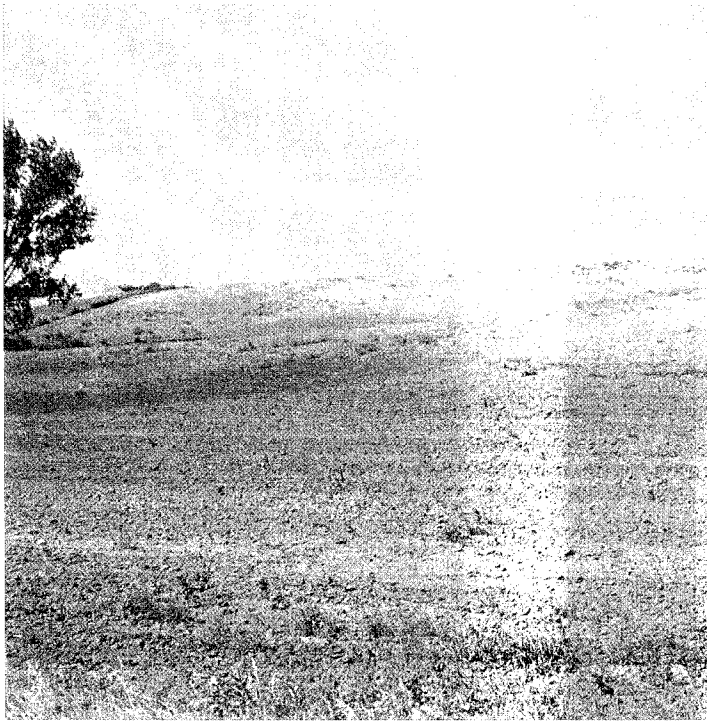


MINNESOTA SOIL ATLAS

new ulm sheet

Agricultural Experiment Station
University of Minnesota





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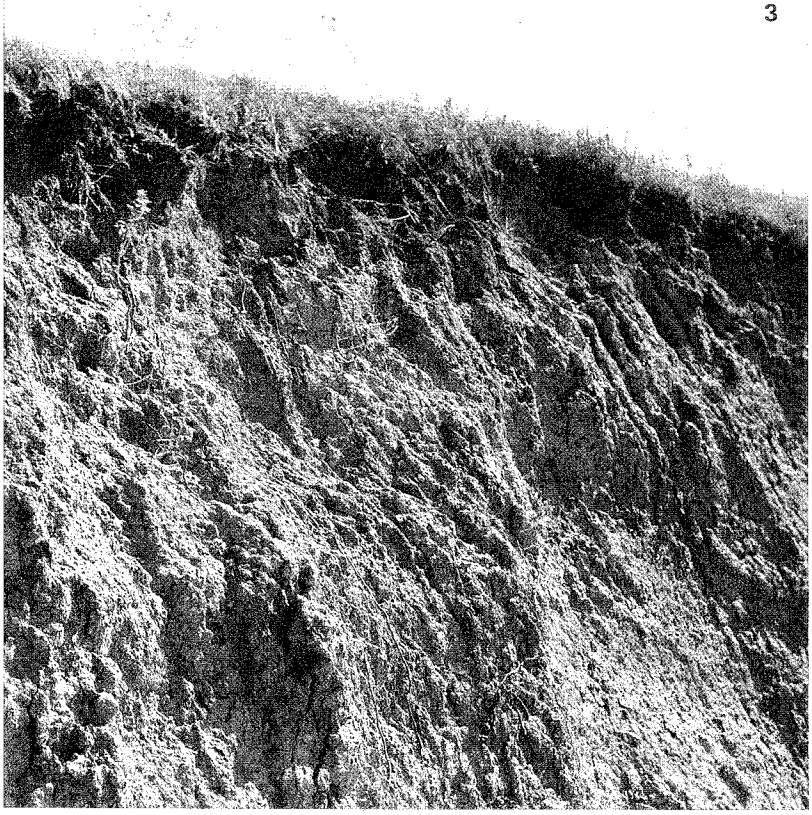

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1. The Minnesota River Valley is a prominent feature of southwestern Minnesota. The one to two mile wide valley extends 120 miles from eastern Lac qui Parle County to southern Nicollet County. 2. Light-colored hills in the northwestern part of the New Ulm Sheet are Buse soils. They are often associated with the darker colored Barnes soil. 3. A profile of Buse soil. 4. Long uniform slopes are common in Rock County. 5. Prairie clover is a reminder of the vast areas of prairie which originally covered western Minnesota.

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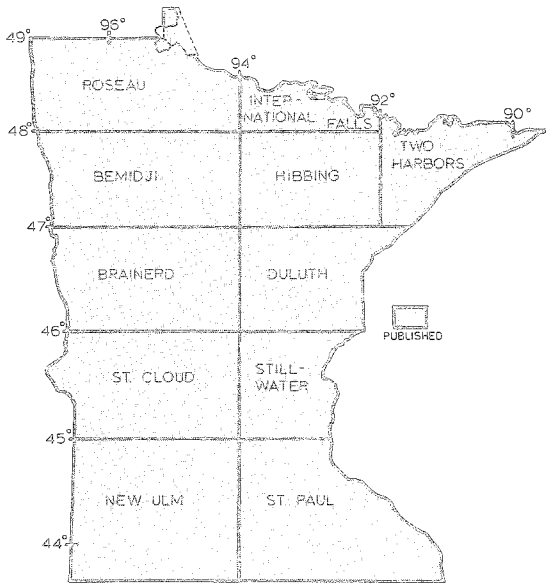


Status of Minnesota Soil Atlas Project

Acknowledgement

The Department of Soil Science, University of Minnesota, in cooperation with the Soil Conservation Service, U.S. Department of Agriculture, and the Minnesota Geological Survey prepared this Minnesota Soils Atlas-New Ulm sheet, eleventh and last in a series covering the entire state. Already published are the Brainerd Sheet, Miscellaneous Report 90, 1969 ($3); Hibbing Sheet, Miscellaneous Report 110, 1971 ($3); St. Paul Sheet, Miscellaneous Report 120, 1973 ($4); Metro Sheet, Miscellaneous Report 130, 1975 ($3); Duluth Sheet, Miscellaneous Report 148, 1977 ($4); St. Cloud Sheet, Miscellaneous Report 159, 1979 ($5); Bemidji Sheet, Miscellaneous Report 168, 1980 ($5); Stillwater Sheet, Miscellaneous Report 171, 1979 ($5); Roseau Sheet, Miscellaneous Report 173, 1980 ($5); International Falls-Two Harbors Sheets, Miscellaneous Report 177, 1981 ($6); and New Ulm Sheet, Miscellaneous Report 162, 1981 ($5).

G. F. Harms, R. H. Rust, and L. D. Hanson did the field work, maps, and report. J. F. Cummins prepared the geomorphic delineations in cooperation with H. E. Wright, Jr., Department of Geology, University of Minnesota. E. L. Kuehnast, state climatologist, prepared the section on climate.

The cooperation of the soil survey and district personnel of the Soil Conservation Service is gratefully acknowledged.

Project funds were supplied in part by an allocation from the Legislative Commission on Minnesota Resources.

CONTENTS PAGE

Introduction

Information is lacking on the soils and landscape characteristics of large areas of Minnesota. Many planning agencies simply have to go without information needed for their work. Detailed soil surveys published at a scale of 1:20,000 are being made by United States Department of Agriculture, Soil Conservation Service (USDA, SCS) in cooperation with the Minnesota Agricultural Experiment Station to fill this need, but because they cannot be supplied rapidly enough for broad planning, the Minnesota Soil Atlas has been developed. It is not intended to replace detailed soil survey reports, which are essential for planning the use of smaller land areas. Detailed soil survey information not yet available in published form has been gathered and supplemented with field work to compile the New Ulm sheet of the Minnesota Soil Atlas.

Until detailed soil surveys are available for all Minnesota counties, broad planning can be facilitated by the eleven sheets published in Minnesota Soil Atlas series (see map this page). As detailed soil surveys become available, the broad view of large planning areas will still be necessary. The maps of the series are published along with explanatory texts for each sheet in the state. For uniformity the atlas sheets are prepared at the same scale (1:250,000) as the U.S. Geological Survey topographic maps and other maps prepared by the Minnesota Geological Survey.

Use of the Soil Atlas

The Minnesota Soil Atlas provides essential information for broad planning. Some of the uses that can be developed from this map follow:

1. To provide soils information related to the suitability for crops and to enable food processors and agricultural service industries to locate facilities in appropriate locations.
2. To determine areas that would benefit from drainage or irrigation.
3. To locate sources of sand and gravel.
4. To identify soil conditions for highway and utility line routes.
5. To serve as a reference for science teachers in junior high, high school, and college courses.

For specific planning of individual farms, cities, towns, recreation areas, tax equalization, and road building purposes, more detailed surveys are necessary. However, this map may point to priority areas where detailed surveys will be most useful.

How the Maps Were Prepared

The base map for the New Ulm sheet was compiled from quadrangles published by the U.S. Geological Survey. The scale of 1:250,000 or about ¼ inch to 1 mile, makes it possible to show areas as small as 1 square mile. Contour intervals of 50 feet indicate some of the topography.

Sixteen geomorphic areas are mapped in the New Ulm sheet. These units illustrate physiographic features and identify the nature of present materials in which the soils have developed (table 1).

Within the geomorphic areas soil landscape units are delineated. Tables 3 through 17 indicate which soil series (if known) are associated with the various soil landscape units. The same soil landscape unit occurring in two different geomorphic areas may contain different soil series.

Soil landscape delineations were developed from detailed soil surveys where available. Field work was necessary where no detailed soil survey existed.

To provide a generalized map for the user with minimum soils knowledge, soils were grouped into soil landscape units based on the following factors:

1. Texture of the soil material below 5 feet into sandy (S); loamy or silty (L); clayey (C); mixed sandy and loamy (X); mixed loamy and clayey (Y); and bedrock (R).
2. Texture of the material above 5 feet, or a significant part of it, into sandy (S); loamy or silty (L); and clayey (C).
3. Drainage with moderately well, well, and excessively drained soils designated (W); and somewhat poorly, poorly, and very poorly drained soils designated (P). Units with (W) designation will normally have water tables below the rooting zone and units with (P), water table commonly within the rooting zone.
4. Color of surface soil with dark color is designated (D); and light color designated (L).

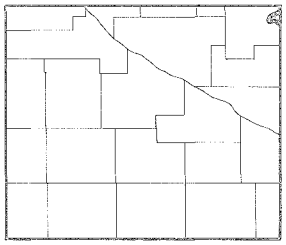
Thus, the Nicollet series would appear on the map as LLWD and would be interpreted from the map as dark-colored, well-drained loamy soil over loamy material (in this instance loamy glacial till). Some areas on the map do not have a four letter symbol of a soil landscape unit. These are land types such as P for peat or muck, M for marsh, and A for floodplains.

Several geomorphic areas will extend into adjoining Atlas sheets. Soil landscape units are mostly delineated within the geomorphic areas. The soil series which occur within a soil landscape unit commonly differ among geomorphic areas. Tables 2 through 17 include representative soil series, when known.

Table 1. Acreage estimate of geomorphic areas within the New Ulm sheet

Geomorphic area number and name		Acres	Percent of sheet
29	Mississippi Valley Outwash	3,265	<1
32	Minnesota Valley Outwash	220,300	3
34	Waconia-Waseca Moraine, loamy, rolling	816,160	10
35B	Emmons-Faribault Moraine, irregular, rolling	1,945	<1
42	Wells-Rush River Ground Moraine, clayey, level	158,200	2
43	Arlington-Matowan Ground Moraine, loamy, undulating	174,380	2
44	Blue Earth-Garden City Ground Moraine, silty, rolling	110,560	1
46	Minnesota Lake Plain, clayey	85,565	1
50	Benson Lacustrine Plain, silty	71,100	1
64	Olivia Till Plain	773,715	10
64A	Olivia Till Plain, clayey	40,705	<1
66	Blue Earth Till Plain, undulating, loamy	3,169,730	39
66A	Blue Earth Till Plain, clayey	79,040	1
67	Lake Benton-Adrian Coteau, undulating, loamy	702,840	9
67A	Luverne Coteau, gently sloping, silty	261,915	3
68	Ivanhoe-Worthington Coteau, gently sloping, loamy	1,388,845	17
	Total	8,058,265	

29 Mississippi Valley Outwash



This region encompassed 3,785 acres or less than 1 percent of the New Ulm sheet.

The Mississippi Valley Outwash consists of nearly level terraces and bottoms along the Mississippi River and some of its tributaries. The water table is normally deeper than 10 feet on the terraces, but on the bottom lands is between the surface and 6 feet deep. No lakes occur.

Most of the soils on the terraces range from loamy sand to a loam or silt loam less than 30 inches thick over sand and gravel. The terraces are frequently a good source of gravel. The water holding capacity ranges from low to moderate. Bottomland soils, mostly loam or silt loam in texture, are subject to occasional to frequent flooding.

The original vegetation on the terraces was prairie grass. On the bottomlands, river bottom forest consisting of elm, ash, cottonwood, boxelder, basswood, soft maple, willow, and hackberry was the original vegetation. The terraces are mostly tilled with corn, oats, and alfalfa-brome hay. Bottomlands are about 75 percent in woodland, 15 percent in pasture, and 10 percent in corn.

Four soil landscape units are mapped in the region: SSWD, LLWD, A, and LP. Table 2 lists selected characteristics of the units. Additional information on the units follows:

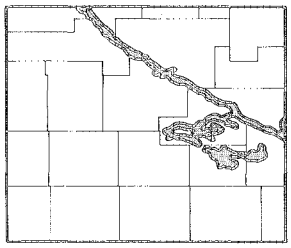
SSWD — Sandy loam, loam or silt loam soils 24 to 36 inches thick comprise 10 to 20 percent of this unit.

LLWD — Actually upland islands of till. May include some SLWD within the unit.

A — This unit includes about 5 percent small islands of sandy terrace soils. The bottoms range from well to moderately well-drained loam or silt loam soils to poorly drained silty clay soils. Near the rivers, where flooding is frequent, the soil materials are mixed, ranging from sand and gravel to clay.

Table 2. Selected features of soil landscape units within the Mississippi Valley Outwash geomorphic region (29)

Soil landscape unit	Percent geomorphic area	Landscape position	Most common texture and thickness (feet)		Moisture relationships		Approximate fertility in rooting zone			Major soil series
			Rooting zone	Substratum	Average water capacity to 5 feet	Drainage class	pH	P	K	
SSWD	40	nearly level to gently rolling outwash plain	loamy sand (1-3)	sand and gravel (3-20+)	<4	well drained	5.1-6.5	low to medium	low	Hubbard Sparta Estherville
LLWD	26	gently sloping to steep till islands	silt loam, loam, clay-loam (4)	silt loam, loam or clay loam (4-20+)	8-12	well drained	5.1-6.5	low to high	medium	Clarion LeSueur Lester
A	26	nearly level stream bottom and low terraces	loam or silt loam (2-4)	loam or silt loam (4+)	4-12	well to poorly drained	5.6-7.8	variable	variable	Huntsville Colo Dorchester Unnamed
LP	6	low lying depressions	peat (1-3)	loam (3+)	8-12+	very poorly drained	5.1-7.3	low	low	Cathro Millerville



32 Minnesota Valley Outwash

This region encompasses approximately 255,230 acres or 3 percent of the New Ulm sheet.

