

## Soils Chapter 2

### Introduction

All soils and soil phases found in North Dakota have been rated and assigned to an irrigation group. Although each soil has its own characteristics, for the purpose of this guide, soils have been placed into twenty nine groups. Soil properties such as texture, sodicity, salinity and surface pH along with soil interpretations that include drainage class, water holding capacity and restrictive substrata are used to develop irrigation groups. Soils in each group can be considered similar for irrigation purposes and will have the same irrigation requirements, water quality limitations and irrigations management recommendations.

In considering design for irrigation, the more important criteria to consider are drainage, soil and water compatibility, slope and intake rate. The following is a brief discussion of soil properties and interpretations used to design the irrigation groups.

Available water capacity (AWC) is the volume of water that should be available to plants if the soil, inclusive of fragments, were at field capacity (see table 2.1). It is commonly estimated as the amount of water held between field capacity and wilting point, with corrections for salinity, fragments, and rooting depth. AWC of a soil is primarily related to the soil texture, organic matter content, and bulk density. Soils with higher organic matter generally hold more water than a soil with lower organic matter. Classes of available water capacity are listed below:

<u>Inches water in 60" depth of soil or to a limiting layer whichever is shallower</u>	<u>Class name</u>
Less than 3	Very low
3-6	Low
6-9	Moderate
More than 9	High

The computation for available water capacity can be obtained in the Natural Resources Conservation Services Nation Soils Survey Handbook at: <http://soils.usda.gov/technical/handbook/contents/part618.html#05> Available water capacity is reduced by the presence of soluble salts in the soil. Table 2.2 can be used to make adjustments in the estimated available water capacity if the salinity expressed as millimhos per centimeter (1 millimhos per centimeter is equivalent to 1 decisiemens per meter) is known.

Drainage is a natural condition of the soil that refers to the frequency and duration of periods when the soil is free of saturation. For example, in well drained soils the water is removed readily but not rapidly; in poorly drained soils the root zone is waterlogged for long periods. In excessively drained soils water is removed so completely that most plants suffer from lack of water.

Except for very young soils, the natural soil drainage conditions are reflected in soil morphology. The following classes (with their abbreviation) are used to define natural soil drainage in broad terms.

Very poorly drained	VP
Poorly- drained	P
Somewhat poorly drained	SP
Moderately well drained	MW
Well drained	W
Somewhat excessively drained	SE
Excessively drained	E

High water table is defined as the top of the zone of saturation at the highest average depth during the wettest season. It persists in the soil for more than a few days.

The presence of a saturated zone (water table) is a prime factor in determining soils adaptability for irrigation. If a saturated zone is at shallow depths, a hazard always exists that heavy rains can raise the saturated zone to depths shallow enough to slow or inhibit plant growth. Thus, soils with wetness limitations are placed in groups separate from other similar soils except for that feature.

EC - Salinity is a soil property that changes relatively quickly with time compared to other properties. Soil testing for salts is necessary to not only follow possible increases over time in irrigated fields, but also determine if irrigation should be attempted in the first place. Salinity is measured at the maximum electrical conductivity (EC) within 40 inches in decisiemens per meter (dS/m) for each soil series. The following classes are used for soil salinity.

None	0-4 decisiemens per meter
Slight	4-8 decisiemens per meter
Moderate	8-15 decisiemens per meter
Strongly	15+ decisiemens per meter

Intake rate is a measure of a soils capacity to absorb irrigation water from the surface and movement into and through the soil profile. It is an expression of several factors, including infiltration and percolation.

Infiltration is the downward flow of water from the surface through the soil. Water enters the soil through pores, cracks, worm and decayed root holes, and cavities introduced by tillage. Surface sealing or crusting will restrict infiltration. Percolation is the movement of water through the soil profile. In order for irrigation water to be effective in replenishing the soils water supply, it must be able to move through the profile, or percolate, to a predetermined irrigation depth. The percolation rate is governed by the permeability of the soil or its hydraulic conductivity. Both terms are used to describe the ease with which soil transmits water and air.

Permeability is expressed as inches per hour and micrometers per second. The permeability class of a soil is based on the most restrictive layer in the soil. The relative permeability of soils is described in the following terms:

Permeability Class	Inches per hour	Micrometer per second
Very slow	less than 0.06	0.01 - 0.42
Slow	0.06 - 0.2	0.42 - 1.4
Moderately Slow	0.2 - 0.6	1.4 - 4
Moderate	0.6 - 2.0	4 - 14
Moderately Rapid	2.0 to 6.0	14 - 42
Rapid	6 - 20	42 - 141
Very Rapid	20 - 100	141 - 705

The amount of moisture already in the soil greatly influences the rate at which water enters the soil. The soil takes in and absorbs irrigation water rapidly when water is first applied to the field surface. As the irrigation application continues, the surface soil gradually becomes saturated and the intake rate decreases until it reaches a nearly constant value.

The intake rate of any soil is limited by any restriction to the flow of water into or through the soil profile. The soil layer with the lowest transmission rate, either at the surface or directly below it, usually determines intake rate. The most important general factors that influence intake rate are the physical properties of the soil and, in sprinkler irrigation, the plant cover. But for any given soil, other factors may affect the intake rate.

Since so many factors affect water intake, it is not surprising that it varies so much among soils. Furthermore, the intake characteristics of a given field vary from place to place, from irrigation to irrigation, and from season to season. The intake characteristics that must be considered in sprinkler irrigation design differ from those for surface methods.

Intake Family	Irrigation Group(s)
0.3	10c, 11c, 21c, 22c
0.5	8c, 9c, 12c, 13c, 15c,
1.0	5i, 6i, 7i, 9c, 13c, 14c, 16c, 17c, 20c
1.5	4i, 19c
2.0	3i, 18c
3.0	1i, 2i,

The above intake families will be used when calculating CPNOZZLE(erosion program). If available, onsite soil properties may be used to calculate intake families.

Lime or calcium carbonate is present in most North Dakota soils. It is relatively easily weathered and transported by water through the soil. The soil forming factors determine where lime concentrates in the soil profile. Soils with lime in the surface layer rarely have crusting problems but are at risk from wind erosion.

SAR - The sodium adsorption ratio (SAR) is the standard measure of the sodicity of soil or irrigation water. Sodium affects the physical condition of the soil by dispersing aggregates. Sodium buildup is one of the most serious long term dangers to productivity. Water management becomes difficult, seed germination may be poor and roots cannot penetrate well into the soil. Soils that have more than 15 percent exchangeable sodium or a SAR greater than 13 are considered sodium affected. Soil testing is recommended to determine long-term trends in sodium accumulation.

Slope refers to the incline of the surface of the soil area and is expressed in terms of percentage. It is the difference in elevation in feet for each 100 feet horizontal. A soil slope of 45 degrees is 100 percent since the difference in elevation of two points 100 feet apart horizontally is 100 feet. Slope is important in determining the water runoff potential from a field.

Soil Texture is the relative proportions of sand, silt and clay in a mass of soil. Texture influences interpretations such as water holding capacity, intake rate and internal drainage. Surface and subsoil texture is shown for all irrigation groups. The following abbreviations are used:

Sand	S
Coarse sand	COS
Fine sand	FS
Loam coarse sand	LCOS
Loamy sand	LS
Loamy fine sand	LFS
Coarse sandy loam	COSL
Sandy loam	SL
Fine sandy loam	FSL
Very fine sandy loam	VFSL
Loam	L
Silt loam	SIL
Clay loam	CL
Sandy clay loam	SCL
Silty clay loam	SICL
Silty clay	SIC
Clay	C

Additional textural modifiers are:

Channery	CN
Gravelly	GR

### General Information

All soils and soil phases found in North Dakota have been rated and assigned to an irrigation group. As additional soil series or phases are recognized, they will be rated and placed in the appropriate irrigation group.

Soil series, including phases of soil series were evaluated and placed in 29 categories called "Irrigation Groups". Each soil has its own properties but differences between some soils are so minor that for practical purposes they can be considered together. Criteria used to group soils included; slope, drainage, surface texture, substratum texture, surface intake rate for sprinkler irrigation, limiting permeability within 40 inches, profile characteristics, water holding capacity, depth to lime, surface pH, EC and SAR.

