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Minnesota Rating Guide for Potential Leaching and Surface Runoff of Pesticides

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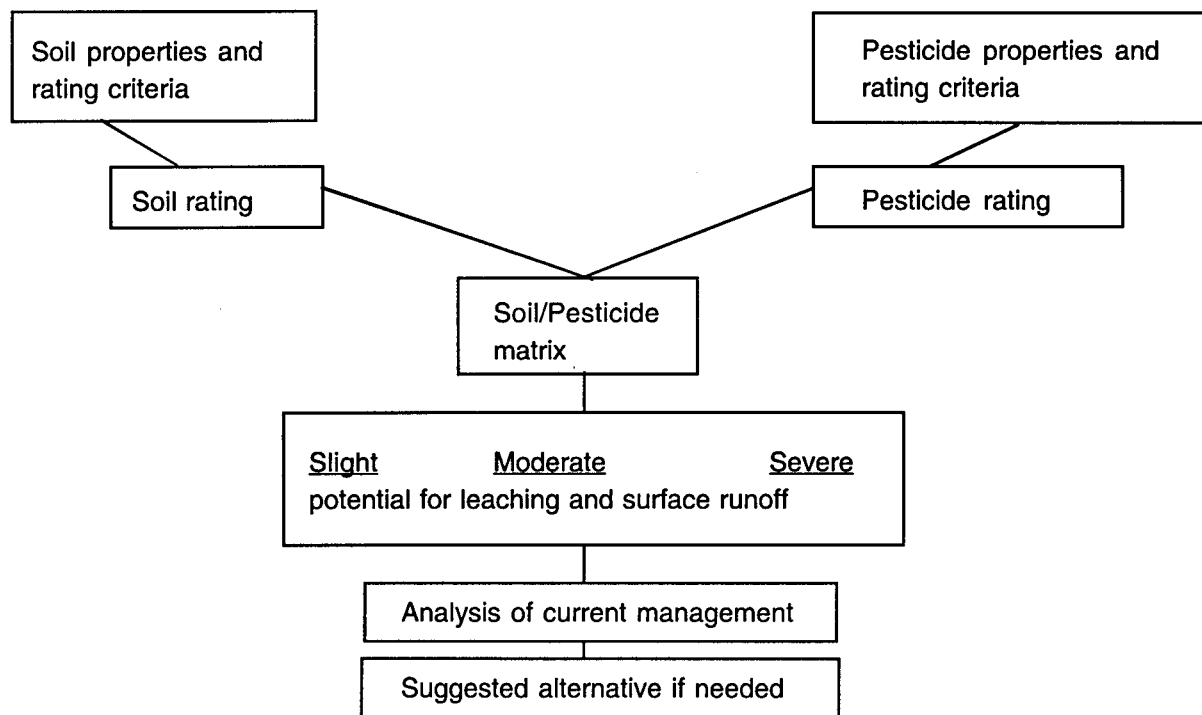
1. Introduction

The United States Department of Agriculture, Soil Conservation Service (USDA-SCS), in collaboration with the Agricultural Research Service (USDA-ARS), developed a screening method to evaluate the relative potential loss of pesticides from soils by leaching and by runoff. In this approach, pesticides are assumed to be lost if they are leached below the root zone or transported outside the field boundary in solution or adsorbed on sediment suspended in runoff waters. Pesticides that are rated for leaching or runoff loss potential are those applied to control pests such as

weeds, insects, fungus, mites, algae, rodents, and other undesirable agents. The relative potential for pesticide loss is given for each recognized soil map unit. A soil map unit is a group of soils that are similar in all major characteristics, use and management.

The pesticide potential loss rating combines soil and pesticide properties and ratings. **Figure 1** outlines the procedure used to determine the potential loss by leaching and surface runoff.

Figure 1. Schematic procedure for rating the potential loss of pesticides by leaching and surface runoff.



Climatic, pesticide rate and soil management factors are not taken into consideration. The primary objective of the rating is to express the capacity of soils to retain pesticides independently of climatic conditions and management practices. Factors such as rainfall intensity can alter soil leaching and runoff; soil moisture and temperature can modify the rate of degradation of chemical; and method and rate of pesticide application can vary the pesticide leaching and/or runoff loss.

The pesticide potential loss is determined using a matrix combining soil and pesticide ratings. Two matrices have been developed. The pesticide potential loss due to leaching matrix combines pesticide leaching ratings and soil leaching ratings (Table 4). The pesticide potential loss to surface runoff matrix combines pesticide runoff ratings and soil runoff ratings (Table 5). The use of the matrices is ex-

plained in section 5.1. The ratings should not be considered absolutes, but only approximations. They provide relative risk estimates for pesticide loss below the root zone or beyond the field boundary. A geologic leaching assessment may be needed to evaluate the potential leaching into groundwater. **The ratings should not be used to make pesticide use recommendations by themselves but rather to serve as a guide for better management decisions.**

The Minnesota soil leaching and runoff ratings are based on the national guidelines as developed by Don Goss, SCS National Technical Center, Fort Worth, Texas. However, the ratings procedures have been modified to better reflect Minnesota conditions.

2. Minnesota soil potential leaching ratings

Soil potential leaching ratings are based on several soil properties and features affecting soil water infiltration, soil permeability, and soil attenuation capacity. These soil characteristics include:

- ✓ soil texture
- ✓ surface layer thickness
- ✓ organic matter content
- ✓ bulk density
- ✓ permeability
- ✓ depth to bedrock
- ✓ depth to water table
- ✓ slope

Soil infiltration rate is interpreted from the soil hydrologic group which considers soil texture, permeability, restrictive layers, depth, and shrink-swell potential. Hydrologic soil groups refer to soils grouped according to their runoff-producing characteristics. For example, group A contains soils having a high infiltration rate when thoroughly wet and having a low runoff potential. They are mainly deep, well drained, and sandy or gravelly soils.

Soil permeability is characterized by: a) the soil structure, particle size distribution, and bulk density; and b) the presence of a restricting layer and its depth.

Table 1. Soil potential leaching rating

SOIL FACTORS			SOIL LEACHING RATING			Restrictive features
S	Hydrologic group	Slope %	Slight	Moderate	Severe	
L	A ⁽²⁾	0-12	>65	30-65	<30	Low Adsorption
		>12	>30	<30	—	
L	B ⁽²⁾	<6	>45	5-45	<5	
		6-18	>5	<5	—	
R ⁽¹⁾	C/D	>18	ALL	—	—	
		N/A	ALL	—	—	
Depth to bedrock with permeability >2.0 in/hr. ⁽³⁾	A/B	N/A	>60	—	<60	Poor filter
	C/D	N/A	>40	20-40	<20	Poor filter
Depth to high natural water table (ft.)			>4	2-4	<2	Wetness
Depth to layer with permeability >6.0 in/hr.			>60	24-60	<24	Percs rapidly

⁽¹⁾ SLLR, Soil Leaching Loss Rating = (Surface layer depth) x (Organic matter content).