The Minnesota Valley Outwash consists of nearly level to rolling terraces or outwash and bottomlands along the Minnesota River. The water table is normally deeper than 10 feet on the deep sandy soils, but where bedrock is shallow it may be less than 2 feet from the surface. On bottomlands the watertable occurs at the surface to as deep as 6 feet. No lakes larger than 160 acres are located in the region and total water area is approximately 945 acres.

The terraces and outwash plains are frequently a good source of gravel, consequently many large gravel pits are located there.

Most of the soils on the terraces and outwash range from loamy sand to loam or silt loam less than 36 inches thick over sand and gravel. The waterholding capacity ranges from low to moderate. Part of the terraces are actually structural benches of bedrock. Soil material above the rock ranges from less than 1 foot to about 4 feet. On these soils the waterholding capacity ranges from very low to moderate. Bottomland soils are subject to occasional to frequent flooding. Most are loam or silt loam or silty clay loam in texture.

The original vegetation on the terraces and outwash was dominantly prairie grass. Bottomland hardwoods and marsh grasses were the original bottomlands' cover. The bottomland hardwoods consist of elm, ash, cottonwood, boxelder, basswood, soft maple, willow, and hackberry. The terraces and outwash are cropped with corn, soybeans, oats, rye, and alfalfa-brome hay. Bottomlands are cropped with corn on about 60 percent of the area and the rest is pasture or woodland.

Eight soil landscape units are mapped in this region: A, SLWD, SLPD, SSWD, RLWD, LLPD, LLWD, and RLPD.

Table 3 lists selected characteristics of the units. Some additional information follows:

A — Small areas of sandy terrace soils comprise about 10 percent of this unit. Many areas of this unit have a corrugated surface with 5 to 10 feet difference in height between the lows and highs of narrow parallel ridges and swales.

SLWD — This unit includes 5 to 10 percent of loamy sand soil. These are indicated by sand spot symbols on the map.

SLPD — Included with this unit are 5 to 10 percent well-drained soils. Some loamy sand areas occur which are shown by sand symbols on the map.

SSWD — Sandy loam, loam, or silt loam soils 24 to 36 inches thick comprise about 10 to 15 percent of this unit.

RLWD — This unit consists of structural benches on which from 1 to 3 feet of outwash material has been deposited. Boulders 2 to 4 feet in diameter are present on much of the unit and most of it is used as woodland pasture. Small areas in other landscape units are shown by rock outcrop symbols.

LLPD, LLWD — These units are developed in outliers of till within the outwash plain.

RLPD — This unit consists of structural benches on which from 1 to 3 feet of outwash material has been deposited. Because springs follow the surface of the bedrock, the unit is hummocky with a peaty or mucky surface. Boulders 2 to 4 feet in diameter frequently occur on the surface and this unit is nearly all in pasture.

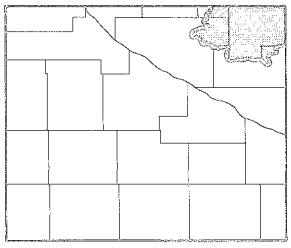
Table 3. Selected features of soil landscape units within the Minnesota Valley Outwash geomorphic region (32)

Soil landscape unit	Percent geomorphic area	Landscape position	Most common texture and thickness (feet)		Moisture relationships		Approximate fertility in rooting zone			Major soil series
			Rooting zone	Substratum	Average water capacity to 5 feet	Drainage class	pH	P	K	
A	34	nearly level stream bottoms and low terraces	loam or silt loam (2-4)	loam or silt loam (4+)	4-12	well to poorly drained	5.6-8.4	variable	variable	Dorchester Comfrey Unnamed
SLWD	28	nearly level outwash plain	sandy loam, loam, or silt loam (2-3)	sand and gravel (3-20+)	4-8	well drained	5.1-7.3	low to medium	low	Kasota Wadena Waukegan Dakota
SLPD	20	nearly level outwash plain	loam, silt loam or silty clay loam (2-3)	sand and gravel (3-20+)	4-8	poorly drained	6.1-7.8	low	low	Talcot Biscay Kato Marshan

Table 3. (continued) Selected features of soil landscape units within the Minnesota Valley Outwash geomorphic region (32)

Soil landscape unit	Percent geomorphic area	Landscape position	Most common texture and thickness (feet)		Moisture relationships		Approximate fertility in rooting zone			Major soil series
			Rooting zone	Substratum	Average water capacity to 5 feet	Drainage class	pH	P	K	
SSWD	11	nearly level to gently rolling outwash plain	loamy sand (1-3)	sand and gravel (3-20+)	<4	well drained	5.1-6.5	low to medium	low	Hubbard Sparta Estherville Estelline
RLWD	9	nearly level to rolling structural benches	loam (2-4)	limestone or sandstone bedrock (4+)	4-8	well drained	5.1-6.5	high	medium	Rockton Copas
LLPD	2	depressional to gently sloping upland	loam to clay loam (3-4)	loam to clay loam (4+)	8-12	poorly drained	6.6-7.3	low	low to medium	Glencoe Webster
LLWD	1	gently rolling to rolling upland	loam to clay loam (4)	loam to clay loam (4+)	8-12	well drained	6.1-7.3	low	medium	Nicollet Clarion Lester LeSueur
RLPD	2	gently sloping to depressional structural benches	loam or clay loam (2-4)	limestone or sandstone bedrock (4+)	4-8	poorly drained	7.4-7.8	medium	medium	Faxon
Water	<1									

Bench like position terrace soils and level "bottom" soils occur along the Minnesota River Valley.



34 Waconia-Waseca Moraine, loamy, rolling

This region encompasses approximately 945,520 acres or about 12 percent of the New Ulm sheet.

The Waconia-Waseca Moraine consists of loamy mantled moraines and ice disintegration features. The dominant landform is one of circular, level topped hills bounded by smooth side slopes and above a broad lower level.

The broad upper levels have nearly concurrent elevations. In places, the unobstructed view gives the impression of a level plain. Summit widths vary: some are between 200 and 500 feet, others from 1,000 to 4,000 feet, and a few up to 2 miles. The summits are from 10 to 30 feet above the lower level. Summit slopes are irregular and normally between 2 and 3 percent but range up to 6 percent.

Side slopes are smooth with convex shoulders and concave back slopes. Slopes range from 4 to 35 percent but are dominantly 8 to 14 percent. Contour lines are reasonably parallel.

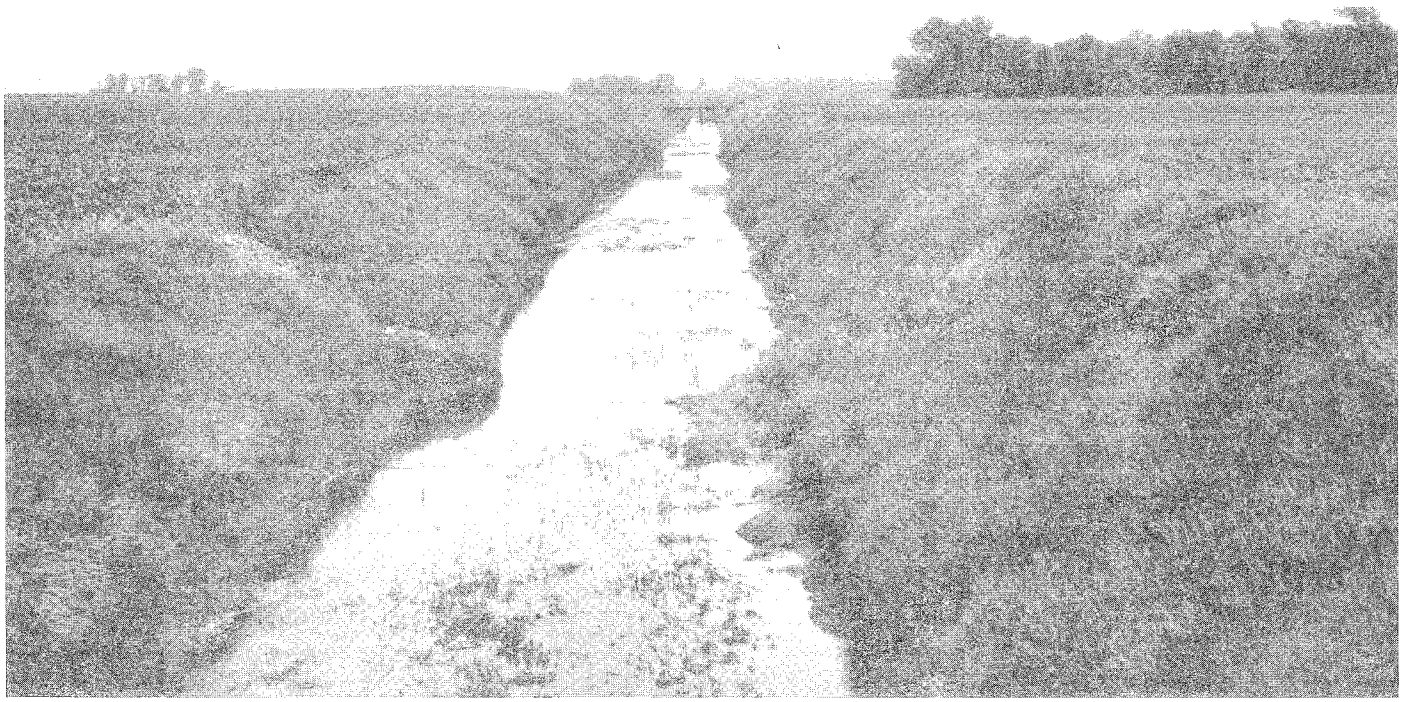
The lower level is interspersed with closed depressions containing lakes and peat bogs. Drainage is often controlled by the lake levels.

The water table ranges from about 3 feet on the upper level to 10 feet on the more sloping sides and side slopes. Water tables on the lower level range from above the surface to about 6 feet deep. Water tables vary seasonally. There are 24 lakes, each 160 acres or more in size, located in the region. Total water area is approximately 29,674 acres.

Original vegetation consisted of tall prairie grass with small areas of aspen-oak land and brush prairie. Present crops are corn, soybeans, alfalfa-brome hay, oats, and wheat. About 10 percent of the region is pastured. Woodland makes up another 5 to 10 percent.

Nine soil landscape units are mapped in the region: LLWD, LLPD, LP, A, SLWD, NP, RLWD, M, and P. Table 4 lists selected features of the units. Additional information follows:

- LLWD — Poorly drained soils comprise about 15 to 20 percent of the unit. About 5 percent of the unit is peat. Small areas of sand and gravel are shown by sand and gravel symbols on the map.
- LLPD — 15 to 20 percent of this unit is well-drained soil. About 5 percent of the unit is peat. Small areas of sand and gravel are shown by sand and gravel symbols on the map.
- LP — About 10 percent of this unit includes mineral soil. Another 10 percent is deep peat.
- A — Small areas of sandy terrace soils are indicated by sand and gravel symbols.
- NP — About 10 percent of this unit is shallow peat. Another 5 percent is mineral soil.

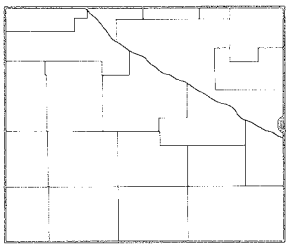


County ditches are necessary to farm many of the soils in the geomorphic regions adjacent to the Minnesota River.

Table 4. Selected features of soil landscape units within the Waconia-Waseca Moraine, loamy, rolling geomorphic region (34)

Soil landscape unit	Percent geomorphic area	Landscape position	Most common texture and thickness (feet)		Moisture relationships		Approximate fertility in rooting zone			Major soil series
			Rooting zone	Substratum	Average water capacity to 5 feet	Drainage class	pH	P	K	
LLWD	66	undulating to rolling upland	loam to clay loam (4)	loam to clay loam (4+)	8-12	well drained	6.1-7.3	low	medium	Clarion Nicollet Lester LeSueur
LLPD	27	depressional to gently sloping upland	loam to clay loam (4)	loam to clay loam (4)	8-12	poorly drained	6.6-7.3	low	low to medium	Glencoe Webster
LP	1	low lying depressions	peat (1-3)	loam (3+)	8-12+	very poorly drained	5.1-7.3	low	low	Cathro Millerville
A	1	nearly level stream bottoms	loam or silt loam (2-4)	loam or silt loam (4+)	4-12	well to poorly drained	5.6-7.8	variable	variable	Huntsville Colo Oshawa
SLWD	0	nearly level outwash plain	sandy loam, loam or silt loam (2-3)	sand and gravel (3-20+)	4-8	well drained	5.1-7.3	low to medium	low	Kasota Wadena
XLWD	<1	rolling upland	sandy loam loam and clay loam (2-3)	sand, gravel and loam (2-4+)	4-12	well	5.1-7.3 drained	low to medium	low to medium	Clarion Storden Dickinson
NP	<1	low lying depressions	peat (1-3)	peat (3+)	12+	very poorly drained	5.1-7.3	low	low	Seelyville
RLWD	<1	nearly level to rolling structural benches	loam (2-4)	limestone or sandstone bedrock (4+)	4-8	well drained	5.1-6.5	high	medium	Copas
M	<1	low lying depressions	either peat or mineral soil	either peat or mineral soil	1-4 feet of water on surface	marshy				
P	<1	low lying depressions	peat (1-3)	peat (3+)	12+	very poorly drained	5.1-7.3	low	low	Unnamed
Water	4									

35B Emmons-Faribault Moraine, irregular, rolling



This region has approximately 2,255 acres or less than 1 percent of the New Ulm sheet. Most of the Emmons-Faribault Moraine is on the St. Paul sheet.

The portion of the Emmons-Faribault Moraine occurring on the New Ulm sheet consists of the steep bluffs bordering the Minnesota River bottoms on the east. Bedrock is mantled by 2 to 4 feet of loam soil material.

The water table is deep. No lakes or water areas occur in this region.

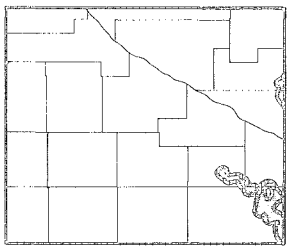
Original vegetation known as the Big Woods consisted of oak, elm, basswood, ash, maple, aspen, birch, wild cherry, butternut, and black walnut. Because of the steep slopes this area remains in woodland although some parts may be pastured.

Only one soil landscape unit is mapped in this region: RLWD. Table 5 lists selected features of this unit. Additional information follows:

RLWD— About 10 to 15 percent of this unit consists of loamy soil material deeper than 5 feet. About 10 percent has a light-colored surface.

Table 5. Selected features of soil landscape units within the Emmons-Faribault Moraine, irregular, rolling geomorphic region (35B)

			Most common texture and thickness (feet)		Moisture relationships		Approximate fertility in rooting zone			
Soil landscape unit	Percent geomorphic area	Landscape position	Rooting zone	Substratum	Average water capacity to 5 feet	Drainage class	pH	P	K	Major soil series
RLWD	100	bluff bordering Minnesota River bottoms	loam (2-4)	limestone or sandstone bedrock (4+)	4-8	well drained	5.6-7.3	high	medium	Rockton Copas



42 Wells-Rush River Ground Moraine, clayey, level

This geomorphic region encompasses approximately 182,125 acres, or 2 percent of the New Ulm sheet.