The irrigation groups have been placed in three classes according to their adaptability to irrigation. The three classes are Irrigable, Conditional and Non-irrigable and are defined as follows:

Irrigable - The soils in these irrigation groups have no limitations to continued irrigation using the proper water application rates, amounts, timing and water quality.

Conditional - The soils in these irrigation groups have moderate limitations and many are marginal for irrigation. The limitations are due to high water tables, moderately slow to slow permeability, moderately deep (<40 inches) to bedrock, salinity, or sodicity. Limitations may be overcome or managed with proper conservation practices, improved internal drainage and on site monitoring. Extensive irrigation of these areas will require a complex management system for sustaining production and soil health.

Non-irrigable - These soils have very severe limitations. Irrigation generally is not feasible or economical because of depth to bedrock (<20 inches), frequent flooding, root restrictive layer, ponding, salinity, sodicity, slope or surface stones and boulders. Avoid irrigation.

### Soil Monitoring

Soil and irrigation water quality should be monitored on a regular basis to determine irrigation effects on soil quality. A 3 to 5 year interval is recommended if conditional soils are irrigated or marginal irrigation water is used. Certain criteria and procedures should be followed. The monitoring criteria and procedures are defined as follows:

1. Monitor one site per 40 acres of each major soil in a map unit identified for monitoring. These statements are located in the "Water Management Practices" section of irrigable and conditional groups. Soil samples will be analyzed for sodium (SAR) and salinity (EC).
2. Monitoring procedures
  - a. Reference monitor sites to permanent landmarks or by the use of a global position system (GPS).
  - b. Monitor duplicate (2) sites of each major soil.
  - c. Sample after harvest.
  - d. Sample every 3 to 5 years or more frequently if plant growth is restricted.
  - e. Sample to 6 feet and examine to 10 feet noting water table depth. Sample each genetic soil horizon or portion no greater than 12 inches.
  - f. Sample irrigation water from surface or subsurface sources at peak irrigation time. Irrigation water samples will be analyzed for sodium (SAR) and salinity (EC).
3. Monitoring should be done by or under the supervision of a experienced soil scientist.

**NORTH DAKOTA IRRIGATION GUIDE**

**Version 1.5**

Irrigation Group: 1i  
Irrigation Class: Irrigable  
Old Irrigation Group: 10

Slope:  $\leq$  6 percent <sup>1/</sup>

Drainage: excessively drained

Surface texture: L, SL

Substratum texture: sand and gravel

Surface intake rate for sprinkler irrigation: 0.5 – 0.7 in/hr

Limiting permeability within 40 inches: 0.6 to 2.0 in/hr in the upper part and  $>$  6.0 in/hr in the lower part

Profile characteristics: shallow/very shallow ( $<$  20 inches) to sand, gravel and porcellanite

Water Holding Capacity:

<u>Depth</u>	<u>Average Cumulative Available Water Capacity</u>
1 foot	1.5 inches
2 feet	2.0 inches
3 feet	2.5 inches
4 feet	3.0 inches
5 feet	3.0 inches

(rounded to the nearest 0.5 inch; on-site values may vary)

Depth to lime: 0 - 10 inches

Surface pH: 6.6 - 8.4 inches

EC - (maximum within 40 inches in dS/m): 0

SAR - (maximum within 40 inches): 0

Typical Soils: Brandenburg, Coe, Ringling, Sioux, Wabek

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<sup>1/</sup>For slopes  $>$ 6% refer to the water erosion hazard table.

Irrigation Water Quality

Maximum allowable EC <3000

Maximum allowable SAR <12

Water Management Practices

Water management on these soils is critical because of low available water capacity and nutrient leaching hazard. An irrigation scheduling system must be used (e.g., NDSU Extension Bulletin AE-792(revised), Commercial Irrigation Scheduling Service).

**NORTH DAKOTA IRRIGATION GUIDE**

**VERSION 1.5**

Irrigation Group: 2i  
Irrigation Class: Irrigable  
Old Irrigation Group: 9

Slope:  $\leq$  9 percent <sup>1/</sup>

Drainage: moderately well to excessively drained

Surface texture: CoS, S, FS, LCoS, LS, LFS, CoSL, SL, FSL

Subsoil texture: FS, S, LCoS, CoS

Surface intake rate for sprinkler irrigation: 0.5 - >1.0 in/hr

Limiting permeability within 40 inches: 6.0 - 20.0 in/hr

Profile characteristics: sandy and moderately coarse textured  
material

Water Holding Capacity:

<u>Depth</u>	<u>Average Cumulative Available Water Capacity</u>	
1 foot	1.0	inches
2 feet	2.0	inches
3 feet	2.5	inches
4 feet	3.0	inches
5 feet	4.0	inches

(rounded to the nearest  
0.5 inch; on-site values  
may vary)

Depth to lime: 10 - 30 inches

Surface pH: 6.1 - 7.3

EC - (maximum within 40 inches in dS/m): 0

SAR - (maximum within 40 inches): 0

Typical Soils: Aylmer, Claire, Falsen, Lohnes, Serden,  
Seroco, Yetull, Zeona

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<sup>1/</sup>For slopes >9% refer to the water erosion hazard table

Irrigation Water Quality

Maximum allowable EC <3000

Maximum allowable SAR <12

Water Management Practices

Water management on these soils is critical because of low available water capacity and nutrient leaching hazard. An irrigation scheduling system must be used (e.g., NDSU Extension Bulletin AE-792(revised), Commercial Irrigation Scheduling Service).

**NORTH DAKOTA IRRIGATION GUIDE**

**VERSION 1.5**

Irrigation Group: 3i  
Irrigation Class: Irrigable  
Old Irrigation Group: 8A

Slope:  $\leq$  6 percent <sup>1/</sup>

Drainage: moderately well to somewhat excessively drained

Surface texture: FSL, SL, CoSL, LFS, LS

Subsoil and substratum texture: SL and L in the upper part and LS to sand and gravel in the lower part

Surface intake rate for sprinkler irrigation: 0.4 - 1.5 in/hr

Limiting permeability within 40 inches: 2.0 - 20.0 in/hr in the upper part and  $>$  6.0 in/hr in the lower part

Profile characteristics: moderately coarse and medium textured material in the upper part and coarse textured material in the lower part

Water Holding Capacity:

<u>Depth</u>	<u>Average Cumulative Available Water Capacity</u>	
1 foot	1.5	inches
2 feet	3.0	inches
3 feet	3.5	inches
4 feet	4.5	inches
5 feet	5.5	inches

(rounded to the nearest 0.5 inch; on-site values may vary)

Depth to lime: 10 - 30 inches

Surface pH: 6.1 - 7.8

EC - (maximum within 40 inches in dS/m): 0

SAR - (maximum within 40 inches): 0

Typical Soils: Arvilla <sup>2/</sup>, Banks, Binford <sup>2/</sup>, Hecla, Lihen, Manning <sup>2/</sup>, Osakis, Ruso <sup>3/</sup>, Telfer, Walum <sup>2/</sup>

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<sup>1/</sup>For slopes  $>$ 6% refer to the water erosion hazard table

<sup>2/</sup>Underlain by sand or sand and gravel within depths of 14 to 20 inches

<sup>3/</sup>Underlain by sand or sand and gravel within depths of 20 to 40 inches

Irrigation Water Quality

Maximum allowable EC <3000

Maximum allowable SAR <12

Water Management Practices

An irrigation scheduling system must be used (e.g., NDSU Extension Bulletin AE-792(revised), Commercial Irrigation Scheduling Service).

