Compatibility of North Dakota Soils for Irrigation

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How to Use This Information

Irrigation increases the productivity of soils, increases the effectiveness and consistency of certain soil applied herbicides, and provides a more stable supply of farm products to food and feed processors. However, irrigation can degrade the quality of soil and cause crop yields to decline even to the point of field abandonment when soils and water are not compatible. There are examples throughout history of soil degradation and land abandonment due to improper irrigation. When irrigation acreage expands to new areas, determining soil and water compatibility is critical to sustain yields at high levels.

This is intended as a first step to help present and prospective irrigators understand the principles behind the irrigability of soils in North Dakota. **This circular should be used in combination with a soil survey of the land to be irrigated.** Each soil description may have different phases of slope and other properties which modify its suitability for irrigation. Consultation with a qualified soil scientist is highly recommended before making the decision to irrigate.

Classification of Soils for Irrigation Suitability

Soil series are classified for irrigation suitability. A soil series is based on distinguishing characteristics including the kind of subsoil layers, or horizons, the depth of each horizon, and the texture, color, carbonate content, sodium content, structure, organic matter and other diagnostic characteristics of each horizon.

Soil series are grouped into three irrigation categories – Non-irrigable (N), Conditional (C), and Irrigable (I). Non-irrigable soils should not be irrigated by any water source and under any circumstance. The decision to classify a soil as non-irrigable is based on the knowledge that irrigation will not benefit the irrigator economically and may decrease the productivity of the soil.

A conditional soil can be irrigated under a high degree of management that will vary according to the quality of water and soil properties. Specific recommendations for conditional soil management are important for sustaining irrigation and soil health for the future.

An irrigable soil can be irrigated with most irrigation water under most circumstances. A high level of management is advised to increase the efficiency of the operation and decrease possible nutrient or pesticide pollution due to excess water movement through the soil.

Some fields will contain soils that fall into two or perhaps all three irrigation categories. Assistance of a qualified soil professional is advised for fields with conditional soils. An irrigation system should be set up to exclude areas that fall into the non-irrigable category, but this may not always be possible. If most of the field falls into the irrigable category, but significant areas are conditional and non-irrigable, management decisions will be strongly influenced by the soils in these catagories. Required management may include annual soil testing for nitrates, sodium and salts, addition of calcium amendments, lower nitrogen fertilizer rates, drainage tile, or other special activities. Special management methods will depend on the reason for placement into conditional or non-irrigable classes.

The special requirements for irrigating small areas of conditional or nonirrigable soils should be part of the estimate of total irrigation costs. From a practical point of view, separate management of these small areas in irrigated fields is not likely to occur. As site-specific farming techniques are developed, more practical methods of managing soil inclusions will become available. Research is underway to develop an irrigation system that will vary the amount of water given to an area under pivot irrigation on-the-go. However, this technology may not be adopted commercially for some time.

Irrigation Suitability Groups

Understanding the irrigability of an area begins with knowledge of local soil series and the way they are represented on a soil survey map. When soil boundaries are drawn on soil maps, the soil mapping unit is not purely one soil. The other soils present are of minor extent and are called mapping unit inclusions. Mapping unit inclusions should be considered when making an irrigation management decision. Soil series have been evaluated and placed into groups called Irrigability Groups.

Finding and using a soil survey

Soil surveys for each county are available through the local NRCS office. Copies of the soil survey for a North Dakota county may also be found in county extension offices, local libraries, the NDSU library and the NDSU Soils Department. The soil survey contains maps that show the different soils on each parcel of land in the county. Information regarding these soils and their use, such as general irrigation suitability is also included in the soil survey. NDSU Extension Bulletin EB-60, Soil Survey: the Foundation for Productive Natural Resources Management, provides details regarding the use of soil survey reports.

Determining the soils within a field is all that is necessary to use the information in this circular. The irrigability classification system and recommendations are based on the North Dakota Irrigation Guide. This document should be referred to for a more comprehensive discussion of soils and irrigation compatibility, compared to the irrigation suitability ratings found in the county soil survey report. Questions about how to use a soil survey can be answered by the local NRCS office or the local county extension office. Reviewing the irrigability ratings with a qualified soil scientist such as a registered North Dakota Professional Soil Classifier is always a good idea before the decision to irrigate is made.

Table 1a. Alphabetical list of soil series, irrigability group and irrigability. Soil type names Aastad - Grassna.

Soil Series	Group	Soil Series	Group	Soil Series	Group
Aastad	C, 3D	Brandenburg	N,1A/I,10	Eckman	I, 4A
Aberdeen	N, 2A	Brantford	I, 6A	Edgeley	N, 3C
Absher	N, 1B	Breien	C, 7A	Egeland	I, 7A
Acel	C, 2B	Brisbane	I, 6B	Ekalaka	N, 1B
Alkabo	N, 1B	Bryant	I, 4A	Embden	I, 7A
Amor	N, 3C	Buse	N,1A/C,3D	Emrick	I, 4A
Antler	C, 3B	Cabba	N, 1A	Enloe	C, 2C
Appam	I, 8A	Cabbart	N, 1A	Eramosh	C, 2C
Aquents	N,	Cashel	C, 3B	Esmond	N,1A/I,4A
Arikira	N, 1A	Cathay	N, 2A	Etheridge	C, 2B
Arnegard	I, 4A	Cathro	N, 1F	Evridge	N, 1B
Arveson	C, 7B	Cavour	N, 1B	Exline	N, 1B
Arvilla	I, 8A	Chama	N, 3C	Fairdale	I, 4A
Aylmer	I, 9	Chanta	I, 6B	Falkirk	C, 3D
Baahish	I, 6A	Cherry	C, 3A	Falsen	I, 9
Badland	N, 1A	Chinook	C, 7A	Fargo	C, 2C
Banks	I, 8A	Claire	I, 9	Farland	C, 3A
Bantry	C, 8B	Clontarf	I, 8A	Farnuf	C, 3A
Barnes	C, 3D	Coe	N,1A/I,10	Felor	C, 3A
Bearden	C, 3B	Cohagen	N, 1A	Flasher	C, 3A
Bearpaw	C, 2B	Colvin	C, 3B	Flaxton	C, 5A
Beisigl	C, 7A	Cormant	C, 3B	Fleak	N, 1A
Belfield	N, 2A	Cozberg	I, 7A	Foldahl	C, 5A
Benoit	C, 6C	Cresbard	N, 2A	Fordville	I, 6B
Benz	C, 1C	Daglum	N, 1B	Forman	C, 3D
Beotia	C, 3A	Darnen	I, 4A	Fossum	C, 3D
Bigsandy	C, 3B	Desart	N, 1B	Fram	C, 4B