The Wells-Rush River Ground Moraine consists of clayey mantled ground moraine and ice disintegration features. The dominant landform is one of a nearly level to very gently undulating ground moraine further subdued by a 2 to 6 feet mantle of clayey sediments. Local relief has a range of 3 to 10 feet. This landform seemingly formed under glacial lake water or lake washed till plain or was downwasted from the ice as a clayey slurry. Little or no sand or gravel occurs in the region.

Water tables vary from 1 to 6 feet deep, seasonally.

Five lakes of 160 acres or more occur in the region. The total water area is approximately 1,347 acres.

Original vegetation was tall prairie grass on the well-drained soils: sedges, on the poorly drained soils. Present crops are corn, soybeans, oats, and wheat. Little or no woodland and pasture presently exists in the region.

Six soil landscape units are mapped in this region: LCPD, LLPD, LCWD, A, LLWD, and NP. Table 6 gives selected features of the units. Additional information follows:

LCPD — About 10 percent of this unit has a clay loam or loam surface.

LLPD — About 10 percent of this unit has a silty clay loam or silty clay surface. It also includes about 10 percent well-drained soil.

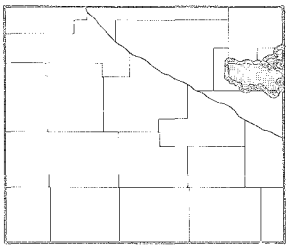
LCWD — About 10 percent of this unit has a clay loam or loam surface.

LLWD — Poorly drained soils comprise about 10 percent of the unit. About 10 percent of the surface is clayey.

Table 6. Selected features of soil landscape unit within the Wells-Rush River Ground Moraine, clayey, level geomorphic region (42)

Soil landscape unit	Percent geomorphic area	Landscape position	Most common texture and thickness (feet)		Moisture relationships		Approximate fertility in rooting zone			Major soil series
			Rooting zone	Substratum	Average water capacity to 5 feet	Drainage class	pH	P	K	
LCPD	48	nearly level to depressional upland	silty clay loam to silty clay (3-4)	loam to clay loam (4+)	8-12	poorly drained	6.1-6.5	low to medium	medium	Marna Lura Cordova
LLPD	19	nearly level to depressional upland	loam to clay loam (4)	loam to clay loam (4+)	8-12	poorly drained	6.6-7.3	low	low to medium	Webster Glencoe
LCWD	13	gently undulating upland	silty clay loam to silty clay (3-4)	loam to clay loam (4+)	8-12	well drained	5.6-6.5	medium	medium	Guckeen
A	9	narrow stream bottoms	loam to silty clay loam (2-4)	loam to silty clay loam (4+)	8-12	well to poorly drained	5.6-7.8	variable	variable	Colo Huntsville Comfrey
LLWD	7	gently undulating upland	silt loam to clay loam (4)	loam to clay loam (4+)	8-12	well drained	6.1-7.3	medium	medium	Clarion Nicollet Truman Kingston
NP	*t	low lying depressions	peat (1-3)	peat (3+)	12+	very poorly drained	5.1-7.3	low	low	Seeleyville
Water	1									

*t = trace



43 Arlington-Matowan Ground Moraine, loamy, undulating

This geomorphic region encompasses approximately 202,035 acres, or about 2 percent of the New Ulm sheet.

The Arlington-Matowan Ground Moraine consists of an undulating ground moraine. The dominant landform is one of a nearly level to gently undulating moraine. The few highs are typically 5 to 15 feet above the lows. Sand and gravel deposits are rare.

Water tables range seasonally from 1 to 10 feet in depth. Depressions are very small in size. Many depressions are closed at the surface and drain underground to tile. Four lakes larger than 160 acres occur in this region. Total water area is approximately 1,188 acres.

Original vegetation consisted of tall prairie grass on the well-drained soils and sedges and marsh grasses on the poorly drained soils. Present crops are corn, soybeans, oats, wheat, and alfalfa-brome hay. Little or no woodland or pasture exists in the region.

Four soil landscape units are mapped in this region: LLPD, LLWD, LCPD, and M. Table 7 gives selected features of the units. Additional information follows:

LLPD — About 10 to 15 percent of this unit consists of well-drained soil.

LLWD — About 10 to 15 percent of this unit consists of poorly drained soil.

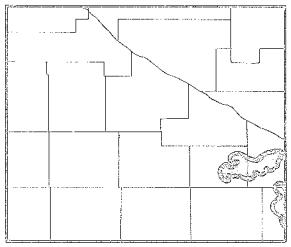
Table 7. Selected features of soil landscape units within the Arlington-Matowan Ground Moraine, loamy, undulating geomorphic region (43)

Soil landscape unit	Percent geomorphic area	Landscape position	Most common texture and thickness (feet)		Moisture relationships		Approximate fertility in rooting zone			Major soil series
			Rooting zone	Substratum	Average water capacity to 5 feet	Drainage class	pH	P	K	
LLPD	97	nearly level to depressional upland	loam to clay loam (4)	loam to clay loam (4+)	8-12	poorly drained	6.6-7.3	low	low to medium	Webster Glencoe
LLWD	1	gently undulating upland	silt loam to clay loam (4)	loam to clay loam (4+)	8-12	well drained	6.1-7.3	low	medium	Clarion Nicollet Truman Kingston
M	*t	low lying depressions	either peat or mineral soil	either peat or mineral soil	1-4 feet of water on surface	marshy				
LCPD	<1	level lake plain	silty clay loam or silty clay (4)	loam to clay loam (4-20+)	8-12	poorly drained	6.1-6.5	low to medium	medium	Marna Lura Cordova
Water	<1									

*t = trace

Soybeans on a LLPD soil landscape unit south of Gaylord in Sibley County.

44 Blue Earth-Garden City Ground Moraine, silty, rolling



This geomorphic region has approximately 128,090 acres or about 1 percent of the New Ulm sheet.

The Blue Earth-Garden City Ground Moraine consists of a gently rolling to rolling silt mantled ground moraine. The dominant landform is a complex of low knolls that rise irregularly above a lower level. Slope irregularity has been subdued by a silt mantle. The knolls seemingly are irregularly emplaced on a regional slope. The dominant relief is 5 to 20 feet above the knoll base. Contour lines have a very erratic pattern.

Water tables range from the surface in depressions to deeper than 10 feet on the knolls seasonally. Depressions are common and generally closed. Water leaves the depressions mostly through drain tile. A few depressions have developed a shallow peat surface. No lakes larger than 160 acres occur in this region. Total water area is approximately 593 acres.

Original vegetation consisted of tall prairie grass on the well-drained soils and sedges and marsh grasses on the poorly drained soils. Present crops are corn, soybeans, oats, wheat, and alfalfa-brome hay. Little or no woodland or pasture exists in the region.

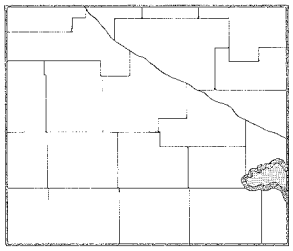
Seven soil landscape units are mapped: LLWD, LLPD, A, SSWD, SLPD, LCPD, and LP. Table 8 gives selected features of the units. Additional information follows:

- LLWD — About 10 to 15 percent of this unit consists of poorly drained soil. In an area north of the town of Blue Earth a few sandy knolls are included with this unit. These knolls are shown on the map by sand symbols.
- LLPD — About 10 to 15 percent of this unit consists of well-drained soil.
- SSWD — About 5 to 10 percent of this unit has a loamy surface.
- SLPD — About 10 percent of this unit consists of well-drained soil.
- LCPD — About 10 percent of this unit has a silty surface.

Table 8. Selected features of soil landscape units within the Blue Earth-Garden City Ground Moraine, silty, rolling geomorphic region (44)

Soil landscape unit	Percent geomorphic area	Landscape position	Most common texture and thickness (feet)		Moisture relationships		Approximate fertility in rooting zone			Major soil series
			Rooting zone	Substratum	Average water capacity to 5 feet	Drainage class	pH	P	K	
LLWD	71	undulating to rolling upland	silt loam to clay loam (4)	loam to clay loam (4+)	8-12	well drained	6.1-7.3	low	medium	Clarion Nicollet Truman Kingston
LLPD	21	nearly level to depressional upland	loam,silt-loam to clay loam (4)	loam to clay loam (4+)	8-12	poorly drained	6.6-7.3	low	low to medium	Webster Glencoe
A	3	narrow stream bottoms	loam to silty clay loam (2-4)	loam to silty clay loam (4+)	4-12	well to poorly drained	5.6-7.8	variable	variable	Comfrey Colo Huntsville
SSWD	1	nearly level to gently rolling out-wash plain	loamy sand (2-3)	sand and gravel (3-20+)	<4	well drained	5.1-6.5	low to medium	low	Dickinson Hubbard Estherville
SLPD	<1	nearly level outwash plain	loam, silt loam or silty clay loam (2-3)	sand and gravel (3-20+)	4-8	poorly drained	6.1-7.8	low	low	Telcot Biscay
LCPD	<1	nearly level to depressional upland	silty clay loam to silty clay (3-4)	loam to clay loam (4+)	8-12	poorly drained	6.1-6.5	low to medium	medium	Marna Lura Cordova
LP	*t	low lying depressions	peat (1-2)	loam (4+)	8-12+	very poorly drained	5.1-7.3	low	low	Cathro Millerville
Water	<1									

*t = trace



46 Minnesota Lake Plain, clayey, level

This geomorphic region has an area of approximately 99,135 acres or about 1 percent of the New Ulm sheet.

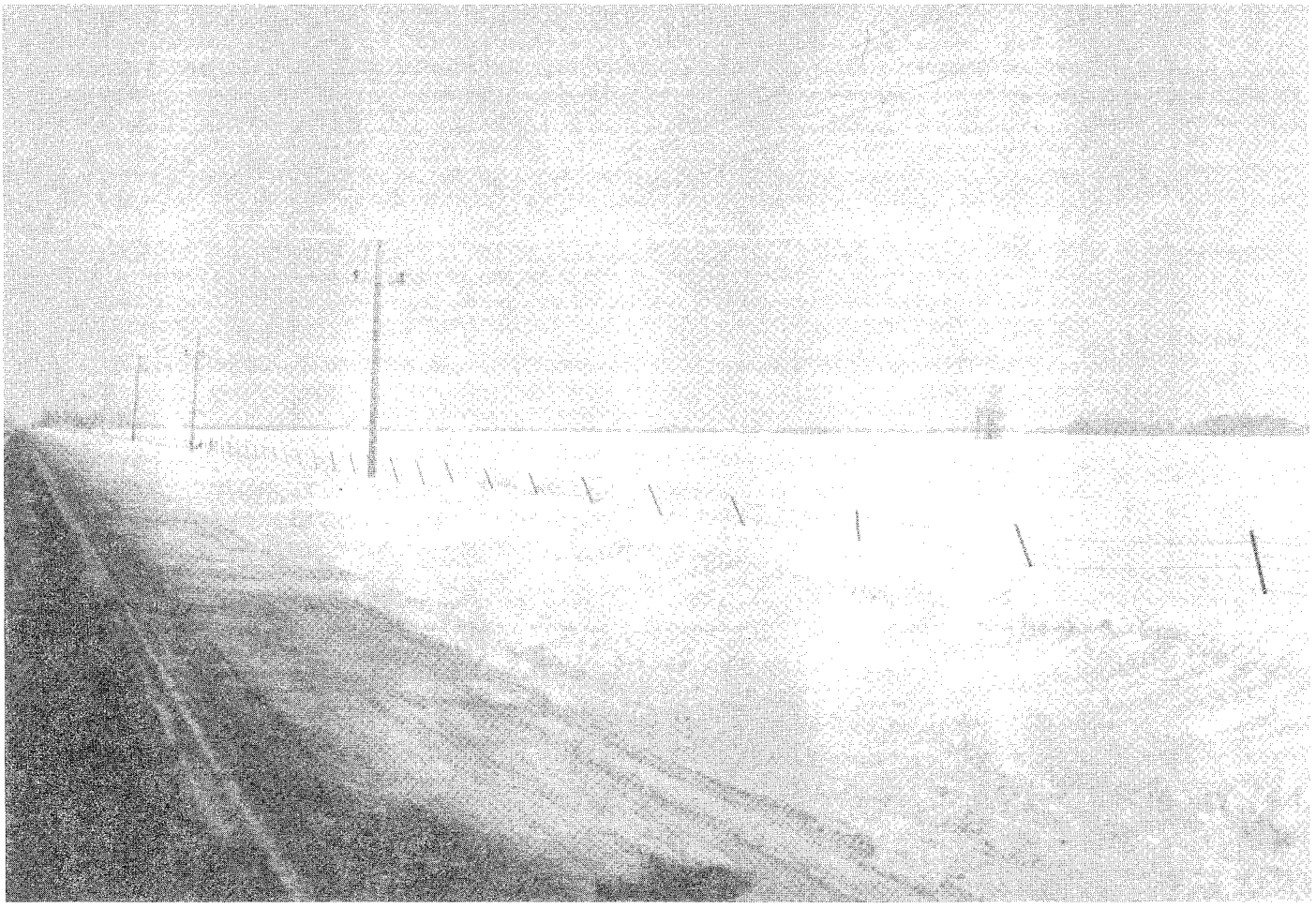
The Minnesota Lake Plain consists of a clayey glacial lake basin. The dominant landform is a level to nearly level clay-mantled low relief ground moraine. The few highs are dominantly 3 to 6 feet above the lows. Depressions are commonly small in size. This landform developed in deep sediment-filled glacial lake water. Clayey sediments range from 4 to 10 feet thick. No sand and gravel occur in this region.

Water tables vary from the surface to 6 feet deep seasonally. One lake of more than 160 acres occurs. The total water area is approximately 1,340 acres.

Original vegetation was tall prairie grass on the well-drained soils, and sedges and marsh grasses on the poorly drained soils. Present crops are corn, soybeans, oats, and wheat. Little or no woodland or pasture exists in the region.

Six soil landscape units are mapped: LCPD, CCPD, A, LLWD, LCWD, and LLPD. Table 9 gives selected features of the units. Additional information follows:

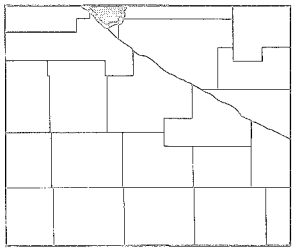
- LCPD — About 10 percent of this unit has a clay loam or loam surface.
- CCPD — About 10 percent of this unit has a clay loam or loam substratum.
- LLWD — Includes about 10 percent poorly drained soil.
- LCWD — Includes about 10 percent poorly drained soil.
- LLPD — Includes about 10 percent well-drained soil.



A 1979 winter scene in Blue Earth County.