**NORTH DAKOTA IRRIGATION GUIDE**

**VERSION 1.5**

Irrigation Group: 4i  
Irrigation Class: Irrigable  
Old Irrigation Group: 7A

Slope:  $\leq$  6 percent <sup>1/</sup>

Drainage: well and moderately well drained

Surface texture: SL, FSL, L

Subsoil texture: SL, FSL, L

Surface intake rate for sprinkler irrigation: .5 - 1.0 in/hr

Limiting permeability within 40 inches: .6 - 6.0 in/hr

Profile characteristics: moderately coarse and medium textured  
material

Water Holding Capacity:

<u>Depth</u>	<u>Average Cumulative Available Water Capacity</u>	
1 foot	2.0	inches
2 feet	4.0	inches
3 feet	5.5	inches
4 feet	7.0	inches
5 feet	9.0	inches

(rounded to the nearest  
0.5 inch; on-site values  
may vary)

Depth to lime: 10 - 20 inches <sup>2/</sup>

Surface pH: 6.1 - 8.4

EC - (maximum within 40 inches in dS/m): 0 - 2

SAR - (maximum within 40 inches): 0

Typical Soils: Breien <sup>3/</sup>, Chinook, Eglund, Embden, Mott,  
Tally, Trembles <sup>3/</sup>, Velva <sup>3/</sup>

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<sup>1/</sup>For slopes >6% refer to the water erosion hazard table

<sup>2/</sup>Depth to lime may be <10 inches

<sup>3/</sup>May be stratified and have slower permeability rates

Irrigation Water Quality

Maximum allowable EC <3000

Maximum allowable SAR <12

Water Management Practices

An irrigation scheduling system must be used (e.g., NDSU Extension Bulletin AE-792(revised), Commercial Irrigation Scheduling Service).

**NORTH DAKOTA IRRIGATION GUIDE**

**VERSION 1.5**

Irrigation Group: 5i  
Irrigation Class: Irrigable  
Old Irrigation Group: 6A

Slope:  $\leq$  6 percent <sup>1/</sup>

Drainage: well and moderately well drained

Surface texture: SL, L

Substratum texture: 2C material is GrSL to sand and gravel

Surface intake rate for sprinkler irrigation: 0.5 - 0.7 in/hr

Permeability within 40 inches: 0.6 - 2.0 in/hr in the  
upper part and  $>$  6.0 in/hr in the lower part

Profile characteristics: moderately coarse and medium textured  
material over sand and gravel that is shallow to moderately  
deep ( $<$ 40 inches)

Water Holding Capacity:

<u>Depth</u>	<u>Average Cumulative Available Water Capacity</u>	
1 foot	2.0	inches
2 feet	3.0	inches
3 feet	3.5	inches
4 feet	4.0	inches
5 feet	4.5	inches

(rounded to the nearest  
0.5 inch; on-site values  
may vary)

Depth to lime: 10 - 20 inches

Surface pH: 6.1 - 7.8

EC - (maximum within 40 inches in dS/m): 0 - 1

SAR - (maximum within 40 inches): 0

Typical Soils: Brantford, Hidatsa, Kensal, Lehr, Renshaw, Warsing

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<sup>1/</sup>For slopes  $>$ 6% refer to the water erosion hazard table

Irrigation Water Quality

Maximum allowable EC <3000

Maximum allowable SAR <9

Water Management Practices

An irrigation scheduling system must be used (e.g., NDSU Extension Bulletin AE-792(revised), Commercial Irrigation Scheduling Service).

**NORTH DAKOTA IRRIGATION GUIDE**

**VERSION 1.5**

Irrigation Group: 6i  
Irrigation Class: Irrigable  
Old Irrigation Group: 6B

Slope:  $\leq 6$  percent <sup>1/</sup>

Drainage: moderately well and well drained

Surface texture: L, SIL, CL

Subsoil texture: L and CL in B horizons and GrL to GrS in the 2B  
or 2C horizons

Surface intake rate for sprinkler irrigation: 0.5 - 0.7 in/hr

Limiting permeability within 40 inches: 0.6 - 2.0 in/hr in the  
upper part and  $> 6.0$  in/hr in the lower part

Profile characteristics: moderately fine textured material over  
moderately deep (20-40 inches) sand and gravel

Water Holding Capacity:

<u>Depth</u>	<u>Average Cumulative Available Water Capacity</u>	
1 foot	2.5	inches
2 feet	4.5	inches
3 feet	5.5	inches
4 feet	6.0	inches
5 feet	6.5	inches

(rounded to the nearest  
0.5 inch; on-site values  
may vary)

Depth to lime: 15 - 30 inches

Surface pH: 6.1 - 7.3

EC - (maximum within 40 inches in dS/m): 0 - 1

SAR - (maximum within 40 inches): 0

Typical Soils: Bowdle, Chanta, Fordville, Spottswood, Stady,  
Vang <sup>2/</sup>

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<sup>1/</sup>For slopes  $>6\%$  refer to the water erosion hazard table

<sup>2/</sup>Vang soils may have lower pHs because of the influence of shale

Irrigation Water Quality

Maximum allowable EC <3000

Maximum allowable SAR <9

Water Management Practices

An irrigation scheduling system must be used (e.g., NDSU Extension Bulletin AE-792(revised), Commercial Irrigation Scheduling Service).

**NORTH DAKOTA IRRIGATION GUIDE**

**VERSION 1.5**

Irrigation Group: 7i  
Irrigation Class: Irrigable  
Old Irrigation Group: 4A

Slope:  $\leq$  3 percent <sup>1/</sup>

Drainage: moderately well and well drained

Surface texture: VFSL, SIL, L

Subsoil texture: VFSL, SIL, L, SICL

Surface intake rate for sprinkler irrigation: 0.1 - 0.5 in/hr <sup>2/</sup>

Limiting permeability within 40 inches: 0.2 - 2.0 in/hr

Profile characteristics: medium and moderately fine textured material

Water Holding Capacity:

<u>Depth</u>	<u>Average Cumulative Available Water Capacity</u>	
1 foot	2.5	inches
2 feet	5.0	inches
3 feet	7.0	inches
4 feet	9.0	inches
5 feet	11.5	inches

(rounded to the nearest 0.5 inch; on-site values may vary)

Depth to lime: 15 - 30 inches

Surface pH: 6.6 - 7.8

EC - (maximum within 40 inches in dS/m): 0 - 2

SAR - (maximum within 40 inches): 0

Typical Soils: Arnegard, Eckman, Emrick, Gardena, Shambo

<sup>1/</sup>For slopes >3% refer to the water erosion hazard table

<sup>2/</sup>SICL surface texture intake rate for sprinkler irrigation is 0.1-0.4 in/hr

Irrigation Water Quality

Maximum allowable EC <2250

Maximum allowable SAR <6

Water Management Practices

An irrigation scheduling system must be used (e.g., NDSU Extension Bulletin AE-792(revised), Commercial Irrigation Scheduling Service).

**NORTH DAKOTA IRRIGATION GUIDE**

**VERSION 1.5**

Irrigation Group: 8c  
Irrigation Class: Conditional  
Old Irrigation Group: 3A

Slope:  $\leq$  3 percent <sup>1/</sup>

Drainage: moderately well to well drained

Surface texture: L, SIL, SICL

Subsoil texture: L, CL, SICL

Surface intake rate for sprinkler irrigation: 0.1 - 0.7 in/hr

Limiting permeability within 40 inches: 0.2 - 2.0 in/hr

Profile characteristics: medium and moderately fine textured material

Water Holding Capacity:

<u>Depth</u>	<u>Average Cumulative Available Water Capacity</u>	
1 foot	2.5	inches
2 feet	4.5	inches
3 feet	6.5	inches
4 feet	8.5	inches
5 feet	10.0	inches

(rounded to the nearest 0.5 inch; on-site values may vary)

Depth to lime: 10 - 20 inches

Surface pH: 6.1 - 7.8

EC - (maximum within 40 inches in dS/m): 0 - 4

SAR - (maximum within 40 inches): < 2

Typical Soils: Barnes, Makoti, Overly, Svea, Williams

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<sup>1/</sup>For slopes >3% refer to the water erosion hazard table

Irrigation Water Quality

Maximum allowable EC <1800

Maximum allowable SAR <6

Water Management Practices

These soils are conditional for irrigation due to moderate and moderately slow permeability and a potential for salinity increase in the subsoil. Salinity of the root zone should be monitored on a 3 to 5 year basis or more frequently if plant growth is restricted. Water, additional to that used for crop production may be required for leaching. Leaching should be done in the fall or early spring when crop requirements for water are low.

An irrigation scheduling system must be used (e.g., NDSU Extension Bulletin AE-792(revised), Commercial Irrigation Scheduling Service).