⁽²⁾ Reduce rating limitations one class for Aridic and Ustic moisture regimes; Pachic and Cumulic subgroups; and soils with a duff layer more than 2 inches thick.

⁽³⁾ Bedrock permeability is related to the type of bedrock and the size, extent, and interconnection of fractures and bedding planes.

Soil attenuation capacity is represented by the soil leaching loss rating (SLLR). The SLLR is the product of organic content of the surface layer and the thickness of the surface layer.

The procedure to determine the Minnesota soil potential leaching rating is based on the following soil properties:

- ✓ Hydrologic group, SLLR, and slope
- ✓ Depth to high natural water table
- ✓ Depth to soil layer with a permeability > 6 in/hr
- ✓ Depth to bedrock and permeability of the bedrock.

The criteria used to rate soils are presented in **Table 1**. Ratings should be based on the **CAMPS** (Computer Assisted Management and Planning System for Field Offices), or State Soil Survey Database (**3SD**). The most limiting factor is used to select the rating. For example, if the hydrologic group, SLLR and slope factors correspond to a

slight rating but the depth to high natural water table rating is severe, then the final rating is severe.

The SLLR rating is modified by the slope factor to adjust for the increased surface runoff and decreased infiltration/leaching due to greater slope gradients. Depth to bedrock can be a significant factor for soil leaching potential below the root zone particularly when the underlying bedrock is fractured. The depth of 20 inches was used since it corresponds to the taxonomic definition of a lithic subgroup. Soil with high natural water tables above a depth of 4 ft. can have an important impact on soil water movement and leaching. For soil with layers that have a permeability greater than 6 in/hr, the leaching hazard is considered severe. This identifies the sandy or gravelly soil layers. Classes represent a relative hazard of contamination to shallow water tables within the soil root zone.

3. Minnesota soil surface runoff potential loss ratings

Soil surface runoff potential loss is the potential for pesticides to be transported by surface runoff beyond the field boundary where the pesticide was applied. Pesticides are transported in surface runoff as either pesticides in solution or adsorbed to sediment suspended in runoff. Surface transported particles have a potential to contaminate surface waters such as lakes, ponds, streams, and rivers.

The soil surface potential loss ratings are based on soil properties and features affecting soil surface water runoff and erosion susceptibility. The soil properties and features considered in the soil surface potential loss ratings are:

- ✓ oil texture
- ✓ organic matter content
- ✓ structure
- ✓ particles size distribution
- ✓ permeability
- ✓ restricting layer
- ✓ depth
- ✓ drainage
- ✓ depth to water table
- ✓ slope
- ✓ shrink-swell

Table 2. Soil surface loss rating calculation

SOIL FACTORS		SOIL SURFACE LOSS RATING			
S	Slope (%)	Slight	Moderate	Severe	Restrictive Features
S	<2	All	—	—	
L	2-6	<1.0	1.0-2.8	>2.8	Excess runoff
R ⁽¹⁾	>6-12	—	<2.8	>2.8	
	>12	—	<0	>0	
Flooding		None or Rare	Occasional	Frequent	Flooding
Ponding ⁽²⁾		Undrained	—	Drained	Artificial drainage

⁽¹⁾ SLLR: Soil surface loss rating. The SLLR is calculated using **Table 3**.

⁽²⁾ Drainage considered in artificial surface drainage, ditching or tile drains with surface inlets, which drains ponded soils and discharges the effluent into surface water bodies or drainage systems.

The Soil Surface Loss Rating (SSLR) is determined from soil hydrologic group and K factor characteristics. The soil hydrologic group has already been described above. The K factor indicates the susceptibility of a soil for sheet and rill erosion by water. Estimates are based primarily on percentage of silt, sand, organic matter content, soil structure, and permeability. The higher the value, the more susceptible the soil is to sheet and rill erosion.

The procedure to determine the Minnesota soil surface potential loss ratings is based on the following soil properties:

- ✓ Hydrologic group, SSLR, and slope
- ✓ Flooding frequency
- ✓ Ponding

The criteria used to rate soils are presented in Table 2. Ratings should be based on the CAMPS database or the

State Soil Survey Database (3SD). The most limiting factor will always be used.

A slope factor is considered because slope gradients can increase the runoff potential for soils in hydrologic group A. Flooding frequency is given special attention because flood water can result in movement either in solution or attached to soil particles. Soils that are naturally ponded (depressional areas with a water table at or above the soil surface) and have been drained by surface ditching or surface inlets are considered as a surface runoff hazard because they have the potential to deliver pesticides in solution and attached to soil particles to a surface water outlet such as a ditch, stream, or body of water. Soils with subsurface drainage lines or without surface inlets are not rated for a hazard of surface runoff.

Table 3 shows how to obtain SSLR ratings.

Table 3. SSLR ratings.

SOIL FACTORS		SOIL SURFACE LOSS RATING (SSLR)
Hydrologic group	K factor	
A	ALL	<0.0
B	≤.17	0-<1.0
	>.17	
C	ALL	1.0-2.8
D	≤.20	>2.8
	>.20	

4. Pesticide leaching and surface runoff potential loss ratings

The pesticide soil leaching and runoff potential loss is determined by a matrix which combines soil and pesticide ratings (Tables 4 and 5).

The soil potential loss ratings were described in the two previous sections. The pesticide ratings for leaching and surface runoff are based on pesticide soil adsorption coefficient (Koc), water solubility, and half-life variables. Ratings were developed by Dr. D.W. Goss, SCS National Technical Center, Fort Worth, Texas, in collaboration with the Agricultural Research Service. Ratings are *relative*

risk estimates for surface and root zone loss. The procedure to estimate pesticide ratings and the rating of the commonly used pesticides in Minnesota can be found in *Pesticides: Surface Runoff, Leaching, and Exposure Concerns*, available from the Minnesota Extension Service (AG-BU-3911, 1989). A table gives the values of the three physical properties used to rank the pesticides by leaching and surface runoff and the ratings for movement by leaching and surface runoff for common pesticides.

5. Determining soil specific leaching and surface runoff potential loss of pesticides

5.1 Pesticide potential loss matrices

Pesticide soil potential losses can be determined by combining pesticide and soil ratings. A pesticide applied to different soil or different pesticides applied to a soil may have a different leaching or surface runoff potential.

Two matrices have been developed. One estimates the pesticide potential loss due to leaching (**Table 4**) and the other, the pesticide potential loss due to surface runoff (**Table 5**).