Table 9. Selected features of soil landscape units within the Minnesota Lake Plain, clayey, level geomorphic region (46)

Soil landscape unit	Percent geomorphic area	Landscape position	Most common texture and thickness (feet)		Moisture relationships		Approximate fertility in rooting zone			Major soil series
			Rooting zone	Substratum	Average water capacity to 5 feet	Drainage class	pH	P	K	
LCPD	54	level lake plain	silty clay loam or silty clay (4)	loam to clay loam (4-20+)	8-12	poorly drained	6.1-6.5	low to medium	medium	Marna Lura Cordova
CCPD	25	level lake plain	silty clay to clay (4)	silty clay to clay (4-20)	8-12	poorly drained	6.5-7.3	low	high	Fulda Dovray
A	11	narrow stream bottoms	silt loam, loam, clay loam (5)	loam, clay loam, silty clay (5-20+)	8-12	well to poorly drained	5.6-7.8	variable	variable	Huntsville Colo Comfrey
LLWD	3	nearly level lake plain	silt loam to clay loam (4)	loam, clay loam (4-20+)	8-12	well drained	6.1-7.3	low	medium	Clarion Nicollet Truman Kingston
LCWD	3	nearly level lake plain	silty clay loam to silty clay (3-4)	loam to clay loam (4+)	8-12	well drained	5.6-6.5	medium	medium	Guckeen
LLPD	1	level lake plain	loam to clay loam (4)	loam to clay loam (4+)	8-12	poorly drained	6.6-7.3	low	low to medium	Webster Glencoe
Water	2									



50 Benson Lacustrine Plain, silty

This geomorphic region has an area of approximately 82,380 acres or about 1 percent of the New Ulm sheet.

The Benson Lacustrine Plain consists of a broad low relief lake plain. Higher positions are gently sloping to undulating. Lower positions are nearly level to slightly depressional.

The seasonally high water table in better drained positions ranges from 3 to 4 feet deep. In poorly drained areas it is 2 to 3 feet deep. In the sandy and gravelly areas the water table is more than 5 feet deep. No lake of more than 160 acres occurs in the region. Total water area is approximately 290 acres.

Alkaline soils are quite common in this region. The high lime content may cause iron and zinc deficiencies in some crops. Soybeans, flax, and many ornamental shrubs and trees are affected by iron deficiencies. Corn can also be affected, but less seriously. Crops most seriously affected by zinc deficiencies are corn, soybeans, and flax. Potatoes, sugar beets, alfalfa, sorghum, tomatoes, and onions are mildly affected crops.

The original vegetation was tall prairie grass on the well-drained soils and sedges and marsh grasses on the poorly drained soils. Present crops are corn, soybeans, wheat, barley, and oats. Less than 10 percent is pasture, and less than 5 percent is wooded.

Six soil landscape units are mapped in the region: LLWD, LLPD, CCPD, A, SLWD, and LP. Table 10 lists selected features of the units. Additional information follows:

LLWD — Poorly drained soils comprise 10 to 20 percent of the unit. About 5 percent of the soils are clayey and another 5 percent have a sandy substratum below 2 to 3 feet.

LLPD — About 15 percent of this unit is moderately well-drained soil. About 5 percent have a clayey surface and 5 percent are underlain at less than 36 inches by sandy sediments.

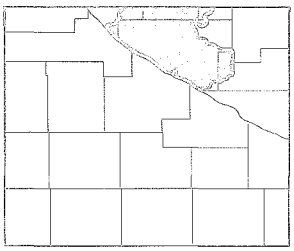
CCPD — This unit includes 10 to 15 percent moderately well-drained soils and 10 to 15 percent silty or loamy soils.

SLWD — Deep silty or loamy soils occur in about 10 percent of the unit; 10 percent are poorly drained; and 5 percent have a sandy surface.

Table 10. Selected features of soil landscape units within the Benson Lacustrine Plain, silty geomorphic region (50)

Soil landscape unit	Percent geomorphic area	Landscape position	Most common texture and thickness (feet)		Moisture relationships		Approximate fertility in rooting zone			Major soil series
			Rooting zone	Substratum	Average water capacity to 5 feet	Drainage class	pH	P	K	
LLWD	56	level to gently sloping lake plain	silt loam to loam (4)	silt loam to loam (4+)	8-12	moderately well to some-what poorly drained	7.8+	low	high	Seaforth McIntosh
LLPD	26	level to depressional lake plain	silt loam to silty clay loam (2-3)	loam to silty clay loam (3-4+)	8-12	poorly to very poorly drained	7.8+	low	high	Colvin Sletten
CCPD	10	level to depressional lake plain	silty clay loam to silty clay (2-4)	silty clay loam to silty clay (4+)	8-12	poorly to very poorly drained	6.5-7.3	low	high	Fulda Dovray
A	4	nearly level stream bottoms	variable: sandy loam to silt loam (2-4)	variable: sandy loam to silt loam (4+)	4-12	poorly to moderately well drained	6.1-7.2	variable	variable	Alluvial land
SLWD	1	nearly level lake plain	silt loam to very fine sandy loam (2-3)	loamy very fine sand (3-4+)	4-8	moderately well to some-what poorly drained	7.8+	low	medium	Glyndon
LP	<1	low lying depressions	peat (1-4)	loam (4+)	8-12+	very poorly drained	5.5-7.3	low	low	Cathro Millerville
Water	<1									

64 Olivia Till Plain



This geomorphic region has an area of approximately 896,380 acres or about 11 percent of the New Ulm sheet.

The Olivia Till Plain consists of a gently undulating till plain. Many nearly level and low depressional areas also occur. The soils developed in limy grayish loam till. Only pockets of sandy and gravelly areas occur and are too small to show on the map as separate landscape units. A silt cap usually less than 4 feet thick covers the till in some areas.

Depth to seasonally high water tables is less than 5 feet deep in most of the region. In higher positions it is more than 5 feet deep. Three lakes, each 160 acres or larger are in the region. The total water area is approximately 4,441 acres.

The original vegetation was tall-grass prairie on the well-drained soils and sedges and marsh grasses on the poorly drained soils. Narrow bands of woods border some streams and lakes. Present crops are corn, soybeans, oats, barley, and wheat. Very little land is in woodland and pasture.

Five soil landscape units are mapped in the region: LLWD, LLPD, LP, A, and NP. Table 11 lists selected features of the units. Additional information follows:

LLWD — The Barnes and Svea soils are confined to the western part of the region and Clarion and Nicollet soils to the eastern part. Approximately 15 percent are poorly drained soils and 10 percent are alkaline soils. Sandy spots are shown on the color map by sand symbols.

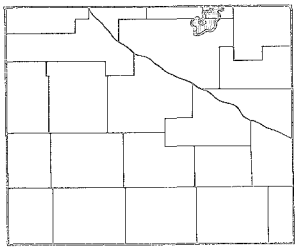
LLPD — Flom and Quam soils occur mostly along the western part of the region. Webster and Glencoe are the soils in similar positions in the eastern part. Approximately 15 percent of the unit is moderately well drained and 10 to 15 percent are alkaline soils.

LP — Approximately 15 percent of this unit are deep peat soils and 15 percent are mineral soils.

NP — This unit includes about 20 percent shallow peat soils and 10 percent poorly drained mineral soils.

Table 11. Selected features of soil landscape units within the Olivia Till Plain geomorphic region (64)

Soil landscape unit	Percent geomorphic area	Landscape position	Most common texture and thickness (feet)		Moisture relationships		Approximate fertility in rooting zone			Major soil series
			Rooting zone	Substratum	Average water capacity to 5 feet	Drainage class	pH	P	K	
LLWD	51	gently rolling to rolling upland	loam to clay loam (4)	loam to clay loam (4-20+)	8-12	moderately well to well drained	6.1-7.3	low	medium	Clarion Nicollet Ves Normania Svea
LLPD	47	gently sloping to depressional upland	loam to clay loam (4)	loam to clay loam (4-20+)	8-12	poorly to very poorly drained	6.6-7.3	low	low to medium	Webster Glencoe Flom Quam
LP	<1	low lying depressions	peat (1-4)	loam to clay loam (4+)	8-12+	very poorly drained	6.6-7.8	low	low	Cathro Millerville
A	<1	nearly level stream bottoms	variable: sandy loam to silt loam (4+)	variable: sandy loam to silt loam (4+)	4-12	poorly to moderately well drained	6.1-7.2	variable	variable	Alluvial land
NP	<1	low lying depressions	peat (1-3)	peat (3-4+)	12+	very poorly drained	5.5-7.3	low	low	Seeleyville
Water	<1									



64A Olivia Till Plain, clayey

This geomorphic region encompasses approximately 47,160 acres or less than 1 percent of the New Ulm sheet.

This portion of the Olivia Till Plain consists of an undulating to gently rolling ground moraine. Approximately 82 percent of the region has either a clayey surface or a clayey substratum, indicating that ice-blocked lakes probably existed for periods long enough for clays to be deposited on the loamy till. Some areas have silt cap. No sand and gravel areas occur in this region.

Seasonally high water tables are generally more than 5 feet deep on higher ground and less than 5 feet deep on lower positions. No lakes 160 acres or larger occur in the region. Total water area is approximately 191 acres.

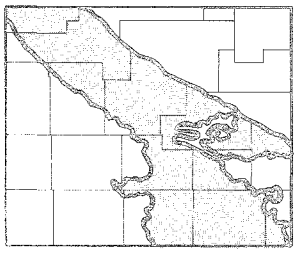
The original vegetation was tall-grass prairie on the well-drained soils, and sedges and marsh grasses on the poorly drained soils. Present crops are corn, soybeans, wheat, oats, and barley. Very little, if any, land is in woodland and pasture.

Seven soil landscape units are mapped in the region: LCPD, LLWD, LCWD, A, NP, M, and LLPD. Table 12 gives selected features of the units. Additional information follows:

- LCPD — This unit includes approximately 10 percent better drained soils; 10 percent has a silt loam surface. Five percent are alkaline soils.
- LLWD — Approximately 15 percent of this unit are poorly drained soils. About 10 percent has a clayey surface.
- LCWD — About 10 percent of this unit is poorly drained. About 10 percent has a silty surface.
- NP — About 10 percent of this unit is shallow peat or poorly drained mineral soil.
- LLPD — About 10 percent of the unit is moderately well drained.

Table 12. Selected features of soil landscape units within the Olivia Till Plain, clayey geomorphic region (64A)

Soil landscape unit	Percent geomorphic area	Landscape position	Most common texture and thickness (feet)		Moisture relationships		Approximate fertility in rooting zone			Major soil series
			Rooting zone	Substratum	Average water capacity to 5 feet	Drainage class	pH	P	K	
LCPD	55	nearly level to depressional upland	silty clay loam (2-3)	clay loam (3-4+)	8-12	poorly to very poorly drained	6.1-6.5	low to medium	medium	Marna Lura
LLWD	11	gently rolling to rolling upland	loam to clay loam (4)	loam to clay loam (4-20+)	8-12	moderately well to well drained	6.1-7.3	low	medium	Lester LeSueur Clarion Nicollet
LCWD	26	level to gently undulating upland	silty clay loam to silty clay (3-4)	loam to clay loam (4+)	8-12	well drained	5.6-6.5	medium	medium	Guckeen
A	4	nearly level stream bottoms	variable: sandy loam to silt loam (2-4)	variable: sandy loam to silt loam (4+)	4-12	poorly to moderately well drained	6.1-7.2	variable	variable	Alluvial land
NP	1	low lying depressions	peat (1-3)	peat (3-4+)	12+	very poorly drained	5.5-7.3	low	low	Seeleyville
M	<1	low lying depressions	peat or mineral soil	peat or mineral soil	1-4 feet water on surface	marshy				
LLPD	<1	gently sloping to depressional upland	loam, clay loam and silty clay loam (4)	loam, clay loam and silty clay loam (4-20+)	8-12	poorly to very poorly drained	6.6-7.3	low	low to medium	Webster Glencoe Cordova
Water	<1									



66 Blue Earth Till Plain, undulating, loamy

The region has an area of approximately 3,673,070 acres or about 46 percent of the New Ulm sheet.

The Blue Earth Till Plain consists of a gently undulating to rolling till plain. Nearly level to depressional poorly drained areas are common throughout the region. The till covering this region is grayish, limy, and loamy. In places a silt cap up to 4 feet thick overlays the till. Less than 3 percent of the region has soils containing sand and gravel either in moraines or terraces. These sandy or gravelly areas are generally small but are widespread through the region.

Depth to seasonally high water tables is more than 5 feet on well-drained locations and less than 5 feet on lower positions. Forty eight lakes, 160 acres or more in size, are located in the region. The total water area is approximately 35,099 acres.

The original vegetation was tall-grass prairie on the well-drained soils and sedges and marsh grasses on the poorly drained soils. Narrow bands of woods, mostly oak and cottonwood, border some streams and lakes. Present crops are corn, soybeans, wheat, oats, and barley. Very little woodland and pasture exist in the region.

Thirteen soil landscape units are mapped in the region: LLWD, LLPD, A, SLWD, XLWD, CCPD, SSWD, SLPD, LCPD, RLWD, LP, M, and NP. Table 13 gives selected features of the units. Additional information follows:

LLWD — The Barnes and Svea soils are confined to the western part of the region and Clarion and Nicollet soils to the eastern part. An estimated 10 to 15 percent of this unit are poorly drained soils. Another 5 to 15 percent is alkaline and less than 5 percent is sandy and gravelly. These areas are shown on the map by sand and gravel symbols. A few areas of shallow to rock soils are shown by rock outcrop symbols.

LLPD — Flom and Quam soils occur mostly along the western part of the region. Webster and Glencoe are the soils in similar positions in the eastern part. Approximately 25 percent of the soils in this unit are alkaline. Another 15 percent is moderately well drained. The unit also includes small areas of soils with a clayey surface.

A — These soils are subject to frequent overflow.

SLWD — This unit includes about 10 percent loamy till substratum. About 5 percent of this unit has a sandy surface.

CCPD — Moderately well-drained soils make up to 10 to 15 percent of the unit.

SSWD — About 10 percent of this unit has a loam surface soil.

SLPD — Includes about 10 percent moderately well-drained soil. About 10 percent has a loamy till substratum.

RLWD — Outcrops of bedrock occur within this unit.

Table 13. Selected features of soil landscape units within the Blue Earth Till Plain, undulating, loamy geomorphic region (66)

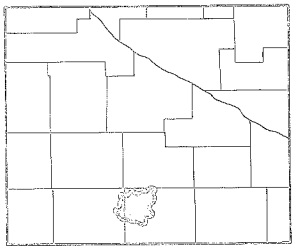
Soil landscape unit	Percent geomorphic area	Landscape position	Most common texture and thickness (feet)		Moisture relationships		Approximate fertility in rooting zone			Major soil series
			Rooting zone	Substratum	Average water capacity to 5 feet	Drainage class	pH	P	K	
LLWD	55	undulating to gently rolling upland	loam to clay loam (4)	loam to clay loam (4-20+)	8-12	well drained	6.6-7.8	low	high	Clarion, Ves, Normania Nicollet Storden Barnes, Buse
LLPD	36	nearly level to depressional upland	loam to clay loam (4)	loam to clay loam (4-20+)	8-12	poorly to very poorly drained	6.6+	low	medium	Webster, Glencoe Cordova, Flom Vallers, Okoboji Quam
A	3	nearly level stream bottoms	variable: loamy sand to silt loam (1-4)	variable: loamy sand to silt loam (4+)	4-12	poorly drained	5.6+	variable	variable	Alluvial land Lamoure
SLWD	<1	level to sloping outwash plain	loam to sandy loam (2-3)	sand and gravel (3-20+)	4-8	well drained	6.6-7.3	medium	low to medium	Fordville Arvilla Fairhaven, Wadena Sverdrup

Table 13. (continued) Selected features of soil landscape units within the Blue Earth Till Plain, undulating, loamy geomorphic region (66)

Soil landscape unit	Percent geomorphic area	Landscape position	Most common texture and thickness (feet)		Moisture relationships		Approximate fertility in rooting zone			Major soil series
			Rooting zone	Substratum	Average water capacity to 5 feet	Drainage class	pH	P	K	
XLWD	<1	rolling upland	sandy loam, loam and clay loam (2-3)	sand, gravel and loam (3-4+)	4-12	well drained	6.1-7.3	low to medium	low to medium	Clarion, Storden Dickinson
CCPD	<1	nearly level to depressional lake plain	silty clay loam to silty clay (2-4)	silty clay loam to silty clay (4+)	8-12	poorly to very poorly drained	6.5-7.3	low	high	Fulda Dovray
SSWD	<1	nearly level to gently rolling outwash plain	loamy sand (1-3)	sand and gravel (3-20+)	<4	well drained	5.1-6.5	low to medium	low	Hubbard Estherville Dickinson
SLPD	<1	level to depressional outwash plain	loam to sandy loam (2-3)	sand and gravel (3-20+)	4-8	poorly to very poorly drained	6.6-7.3	medium	medium	Forada
LCPD	*t	nearly level to depressional upland	silty clay loam (2-3)	clay loam (3-4+)	8-12	poorly to very poorly drained	6.1-6.5	low to medium	medium	Marna Lura
RLWD	*t	undulating to rolling upland	loam to clay loam (2-3)	Quartzite Limestone Granite (3+)	4-8	well drained	5.6-7.3	high	medium	Ihlen Copas
LP	*t	low lying depressions	peat (1-4)	loam to clay loam (4+)	8-12+	very poorly drained	5.5-7.3	low	low	Cathro Millerville
M	*t	low lying depressions	peat or mineral soil	peat or mineral soil	1-4 ft water on surface	marshy				
NP	*t	low lying depressions	peat (1-3)	peat (3-4+)	12+	very poorly drained	5.5-7.3	low	low	Seelyville
Water	1									

*t = trace

A scene east of Morgan in Redwood County.