**NORTH DAKOTA IRRIGATION GUIDE**

**VERSION 1.5**

Irrigation Group: 9c  
Irrigation Class: Conditional  
Old Irrigation Group: 1A, 3D, 3A, 4A,

Slope:  $\leq$  3 percent <sup>1/</sup>

Drainage: moderately well and well drained

Surface texture: VFSL, FSL, SL, L, SIL, CL, SICL <sup>2/</sup>

Subsoil texture: L, SIL, CL, SICL

Surface intake rate for sprinkler irrigation: 0.5 - 0.7 in/hr

Limiting permeability within 40 inches: 0.6 - 2.0 in/hr

Profile characteristics: calcareous/medium and moderately fine textured materials

Water Holding Capacity:

<u>Depth</u>	<u>Average Cumulative Available Water Capacity</u>	
1 foot	2.5	inches
2 feet	4.5	inches
3 feet	6.5	inches
4 feet	8.5	inches
5 feet	10.0	inches

(rounded to the nearest 0.5 inch; on-site values may vary)

Depth to lime: 0 - 10 inches

Surface pH: 6.6 - 8.4

EC - (maximum within 40 inches in dS/m): < 4

SAR - (maximum within 40 inches): < 2

Typical Soils: Buse, Cherry <sup>3/</sup>, Esmond, Havre <sup>3/</sup>, Havrelon <sup>3/</sup>, Korchea <sup>3/</sup>, Lonna <sup>4/</sup>, Rusklyn, Sakakawea, Sutley, Zell, Zahl

<sup>1/</sup>For slopes >3% refer to the water erosion hazard table

<sup>2/</sup>VFSL, FSL and SL surface textures have an intake rate for sprinkler irrigation of 1.0 in/hr.

<sup>3/</sup>May be stratified and have a lower permeability rates

<sup>4/</sup>Lonna soils have ECs of 0 - 8 dS/m

Irrigation Water Quality

Maximum allowable EC <1800

Maximum allowable SAR <6

Water Management Practices

These soils are conditional for irrigation due to moderate and moderately slow permeability and a potential for salinity increase in the subsoil. Salinity of the root zone should be monitored on a 3 to 5 year basis or more frequently if plant growth is restricted. Water, additional to that used for crop production, may be required for leaching. Leaching should be done in the fall or early spring when crop requirements for water are low.

An irrigation scheduling system must be used (e.g., NDSU Extension Bulletin AE-792(revised), Commercial Irrigation Scheduling Service).

**NORTH DAKOTA IRRIGATION GUIDE**

**VERSION 1.5**

Irrigation Group: 10c  
Irrigation Class: Conditional  
Old Irrigation Group: 2B

Slope:  $\leq$  3 percent <sup>1/</sup>

Drainage: moderately well and well drained

Surface texture: L, CL, SICL

Subsoil texture: CL, SICL, SIC, C (>35% clay)

Surface intake rate for sprinkler irrigation: 0.1 - 0.5 in/hr

Limiting permeability within 40 inches: 0.06 - 0.6 in/hr

Profile characteristics: moderately fine to fine texture material

Water Holding Capacity:

<u>Depth</u>	<u>Average Cumulative Available Water Capacity</u>	
1 foot	2.5	inches
2 feet	4.5	inches
3 feet	6.5	inches
4 feet	8.5	inches
5 feet	10.5	inches

(rounded to the nearest 0.5 inch; on-site values may vary)

Depth to lime: 15 - 40

Surface pH: 6.1 - 7.8

EC - (maximum within 40 inches in dS/m): < 4

SAR - (maximum within 40 inches): < 4

Typical Soils: Bearpaw, Ethridge, Grail, Mondamin, Savage, Zeeland

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<sup>1/</sup>For slopes >3% refer to the water erosion hazard table.

Irrigation Water Quality

Maximum allowable EC <1000

Maximum allowable SAR <6

Water Management Practices

These soils are conditional for irrigation due to moderately slow and slow permeability and a potential for salinity increase in the subsoil.

Salinity of the root zone should be monitored on a 3 to 5 year basis or more frequently if plant growth is restricted. Water, additional to that used for crop production may be required for leaching. Leaching should be done in the fall or early spring when crop requirements for water are low. An internal drain system may be required for continued irrigation.

These soils are somewhat marginal for irrigation and irrigation of extensive areas should be avoided. If soils in this irrigation group exceed 20% of an irrigated area, an experienced soil scientist should be consulted.

An irrigation scheduling system must be used (e.g., NDSU Extension Bulletin AE-792(revised), Commercial Irrigation Scheduling Service).

**NORTH DAKOTA IRRIGATION GUIDE**

**VERSION 1.5**

Irrigation Group: 11c  
Irrigation Class: Conditional  
Old Irrigation Group: 2A

Slope:  $\leq$  3 percent <sup>1/</sup>

Drainage: moderately well and well drained

Surface texture: L, SIL, SICL

Subsoil texture: CL, SICL (>35% clay)

Surface intake rate for sprinkler irrigation: 0.1 - 0.7 in/hr

Limiting permeability within 40 inches: 0.06 - 0.2 in/hr

Profile characteristics: moderately fine and fine textured  
material that have a degraded natric horizon within 20  
inches

Water Holding Capacity:

<u>Depth</u>	<u>Average Cumulative Available Water Capacity</u>	
1 foot	2.5	inches
2 feet	4.5	inches
3 feet	6.0	inches
4 feet	8.0	inches
5 feet	10.0	inches

(rounded to the nearest  
0.5 inch; on-site values  
may vary)

Depth to lime: 20 - 30 inches

Surface pH: 5.6 - 7.3

EC - (maximum within 40 inches in dS/m): 2 - 8

SAR - (maximum within 40 inches): 5 - 13

Typical Soils: Aberdeen, Belfield, Cathay, Cresbard, Niobell

---

<sup>1/</sup>For slopes >3% refer to the water erosion hazard table

Irrigation Water Quality

Maximum allowable EC <1500

Maximum allowable SAR <4

Water Management Practices

These soils are marginal for irrigation and irrigation of extensive areas should be avoided. Continued irrigation could potentially cause restricted water intake and permanent soil damage. Salinity of the root zone should be monitored on a 3 to 5 year basis or more frequently if plant growth is restricted. Water, additional to that used for crop production may be required for leaching. Leaching should be done in the fall or early spring when crop requirements for water are low. An internal drain system may be required for continued irrigation.

If soils in this irrigation group exceed 20% of an irrigated area, an experienced soil scientist should be consulted.

An irrigation scheduling system must be used (e.g., NDSU Extension Bulletin AE-792(revised), Commercial Irrigation Scheduling Service).

**NORTH DAKOTA IRRIGATION GUIDE**

**VERSION 1.5**

Irrigation Group: 12c  
Irrigation Class: Conditional  
Old Irrigation Group: 3C

Slope:  $\leq$  3 percent <sup>1/</sup>

Drainage: well drained

Surface texture: L, SIL, SICL

Subsoil texture: L, SIL, SICL

Surface intake rate for sprinkler irrigation: 0.1 - 0.5 in/hr

Limiting permeability within 40 inches: 0.0 - 0.6 in/hr  
depending on texture of soft weathered bedrock

Profile characteristics: medium and moderately fine textured  
materials moderately deep (20-40 inches) to soft weathered  
bedrock

Water Holding Capacity:

<u>Depth</u>	<u>Average Cumulative Available Water Capacity</u>	
1 foot	2.5	inches
2 feet	4.5	inches
3 feet	6.5	inches
4 feet	.08	inches
5 feet	.08	inches

(rounded to the nearest  
0.5 inch; on-site values  
may vary)

Depth to lime: 10 - 20 inches

Surface pH: 6.1 - 7.8

EC - (maximum within 40 inches in dS/m): 2 - 8

SAR - (maximum within 40 inches): 0 - 4

Typical Soils: Amor, Chama <sup>2/</sup>, Moreau <sup>3/</sup>, Morton, Omio, Regent <sup>3/</sup>

---

<sup>1/</sup>For slopes >3% refer to the water erosion hazard table

<sup>2/</sup>Chama soils are calcareous to the surface

<sup>3/</sup>Moreau and Regent soils permeability is 0.06 - 2.0 in/hr

Irrigation Water Quality

Maximum allowable EC <1800

Maximum allowable SAR <6

Water Management Practices

These soils are marginal for irrigation due to moderately deep (20-40 inches) bedrock and the potential for lateral seepage. Avoid irrigating extensive areas or where stratification is evident and seeps are present. Salinity monitoring should be done on a 3 to 5 year basis or more frequently if plant growth is restricted.