Table 4. Pesticide potential loss to leaching matrix

Soil leaching potential loss ratings (SLLR)	Pesticide leaching potential loss ratings		
	Large	Medium	Small
Severe	Potential 1	Potential 1	Potential 2
Moderate	Potential 1	Potential 2	Potential 3
Slight	Potential 2	Potential 3	Potential 3

Table 5. Pesticide potential loss to surface runoff matrix

Soil surface potential loss ratings (SSLR)	Pesticide surface potential loss ratings		
	Large	Medium	Small
Severe	Potential 1	Potential 1	Potential 2
Moderate	Potential 1	Potential 2	Potential 3
Slight	Potential 2	Potential 3	Potential 3

The intersection of soil and pesticide ratings gives a pesticide potential loss by leaching or surface runoff for a specific site. **Potential 1** indicates that a specific pesticide on a specific soil has a high probability of being lost to surface runoff or leaching. **Potential 1** pesticides should be further evaluated for their health hazard to humans and animals. If a pesticide is a potential danger to health, an alternate pesticide or other pest management technique should be considered. The land user should check with consultants, chemical manufactures, or Minnesota Extension Service for health advisory information. **Potential 2** is an intermediate area. The specific pesticide applied on a specific soil has a

possibility of being lost. The effect of the pesticide on the water resource will need additional onsite evaluation. Some pesticide when applied directly on foliage will rapidly dissipate and will not be a concern. Other concerns may include nearby sources of both surface and subsurface water, the proximity of the field to these sources, etc. **Potential 3** indicates that a specific pesticide applied on a specific soil has a low probability of being lost to surface runoff or leaching. The pesticide could be used according to label with little potential hazard to the respective water resource.

For example, if atrazine is applied to a Ves loam, 3 to 6 percent slope, eroded, the soil leaching rating is moderate

and the pesticide leaching rating is large. Reading Table 4, the pesticide potential loss by leaching is rated "Potential 1". Atrazine has a high probability of being lost by leaching. Since the atrazine soil surface loss rating is moderate and the pesticide surface rating is medium, the potential pesticide loss by surface runoff is rated "Potential 2" (Table 5). Thus atrazine has a medium probability of being lost by surface runoff. Additional weed management strategies and other labeled pesticides should be explored for use on this site.

5.2 Expert System

The Department of Soil Science, University of Minnesota, in collaboration with SCS, has developed a user friendly expert system capable of computing the pesticide leaching and surface runoff potential loss. Ratings can be computed interactively one soil at a time, or automatically for an entire county. When using the interactive system, the user enters the soil characteristics and features requested by the expert system. With the automatic system, the expert system reads the CAMPS or (3SD) county soil database and displays the county list of soils and ratings. An example of the output tables generated by this system for Anoka county is provided in Table 6.

5.3 Soil Survey Information System (SSIS)

The Soil Survey Information System (SSIS) is a user friendly software running on standard IBM or compatible microcomputers. It provides easy access to the county soil survey reports. At this time, SSIS has been developed for more than 40 Minnesota counties. It provides access to the detailed soil maps, soil description, physical and chemical characteristics of each soil type, and interpretations of soils for various applications. Common applications are farm management, land evaluation, planning and zoning, soil conservation and environmental protection. New soil data interpretations can be easily added to the system.

Pesticide leaching and surface runoff potential loss ratings are added to the ENVIRONMENTAL QUALITY menu of SSIS (Figure 2). The system provides menu options to display on map and tabular basis the pesticide potential losses by leaching and surface runoff and the soil leaching and surface runoff ratings terms of the two matrices. Sub-menus let users select common herbicides, insecticides, and fungicides. Potential losses can be displayed by soil mapping units for a selected map or parcel (Figure 3). Another option is to highlight all mapping units with one or two selected potential loss levels and calculate the corresponding acreage (Figure 4). Potential losses by leaching and surface can be combined using boolean operators. For example, one can indicate, for a given pesticide, soils that have a high potential loss for pesticide leaching and a high potential loss for pesticide surface runoff.

Figure 2. SSIS. Environmental quality menu.

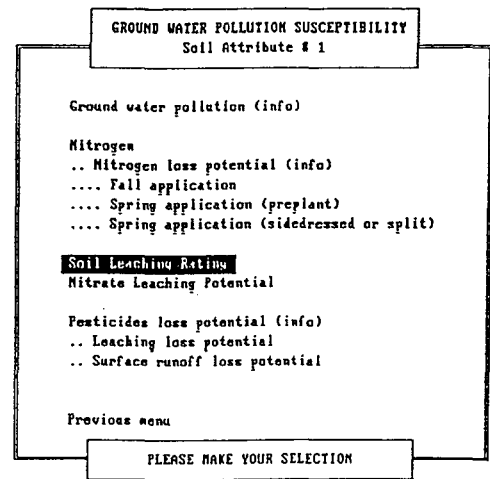


Figure 3. SSIS. Atrazine potential loss for a field in section 22, Sherman Township, Redwood County.

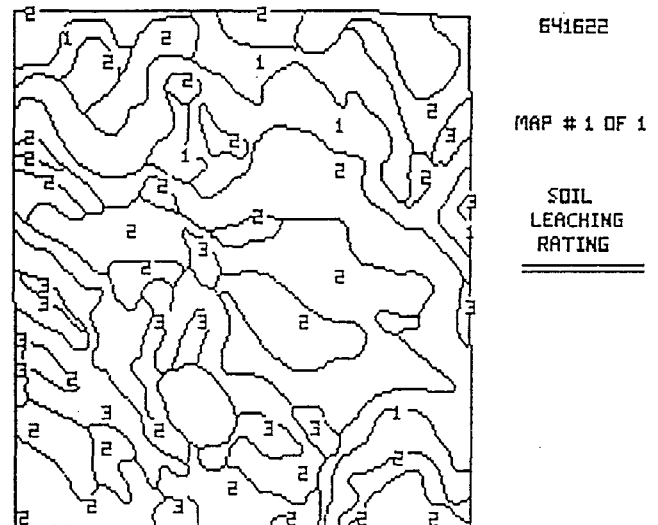
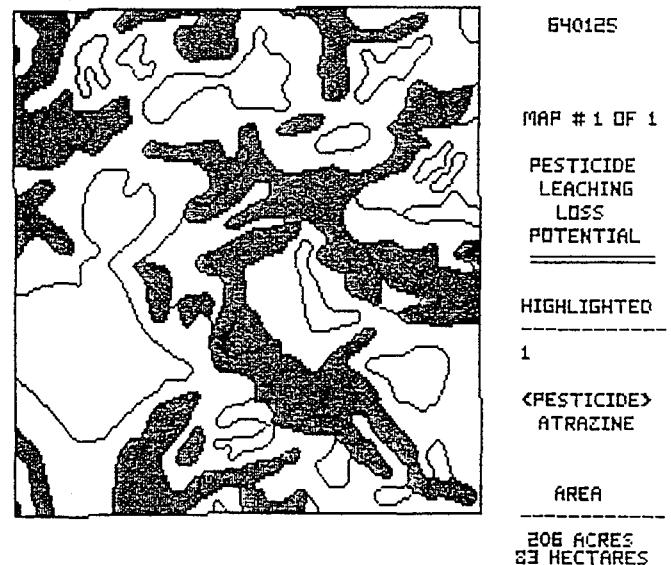


Figure 4. SSIS. High potential atrazine loss highlighted with the indicated acreage in section 25, Brookville Township, Redwood County.