66A Blue Earth Till Plain, clayey

This geomorphic region has an area of approximately 91,570 acres or, about 1 percent of the New Ulm sheet.

The Blue Earth Till Plain, clayey consists of clayey mantled till plain. The dominant land form is one of a nearly level to depressional till plain. This land form seemingly formed under glacial lake water or lake-washed till plain or was downwasted from the ice as a clayey slurry. Little or no sand or gravel occurs in the region.

Water tables vary from the surface in depressions to 6 feet deep seasonally. Heron Lake is the only large lake in the region. The total water area is approximately 2,255 acres.

Original vegetation was tall prairie grass on the well-drained soils and sedges and marsh grasses on the poorly drained soils. Present crops are corn, soybeans, oats, and wheat. Reed canarygrass hay is harvested in very poorly drained areas. Little or no woodland or pasture exists in the region.

Eight soil landscape units are mapped in this region: LCPD, CCPD, LLWD, LLPD, A, M, LCWD, and LP. Table 14 gives selected features of the units. Additional information follows:

LCPD — About 10 percent of this unit has a clay loam or silt loam surface. About 10 percent is also moderately well drained.

CCPD — Moderately well drained soils make up 10 to 15 percent of this unit. Also 10 percent has a clay loam substratum.

LLWD — An estimated 10 to 15 percent of this unit are poorly drained soils. Also 5 to 10 percent may have a clayey surface.

LLPD — About 10 percent of this unit is moderately well drained. This unit also includes small areas of soils with a clayey surface.

LCWD — About 10 percent of this unit has a clay loam or silt loam surface. About 10 percent is also poorly drained.

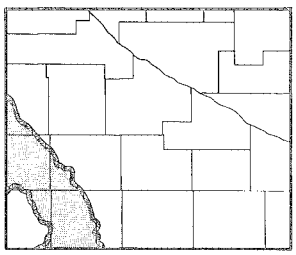
LP — Included in this unit is 10 to 15 percent deep peat. Also 5 to 10 percent is poorly drained mineral soil.

The Cottonwood River drains water from the Coteau des Prairie northeast toward the Minnesota River.

Table 14. Selected features of soil landscape units within the Blue Earth Till Plain, clayey geomorphic region (66A)

Soil landscape unit	Percent geomorphic area	Landscape position	Most common texture and thickness (feet)		Moisture relationships		Approximate fertility in rooting zone			Major soil series
			Rooting zone	Substratum	Average water capacity to 5 feet	Drainage class	pH	P	K	
LCPD	62	nearly level to depressional upland	silty clay loam to silty clay (0-3)	clay loam (3-4+)	8-12	poorly to very poorly drained	6.1-6.5	low to medium	medium	Marna Lura Webster
CCPD	12	nearly level to depressional lake plain	silty clay loam to silty clay, or clay (0-4)	silty clay loam to silty clay or clay (4+)	8-12	poorly to very poorly drained	6.5-7.3	low	high	Fulda Dovray
LLWD	10	undulating to gently rolling upland	loam to clay loam (4)	loam to clay loam (4-20+)	8-12	well drained	6.6-7.8	low	high	Clarion Nicollet Truman Kingston
LLPD	4	nearly level to depressional upland	loam to clay loam (4)	loam to clay loam (4-20+)	8-12	poorly to very poorly drained	6.6+	low	medium	Webster Glencoe Cordova, Madelia
A	4	nearly level stream bottoms	variable: loam, silt loam to clay (1-4)	variable: loam, silt loam to clay (4+)	4-12	poorly drained	5.6+	variable	variable	Comfrey Lamoure
M	2	low lying depressions	peat or mineral soil	peat or mineral soil	1 to 4 feet of water on surface	marshy				
LCWD	2	level to gently undulating upland	silty clay loam to silty clay (2-3)	loam to clay loam (3+)	8-12	moderately well drained	5.6-6.5	medium	medium	Guckeen
LP	1	low lying depressions	peat (1-4)	loam to clay loam (4+)	8-12+	very poorly drained	5.5-7.3	low	low	Cathro Millerville
Water	3									

67 Lake Benton-Adrian Coteau, undulating, loamy



This geomorphic region has an area of approximately 801,860 acres or about 10 percent of the New Ulm sheet.

The Lake Benton-Adrian Coteau consists of loess-mantled ground moraine. The relief is marked predominantly by long smooth gentle slopes. The wind-deposited loess has filled in the irregularities of the glacial till plain. The glacial till is of an older phase of the Wisconsin glaciation (see Development of Landforms, page 27). Most of this till has been covered by loess from 1 to 3 feet thick. Closed depressions characteristic of younger till areas are absent in this region. Contour lines are reasonably parallel.

Depth to seasonally high water tables is more than 5 feet on well-drained locations and less than 5 feet on lower positions. No lakes are present in this region.

The original vegetation was tall-grass prairie on the well-drained soils and sedges and marsh grasses on the poorly drained soils. Present crops are corn, soybeans, oats, and flax. Little or no woodland or pasture occurs in the region.

Seven soil landscape units are mapped: LLWD, LLPD, LCPD, A, SLWD, SLPD, and XLWD. Table 15 gives selected features of the units. Additional information follows:

LLWD — Thickness of this silt cap varies from 0 to 3 feet thick. Where the silt cap is absent or thin, the surface is loam or clay loam. About 5 percent of this unit is poorly drained.

LLPD — These poorly drained soils occur mostly in drainageways. About 10 percent of the unit is moderately well drained.

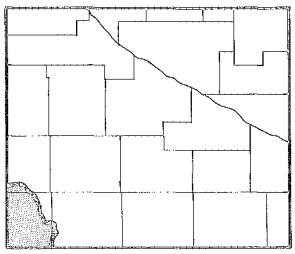
A — This unit is subject to frequent overflow.

SLWD — These are terrace areas along the major rivers. About 5 percent of this unit is poorly drained. This unit is a source of sand and gravel.

SLPD — These are terrace areas along the major rivers. About 5 to 10 percent of this unit is moderately well drained.

Table 15. Selected features of soil landscape units within the Lake Benton-Adrian Coteau, undulating, loamy geomorphic region (67)

Soil landscape unit	Percent geomorphic area	Landscape position	Most common texture and thickness (feet)		Moisture relationships		Approximate fertility in rooting zone			Major soil series
			Rooting zone	Substratum	Average water capacity to 5 feet	Drainage class	pH	P	K	
LLWD	78	undulating to rolling to steep upland	loam, silt loam & clay loam (0-3-4+)	loam and clay loam (4-20+)	8-12	well drained	6.6-7.8	very low	medium	Barnes, Buse Kranzburg, Vienna Brookings, Everly Sac, Galva
LLPD	1	nearly level to depressional upland	loam, silt loam and clay loam (4)	loam, silt loam and clay loam (4-20+)	8-12	poorly to very poorly drained	6.6-7.8	low	medium	Hidewood Rushmore Letri
A	11	nearly level stream bottoms	variable: loamy sand to silt loam (1-4)	variable: loamy sand to silt loam (4+)	4-12	poorly drained	6.6-7.8	variable	variable	Lamoure, Spillville LaPrairie, Comfrey Millington
SLWD	6	level to sloping outwash plain	sandy loam to loam or silt loam (2-3)	sand and gravel (3-20+)	4-8	well drained	6.6-7.8	low	medium	Sverdrup Fairhaven Wadena
SLPD	1	level to depressional outwash plain	loam to silty clay loam (2-3)	sand and gravel (3-20+)	4-8	poorly to very poorly drained	6.6-7.8	low	medium	Trosky Talcot Biscay
XLWD	1	rolling upland	sandy loam, loam and clay loam (2-3)	sand, gravel and loam (3-4+)	4-12	well drained	6.6-7.3	low to medium	low to medium	Everly-Storden-Estherville Complex Barne-Buse-Arvilla-Complex
LCPD	<1	nearly level to depressional upland	silty clay loam to silty clay (0-3)	clay loam (3-4+)	8-12	poorly to very poorly drained	6.1-6.5	low to medium	medium	Marna Lura Webster
Water	<1									



67A Luverne Coteau, gently sloping, silty

This geomorphic region encompasses approximately 307,830 acres or about 4 percent of the New Ulm sheet.

The Luverne Coteau consists of a loess-mantled older glacial till plain. The Iowan age till has a relief of long smooth gentle slopes. The drainage is well established and no closed depressions occur in this region. The 4 to 10 foot loess mantle has smoothed the irregularities of the till plain.

Depth to seasonally high water tables is more than 5 feet on well-drained locations and less than 5 feet on lower positions. No lakes or measurable water areas occur in this region.

The original vegetation was tall-grass prairie on the well-drained soils, and sedges and marsh grasses on poorly drained soils. Present crops are corn, soybeans, oats, flax, and alfalfa-brome hay. Little or no woodland and pasture occurs in the region.

Five soil landscape units are mapped in the region: LLWD, A, RLWD, SDWD, and LLPD. Table 16 gives selected features of the units. Additional information follows:

LLWD — About 5 percent of this unit is poorly drained.

A — This unit is subject to frequent overflow. About 5 percent of this unit consists of small islands of sandy terrace soils.

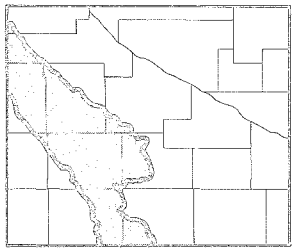
RLWD — Within this unit are numerous outcrops of Sioux quartzite.

SLWD — These are terrace areas along the Rock River. About 5 percent of this unit is poorly drained. This unit is a source of sand and gravel.

LLPD — Most of this unit consists of an old lake bed.

Table 16. Selected features of soil landscape units within the Luverne Coteau, gently sloping, silty geomorphic region (67A)

Soil landscape unit	Percent geomorphic area	Landscape position	Most common texture and thickness (feet)		Moisture relationships		Approximate fertility in rooting zone			Major soil series
			Rooting zone	Substratum	Average water capacity to 5 feet	Drainage class	pH	P	K	
LLWD	85	nearly level to sloping upland	loam, silt loam or silty clay loam (3-4)	silt loam to clay loam (4+)	8-12	moderately well to well drained	6.1-7.3	low	medium	Moody Crofton Vienna, Kranzburg
A	8	nearly level stream bottoms	variable: loamy sand to silty clay loam (1-4)	variable: loamy sand to silty clay loam (4+)	4-12	poorly drained	6.1-7.3	low	medium	Alluvial Soils Lamoure
RLWD	4	sloping to steeply sloping upland	silt loam (1-4)	Sioux Quartzite bedrock (4+)	<4-8	well drained	6.1-7.3	low	medium	Ihlen Rock Outcrop
SLWD	2	level to sloping outwash plain or terrace	sandy loam, loam or silt loam (1-3)	sand and gravel (3-20+)	<4-8	well drained	6.1-7.3	low	low to medium	Estherville Fairhaven Fordville
LLPD	1	nearly level lake bed	loam, silt loam or silty clay loam (1-3)	silty clay loam to clay (3+)	8-12	poorly to very poorly drained	6.6-7.3	low	medium	Unnamed



68 Ivanhoe-Worthington Coteau, gently sloping, loamy

This geomorphic region encompasses approximately 1,393,963 acres or 17.26 percent of the New Ulm sheet.

The Ivanhoe-Worthington Coteau consists of a series of terminal and end moraines with ground moraines separating them. The topography ranges from gently undulating to steeply rolling and hilly. This Coteau or Highland of the Prairies is some of the highest land in Minnesota and forms the divide between the Missouri and the Mississippi drainage. The crest elevation is about 2,000 feet above sea level. The highland is a large plateau or massive ridge, in part smoothly undulating or rolling, with two terminal moraine zones that are irregularly broken by steep hills, knolls, and small ridges. The south ends of these moraines rest on ridges of the old Sioux quartzite. The till covering this region is grayish, limy, and loamy. Less than 1 percent of the soils contain sand or gravel.

Depth to seasonally high water tables is more than 5 feet on well-drained locations and less than 5 feet on lower positions. Sixteen lakes, 160 acres or more in size, are located in the region. The total water area is approximately 24,734 acres.

The original vegetation was tall-grass prairie on the well-drained soils, and sedges and marsh grasses on the poorly drained soils. Narrow bands of woods, mostly oak and cottonwood, border some streams and lakes. Present crops are corn, soybeans, wheat, oats, and flax. Very little woodland exists in the region. Pasture makes up about 10 percent of the region.

Nine soil landscape units are mapped in the region: LLWD, LLPD, A, SLWD, XLWD, CCPD, LCPD, SSWD, and M. Table 17 gives selected features of the units. Additional inforn follows:

LLWD — The Barnes and Svea soils are confined to the western part of the region and Clarion and Nicollet soils to the eastern part. An estimated 10 to 15 percent of this unit are poorly drained soils. Another 5 to 15 percent are alkaline. Less than 2 percent is sandy and gravelly.

LLPD — Flom and Parnell soils occur mostly along the western part of the region. Webster and Glencoe are the soils in similar positions in the eastern part. Approximately 25 percent of the soils in this unit are alkaline. Another 15 percent is moderately well drained. The unit also includes small areas of soils with a clayey surface.

A — These soils are subject to frequent overflow.

SLWD — About 5 percent of the surface of this unit has a sandy surface. This unit is a source of sand and gravel.

XLWD— This unit is a limited source of sand and gravel.

CCPD — Moderately well drained soils make up 10 to 15 percent of this unit.

LCPD — About 10 percent of this unit is moderately well drained.

SSWD — About 10 percent of this unit has a sandy loam or loam surface.

A profile of Ves soil located on the Southwest Experiment Station near Lamberton.