If soils in this irrigation group exceed 20% of an irrigated area, an experienced soil scientist should be consulted.

An irrigation scheduling system must be used (e.g., NDSU Extension Bulletin AE-792(revised), Commercial Irrigation Scheduling Service).

**NORTH DAKOTA IRRIGATION GUIDE**

**VERSION 1.5**

Irrigation Group: 13c  
Irrigation Class: Conditional  
Old Irrigation Group: 7A, 3C

Slope:  $\leq$  3 percent <sup>1/</sup>

Drainage: well to somewhat excessively drained

Surface texture: LS, LFS, SL, FSL

Subsoil texture: LS, LFS, SL, FSL

Surface intake rate for sprinkler irrigation: 0.5 - 1.5 in/hr

Limiting permeability within 40 inches: 0.0 - 0.6 in/hr

Profile characteristics: coarse and moderately coarse textured  
material moderately deep (20-40 inches) to soft weather beds

Water Holding Capacity:

<u>Depth</u>	<u>Average Cumulative Available Water Capacity</u>	
1 foot	1.5	inches
2 feet	3.0	inches
3 feet	3.5	inches
4 feet	.08	inches
5 feet	.08	inches

(rounded to the nearest  
0.5 inch; on-site values  
may vary)

Depth to lime: 10 - 20 inches

Surface pH: 6.1 - 7.8

EC - (maximum within 4 inches in dS/m): 0

SAR - (maximum within 40 inches): 0

Typical Soils: FSL Amor, Beisigl, Lefor <sup>2/</sup>, Rhame, Tulser, Vebar

<sup>1/</sup>For slopes >3% refer to the water erosion hazard table

<sup>2/</sup>Lefor soils have lower pHs

Irrigation Water Quality

Maximum allowable EC <1800

Maximum allowable SAR <6

Water Management Practices

These soils are marginal for irrigation due to moderately deep (20-40 inches) bedrock and the potential for lateral seepage. Avoid irrigating extensive areas or where stratification is evident and seeps are present. Salinity monitoring should be done on a 3 to 5 year basis or more frequently if plant growth is restricted.

If soils in this irrigation group exceed 20% of an irrigated area, an experienced soil scientist should be consulted.

An irrigation scheduling system must be used (e.g., NDSU Extension Bulletin AE-792(revised), Commercial Irrigation Scheduling Service).

**NORTH DAKOTA IRRIGATION GUIDE**

**VERSION 1.5**

Irrigation Group: 14c  
Irrigation Class: Conditional  
Old Irrigation Group: 5A

Slope:  $\leq 3$  percent <sup>1/</sup>

Drainage: moderately well and well drained

Surface texture: LS, LFS, SL, FSL

Subsoil texture: L, CL, SICL

Surface intake rate for sprinkler irrigation: 0.5 - 1.5 in/hr

Limiting permeability within 40 inches: 0.2 - 0.6 in/hr

Profile characteristics: coarse textured material over medium and moderately fine textured material

Water Holding Capacity:

<u>Depth</u>	<u>Average Cumulative Available Water Capacity</u>	
1 foot	1.5	inches
2 feet	3.0	inches
3 feet	4.5	inches
4 feet	6.5	inches
5 feet	8.0	inches

(rounded to the nearest 0.5 inch; on-site values may vary)

Depth to lime: > 15 inches

Surface pH: 6.1 - 7.3

EC - (maximum within 40 inches in dS/m): 0 - 4

SAR - (maximum within 40 inches): < 2

Typical Soils: Dickey <sup>2/</sup>, Flaxton, Krem <sup>2/</sup>, Livona, Swenoda, Towner <sup>2/</sup>, Virgelle <sup>3/</sup>

---

<sup>1/</sup>For slopes >3% refer to the water erosion hazard table

<sup>2/</sup>Dickey, Krem, and Towner soils have lower AWC in the upper profile

<sup>3/</sup>May have lower permeability rates

Irrigation Water Quality

Maximum allowable EC <1800

Maximum allowable SAR <9

Water Management Practices

These soils are conditional for irrigation due to subsoil's moderately slow permeability and potential for salinity increase. Salinity of the root zone should be monitored on a 3 to 5 year basis or more frequently if plant growth is restricted. Water, additional to that used for crop production may be required for leaching. Leaching should be done in the fall or early spring when crop requirements for water are low.

An irrigation scheduling system must be used (e.g., NDSU Extension Bulletin AE-792(revised), Commercial Irrigation Scheduling Service).

**NORTH DAKOTA IRRIGATION GUIDE**

**VERSION 1.5**

Irrigation Group: 15c  
Irrigation Class: Conditional  
Old Irrigation Group: 3B

Slope:  $\leq$  3 percent <sup>1/</sup>

Drainage: somewhat poorly and poorly drained <sup>2/</sup>

Surface texture: L, SIL, SICL, SIC, C

Subsoil texture: L, SIL, SICL, SIC, C

Surface intake rate for sprinkler irrigation: 0.1 - 0.7 in/hr

Limiting permeability within 40 inches: 0.2 - 0.6 in/hr

Profile characteristics: medium to fine textured materials

Water Holding Capacity:

<u>Depth</u>	<u>Average Cumulative Available Water Capacity</u>	
1 foot	2.5	inches
2 feet	4.5	inches
3 feet	7.0	inches
4 feet	9.0	inches
5 feet	10.0	inches

(rounded to the nearest 0.5 inch; on-site values may vary)

Depth to lime: 0 - 10 inches

Surface pH: 6.6 - 8.4

EC - (maximum within 40 inches in dS/m): < 6

SAR - (maximum within 40 inches): < 3

Typical Soils: Antler, Bearden, Cashel <sup>3/</sup>, Galchutt <sup>4/</sup>, Hamerly, Neche <sup>4/</sup>, LaMoure, Perella <sup>4/</sup>, Wheatville, Suomi <sup>4/</sup>, Vallers, Wyard <sup>4/</sup>

<sup>1/</sup>For slopes >3% refer to the water erosion hazard table

<sup>2/</sup>Seasonal water table for somewhat poorly drained soil is generally >1.5 feet and poorly drained is 0-1.5 feet

<sup>3/</sup>Galchutt soils have lower permeability rates

<sup>4/</sup>These soils have lime at deeper depths

Irrigation Water Quality

Maximum allowable EC <1500

Maximum allowable SAR <6

Water Management Practices

Irrigate only if adequate surface and subsurface drainage has been provided. Salinity of the root zone should be monitored on a 3 to 5 year basis or more frequently if plant growth is restricted.

An irrigation scheduling system must be used (e.g., NDSU Extension Bulletin AE-792(revised), Commercial Irrigation Scheduling Service).

**NORTH DAKOTA IRRIGATION GUIDE**

**VERSION 1.5**

Irrigation Group: 16c  
Irrigation Class: Conditional  
Old Irrigation Group: 6C

Slope:  $\leq 3$  percent <sup>1/</sup>

Drainage: somewhat poorly and poorly drained <sup>2/</sup>

Surface texture: L, CL, SIL

Subsoil texture: L, CL

Surface intake rate for sprinkler irrigation: 0.1 - 0.5 in/hr

Limiting permeability within 40 inches: 0.6 - 2.0 in/hr in  
the upper part and  $> 6.0$  in/hr in the lower part

Profile characteristics: Aeric and Typic Calciaquolls, medium and  
moderately fine textured material over sand and gravel

Water Holding Capacity:

<u>Depth</u>	<u>Average Cumulative Available Water Capacity</u>	
1 foot	2.5	inches
2 feet	4.5	inches
3 feet	5.0	inches
4 feet	5.5	inches
5 feet	6.0	inches

(rounded to the nearest  
0.5 inch; on-site values  
may vary)

Depth to lime: 0 - 10 inches

Surface pH: 7.4 - 8.4

EC - (maximum within 40 inches in dS/m):  $< 2$

SAR - (maximum within 40 inches): 0

Typical Soils: Divide, Marysland, Vang variant drained

---

<sup>1/</sup>For slopes  $>3\%$  refer to the water erosion hazard table

<sup>2/</sup>Seasonal water table for somewhat poorly drained is generally  
 $>1.5$  feet and poorly drained is 0-1.5 feet

Irrigation Water Quality

Maximum allowable EC <3000

Maximum allowable SAR <9

Water Management Practices

Irrigate only if adequate surface and subsurface drainage has been provided. Salinity of the root zone should be monitored on a 3 to 5 year basis or more frequently if plant growth is restricted.