6. Minnesota Soil Ratings

Table 6 provides an example of the output data from the soil expert system. For the availability of these tables in your area, contact either the state soil scientist located in St. Paul

or the area soil scientist located in your area, as indicated in Figure 5.

Figure 5. USDA-SCS state areas.

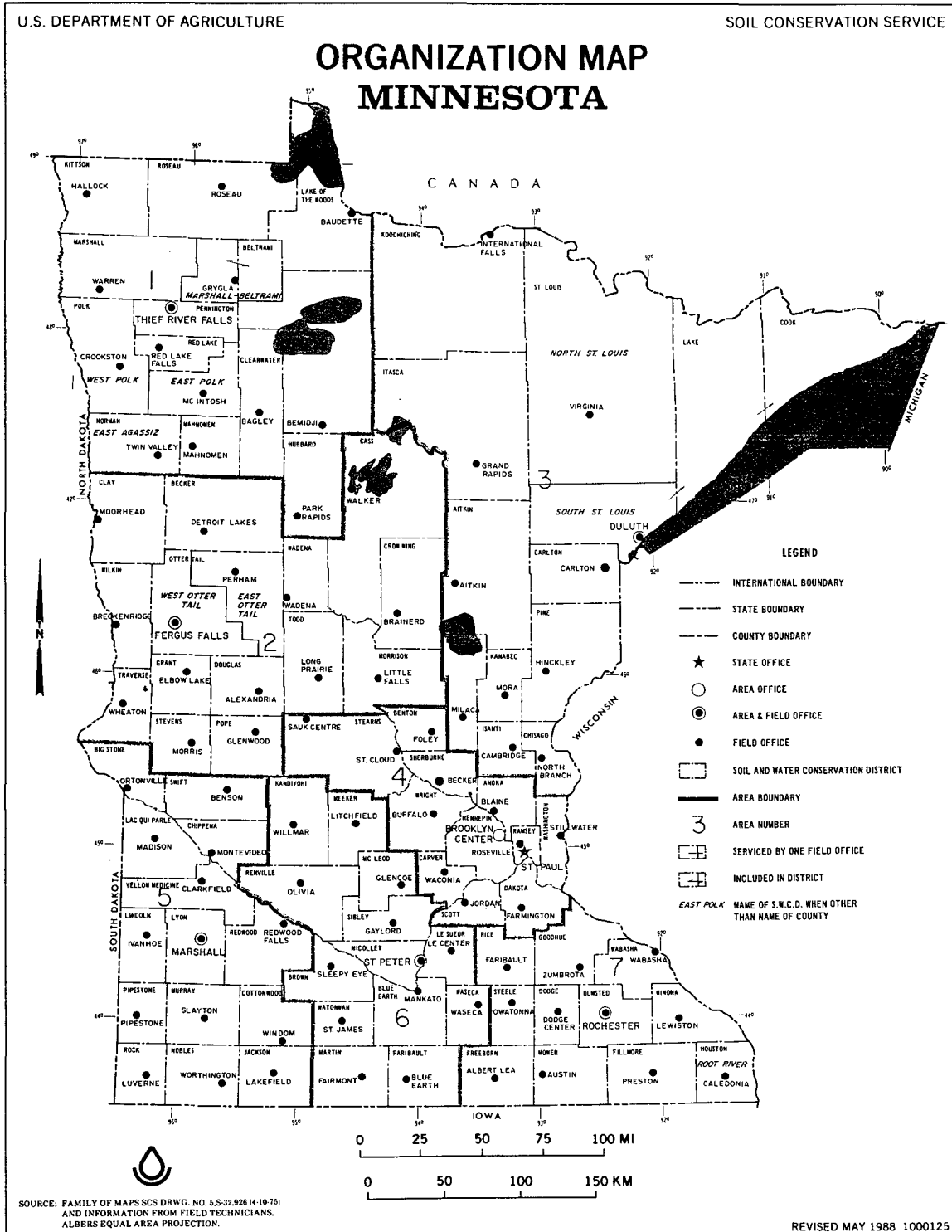


Table 6. Soil leaching and surface runoff potential and soil properties.