Table 17. Selected features of soil landscape units within the Ivanhoe-Worthington Coteau, gently sloping loamy geomorphic region (68)

Soil landscape unit	Percent geomorphic area	Landscape position	Most common texture and thickness (feet)		Moisture relationships		Approximate fertility in rooting zone			Major soil series
			Rooting zone	Substratum	Average water capacity to 5 feet	Drainage class	pH	P	K	
LLWD	26	undulating to gently rolling upland	loam to clay loam (4)	loam to clay loam (4-20+)	8-12	well drained	6.1-7.8	low	high	Clarion, Storden, Svea Nicollet, Barnes, Ves, Wilmonton, Buse, Forman, Normania, Aastad
LLPD	47	nearly level to depressional upland	loam to clay loam (4)	loam to clay loam (4-20+)	8-12	poorly to very poorly drained	6.1-7.8	low	medium	Webster Glencoe Flom Parnell
A	18	nearly level stream bottoms	variable: loamy sand to silt loam (1-4)	variable: loamy sand to silt loam (4+)	4-12	poorly drained	6.1-7.8	variable	variable	Comfrey, Spillville, Millington, Lamoure, LaPrairie, Alluvial land
SLWD	<2	level to sloping outwash plain	loam to sandy loam (2-3)	sand and gravel (3-20+)	4-8	well drained	6.6-7.3	medium	low to medium	Fairhaven Wadena
XLWD	<2	rolling upland	sandy loam, loam, and clay loam (2-3)	sand, gravel and loam (3-4+)	4-12	well drained	5.1-7.3	low to medium	low to medium	Clarion-Storden-Estherville, Barnes-Buse-Arvilla
CCPD	<1	nearly level to depressional lake plain	silty clay loam to silty clay (2-4)	silty clay loam to silty clay (4+)	8-12	poorly to very poorly drained	6.6-7.3	low	high	Collinwood Lura Waldorf Fulda
LCPD	<1	nearly level to depressional upland	silty clay loam (2-3)	clay loam (3-4+)	8-12	poorly to very poorly drained	6.1-7.3	low to medium	medium	Galva Kingston Marna
SSWD	<1	nearly level to gently rolling outwash plain	loamy sand (1-3)	sand and gravel (3-20+)	<4	well drained	5.1-6.5	low to medium	low	Dickman Estherville
M	<1	low lying depressions	peat or mineral soil	peat or mineral soil	1-4 feet of water on surface	marshy				
Water	2									

A sign welcoming visitors to the Southwest Experiment Station.

Development of Landforms

The underlying bedrock consists of patchy Cretaceous clays over crystalline rocks of Precambrian Age. Rock outcrops occur most extensively along the Minnesota River Valley. Sioux Quartzite outcrops are common in the southwestern part of the New Ulm sheet and in the vicinity of the city of New Ulm. These areas are generally higher topographically because the rock is extremely resistant to erosion.

The unexposed bedrock is covered by glacial drift which in places is several hundred feet thick. Possibly four glacial advances occurred during the Wisconsin stage. Two of these events were probably more recently than 34,000 years ago. The four deposits are as follows from oldest to youngest:

1) an early phase, which deposited calcareous drift
2) Hawk Creek phase, represented by till derived from the Lake Superior region
3) Granite Falls phase, an extensive glaciation associated with the Wadena Lobe
4) New Ulm phase, the latest advance of the Des Moines Lobe

Still older deposits indicate a complex earlier glacial history. In this report no attempt has been made to identify these deposits other than the pre-Wisconsin. Sediments indicate the origin was from the north and northwest.

Land forms of the New Ulm sheet may be divided into two major regions:

1) Coteau Des Prairie—an area of early to late Wisconsin and pre-Wisconsin drift which includes regions 67, 67A, and 68. The southwestern area underlain by the oldest drift is buried by loess.
2) Late Wisconsin Drift outside the Coteau—an area covered by the Des Moines lobe in its last advance and includes regions 29 through 66A.

1. Coteau Des Prairie Region

A major divide occurs on the Coteau separating drainage between the Mississippi and Missouri rivers. Generally the divide follows the boundary between 67 and 68 in a southeasterly direction to Worthington. The Coteau slopes towards the southeast along the divide and ranges from 1,930 feet above sea level in the northwest to 1,750 feet towards the southeast.

The Luverne Coteau (67A), located in the southwestern corner, consists of firm, loamy glacial till of pre-Wisconsin age

Large areas of uniform high organic matter soils are common in southwestern Minnesota.

and is covered by loess which becomes thicker towards the southwest. The wind-carried silt may have come from outwash deposits of the Big Sioux River.

Firm, loamy till on the Lake Benton-Adrian Coteau (67) probably is largely early Wisconsin. This glacier advanced from the north and northwest. However, the extent of this ice sheet is generally unknown. The till is calcareous and is lower in shale content than the Wisconsin drift north of region 67. Loess covering region 67A also extends over 67, but is thinner and patchy. Regions 67 and 67A have well-developed drainage systems with most of the areas draining down the Rock River and tributaries. Glacial melt water built outwash plains along these streams.

The Ivanhoe-Worthington Coteau (68) upland consists of a straight and steep escarpment on the east where it borders the Minnesota Lowlands. It seems like a structurally controlled plateau, but well borings along the scarp show several hundred feet of glacial drift. However, some kind of bedrock upland possibly occurs below the drift. Surface drift, mainly till, covering the region probably is late Wisconsin. When the Des Moines lobe advanced down the Minnesota Lowlands, lateral movement pushed the west flank of the glacier up over the crest of the Coteau and formed the Bemis Moraine. In retreat, the Altamont moraine, a massive land form resulting from ice stagnation and disintegration formed.

2. *Late Wisconsin Drift*

Before a significant soil profile had developed on the early Wisconsin till, a glacial advance from the Lake Superior area deposited the sandy, reddish-brown Hawk Creek till. It is named for exposures along Hawk Creek occurring a few miles south of Maynard, Minnesota. The unit is not continuous. Twenty feet of this till was encountered at 90 feet below the surface from deep test cores for the Big Stone Power Plant northwest of Big Stone City, South Dakota. In Minnesota, the till is extensively exposed along Watson Sag, near Watson and has been observed at Franklin and near Henderson. Later glacial deposits have almost completely obscured the history of this ice sheet advance and retreat in the sheet area. The Hawk Creek till contains a high percent of crystalline rocks. Some varieties are restricted to bedrock of the Lake Superior region.

Renewed ice activities deposited the calcareous, loamy, relatively shale-free Granite Falls Till, which has been correlated with the surface till in the Wadena area. This extends the range of activity for the Wadena lobe far south and west of the limits set in the past. Carbon-14 datings on wood indicate that the glacial activity may have taken place more recently than 34,000 years ago.

The Wadena lobe retreated and subsequently the Des Moines lobe, coming from the Winnipeg Lowlands, advanced down the Minnesota Lowland and terminated near Des Moines, Iowa about 14,000 years ago. The lobe formed the Bemis Moraine as it terminated, then the Altamont and other moraines as it retreated. Based on dates beneath outwash, the ice had retreated from Iowa by 13,000 years before present (B.P.). By 12,650 years B.P., peat was accumulating in bogs south of Mankato, Minnesota, and the Herman Beach along the shore of Glacial Lake Agassiz had been formed by 11,740 years B.P. This indicates that the leading edge of the active glacier had retreated at least 350 miles northward during little more than 2,000 years.

The Des Moines lobe was a broad valley glacier along its course in Minnesota. Erosion along the thinner margin of the glacier was fairly active; consequently, the shale-rich New Ulm Till was diluted by the underlying shale-poor Granite Falls Till. Along the center of the lobe where the ice was thicker, very little mixing occurred. Consequently, the till is richer in shale along the center than along the margin. The shale probably came from the Upper Cretaceous Pierre formation that covers an extensive area in southern Manitoba, eastern North Dakota and eastern South Dakota. The calcareous loamy New Ulm Till is pale yellow to olive brown where oxidized, and dark gray where unoxidized.

As the Des Moines lobe retreated north of the Continental Divide, water became ponded in the exposed Red River Valley forming Glacial Lake Agassiz. During the earlier stages, while outlets in Canada were blocked by ice, the lake drained southward into Glacial River Warren. The high volume stream cut through several till sheets and finally exposed the Precambrian bedrock to form a deep valley 1 to 3 miles wide and in places 150 feet deep. Outcrops of crystalline rocks continue along the valley as far as the big bend at Mankato where the Minnesota Lowlands join the Minneapolis Lowlands. There the bedrock changes to a Cambrian soft sandstone, which accounts indirectly for the sharp angle bend. About 11,000 years B.P. the glacier had retreated far enough north to establish an eastern outlet for Lake Agassiz, bringing an end to River Warren. It also completed the formation of the Minnesota Valley Outwash (32). The Minnesota River which presently flows down the vast valley is a gross misfit of the former river. The Minnesota Valley Outwash (32) originally formed by deposits of sand and gravel along the main streams carrying large volumes of water from the melting glacier. Geomorphic area 32 along the Minnesota River Valley is made up of the modern flood plain, rock outcrops, gravel and boulder areas, braided stream deposits at slightly higher elevations, and several layers of till along the valley border.

The Mississippi Valley Outwash (29) represents glacial melt water deposits along the South Fork, Crow River. This is a minor region located in the northeastern corner of the sheet area. Most of the unit occurs in the St. Paul and St. Cloud sheets.

The topography in the till plains and moraines associated with the Des Moines lobe is one of ice stagnation and disintegration. The Waconia-Waseca Moraine (34) surface form is definitely related to ice decay. However, the Emmons-Faribault Moraine (35B) seems to have formed by more active ice movement. Only a small part of this moraine extends into this sheet from the St. Paul sheet. The ground moraines (42, 43, 44, 64, 64A, 66, 66A) also have land forms related to ice decay. These regions are characterized by flat-topped hills, many of which have slightly depressed centers. During the period of ice stagnation and decay, temporary ponding in many places resulted in the accumulation of clay sediments and some strand features, which may be the source of clayey textures dominating regions 42, 64A, and 66A. A few clayey areas occur in the northwestern part of region 66. However, the clay in those areas may have been brought in by the glacier from the bed of Lake Agassiz.

The Minnesota Lake Plain (46) may have been formed in an ice blocked low relief ground plain. Lacustrine sediments high in clay may have been deposited in and around decaying masses of ice, because it has the appearance of a clay-mantled low relief ground moraine.

The Benson Lacustrine Plain (50) appears to have received silty materials brought down from the Pomme de Terre and Chippewa Valleys. Blockage by stagnant ice probably formed the glacial lake.

Agriculture

Compared to the other 10 Soil Atlas sheets, the New Ulm sheet area has resources uniquely suited for crop production. Soils are usually loamy in texture, have thick friable surface horizons high in organic matter, and the topography is level to gently rolling. Soybeans and corn are particularly important crops in the New Ulm sheet.

According to statistics compiled by the Minnesota Crop and Livestock Reporting Service, the counties in this area had a soybean acreage of 2,863,000 acres or about 54 percent of the total state crop. The state's corn acreage is not quite as concentrated in the New Ulm sheet, but 2,732,000 acres were grown in the area, about 40 percent of total state corn acreage (1979 corn and soybean statistics).

Types of farming are relatively uniform over the area as the main crops of soybeans, corn, small grains, and forages can be grown successfully in all parts of the area. Livestock enterprises are an integral part of many farm operations but are somewhat more important in the northeast and southwest parts of the sheet. Geomorphic areas 34 and 67 have undulating to rolling topography which is suitable for forages and pasture.

A number of general agricultural interpretations can be made from the map and explanatory tables regarding waterholding capacity, plant nutrient availability, and soil texture. However farm managers are encouraged to use county soil survey reports for specific information on individual farms.

Climate[1]

Climate in southwestern Minnesota is a continental type. It is greatly influenced by polar and arctic air from the north and the gulf air from the south.

The major topography influences to the climate are the upper Minnesota River Valley and Buffalo Ridge, Coteau Des Prairies, which is parallel, about 1,000 feet higher and to the southwest of the valley.

Both the maximum and minimum temperature are 2 to 4 degrees Fahrenheit warmer in the Minnesota River Valley than on the Buffalo ridge. This is a result of adiabatic warming caused by descending air off the ridge into the valley.

The annual precipitation through the area varies from 24 inches in Pipestone and Lincoln counties to more than 30 inches in parts of Martin and Faribault counties. The wettest month is June with 4 inches along the Minnesota River Valley to more than 5 inches along the Iowa border. January is the driest month with less than 0.8 inches for the entire area.

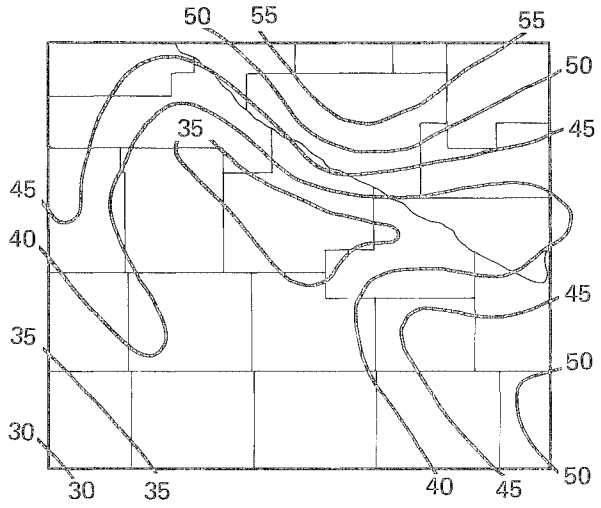


Figure 1. Average number of days per year when snow cover is more than 6 inches, New Ulm Sheet.

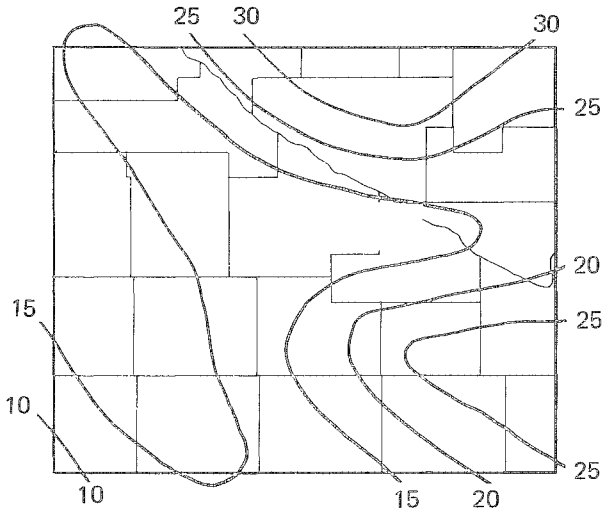


Figure 2. Average number of days per year when snow cover is more than 12 inches, New Ulm Sheet.

[1]Prepared by E. L. Kuehnast, state climatologist

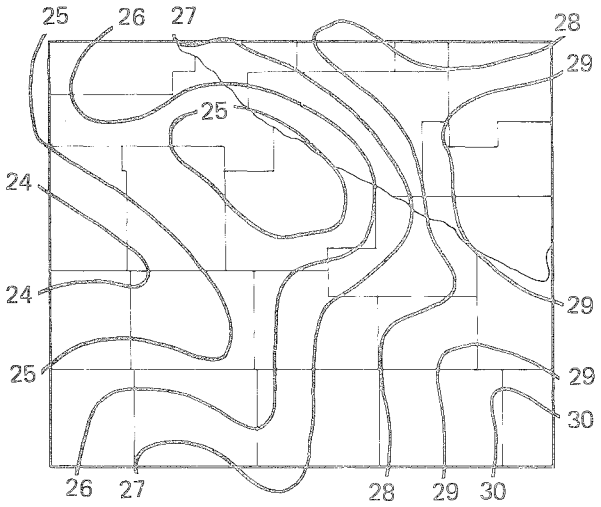


Figure 3. Annual normal precipitation in inches, 1941-1970, New Ulm Sheet.