An irrigation scheduling system must be used (e.g., NDSU Extension Bulletin AE-792(revised), Commercial Irrigation Scheduling Service).

**NORTH DAKOTA IRRIGATION GUIDE**

**VERSION 1.5**

Irrigation Group: 17c  
Irrigation Class: Conditional  
Old Irrigation Group: 4B

Slope:  $\leq$  3 percent <sup>1/</sup>

Drainage: somewhat poorly and poorly drained <sup>2/</sup>

Surface texture: FSL, SIL, L

Subsoil texture: FSL, SIL, L

Surface intake rate for sprinkler irrigation: 0.5 - 1.0 in/hr

Limiting permeability within 40 inches: 0.6 - 2.0 in/hr

Profile characteristics: Aeric and Typic Calciaquolls, moderately coarse and medium textured material

Water Holding Capacity:

<u>Depth</u>	<u>Average Cumulative Available Water Capacity</u>	
1 foot	2.5	inches
2 feet	4.5	inches
3 feet	6.0	inches
4 feet	8.5	inches
5 feet	10.5	inches

(rounded to the nearest 0.5 inch; on-site values may vary)

Depth to lime: 0 - 10 inches

Surface pH: 7.4 to 8.4

EC - (maximum within 40 inches in dS/m): < 6

SAR - (maximum within 40 inches): 0 - 1

Typical Soils: Bonsack, Borup, Fram, Glyndon

---

<sup>1/</sup>For slopes >3% refer to the water erosion hazard table

<sup>2/</sup>Seasonal water table for somewhat poorly drained is generally >1.5 feet and poorly drained is 0-1.5 feet

Irrigation Water Quality

Maximum allowable EC <2250

Maximum allowable SAR <6

Water Management Practices

Irrigate only if adequate surface and subsurface drainage has been provided. Salinity of the root zone should be monitored on a 3 to 5 year basis or more frequently if plant growth is restricted.

An irrigation scheduling system must be used (e.g., NDSU Extension Bulletin AE-792(revised), Commercial Irrigation Scheduling Service).

**NORTH DAKOTA IRRIGATION GUIDE**

**VERSION 1.5**

Irrigation Group: 18c  
Irrigation Class: Conditional  
Old Irrigation Group: 8B

Slope:  $\leq$  3 percent <sup>1/</sup>

Drainage: somewhat poorly and poorly drained <sup>2/</sup>

Surface texture: CoSL, LFS, LS, FS, S

Subsoil texture: LFS, LS, S, FS

Surface intake rate for sprinkler irrigation: 0.5 - 1.5 in/hr

Limiting permeability within 40 inches: 2.0 - 20.0 in/hr

Profile characteristics: coarse and moderately coarse textured material

Water Holding Capacity:

<u>Depth</u>	<u>Average Cumulative Available Water Capacity</u>	
1 foot	1.5	inches
2 feet	2.5	inches
3 feet	3.0	inches
4 feet	4.0	inches
5 feet	5.0	inches

(rounded to the nearest 0.5 inch; on-site values may vary)

Depth to lime: 0 - 30 inches

Surface pH: 6.1 - 8.4

EC - (maximum within 40 inches in dS/m): 0 - 2

SAR - (maximum within 40 inches): 0 - 1

Typical Soils: Cormant, Fossum, Hamar, Karlsruhe, Minnewaukon  
Poppleton, Ulen, Wyrene <sup>3/</sup>

---

<sup>1/</sup>For slopes >3% refer to the water erosion hazard table

<sup>2/</sup>Seasonal water table for somewhat poorly drained is generally >1.5 feet and poorly drained is 0 - 1.5 feet

<sup>3/</sup>Underlain by sand/gravel at depths  $\geq$  20 inches

Irrigation Water Quality

Maximum allowable EC <3000

Maximum allowable SAR <12

Water Management Practices

Irrigate only if adequate surface and subsurface drainage has been provided. Salinity of the root zone should be monitored on a 3 to 5 year basis or more frequently if plant growth is restricted.

An irrigation scheduling system must be used (e.g., NDSU Extension Bulletin AE-792(revised), Commercial Irrigation Scheduling Service).

**NORTH DAKOTA IRRIGATION GUIDE**

**VERSION 1.5**

Irrigation Group: 19c  
Irrigation Class: Conditional  
Old Irrigation Group: 7B

Slope:  $\leq$  3 percent <sup>1/</sup>

Drainage: somewhat poorly and poorly drained <sup>2/</sup>

Surface texture: VFSL, FSL, SL

Subsoil texture: VFSL, FSL, SL

Surface intake rate for sprinkler irrigation: 0.5 - 1.25 in/hr

Limiting permeability within 40 inches: 2.0 - 6.0 in/hr

Profile characteristics: moderately coarse and medium textured  
material

Water Holding Capacity:

<u>Depth</u>	<u>Average Cumulative Available Water Capacity</u>	
1 foot	2.0	inches
2 feet	3.5	inches
3 feet	5.0	inches
4 feet	6.5	inches
5 feet	7.5	inches

(rounded to the nearest  
0.5 inch; on-site values  
may vary)

Depth to lime: Calciaquolls 0 - 10 inches  
Aquolls > 20 inches

Surface pH: 6.1 - 8.4

EC - (maximum within 40 inches in dS/m): 0 - 2

SAR - (maximum within 40 inches): 0 - 1

Typical Soils: Arveson, Tiffany, Tolna <sup>3/</sup>, Wyndmere

---

<sup>1/</sup>For slopes >3% refer to the water erosion hazard table

<sup>2/</sup>Seasonal water table for somewhat poorly drained is generally  
>1.5 feet and poorly drained is 0 - 1.5 feet

<sup>3/</sup>Underlain by gravel at depths of 16 - 40 inches

Irrigation Water Quality

Maximum allowable EC <3000

Maximum allowable SAR <12

Water Management Practices

Irrigate only if adequate surface and subsurface drainage has been provided. Salinity of the root zone should be monitored on a 3 to 5 year basis or more frequently if plant growth is restricted.

An irrigation scheduling system must be used (e.g., NDSU Extension Bulletin AE-792(revised), Commercial Irrigation Scheduling Service).

**NORTH DAKOTA IRRIGATION GUIDE**

**VERSION 1.5**

Irrigation Group: 20c  
Irrigation Class: Conditional  
Old Irrigation Group: 5B

Slope:  $\leq$  3 percent <sup>1/</sup>

Drainage: somewhat poorly and poorly drained <sup>2/</sup>

Surface texture: L, FSL, SL, LFS, LS

Subsoil texture: SL, SIL, L, CL

Surface intake rate for sprinkler irrigation: 0.5 - 1.5 in/hr

Limiting permeability within 40 inches: 0.2 - 2.0 in/hr

Profile characteristics: coarse and moderately coarse textured  
material over medium textured material

Water Holding Capacity:

<u>Depth</u>	<u>Average Cumulative Available Water Capacity</u>	
1 foot	1.5	inches
2 feet	3.0	inches
3 feet	4.5	inches
4 feet	6.5	inches
5 feet	8.0	inches

(rounded to the nearest  
0.5 inch; on-site values  
may vary)

Depth to lime: 0 -10

Surface pH: 7.4 - 8.4

EC - (maximum within 40 inches in dS/m): < 4

SAR - (maximum within 40 inches): < 2

Typical Soils: Espelie <sup>3/</sup>, Grimstad, Kratka <sup>4/</sup>, Rockwell

Include Arveson substratum, Wyndmere substratum and Wyrene substratum over medium or finer textured material.

<sup>1/</sup>For slopes >3% refer to the water erosion hazard table

<sup>2/</sup>Seasonal water table for somewhat poorly drained is generally >1.5 feet and poorly drained is 0 - 1.5 feet

<sup>3/</sup>Espelie soils are sandy over moderately fine to fine textured material

<sup>4/</sup>Depth to lime is > 20 inches and has lower pHs

Irrigation Water Quality

Maximum allowable EC <1800

Maximum allowable SAR <9

Water Management Practices

Irrigate only if adequate surface and subsurface drainage has been provided. Salinity of the root zone should be monitored on a 3 to 5 year basis or more frequently if plant growth is restricted.