Minnesota Area-4 County: Anoka

SOILS	Soil Depth (in)		Soil Ratings		Slope (%)		Hydro Group	O.M. (%)		Permeability (in/hr)		Water Table (ft)		Ponding (ft)		Flooding	Bedrock depth (in)	
	L	H	Leaching	Surface Runoff	L	H		L	H	L	H	L	H	L	H		L	H
AnA ANOKA	0	18	Severe	Slight	0	2	B	0.5	1.	2.	20.	6.	6.			NONE	60	60
AnA ANOKA	18	60	Severe	Slight	0	2	B			0.6	2.	6.	6.			NONE	60	60
AnB ANOKA	0	18	Severe	Slight	2	6	B	0.5	1.	2.	20.	6.	6.			NONE	60	60
AnB ANOKA	18	60	Severe	Slight	2	6	B			0.6	2.	6.	6.			NONE	60	60
AnC ANOKA	0	18	Severe	Moderate	6	12	B	0.5	1.	2.	20.	6.	6.			NONE	60	60
AnC ANOKA	18	60	Severe	Moderate	6	12	B			0.6	2.	6.	6.			NONE	60	60
Ba BECKER	0	9	Moderate	Slight	0	3	B	2.	5.	2.	6.	4.	6.			RARE	60	60
Ba BECKER	9	27	Moderate	Slight	0	3	B			2.	6.	4.	6.			RARE	60	60
Ba BECKER	27	36	Moderate	Slight	0	3	B			6.	20.	4.	6.			RARE	60	60
Ba BECKER	36	60	Moderate	Slight	0	3	B			6.	20.	4.	6.			RARE	60	60
Bm BLOMFORD	0	9	Severe	Slight	0	2	B/D	1.	4.	6.	20.	0.5	1.5			NONE	60	60
Bm BLOMFORD	9	33	Severe	Slight	0	2	B/D			6.	20.	0.5	1.5			NONE	60	60
Bm BLOMFORD	33	42	Severe	Slight	0	2	B/D			0.6	2.	0.5	1.5			NONE	60	60
Bm BLOMFORD	42	60	Severe	Slight	0	2	B/D			0.6	2.	0.5	1.5			NONE	60	60
BtB BRAHAM	0	8	Severe	Slight	2	6	B	0.5	2.	6.	20.	6.	6.			NONE	60	60
BtB BRAHAM	8	24	Severe	Slight	2	6	B			6.	20.	6.	6.			NONE	60	60
BtB BRAHAM	24	42	Severe	Slight	2	6	B			0.2	2.	6.	6.			NONE	60	60
BtB BRAHAM	42	60	Severe	Slight	2	6	B			0.2	2.	6.	6.			NONE	60	60
BtC BRAHAM	0	8	Severe	Moderate	6	18	B	0.5	2.	6.	20.	6.	6.			NONE	60	60
BtC BRAHAM	8	24	Severe	Moderate	6	18	B			6.	20.	6.	6.			NONE	60	60
BtC BRAHAM	24	42	Severe	Moderate	6	18	B			0.2	2.	6.	6.			NONE	60	60
BtC BRAHAM	42	60	Severe	Moderate	6	18	B			0.2	2.	6.	6.			NONE	60	60
Bx BRICKTON	0	9	Severe	Slight	0	2	C	0.3	1.	2.	6.	6.	6.			NONE	60	60
Bx BRICKTON	9	40	Severe	Slight	0	2	C			2.	6.	6.	6.			NONE	60	60
Bx BRICKTON	40	60	Severe	Slight	0	2	C			0.6	2.	6.	6.			NONE	60	60
Cb CATHRO	0	9	Severe	Slight	0	2	A/D	60.	85.	0.2	6.			-1.	1.	NONE	60	60
Cb CATHRO	9	31	Severe	Slight	0	2	A/D	60.	85.	0.2	6.			-1.	1.	NONE	60	60
Cb CATHRO	31	60	Severe	Slight	0	2	A/D			0.2	2.			-1.	1.	NONE	60	60
CkB CHETEK	0	8	Severe	Moderate	2	6	B	1.	3.	2.	6.	6.	6.			NONE	60	60
CkB CHETEK	8	17	Severe	Moderate	2	6	B	0.5	0.5	2.	6.	6.	6.			NONE	60	60
CkB CHETEK	17	60	Severe	Moderate	2	6	B	0.5	0.5	6.	20.	6.	6.			NONE	60	60
CkC CHETEK	0	8	Severe	Moderate	6	12	B	1.	3.	2.	6.	6.	6.			NONE	60	60
CkC CHETEK	8	17	Severe	Moderate	6	12	B	0.5	0.5	2.	6.	6.	6.			NONE	60	60
CkC CHETEK	17	60	Severe	Moderate	6	12	B	0.5	0.5	6.	20.	6.	6.			NONE	60	60
DIA DALBO	0	6	Moderate	Moderate	1	5	B	2.	4.	0.6	2.	2.5	5.			NONE	60	60
DIA DALBO	6	28	Moderate	Moderate	1	5	B	0.5	1.	0.06	0.6	2.5	5.			NONE	60	60
DIA DALBO	28	60	Moderate	Moderate	1	5	B	0.5	0.5	0.2	2.	2.5	5.			NONE	60	60
DnA DICKMAN	0	12	Severe	Slight	0	2	A	2.	4.	2.	6.	6.	6.			NONE	60	60
DnA DICKMAN	12	18	Severe	Slight	0	2	A			2.	6.	6.	6.			NONE	60	60
DnA DICKMAN	18	60	Severe	Slight	0	2	A			6.	20.	6.	6.			NONE	60	60
DnB DICKMAN	0	12	Severe	Slight	2	6	A	2.	4.	2.	6.	6.	6.			NONE	60	60
DnB DICKMAN	12	18	Severe	Slight	2	6	A			2.	6.	6.	6.			NONE	60	60
DnB DICKMAN	18	60	Severe	Slight	2	6	A			6.	20.	6.	6.			NONE	60	60
Dp DUELM	0	11	Severe	Slight	0	2	A	2.	6.	6.	20.	2.	5.			NONE	60	60
Dp DUELM	11	42	Severe	Slight	0	2	A			6.	20.	2.	5.			NONE	60	60
Dp DUELM	42	60	Severe	Slight	0	2	A			6.	20.	2.	5.			NONE	60	60

Table 6 (continued). Soil leaching and surface runoff potential and soil properties.

SOILS		Soil Depth (in)		Soil Ratings		Slope (%)		Hydro Group	O.M. (%)		Permeability (in/hr)		Water Table (ft)		Ponding (ft)		Flooding	Bedrock depth (in)	
				Leaching	Surface Runoff	L	H		L	H	L	H	L	H	L	H		L	H
Symbols	Names	L	H			L	H		L	H	L	H	L	H	L	H		L	H
Du	DUNDAS	0	15	Severe	Slight	0	2	B/D	2.	4.	0.6	2.	1.	3.			NONE	60	60
Du	DUNDAS	15	39	Severe	Slight	0	2	B/D			0.2	0.6	1.	3.			NONE	60	60
Du	DUNDAS	39	60	Severe	Slight	0	2	B/D			0.6	2.	1.	3.			NONE	60	60
EmC	EMMERT	0	4	Severe	Moderate	6	12	A	0.5	1.	6.	20.	6.	6.			NONE	60	60
EmC	EMMERT	4	60	Severe	Moderate	6	12	A			20.	20.	6.	6.			NONE	60	60
EmD	EMMERT	0	4	Severe	Moderate	12	25	A	0.5	1.	6.	20.	6.	6.			NONE	60	60
EmD	EMMERT	4	60	Severe	Moderate	12	25	A			20.	20.	6.	6.			NONE	60	60
EpC	EMMERT	0	4	Severe	Moderate	4	12	A	0.5	1.	6.	20.	6.	6.			NONE	60	60
EpC	EMMERT	4	60	Severe	Moderate	4	12	A			20.	20.	6.	6.			NONE	60	60
EpC	KINGSLEY	0	13	Slight	Moderate	4	12	B	2.	4.	0.6	2.	6.	6.			NONE	60	60
EpC	KINGSLEY	13	34	Slight	Moderate	4	12	B			0.2	0.6	6.	6.			NONE	60	60
EpC	KINGSLEY	34	60	Slight	Moderate	4	12	B			0.2	0.6	6.	6.			NONE	60	60
EpD	EMMERT	0	4	Severe	Moderate	12	25	A	0.5	1.	6.	20.	6.	6.			NONE	60	60
EpD	EMMERT	4	60	Severe	Moderate	12	25	A			20.	20.	6.	6.			NONE	60	60
EpD	KINGSLEY	0	13	Slight	Severe	12	25	B	2.	4.	0.6	2.	6.	6.			NONE	60	60
EpD	KINGSLEY	13	34	Slight	Severe	12	25	B			0.2	0.6	6.	6.			NONE	60	60
EpD	KINGSLEY	34	60	Slight	Severe	12	25	B			0.2	0.6	6.	6.			NONE	60	60
Gc	GLENCOE	0	27	Severe	Slight	0	1	B/D	5.	10.	0.6	2.			-1.	1.	NONE	60	60
Gc	GLENCOE	27	45	Severe	Slight	0	1	B/D			0.2	2.			-1.	1.	NONE	60	60
Gc	GLENCOE	45	60	Severe	Slight	0	1	B/D			0.2	2.			-1.	1.	NONE	60	60
GrA	GROWTON	0	9	Moderate	Moderate	1	4	B	1.	3.	2.	6.	3.	5.			NONE	60	60
GrA	GROWTON	9	23	Moderate	Moderate	1	4	B			2.	6.	3.	5.			NONE	60	60
GrA	GROWTON	23	45	Moderate	Moderate	1	4	B			0.6	2.	3.	5.			NONE	60	60
GrA	GROWTON	45	60	Moderate	Moderate	1	4	B			0.6	2.	3.	5.			NONE	60	60
HdB	HAYDEN	0	10	Moderate	Moderate	2	6	B	0.5	1.	2.	6.	6.	6.			NONE	60	60
HdB	HAYDEN	10	37	Moderate	Moderate	2	6	B			0.6	2.	6.	6.			NONE	60	60
HdB	HAYDEN	37	60	Moderate	Moderate	2	6	B			0.6	2.	6.	6.			NONE	60	60
HdC2	HAYDEN	0	10	Slight	Moderate	6	12	B	0.5	1.	2.	6.	6.	6.			NONE	60	60
HdC2	HAYDEN	10	37	Slight	Moderate	6	12	B			0.6	2.	6.	6.			NONE	60	60
HdC2	HAYDEN	37	60	Slight	Moderate	6	12	B			0.6	2.	6.	6.			NONE	60	60
HdD	HAYDEN	0	10	Slight	Severe	12	24	B	0.5	1.	2.	6.	6.	6.			NONE	60	60
HdD	HAYDEN	10	37	Slight	Severe	12	24	B			0.6	2.	6.	6.			NONE	60	60
HdD	HAYDEN	37	60	Slight	Severe	12	24	B			0.6	2.	6.	6.			NONE	60	60
HeB	HEYDER	0	22	Moderate	Moderate	2	6	B	1.	3.	0.6	2.	6.	6.			NONE	60	60
HeB	HEYDER	22	53	Moderate	Moderate	2	6	B			0.6	2.	6.	6.			NONE	60	60
HeB	HEYDER	53	60	Moderate	Moderate	2	6	B			0.6	2.	6.	6.			NONE	60	60
HeC2	HEYDER	0	22	Slight	Moderate	6	12	B	1.	3.	0.6	2.	6.	6.			NONE	60	60
HeC2	HEYDER	22	53	Slight	Moderate	6	12	B			0.6	2.	6.	6.			NONE	60	60
HeC2	HEYDER	53	60	Slight	Moderate	6	12	B			0.6	2.	6.	6.			NONE	60	60
HeD	HEYDER	0	22	Slight	Severe	12	18	B	1.	3.	0.6	2.	6.	6.			NONE	60	60
HeD	HEYDER	22	53	Slight	Severe	12	18	B			0.6	2.	6.	6.			NONE	60	60
HeD	HEYDER	53	60	Slight	Severe	12	18	B			0.6	2.	6.	6.			NONE	60	60