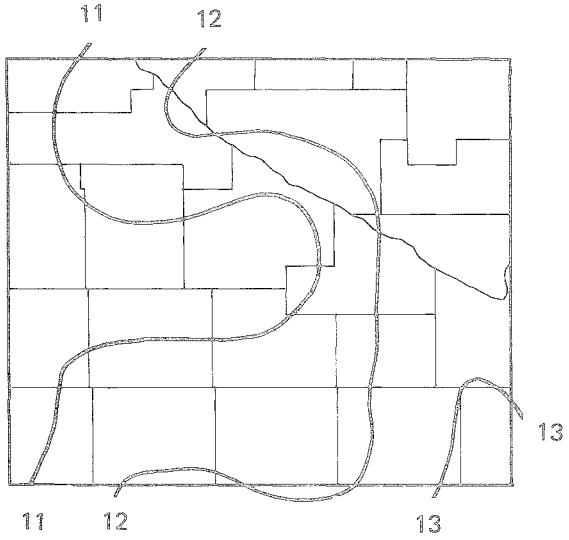


Figure 4. Summer (June, July, August) normal precipitation in inches, 1941-1970, New Ulm Sheet.

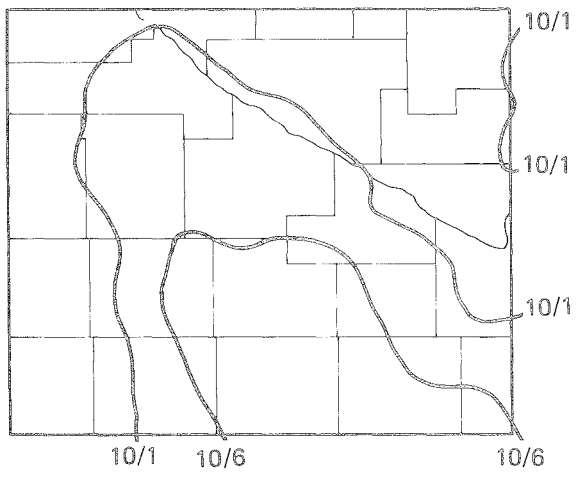


Figure 5. Average date of first occurrence of 32°F. or lower in the fall, New Ulm Sheet. (Adapted from Minn. Tech. Bull. 243, 1963)

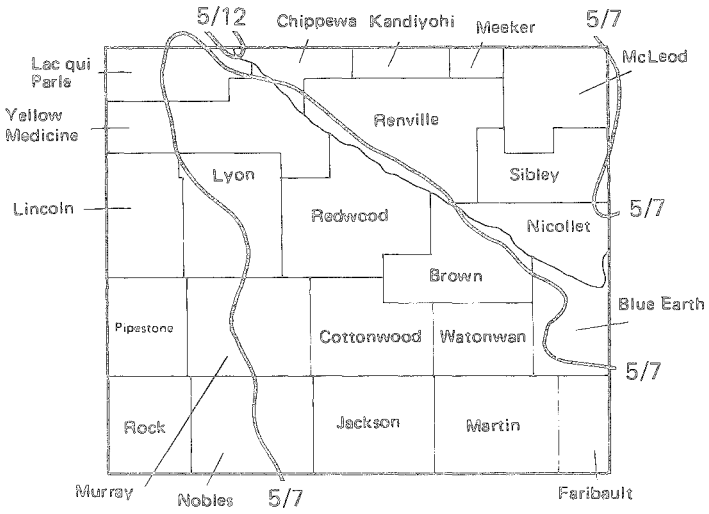


Figure 6. Average date of last occurrence of 32°F. or lower in the spring, New Ulm Sheet. (Adapted from Minn. Tech. Bull 243, 1963)

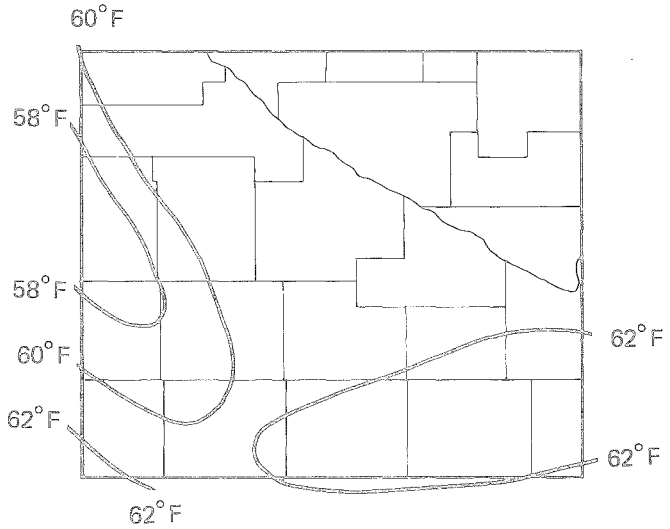


Figure 7. Average daily minimum temperature during July, 1951-1970, New Ulm Sheet. (Adapted from Climatography of the United States. No. 60-21. U.S. Dept. of Commerce, 1972)

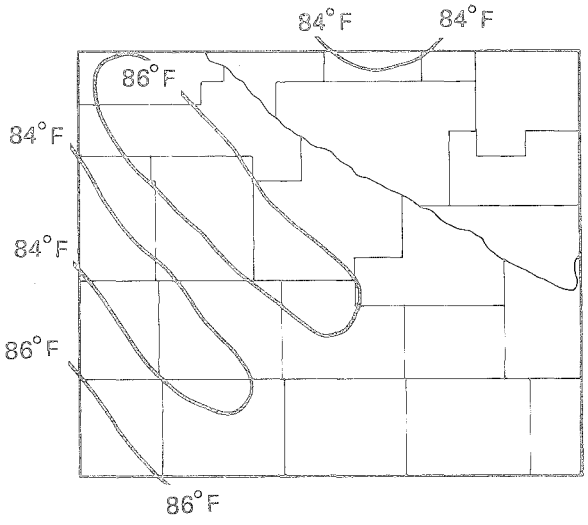


Figure 8. Average daily maximum temperature during July, 1951-1970. New Ulm Sheet. (Adapted from Climatography of the United States. No. 60-21. U.S. Dept. of Commerce, 1972)

Information for the Engineer

Because of the general nature of soil landscape units, which include several major and minor soil series, it is impossible to give specific engineering data such as engineering classification, particle size, liquid limit, plasticity index, percolation rates, shrink-swell potential, and corrosivity. These can be obtained from onsite investigations. Table 18 gives an approximate range in the AASHO and Unified classification of materials in the respective landscape units.

Engineers may find this map useful for locating sources of sand and gravel. Large peat areas which may cause difficulties in road location can be observed. Landscape units with clay will likely have high shrink-swell potential.

Prime sources of gravel will be found in the Mississippi Valley Outwash and Minnesota Valley Outwash. Within the Waconia-Waseca Moraine, Blue Earth Till Plain, Lake Benton-Adrian Coteau, Luverne Coteau, and Ivanhoe-Worthington Coteau, pockets of sand and gravel are common and many are indicated by sand and gravel symbols on the map. Landscape units SSWD, SLWD, and SLPD are also prime sources of sand and gravel.

Bedrock is generally shallow on the RLWD and RLPD soil landscape units. Some shallow to bedrock areas are shown by rock outcrop symbols. Bedrock consists of limestones, sandstones, and quartzite.

Table 18. Approximate engineering classification of materials at the surface and at 5 feet in the soil landscape units

Soil landscape unit	AASHO[1]		Unified[2]	
	Surface	5 feet+	Surface	5 feet+
SSWD	A-2,A-2-4	A-1,A-2,A-3,A-2-4	SP,SP-SM,SM	SP,SP-SM,SM,GP
SLWD	A-2,A-4,A-6	A-1,A-2,A-3,A-2-4	SM,SM-SC,ML-CL,ML	SP,SP-SM,SM,GP
SLPD	A-2,A-4,A-6	A-1,A-2,A-3,A-2-4	SM,SM-SC,ML,ML-CL	SP,SP-SM,SM,GP
LLWD	A-4,A-6,A-7	A-4,A-6,A-7	ML,ML-CL,CL[3]	CL,ML-CL
LLPD	A-4,A-6,A-7	A-4,A-6,A-7	ML-CL,CL[3]	CL,ML-CL,MH-CH
LCWD	A-6,A-7	A-4,A-6,A-7	ML,ML-CL,CL,MH-CH[3]	CL,ML-CL,MH-CH
LCPD	A-6,A-7	A-4,A-6,A-7	ML,ML-CL,CL,MH-CH[3]	CL,ML-CL,MH-CH
CLWD	A-4,A-6,A-7	A-6,A-7	ML,CL,MH-CH	CH,CL,MH
CCPD	A-6,A-7	A-6,A-7 A-4,A-6	CH,CL,MH	CH,CL,MH ML-CL
XLWD	A-4,A-6,A-7	A-1,A-2,A-3,A-2-4	SM,SC,ML,CL	SP,SP-SM,GP,CL
XLWD	A-4,A-6,A-7	A-4,A-6,A-7	ML,ML-CL,CL	CL,ML-CL,CH,MH
RLWD	A-2-4,A-4,A-6	Bedrock	SM,SM-SC,ML,ML-CL	Bedrock
RLPD	A-2-4,A-4,A-6	Bedrock	SM,SM-SC,ML,ML-CL	Bedrock
A	Variable	Variable	Variable	Variable
P	A-8	A-8	P+	P+
LP	A-8	A-4,A-6,A-7	P	CL,ML-CL,MH-CH
NP	A-8	A-8	P+	P+
M				

[1]American Association of State Highway Officials, Standard Specification for Highway Materials and Methods of Sampling and Testing, 1961.
[2]Waterways Experiment Station. U.S. Army Corps of Engineers. The Unified Soil Classification System, Tech. Memo. 3-357, Vol. 2, 1953.
[3]The surface 1 to 2 feet of these soil landscape units has considerable organic matter. The unified classification is OL or OH. This material should be removed and stockpiled for use as topsoil on cuts and embankments.

Short Descriptions of Soil Series[2]

Aastad—Very dark-colored, moderately well drained, near neutral, clay loam about 19 inches thick over clay loam about 13 inches thick. The underlying material is calcareous, clay loam glacial till. (Pachic Udic Haploboroll)

Alluvial land—Consists of recent alluvium of variable textures and of variable drainage on flood plains. (Unclassified)

Arvilla—Dark-colored, somewhat excessively drained, sandy loam to loam surface and subsoil. The substrata below 14 to 25 inches consists of calcareous, coarse, sand and gravel. (Udic Haploboroll)

Barnes—Dark-colored, well drained loam 12 to 23 inches thick over calcareous loam till. (Udic Haploboroll)

Bearden—Dark-colored, somewhat poorly drained, slightly alkaline, silty clay loam or silt loam 7 to 16 inches thick over moderately alkaline, silty clay loam or silt loam. (Aeric Calciaquoll)

Biscay—Dark-colored, poorly drained loam 28 to 36 inches thick over mildly alkaline, coarse sand. (Typic Haplaquoll)

Brookings—Dark-colored, well and moderately well drained, neutral, silty clay loam about 13 inches thick over dark brown and grayish brown, neutral, silty clay loam 10 inches thick. The underlying material is silt loam to a depth of 36 inches and calcareous loam below. (Pachic Udic Haploboroll)

Buse—Dark-colored, well drained, neutral to moderately alkaline, loam about 7 inches thick over light brownish-gray and light yellowish-brown, calcareous glacial till. (Udorthentic Haploboroll)

Cathro—Black, very poorly drained, near neutral, highly decomposed organic layers derived primarily from herbaceous plants 16 to 50 inches thick underlain by sandy loam mineral material. (Terric Borosaprist)

Clarion—Dark-colored, well drained, loam 30 to 40 inches thick over calcareous loam till. (Typic Hapludoll)

Collinwood—Black and very gray, moderately well drained, medium to slightly acid, silty clay loam about 15 inches thick over dark grayish brown, medium acid to neutral, silty clay about 18 inches thick. The underlying material is alkaline, silty clay. These soils were formed in clayey sediments on glacial lake plains. (Aquic Hapludoll)

Colo—Dark-colored, poorly drained, silty clay loam alluvium. (Cumulic Haplaquoll)

Colvin—Dark-colored, poorly drained, mildly alkaline, silty clay loam 7 to 16 inches thick over moderately alkaline silty clay loam. (Typic Calciaquoll)

Comfrey—Dark-colored, poorly drained, silty clay loam alluvium. (Cumulic Haplaquoll)

Copaston—Dark-colored, well drained, sandy loam or loam overlying sandstone or occasionally limestone at about 20 to 30 inches. (Lithic Hapludoll)

Cordova—Dark-colored, poorly to somewhat poorly drained, silty clay loam over clay loam till. (Typic Argiaquoll)

Crofton—Grayish-brown, well drained, mildly alkaline, silt loam about 6 inches thick over pale-brown, mildly to moderately alkaline, calcareous, silt loam. (Typic Ustorthent)

Dakota—Dark-colored, well drained, loam or sandy loam over loam to about 35 to 43 inches over sand containing a few pebbles. (Typic Argiudoll)

Dickinson—Dark-colored, well to somewhat excessively drained, fine sandy loam 24 to 36 inches thick over slightly acid, loamy sand and sand. (Typic Hapludoll)

Dickman—Dark-colored, well drained, medium to slightly acid, sandy loam about 11 inches thick over brown sand about 25 inches thick, underlain by fine to coarse sand. (Typic Hapludoll)

Dorchester—Dark-colored, moderately well drained, calcareous silt loam over stratified silt loam, loam, very fine sandy loam, and fine sandy loam. (Typic Udifluvent)

Dovray—Dark-colored, poorly and very poorly drained, clay or silty clay 20 to 50 inches thick underlain by calcareous, clay or silty clay. (Cumulic Haplaquoll)

Estelline—Dark-colored, well and moderately well drained, silt loam 24 to 36 inches thick over calcareous, fine sand. (Pachic Udic Haploboroll)

Estherville—Dark-colored, well drained, slightly acid sandy loam with sandy clay loam subsoil over limy, coarse sand and gravel below 14 to 24 inches. (Typic Hapludoll)

Everly—Black, well and moderately well drained, medium acid to neutral, clay loam about 12 inches thick over dark colored, slightly acid to neutral, clay loam about 14 inches thick. The underlying material is calcareous glacial till. (Typic Hapludoll)

Fairhaven—Dark-colored, well drained, slightly acid, silt loam underlain at 22 to 40 inches by limy, coarse sand and gravel. (Typic Hapludoll)

Faxon—Dark-colored, poorly to very poorly drained, silt loam about 8 inches thick overlain by a few inches of peaty organic matter, underlain by about 12 inches of silt loam to sandy clay loam over sandy limestone bedrock. (Typic Haplaquoll)

Flom—Dark-colored, poorly and somewhat poorly drained, silty clay loam or clay loam 20 to 30 inches thick over calcareous, clay loam till. (Typic Haplaquoll)

Forada—Dark-colored, poorly and very poorly drained, loam to sandy loam 22 to 40 inches over calcareous coarse sand. (Typic Haplaquoll)

Fordsville—Dark-colored, well drained loam 24 to 30 inches thick over limy, sand and gravel. (Pachic Udic Haploboroll)

Forman—Dark-colored, well drained, clay loam 11 to 26 inches thick over calcareous, clay loam till. (Udic Argiboroll)

Fulda—Dark-colored, poorly drained, silty clay loam about 13 inches thick over silty clay which is calcareous below 20 to 30 inches. (Typic Haplaquoll)

Galva—Dark brown, well drained, medium acid to neutral, silty clay loam about 11 inches thick over brown silty clay loam and silt loam about 34 inches thick, underlain by calcareous silt loam. (Typic Haplaquoll)

[2]Following each description in parentheses is the classification of the series at the subgroup level of Soil Taxonomy (see soils references at the end of this publication).