An irrigation scheduling system must be used (e.g., NDSU Extension Bulletin AE-792(revised), Commercial Irrigation Scheduling Service).

**NORTH DAKOTA IRRIGATION GUIDE**

**VERSION 1.5**

Irrigation Group: 21c  
Irrigation Class: Conditional  
Old Irrigation Group: 2B

Slope:  $\leq$  3 percent <sup>1/</sup>

Drainage: moderately well and well drained

Surface texture: SIC, C

Subsoil texture: SIC, C

Surface intake rate for sprinkler irrigation: 0.1 - 0.2 in/hr

Limiting permeability within 40 inches: 0.06 - 0.2 in/hr

Profile characteristics: fine texture material

Water Holding Capacity:

<u>Depth</u>	<u>Average Cumulative Available Water Capacity</u>	
1 foot	2.5	inches
2 feet	4.5	inches
3 feet	6.0	inches
4 feet	8.0	inches
5 feet	10.0	inches

(rounded to the nearest 0.5 inch; on-site values may vary)

Depth to lime: 0 - 20 inches

Surface pH: 7.3 - 8.4

EC - (maximum within 40 inches in dS/m): 1 - 4

SAR - (maximum within 40 inches): 0 - 1

Typical Soils: Hoffmanville <sup>2/</sup>, Magnus, Marias, Nutley,  
Lawther <sup>3/</sup>, Lohler <sup>2/</sup>, Rolla, Scorio <sup>2/</sup>, Sinai

---

<sup>1/</sup>For slopes >3% refer to the water erosion hazard table

<sup>2/</sup>May be stratified and have lower permeability rates

<sup>3/</sup>May have higher ECs and/or SARs

Irrigation Water Quality

Maximum allowable EC <1000

Maximum allowable SAR <6

Water Management Practices

These soils are conditional for irrigation due to moderately slow and slow permeability and a potential for salinity increase in the subsoil.

Salinity of the root zone should be monitored on a 3 to 5 year basis or more frequently if plant growth is restricted. Water, additional to that used for crop production may be required for leaching. Leaching should be done in the fall or early spring when crop requirements for water are low. An internal drain system may be required for continued irrigation.

If soils in this irrigation group exceed 20% of an irrigated area, an experienced soil scientist should be consulted.

An irrigation scheduling system must be used (e.g., NDSU Extension Bulletin AE-792(revised), Commercial Irrigation Scheduling Service).

**NORTH DAKOTA IRRIGATION GUIDE**

**VERSION 1.5**

Irrigation Group: 22c  
Irrigation Class: Conditional  
Old Irrigation Group: 2C

Slope:  $\leq 3$  percent <sup>1/</sup>

Drainage: poorly drained and drained phases of poorly and very poorly drained

Surface texture: L, SIL, SICL, SIC, C

Subsoil texture: SIC, C

Surface intake rate for sprinkler irrigation: 0.1 - 0.4 in/hr

Limiting permeability within 40 inches: .06 - 0.2 in/hr

Profile characteristics: medium to fine textured material in the upper part and fine texture material lower part

Water Holding Capacity:

<u>Depth</u>	<u>Average Cumulative Available Water Capacity</u>	
1 foot	2.0	inches
2 feet	4.0	inches
3 feet	6.0	inches
4 feet	7.5	inches
5 feet	9.5	inches

(rounded to the nearest 0.5 inch; on-site values may vary)

Depth to lime: 0 > 40 inches

Surface pH: 6.1 - 8.4

EC - (maximum within 40 inches in dS/m): < 4

SAR - (maximum within 40 inches): 0

Typical Soils: Dimmick, Dovray, Enloe, Fargo, Grano, Hegne  
Ludden, Parnell, Southam, Tonka <sup>2/</sup>

---

<sup>1/</sup>For slopes >3% refer to the water erosion hazard table

<sup>2/</sup>May have loam or silt loam surface textures

Irrigation Water Quality

Maximum allowable EC <1000

Maximum allowable SAR <6

Water Management Practices

These soils are conditional for irrigation due to slow permeability, wetness and a potential for salinity increase. Irrigate only if adequate surface and subsurface drainage has been provided. Salinity of the root zone should be monitored on a 3 to 5 year basis or more frequently if plant growth is restricted. Water, additional to that used for crop production may be required for leaching. Leaching should be done in the fall or early spring when crop requirements for water are low. An internal drain system may be required for continued irrigation.

An irrigation scheduling system must be used (e.g., NDSU Extension Bulletin AE-792(revised), Commercial Irrigation Scheduling Service).

**NORTH DAKOTA IRRIGATION GUIDE**

**VERSION 1.5**

Irrigation Group: 23n <sup>1/</sup>  
Irrigation Class: Nonirrigable  
Old Irrigation Group: 1A

Slope:  $\geq$  6 percent slopes

Drainage: well to excessively drained

Surface texture: variable

Subsoil texture: variable

Surface intake rate for sprinkler irrigation: NA

Limiting permeability within 40 inches: NA

Profile characteristics: NA

Water Holding Capacity: NA

<u>Depth</u>	<u>Average Cumulative Available Water Capacity</u>
1 foot	inches
2 feet	inches
3 feet	inches
4 feet	inches
5 feet	inches

(rounded to the nearest 0.5 inch; on-site values may vary)

Depth to lime: variable

Surface pH: variable

EC - (maximum within 40 inches in dS/m): variable

SAR - (maximum within 40 inches): variable

Typical Soils: Buse Cabba, Flasher, Sioux

---

<sup>1/</sup>These soils have very severe limitations. Irrigation generally not feasible because of relief, depth or root restrictive substrata. Avoid irrigation.

If soils in this irrigation group exceed 10% of an irrigated area, an experienced soil scientist should be consulted.

**NORTH DAKOTA IRRIGATION GUIDE**

**VERSION 1.5**

Irrigation Group: 24n <sup>1/</sup>  
Irrigation Class: Nonirrigable  
Old Irrigation Group: 1B

Slope: < 6 percent

Drainage: poorly to well drained

Surface texture: variable

Subsoil texture: variable

Surface intake rate for sprinkler irrigation: variable

Limiting permeability within 40 inches: 0.01 - 0.2 in/hr

Profile characteristics: Typic/Leptic Natriborolls or  
Natraquolls

Water Holding Capacity: NA

<u>Depth</u>	<u>Average Cumulative Available Water Capacity</u>
1 foot	inches
2 feet	inches
3 feet	inches
4 feet	inches
5 feet	inches

(rounded to the nearest  
0.5 inch; on-site values  
may vary)

Depth to lime: 0 - 30 inches

Surface pH: 6.1 - 8.4

EC - (maximum within 40 inches in dS/m): > 4

SAR - (maximum within 40 inches): > 13

Typical Soils: Cavour, Daglum, Harriet, Heil, Lakota, Nahon,  
Noonan

---

<sup>1/</sup>These soils have very severe limitations. Irrigation generally not economically sound because of relief, sodicity, salinity, slow or very slow permeability, or root restrictive subsoil. Avoid irrigation.

If soils in this irrigation group exceed 10% of an irrigated area, an experienced soil scientist should be consulted.

**NORTH DAKOTA IRRIGATION GUIDE**

**VERSION 1.5**

Irrigation Group: 25n <sup>1/</sup>  
Irrigation Class: Nonirrigable  
Old Irrigation Group: 1C

Slope: < 6 percent

Drainage: poorly to well drained

Surface texture: variable

Subsoil texture: variable

Surface intake rate for sprinkler irrigation: variable

Limiting permeability within 40 inches: variable

Profile characteristics: moderate to strong salinity

Water Holding Capacity: NA

<u>Depth</u>	<u>Average Cumulative Available Water Capacity</u>
1 foot	inches
2 feet	inches
3 feet	inches
4 feet	inches
5 feet	inches

(rounded to the nearest  
0.5 inch; on-site values  
may vary)

Depth to lime: 0 - 10 inches

Surface pH: 6.6 - 8.4

EC - (maximum within 40 inches in dS/m): > 8

SAR - (maximum within 40 inches): 4 - 16

Typical Soils: Benz <sup>2/</sup>, Easby, Ojata, Playmoor, Sham, Vallers  
saline, Sham, Vanda <sup>2/</sup>

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<sup>1/</sup>These soils have very severe limitations. Irrigation generally  
not economically sound because of salinity. Avoid irrigation.