Table 6 (continued). Soil leaching and surface runoff potential and soil properties.

SOILS		Soil		Soil Ratings		Slope		Hydro Group	O.M.		Permeability (in/hr)		Water Table (ft)		Ponding (ft)		Flooding	Bedrock depth (in)	
		Depth (in)		Leaching	Surface Runoff	(%)			(%)										
Symbols	Names	L	H			L	H		L	H	L	H	L	H	L	H		L	H
HeE	HEYDER	0	22	Slight	Severe	18	30	B	1.	3.	0.6	2.	6.	6.			NONE	60	60
HeE	HEYDER	22	53	Slight	Severe	18	30	B			0.6	2.	6.	6.			NONE	60	60
HeE	HEYDER	53	60	Slight	Severe	18	30	B			0.6	2.	6.	6.			NONE	60	60
HIC	HEYDER	0	22	Slight	Moderate	4	12	B	1.	3.	0.6	2.	6.	6.			NONE	60	60
HIC	HEYDER	22	53	Slight	Moderate	4	12	B			0.6	2.	6.	6.			NONE	60	60
HIC	HEYDER	53	60	Slight	Moderate	4	12	B			0.6	2.	6.	6.			NONE	60	60
HIC	EMMERT	0	4	Severe	Moderate	4	12	A	0.5	1.	6.	20.	6.	6.			NONE	60	60
HIC	EMMERT	4	60	Severe	Moderate	4	12	A			20.	20.	6.	6.			NONE	60	60
HIC	HAYDEN	0	10	Slight	Moderate	4	12	B	0.5	1.	2.	6.	6.	6.			NONE	60	60
HIC	HAYDEN	10	37	Slight	Moderate	4	12	B			0.6	2.	6.	6.			NONE	60	60
HIC	HAYDEN	37	60	Slight	Moderate	4	12	B			0.6	2.	6.	6.			NONE	60	60
HID	HEYDER	0	22	Slight	Severe	12	25	B	1.	3.	0.6	2.	6.	6.			NONE	60	60
HID	HEYDER	22	53	Slight	Severe	12	25	B			0.6	2.	6.	6.			NONE	60	60
HID	HEYDER	53	60	Slight	Severe	12	25	B			0.6	2.	6.	6.			NONE	60	60
HID	EMMERT	0	4	Severe	Moderate	12	25	A	0.5	1.	6.	20.	6.	6.			NONE	60	60
HID	EMMERT	4	60	Severe	Moderate	12	25	A			20.	20.	6.	6.			NONE	60	60
HID	HAYDEN	0	10	Slight	Severe	12	25	B	0.5	1.	2.	6.	6.	6.			NONE	60	60
HID	HAYDEN	10	37	Slight	Severe	12	25	B			0.6	2.	6.	6.			NONE	60	60
HID	HAYDEN	37	60	Slight	Severe	12	25	B			0.6	2.	6.	6.			NONE	60	60
HuA	HUBBARD	0	20	Severe	Slight	0	2	A	1.	3.	6.	20.	6.	6.			NONE	60	60
HuA	HUBBARD	20	44	Severe	Slight	0	2	A			6.	20.	6.	6.			NONE	60	60
HuA	HUBBARD	44	60	Severe	Slight	0	2	A			6.	20.	6.	6.			NONE	60	60
HuB	HUBBARD	0	20	Severe	Slight	2	6	A	1.	3.	6.	20.	6.	6.			NONE	60	60
HuB	HUBBARD	20	44	Severe	Slight	2	6	A			6.	20.	6.	6.			NONE	60	60
HuB	HUBBARD	44	60	Severe	Slight	2	6	A			6.	20.	6.	6.			NONE	60	60
HuC	HUBBARD	0	20	Severe	Moderate	6	12	A	1.	3.	6.	20.	6.	6.			NONE	60	60
HuC	HUBBARD	20	44	Severe	Moderate	6	12	A			6.	20.	6.	6.			NONE	60	60
HuC	HUBBARD	44	60	Severe	Moderate	6	12	A			6.	20.	6.	6.			NONE	60	60
Is	ISAN	0	11	Severe	Slight	0	1	A/D	3.	10.	6.	20.			-0.5	2.	NONE	60	60
Is	ISAN	11	30	Severe	Slight	0	1	A/D			6.	20.			-0.5	2.	NONE	60	60
Is	ISAN	30	60	Severe	Slight	0	1	A/D			6.	20.			-0.5	2.	NONE	60	60
Iw	ISANTI	0	10	Severe	Slight	0	2	A/D	3.	15.	6.	20.	0.	2.			NONE	60	60
Iw	ISANTI	10	31	Severe	Slight	0	2	A/D			6.	20.	0.	2.			NONE	60	60
Iw	ISANTI	31	60	Severe	Slight	0	2	A/D			6.	20.	0.	2.			NONE	60	60
KmB	KINGSLEY	0	13	Moderate	Moderate	2	6	B	2.	4.	0.6	2.	6.	6.			NONE	60	60
KmB	KINGSLEY	13	34	Moderate	Moderate	2	6	B			0.2	0.6	6.	6.			NONE	60	60
KmB	KINGSLEY	34	60	Moderate	Moderate	2	6	B			0.2	0.6	6.	6.			NONE	60	60
KmC2	KINGSLEY	0	13	Slight	Moderate	6	12	B	2.	4.	0.6	2.	6.	6.			NONE	60	60
KmC2	KINGSLEY	13	34	Slight	Moderate	6	12	B			0.2	0.6	6.	6.			NONE	60	60
KmC2	KINGSLEY	34	60	Slight	Moderate	6	12	B			0.2	0.6	6.	6.			NONE	60	60
KmD	KINGSLEY	0	13	Slight	Severe	12	18	B	2.	4.	0.6	2.	6.	6.			NONE	60	60
KmD	KINGSLEY	13	34	Slight	Severe	12	18	B			0.2	0.6	6.	6.			NONE	60	60
KmD	KINGSLEY	34	60	Slight	Severe	12	18	B			0.2	0.6	6.	6.			NONE	60	60
KmE	KINGSLEY	0	13	Slight	Severe	18	30	B	2.	4.	0.6	2.	6.	6.			NONE	60	60
KmE	KINGSLEY	13	34	Slight	Severe	18	30	B			0.2	0.6	6.	6.			NONE	60	60
KmE	KINGSLEY	34	60	Slight	Severe	18	30	B			0.2	0.6	6.	6.			NONE	60	60
Kr	KRATKA	0	12	Severe	Severe	0	1	B/D	1.	3.	6.	20.	0.5	3.			NONE	60	60
Kr	KRATKA	12	36	Severe	Severe	0	1	B/D			6.	20.	0.5	3.			NONE	60	60
Kr	KRATKA	36	60	Severe	Severe	0	1	B/D			0.2	2.	0.5	3.			NONE	60	60