Glencoe—Dark-colored, very poorly drained, clay loam 24 to 35 inches thick over loam to clay loam calcareous till. (Cumulic Haplaquoll)

Guckeen—Dark-colored, moderately well drained, medium acid, silty clay loam about 12 inches thick over medium acid, silty clay to clay over calcareous, clay loam. (Aquic Hapludoll)

Hidewood—Black, somewhat poorly drained, near neutral, silty clay loam about 17 inches thick over about 20 inches of grayish brown silty clay loam. The underlying material is calcareous, clay loam glacial till. (Typic Haploquoll)

Hubbard—Dark-colored, somewhat excessively drained, slightly to medium acid, loamy coarse sand about 14 inches thick over slightly acid, coarse sand. (Udorthentic Haploboroll)

Huntsville—Dark-colored, well to moderately well drained, mildly alkaline, silt loam about 54 inches thick over mildly alkaline, loam alluvium. (Cumulic Hapludoll)

Ihlen—Very dark brown, well drained, slightly acid to neutral, silty clay loam about 8 inches thick over silty clay loam and silt loam about 22 inches thick. The underlying material is quartzite bedrock. (Udic Hapludoll)

Kasota—Moderately dark-colored, well drained loam about 9 inches thick over slightly to medium acid, clay loam to clay subsoil, grading to calcareous sand at about 30 inches. (Typic Argiudoll)

Kato—Dark-colored, poorly drained, slightly acid, silty clay loam to silt loam over slightly acid, silt loam subsoil grading to sand and coarse sand at about 35 inches. (Typic Haplaquoll)

Kingston—Dark-colored, moderately well drained silt loam about 16 inches thick over silt loam to light silty clay loam about 10 inches thick over silt loam to fine sandy loam about 19 inches thick over calcareous, silt loam to very fine sandy loam. (Aquic Hapludoll)

Kranzburg—Very dark brown, well drained, slightly acid to neutral, silty clay loam about 9 inches thick over brown, silty clay loam about 16 inches thick. The underlying material is clay loam. (Udic Haploboroll)

Lakeville—Dark-colored, excessively drained, fine sandy loam 5 to 10 inches thick over slightly acid loam 6 to 12 inches thick over calcareous, sand, gravel, and stones. (Typic Hapludoll)

Lamoure—Dark-colored, poorly drained, moderately alkaline, silty clay loam about 43 inches thick over a buried, dark-colored loam over mildly alkaline, sandy loam alluvium. (Cumulic Haplaquoll)

La Prairie—Dark-colored, moderately well drained, mildly to moderately alkaline, silt loam about 30 inches thick over moderately alkaline, silt loam. Below 40 inches, strata of sand and clay may occur. (Cumulic Haplaquoll)

Lester—Moderately dark-colored, well drained, medium acid, clay loam about 13 inches thick over medium to slightly acid, clay loam subsoil over strongly calcareous, loam till. (Mollic Hapludalf)

LeSueur—Dark-colored, moderately well to somewhat poorly drained, clay loam about 19 inches thick over medium acid, clay loam subsoil about 20 inches thick over calcareous loam till. (Aquic Argiudoll)

Letri—Dark-colored, poorly drained, near neutral, loamy sediments less than 30 inches thick over calcareous glacial till. (Typic Haplaquoll)

Lura—Dark-colored, poorly drained, slightly acid, silty clay about 35 inches thick over neutral, silty clay about 10 inches thick over neutral to calcareous, clay loam till. (Cumulic Haplaquoll)

Madelia—Black, poorly drained, near neutral, silty clay loam about 8 inches thick over olive-colored, calcareous, silty clay loam and silt loam. (Typic Haplaquoll)

Marna—Dark-colored, poorly drained, slightly acid, silty clay about 20 inches thick over slightly acid to neutral, clay subsoil about 20 inches thick over calcareous, clay loam till. (Typic Haplaquoll)

Marshan—Dark-colored, poorly to very poorly drained, loam to clay loam about 14 inches thick over slightly acid, clay loam to loam or sandy loam subsoil about 18 inches thick over gravelly sand. (Typic Haplaquoll)

McIntosh—Dark-colored, moderately well or somewhat poorly drained, moderately alkaline, silt loam 24 to 40 inches thick over calcareous loam till. (Aeric Calciaquoll)

Millerville—Dark-brown, very poorly drained, slightly acid to neutral, moderately decomposed organic soil derived mostly from herbaceous plants 16 to 51 inches thick over calcareous loamy material with about 10 percent snail shells. (Limnic Borohemist)

Millington—Dark-colored, poorly drained, alkaline loam about 15 inches thick over dark gray loam 20 inches thick. The underlying material is alkaline, stratified silty clay loam, sandy clay loam, and silt loam. (Cumulic Haplaquoll)

Moody—Dark brown, well drained, medium acid to neutral, silty clay loam 5 inches thick over silty clay loam silt loam about 22 inches thick underlain by calcareous, silt loam. (Udic Haplustoll)

Nicollet—Dark-colored, moderately well to somewhat poorly drained, slightly to medium acid, clay loam over strongly calcareous loam till. (Aquic Hapludoll)

Normania—Black, moderately well drained, near neutral loam about 17 inches thick over grayish and olive brown loam about 19 inches thick. The underlying material is calcareous loam glacial till. (Aquic Haplustoll)

Okoboji—Black, very poorly drained, neutral to moderately alkaline, silty clay loam about 32 inches thick over gray and olive-colored silty clay loam about 24 inches thick. The underlying material is gray-colored, silty clay loam. (Cumulic Haplaquoll)

Parnell—Dark-colored, very poorly drained, slightly acid to neutral, silty clay loam about 55 inches thick over calcareous, silty clay loam till. (Typic Argiaquoll)

Quam—Dark-colored, very poorly drained, neutral, silty clay loam about 38 inches thick over calcareous, clay loam till. (Cumulic Haplaquoll).

Rock Outcrop—Areas where bedrock is exposed at the surface.

Rockton—Dark-colored, well drained, slightly to medium acid loam about 20 inches thick over medium acid loam to clay loam about 10 inches thick over limestone bedrock. (Typic Argiudoll)

Rushmore—Dark-colored, poorly drained, neutral, silty clay loam about 28 inches thick over calcareous clay loam glacial till. (Typic Haplaquoll)

Sac—Dark-colored, well drained, medium acid to neutral, silty clay loam about 11 inches thick over silty clay loam and clay loam about 33 inches thick. The underlying material is clay loam glacial till. (Typic Hapludoll)

Seeleyville—Very dark brown, very poorly drained, neutral or slightly acid, highly decomposed organic soil materials that are more than 51 inches thick and deprived primarily from herbaceous plants. (Euic Typic Borosaprist)

Sparta—Dark-colored, excessively drained, neutral, loamy sand about 12 inches thick over medium to strongly acid, loamy sand to sand about 24 inches thick over medium acid sand. (Entic Hapludoll)

Spillville—Very dark-colored, moderately well or somewhat poorly drained, medium acid to neutral loam about 54 inches thick over loamy alluvium. (Cumulic Hapludoll)

Storden—Dark-colored, well drained, slightly calcareous loam about 7 inches thick over calcareous loam till. (Typic Udorthent)

Svea—Dark-colored, moderately well drained loam 20 to 30 inches thick over calcareous loam till. (Pachic Udic Haploboroll)

Sverdrup—Dark-colored, somewhat excessively drained, sandy loam about 16 inches thick over calcareous, medium sand. (Udic Haploboroll)

Talcot—Dark-colored, very poorly drained, slightly calcareous, clay loam about 30 inches thick over calcareous, gravelly sand. (Typic Haplaquoll)

Trosky—Very dark-colored, poorly drained, mildly to moderately alkaline, silty clay loam about 20 inches thick over olive-colored silty clay loam 18 inches thick. The underlying material is loamy coarse sand. (Typic Haplaquoll)

Truman—Dark-colored, well drained, neutral to slightly acid, silt loam about 30 inches thick over mildly alkaline silt loam about 8 inches thick over calcareous silt loam. (Typic Hapludoll)

Vallers—Dark-colored, poorly drained, calcareous, silty clay loam about 12 inches thick over strongly calcareous clay loam over calcareous loam till. (Typic Calciaquoll)

Ves—Very dark-colored, well drained, slightly acid to mildly alkaline, loam about 11 inches thick over brownish-colored loam about 25 inches thick. The underlying material is olive brown, calcareous, loam glacial till. (Udic Haplustoll)

Vienna—Dark-colored, well drained, slightly acid to neutral, silty clay about 9 inches thick over silty clay loam and clay loam about 20 inches thick. The underlying material is calcareous loam glacial till. (Udic Haploboroll)

Wadena—Dark-colored, well drained, slightly acid loam 24 to 40 inches thick over calcareous, coarse sand and fine gravel. (Typic Hapludoll)

Waldorf—Black, poorly drained, slightly acid to neutral, silty clay loam about 20 inches thick over silty clay loam and silty clay about 25 inches thick. The underlying material is silty clay loam. (Typic Haplaquoll)

Waukegan—Dark-colored, well drained, neutral to slightly acid, silt loam about 18 inches thick over neutral, coarse sand and fine gravel about 9 inches thick over calcareous, coarse, sand and gravel. (Typic Hapludoll)

Webster—Dark-colored, poorly drained, clay loam 24 to 36 inches thick over calcareous loam till. (Typic Haplaquoll)

Wilmonton—Black, moderately well and somewhat poorly drained, slightly acid to neutral, clay loam about 17 inches thick over light olive-brown clay loam about 8 inches thick. The underlying material is calcareous loam glacial till. (Aquic Hapludoll)

Glossary

Alluvium (alluvial deposits)—Soil material, such as sand, silt, or clay deposited on land by streams.

Braided streams—In relatively straight streams the low value of turbulence under the thread of maximum velocity tends to accumulate material there. Turbulence is greater on both sides of the center.

Calcareous—Material having a high percentage of lime carbonate.

Drift (glacial drift)—Any deposit in a glaciated area originating as a result of glaciation.

Esker—A ridge of sand and gravel deposited by a sub-glacial stream flowing in an ice tunnel.

Fragipan—A subsoil layer, somewhat compacted or cemented, which restricts downward movement of water.

Ground moraine—Glacial debris consisting chiefly of unsorted material that occurs in wide areas and has a gently irregular surface. The debris is deposited underneath and at the margin of a glacier during the active recession of the ice sheet.

Lacustrine—Deposits formed on the bottom of lakes.

Limy—See calcareous.

Loess—A geological deposit of relatively uniform, silty material transported to its present position by wind.

Meltwater—The water that flows on, in, or out of a glacier.

Moraine—Unconsolidated rock and mineral debris deposited by glacial ice. It commonly consists of a heterogeneous mass of unsorted material, in contrast to sorted material deposited by glacial meltwater. See also ground moraine and terminal moraine.

Natural drainage—The conditions that existed during the development of the soil, as opposed to altered drainage which is commonly the result of artificial drainage or irrigation, but may be caused by the sudden deepening of channels or the blocking of drainage outlets.

Six classes of natural drainage are recognized in this report.

Excessively drained soils are commonly very porous and rapidly permeable (sandy and gravelly) and have a low moisture-storage capacity.

Well-drained soils are nearly free from mottling and are commonly of intermediate texture.

Moderately well-drained soils commonly have a moderately and slowly permeable layer in or immediately beneath the rooting zone. They have uniform color in the upper rooting zone and are mottled below 16 to 20 inches.

Somewhat poorly drained soils are wet for significant periods, and are commonly mottled below a depth of 6 to 16 inches.

Poorly drained soils are wet for longer periods. They are dark gray or black and are generally mottled within a depth of 18 inches. In some soils, mottling may be absent or nearly absent.

Very poorly drained soils are wet nearly all the time. They have a dark-gray or black surface layer and are gray or light gray, with or without mottling, in the rooting zone below the surface soil.

Outwash plain—A plain formed by deposition of sorted and stratified material by glacial meltwaters.

Peat—A dark brown or black residuum produced by the partial decay of plants growing in wet places.

Permeability—The ability of the soil to transmit air or water.

Reaction—The degree of acidity or alkalinity of soil expressed in pH values or in words as follows:

	pH
Extremely acid	below 4.5
Very strongly acid	4.5-5.0
Strongly acid	5.1-5.5
Medium acid	5.6-6.0
Slightly acid	6.1-6.5
Neutral	6.6-7.3
Mildly alkaline	7.4-7.8
Moderately alkaline	7.9-8.4
Strongly alkaline	8.5-9.0
Very strongly alkaline	9.1 and higher

Relief—In geology, the difference in height from the lowest parts to the highest parts of an area.

Stagnant ice—When the supply of snow fails, the ice sheet eventually becomes too thin to flow, resulting in stagnation.

Strands—Include all forms that can be used as indicators of the boundary between land and water.

Subsoil—Roughly, the part of the soil profile between the subsurface and the substratum.

Substratum—A layer beneath the subsoil consisting of material, frequently of dissimilar materials, from which soils were formed.

Subsurface—Soil layer immediately below the surface soil or plow layer ranging from 6 to 12 inches.

Surface soil—Ordinarily the plow layer or the surface 5 to 12 inches.

Terminal moraine—Glacial debris heaped in the form of a belt or zone of hills and basins at the terminus or margin of a glacier. It marks the maximum extent of the ice during a major advance.

Terrace (geological)—An old sandy and gravelly alluvial plain, ordinarily level or nearly level bordering a river. Seldom subject to overflow.

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 as related to the three classes used in this report, follow:

S—sandy and loamy sand (also includes gravel).

L—sandy loam, loam, silt loam, silt, sandy clay loam, and clay loam.

C—silty clay loam, sandy clay, silty clay, and clay.

Till—Unstratified and unsorted glacial drift deposited directly by a glacier.

Till plain—See ground moraine.

Selected References[3]

Soils

Soil survey reports have been published, date of issue in parentheses, for the following counties: Blue Earth (1978), Cottonwood (1979), Lincoln (1970), Lyon (1978), Nobles (1975), and Pipestone (1976).

If still in print, copies are available from the local county agricultural agent or from Soil Science Department, Minnesota Agricultural Experiment Station, 220 Coffey Hall, 1420 Eckles Ave., University of Minnesota, St. Paul, Minn. 55108.

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6. Prairie native vegetation results in this type of soil profile. 7. There are relatively few restrictions to intensive cropland use of soils in the New Ulm Sheet. 8. Almost one half of the Olivia Till Plain and 36 percent of the Blue Earth Till Plain require drainage for crop production. 9. Outcrop of Sioux quartzite in Pipestone County. 10. Residue from the previous crop can reduce erosion substantially in row crops.