<sup>2/</sup>Well drained

If soils in this irrigation group exceed 10% of an irrigated area, an  
experienced soil scientist should be consulted.

**NORTH DAKOTA IRRIGATION GUIDE**

**VERSION 1.5**

Irrigation Group: 26n <sup>1/</sup>  
Irrigation Class: Nonirrigable  
Old Irrigation Group: 1E

Slope: < 6

Drainage: well to excessively well drained

Surface texture: variable

Subsoil texture: variable

Surface intake rate for sprinkler irrigation: variable

Limiting permeability within 40 inches: 0.0 - 0.2 in/hr

Profile characteristics: shallow to very shallow (< 20 inches)  
to stratified weathered bedrock

Water Holding Capacity: NA

<u>Depth</u>	<u>Average Cumulative Available Water Capacity</u>
1 foot	inches
2 feet	inches
3 feet	inches
4 feet	inches
5 feet	inches

(rounded to the nearest  
0.5 inch; on-site values  
may vary)

Depth to lime: 0 - 10

Surface pH: 6.1 - 8.4

EC - (maximum within 40 inches in dS/m): < 4

SAR - (maximum within 40 inches): < 2

Typical Soils: Cabba, Cohagen, Kloten, Dilts, Dupree,  
Flasher <sup>2/</sup>, Werner

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<sup>1/</sup>These soils have very severe limitations. Irrigation generally not economically sound because of depth or root restrictive substrata. Avoid irrigation.

<sup>2/</sup>May have higher permeability rates

If soils in this irrigation group exceed 10% of an irrigated area, an experienced soil scientist should be consulted.

**NORTH DAKOTA IRRIGATION GUIDE**

**VERSION 1.5**

Irrigation Group: 27n <sup>1/</sup>  
Irrigation Class: Nonirrigable  
Old Irrigation Group: 1F

Slope: < 1

Drainage: very poorly drained

Surface texture: variable

Subsoil texture: variable

Surface intake rate for sprinkler irrigation: variable

Limiting permeability within 40 inches: variable

Profile characteristics: undrained phases of very poorly  
drained

Water Holding Capacity: NA

<u>Depth</u>	<u>Average Cumulative Available Water Capacity</u>
1 foot	inches
2 feet	inches
3 feet	inches
4 feet	inches
5 feet	inches

(rounded to the nearest  
0.5 inch; on-site values  
may vary)

Depth to lime: NA

Surface pH: variable

EC - (maximum within 40 inches in dS/m): < 4

SAR - (maximum within 40 inches): < 2

Typical Soils: (undrained Fargo, Parnell, Ludden,  
Southam)...(peat and muck soils - Eramosh,  
Markey, Rifle, Seelyeville)

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<sup>1/</sup>These soils have very severe limitations. Irrigation generally  
not economically sound because of slow or very slow permeability  
or ponding. Avoid irrigation.

If soils in this irrigation group exceed 10% of an irrigated  
Area, an experienced soil scientist should be consulted.

**NORTH DAKOTA IRRIGATION GUIDE**

**VERSION 1.5**

Irrigation Group: 28n <sup>1/</sup>  
Irrigation Class: Nonirrigable  
Old Irrigation Group: 1G

Slope: variable

Drainage: variable

Surface texture: variable

Subsoil texture: variable

Surface intake rate for sprinkler irrigation: variable

Limiting permeability within 40 inches: variable

Profile characteristics: frequently flooded

Water Holding Capacity: NA

<u>Depth</u>	<u>Average Cumulative Available Water Capacity</u>
1 foot	inches
2 feet	inches
3 feet	inches
4 feet	inches
5 feet	inches

(rounded to the nearest 0.5 inch; on-site values may vary)

Depth to lime: variable

Surface pH: variable

EC - (maximum within 40 inches in dS/m): variable

SAR - (maximum within 40 inches): variable

Typical Soils: Banks, Fairdale, Trembles, channeled phases

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<sup>1/</sup>These soils have very severe limitations. Irrigation generally not economically sound because of frequent flooding. Avoid irrigation.

If soils in this irrigation group exceed 10% of an irrigated Area an experienced soil scientist should be consulted.

**NORTH DAKOTA IRRIGATION GUIDE**

**VERSION 1.5**

Irrigation Group: 29n <sup>1/</sup>  
Irrigation Class: Nonirrigable  
Old Irrigation Group: 1H

Slope: variable

Drainage: variable

Surface texture: variable

Subsoil texture: variable

Surface intake rate for sprinkler irrigation: variable

Limiting permeability within 40 inches: variable

Profile characteristics: extremely stony or bouldery  
surface

Water Holding Capacity: NA

<u>Depth</u>	<u>Average Cumulative Available Water Capacity</u>
1 foot	inches
2 feet	inches
3 feet	inches
4 feet	inches
5 feet	inches

(rounded to the nearest  
0.5 inch; on-site values  
may vary)

Depth to lime: variable

Surface pH: variable

EC - (maximum within 40 inches in dS/m): variable

SAR - (maximum within 40 inches): variable

Typical Soils: extremely stony phases of Barnes, Buse, Williams,  
Zahl

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<sup>1/</sup>These soils have very severe limitations. Irrigation generally not economically sound because surface stones or boulders are so numerous that wheeled power equipment can operate only along selected routes. Avoid irrigation.

If soils in this irrigation group exceed 10% of an irrigated area an experienced soil scientist should be consulted.

CONVERSIONS

VOLUME

1 gallon	=	231 cubic inches
1 gallon	=	0.1337 cubic feet
1 cubic foot	=	1,728 cubic inches
1 cubic foot	=	7.48 gallons
1 acre foot	=	43,560 cubic feet
1 acre foot	=	325,850 gallons

WEIGHT

1 gallon	=	8.34 pounds
1 cubic foot	=	62.4 pounds

FLOW

1 gpm	=	0.00223 cfs
1 gpm	=	1,440 gallons per day (24 hours)
1 cfs	=	7.48 gallons per second
1 cfs	=	448.8 gpm
1 cfs	=	1.98 acre feet per day (24 hours)
1 cfs	=	approximately 1 inch on 1 acre in 1 hour
100 gpm	=	.223 acre inches per hour

(cfs = cubic feet per second)  
 (gpm = gallons per minute)

PRESSURE

1 foot of water	=	62.4 pounds per square foot
1 foot of water	=	.433 pounds per square inch

1 pound of water per square inch = 2.31 feet of water

TABLE 2.1  
 Available Water Capacities

Soil Texture Classes	Surface Soil 0- 12"	Subsoil 12 - 36"	Lower Horizons 36 - 60"
<u>Inches per inch of soil</u>			
Coarse sand and gravel	.04 to .06	.03 to .05	.02 to .04
Sands	.07 to .09	.06 to .08	.05 to .07
Fine sands	.06 to .12	.06 to .11	.05 to .09
Loamy sands	.10 to .12	.09 to .11	.08 to .10
Loamy fine sand	.10 to .12	.10 to .13	.08 to .12
Sandy loams	.13 to .15	.12 to .14	.11 to .13
Fine sandy loams	.16 to .18	.15 to .17	.14 to .16
Loams and very fine sandy loams	.20 to .22	.17 to .19	.17 to .19
Silt loams	.22 to .24	.20 to .22	.20 to .22
Silty clay loams	.18 to .23	.16 to .20	.16 to .20
Sandy clay loams	.18 to .20	.16 to .18	.15 to .17
Clay loams	.17 to .19	.15 to .19	.14 to .16
Silty clays	.15 to .18	.14 to .17	.13 to .15
Clays	.15 to .18	.14 to .17	.13 to .15

The ranges of available water capacities are the adjusted water retention difference between 1/3-bar and 15-bar tension for the medium and fine textured soils, and between 1/10-bar and 15-bar for the moderately coarse and coarse textures.

TABLE 2.2

Approximate Reduction of Available Water in Soils as  
Related to the Conductivity of the Saturation Extract.  
(After Fox, Soil Science, 6-57)