Table 6 (continued). Soil leaching and surface runoff potential and soil properties.

SOILS		Soil Depth (in)	Soil Ratings		Slope (%)		Hydro Group	O.M. (%)		Permeability (in/hr)		Water Table (ft)		Ponding (ft)		Flooding	Bedrock depth (in)		
Symbols	Names		L	H	L	H		L	H	L	H	L	H	L	H		L	H	
LgB	LANGOLA	0	10	Severe	Slight	0	6	B	3.	5.	6.	20.	6.	6.		NONE	60	60	
LgB	LANGOLA	10	31	Severe	Slight	0	6	B			6.	20.	6.	6.		NONE	60	60	
LgB	LANGOLA	31	60	Severe	Slight	0	6	B			0.06	0.2	6.	6.		NONE	60	60	
LnA	LINO	0	7	Severe	Slight	0	4	B	0.5	2.	6.	20.	2.	4.		NONE	60	60	
LnA	LINO	7	45	Severe	Slight	0	4	B			6.	20.	2.	4.		NONE	60	60	
LnA	LINO	45	60	Severe	Slight	0	4	B			6.	20.	2.	4.		NONE	60	60	
Lx	LUPTON	0	9	Severe	Slight	0	2	A/D	70.	90.	0.2	6.	0.	1.		NONE	60	60	
Lx	LUPTON	9	60	Severe	Slight	0	2	A/D			0.2	6.	0.	1.		NONE	60	60	
Ma	MARKEY	0	31	Severe	Slight	0	2	A/D	55.	85.	0.2	6.			-1.	1.	NONE	60	60
Ma	MARKEY	31	60	Severe	Slight	0	2	A/D			6.	20.			-1.	1.	NONE	60	60
Me	MEEHAN	0	8	Severe	Slight	0	2	B	0.5	3.	6.	20.	1.	3.		NONE	60	60	
Me	MEEHAN	8	40	Severe	Slight	0	2	B			6.	20.	1.	3.		NONE	60	60	
Me	MEEHAN	40	60	Severe	Slight	0	2	B			6.	20.	1.	3.		NONE	60	60	
Mk	MILLERVILLE	0	30	Severe	Slight	0	2	A/D	50.	90.	0.6	6.			-1.	1.5	NONE	60	60
Mk	MILLERVILLE	30	60	Severe	Slight	0	2	A/D			0.06	0.2			-1.	1.5	NONE	60	60
MoA	MORA	0	8	Moderate	Moderate	1	4	C	0.5	3.	2.	6.	2.	3.		NONE	60	60	
MoA	MORA	8	15	Moderate	Moderate	1	4	C			0.6	6.	2.	3.		NONE	60	60	
MoA	MORA	15	22	Moderate	Moderate	1	4	C			0.6	2.	2.	3.		NONE	60	60	
MoA	MORA	22	41	Moderate	Moderate	1	4	C			0.	0.2	2.	3.		NONE	60	60	
MoA	MORA	41	60	Moderate	Moderate	1	4	C			0.	0.06	2.	3.		NONE	60	60	
NeA	NESSSEL	0	9	Moderate	Moderate	1	4	B	0.5	1.	2.	6.	3.	5.		NONE	60	60	
NeA	NESSSEL	9	16	Moderate	Moderate	1	4	B			0.6	2.	3.	5.		NONE	60	60	
NeA	NESSSEL	16	40	Moderate	Moderate	1	4	B			0.6	2.	3.	5.		NONE	60	60	
NeA	NESSSEL	40	60	Moderate	Moderate	1	4	B					3.	5.		NONE	60	60	
No	NOWEN	0	15	Severe	Slight	0	2	B/D	0.5	2.	0.6	2.	1.	3.		NONE	60	60	
No	NOWEN	15	49	Severe	Slight	0	2	B/D			0.6	2.	1.	3.		NONE	60	60	
No	NOWEN	49	60	Severe	Slight	0	2	B/D			0.6	2.	1.	3.		NONE	60	60	
NrD	NYMORE	0	7	Severe	Moderate	12	25	A	1.	3.	6.	20.	6.	6.		NONE	60	60	
NrD	NYMORE	7	26	Severe	Moderate	12	25	A			6.	20.	6.	6.		NONE	60	60	
NrD	NYMORE	26	60	Severe	Moderate	12	25	A			6.	20.	6.	6.		NONE	60	60	
NyA	NYMORE	0	7	Severe	Slight	0	2	A	1.	3.	6.	20.	6.	6.		NONE	60	60	
NyA	NYMORE	7	26	Severe	Slight	0	2	A			6.	20.	6.	6.		NONE	60	60	
NyA	NYMORE	26	60	Severe	Slight	0	2	A			6.	20.	6.	6.		NONE	60	60	
NyB	NYMORE	0	7	Severe	Slight	2	6	A	1.	3.	6.	20.	6.	6.		NONE	60	60	
NyB	NYMORE	7	26	Severe	Slight	2	6	A			6.	20.	6.	6.		NONE	60	60	
NyB	NYMORE	26	60	Severe	Slight	2	6	A			6.	20.	6.	6.		NONE	60	60	
NyC	NYMORE	0	7	Severe	Moderate	6	12	A	1.	3.	6.	20.	6.	6.		NONE	60	60	
NyC	NYMORE	7	26	Severe	Moderate	6	12	A			6.	20.	6.	6.		NONE	60	60	
NyC	NYMORE	26	60	Severe	Moderate	6	12	A			6.	20.	6.	6.		NONE	60	60	
Rf	RIFLE	0	8	Severe	Slight	0	1	A/D	75.	99.	0.6	6.			-1.	1.	NONE	60	60
Rf	RIFLE	8	60	Severe	Slight	0	1	A/D	25.	99.	0.6	6.			-1.	1.	NONE	60	60
Rg	RIFLE	0	8	Severe	Slight	0	1	A/D	25.	85.	0.2	6.			-1.	1.	NONE	60	60
Rg	RIFLE	8	60	Severe	Slight	0	1	A/D	25.	99.	0.6	6.			-1.	1.	NONE	60	60
Rh	RIFLE	0	8	Severe	Slight	0	1	A/D	75.	99.	0.6	6.			-1.	1.	NONE	60	60
Rh	RIFLE	8	60	Severe	Slight	0	1	A/D	25.	99.	0.6	6.			-1.	1.	NONE	60	60

Table 6 (continued). Soil leaching and surface runoff potential and soil properties.

SOILS		Soil Depth (in)		Soil Ratings		Slope (%)		Hydro Group		O.M. (%)		Permeability (in/hr)		Water Table (ft)		Ponding (ft)		Flooding		Bedrock depth (in)	
Symbols	Names	L	H	Leaching	Surface Runoff	L	H			L	H	L	H	L	H	L	H			L	H
Ru	RONDEAU	0	44	Severe	Slight	0	2	A/D	25	99	0.2	6			-1	1	NONE		60	60	
Ru	RONDEAU	44	60	Severe	Slight	0	2	A/D			0	0.2			-1	1	NONE		60	60	
Ry	RONNEBY	0	5	Severe	Slight	0	2	C	3	6	2	6	1.5	3			NONE		60	60	
Ry	RONNEBY	5	15	Severe	Slight	0	2	C			0.6	6	1.5	3			NONE		60	60	
Ry	RONNEBY	15	32	Severe	Slight	0	2	C			0.6	2	1.5	3			NONE		60	60	
Ry	RONNEBY	32	42	Severe	Slight	0	2	C			0.06	0.2	1.5	3			NONE		60	60	
Ry	RONNEBY	42	60	Severe	Slight	0	2	C			0	0.06	1.5	3			NONE		60	60	
SbB	SARTELL	0	9	Severe	Slight	2	6	A	0.5	2	6	20	6	6			NONE		60	60	
SbB	SARTELL	9	26	Severe	Slight	2	6	A			6	20	6	6			NONE		60	60	
SbB	SARTELL	26	60	Severe	Slight	2	6	A			6	20	6	6			NONE		60	60	
SbC	SARTELL	0	9	Severe	Moderate	6	12	A	0.5	2	6	20	6	6			NONE		60	60	
SbC	SARTELL	9	26	Severe	Moderate	6	12	A			6	20	6	6			NONE		60	60	
SbC	SARTELL	26	60	Severe	Moderate	6	12	A			6	20	6	6			NONE		60	60	
SbC2	SARTELL	0	5	Severe	Moderate	6	12	A	0.5	2	6	20	6	6			NONE		60	60	
SbC2	SARTELL	5	24	Severe	Moderate	6	12	A			6	20	6	6			NONE		60	60	
SbC2	SARTELL	24	60	Severe	Moderate	6	12	A			6	20	6	6			NONE		60	60	
SbD2	SARTELL	0	5	Severe	Moderate	12	24	A	0.5	2	6	20	6	6			NONE		60	60	
SbD2	SARTELL	5	24	Severe	Moderate	12	24	A			6	20	6	6			NONE		60	60	
SbD2	SARTELL	24	60	Severe	Moderate	12	24	A			6	20	6	6			NONE		60	60	
Se	SEELYVILLE	0	10	Severe	Slight	0	2	A/D	25	99	0.2	6			-2	2	NONE		60	60	
Se	SEELYVILLE	10	60	Severe	Slight	0	2	A/D	25	99	0.2	6			-2	2	NONE		60	60	
SoA	SODERVILLE	0	9	Severe	Slight	0	4	A	0.5	1	6	20	2	4			NONE		60	60	
SoA	SODERVILLE	9	36	Severe	Slight	0	4	A			6	20	2	4			NONE		60	60	
SoA	SODERVILLE	36	46	Severe	Slight	0	4	A			6	20	2	4			NONE		60	60	
SoA	SODERVILLE	46	60	Severe	Slight	0	4	A			6	20	2	4			NONE		60	60	
Wb	WEBSTER	0	16	Severe	Slight	0	2	B/D	6	7	0.6	2	1	2			NONE		60	60	
Wb	WEBSTER	16	23	Severe	Slight	0	2	B/D	2	4	0.6	2	1	2			NONE		60	60	
Wb	WEBSTER	23	60	Severe	Slight	0	2	B/D	1	2	0.6	2	1	2			NONE		60	60	
ZmA	ZIMMERMAN	0	10	Severe	Slight	0	2	A	0.5	1	6	20	6	6			NONE		60	60	
ZmA	ZIMMERMAN	10	60	Severe	Slight	0	2	A			6	20	6	6			NONE		60	60	
ZmB	ZIMMERMAN	0	10	Severe	Slight	2	6	A	0.5	1	6	20	6	6			NONE		60	60	
ZmB	ZIMMERMAN	10	60	Severe	Slight	2	6	A			6	20	6	6			NONE		60	60	
ZmC	ZIMMERMAN	0	10	Severe	Moderate	6	12	A	0.5	1	6	20	6	6			NONE		60	60	
ZmC	ZIMMERMAN	10	60	Severe	Moderate	6	12	A			6	20	6	6			NONE		60	60	
ZmD	ZIMMERMAN	0	10	Severe	Moderate	12	24	A	0.5	1	6	20	6	6			NONE		60	60	
ZmD	ZIMMERMAN	10	60	Severe	Moderate	12	24	A			6	20	6	6			NONE		60	60	

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This publication produced by Educational Development System, Minnesota Extension Service. Editor: Phyllis Petersen.



Printed on recycled paper with Agri-based inks



This material is based upon work supported by the U.S. Department of Agriculture, Extension Service, under special project number 90-EWQI-1-9220.

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