Binford	I, 8A	Dickey	C, 5A	Fulda	C, 2C
Blanchard	I, 8A	Dilts	N, 1E	Galchutt	C, 2C
Blown-Out Land	N, 1A	Dimmick	C, 2C	Gardena	I, 4A
Bohnsack	C, 4B	Divide	C, 6C	Gilby	C, 3B
Borup	C, 4B	Dogtooth	N, 1B	Glendive	I, 7A
Bottineau	C, 3D	Dooley	C, 3D	Glyndon	C, 4B
Bowbells	C, 3D	Doran	C, 2C	Golva	I, 4A
Bowdle	I, 6B	Dovray	C, 2C	Grail	C, 2B
Boxwell	N, 3C	Dupree	N, 1E	Grano	C, 2C
Bowdoin	N, 1D	Easby	N, 1C	Grassna	I, 4A

For explanation of irrigability group, see pages - following.
N = nonirrigable, C = conditional, I = irrigable.

Table 1b. Alphabetical list of soil types, irrigabability group and irrigability. Soil type names Great Bend-Oburn.

Soil Series	Group	Soil Series	Group	Soil Type	Group
Great Bend	I, 4A	La Prairie	I, 4A	Makoti	C, 3A
Grimstad	C, 5B	Ladelle	I, 4A	Maladay	I, 7A
Gwinner	C, 2B	Ladner	N, 1B	Mandan	I, 4A
Hamar	C, 2B	Lakoa	N, 1A	Manfred	N, 1B
Hamerly	C, 3B	Lakota	N, 1B	Manning	I, 8A
Hamlet	C, 3D	Lallie	N, 1C	Marias	C,2B/N,1C
Hanly	I, 8A	Lambert	I, 4A	Markey	N, 1F
Harriet	N, 1B	Lamoure	C, 3B	Marmarth	N, 3C
Hattie	C, 2B	Langhei	N,1A/C,3D	Marysland	C, 6C
Havre	I, 4A	Lankin	C, 3D	Maschetah	I, 4A
Haverlon	I, 4A	Lanona	C, 5A	Mauvais	C, 3B
Heda	I, 8A	Larson	N, 1B	Max	C, 3D
Hegne	C, 2C	Lawther	C, 2B	McDonaldsville	C, 2C
Heil	N, 1B	Lefor	N, 3C	McKeen	C, 3B
Heimdal	I, 4A	Lehr	I, 6A	McKenzie	N, 1B
Hidatsa	I, 6B	Lemert	N, 1B	Mekinock	N, 1B
Hoffmanville	C, 6B	Letcher	N, 1B	Metigoshe	I, 9
Inkster	I, 7A	Lihen	I, 8A	Minnewaukan	C, 8B
Janesburg	N, 1B	Lindaas	C, 2C	Miranda	N, 1B
Karlsruhe	C, 8B	Linton	I, 4A	Mondamin	C, 2B
Kelvin	C, 3D	Lisam	N, 1E	Moreau	N, 1D
Kensal	I, 6A	Lismore	C, 3D	Morton	N, 3C
Kirby	N,1A/I,10	Littlemo	C, 6B	Mott	I, 7A
Kloten	N, 1E	Livona	C, 5A	Nahon	N, 1B
Korchea	I, 4A	Lohler	C, 2C	Neche	C, 3B
Korell	I, 4A	Lohnes	I, 9	Niobell	N, 2A
Krantzburg	I, 4A	Lonna	I, 3A	Nobe	N, 1B
Kratka	C, 5B	Ludden	C, 2C	Noonan	N, 1B
Krem	C, 5A	Maddock	I, 8A	Nutley	C, 2B
Kremlin	I, 4A	Magnus	C, 2B	Oburn	N, 1B

For explanation of irrigability groups, see pages - following.
N = Nonirrigable, C = conditional, I = irrigability.

Table 1c. Alphabetical list of soil types, irrigability group and irrigability. Soil type names Ojata-Zeona.

Soil Series	Group	Soil Series	Group	Soil Series	Group
Ojata	N, 1C	Schaller	I, 8A	Vanda	N, 1C
Oldham	C, 2C	Scorio	C, 2C	Vang	I, 6B
Olga	C, 2B	Searing	I, 6B	Vebar	I, 7A
Omio	N, 3C	Seelyeville	N, 1F	Velva	I, 7A
Osakis	I, 8A	Sen	N, 3C	Venlo	C, 8B
Overly	C, 3A	Serden	N,1A/I,9	Venendrye	C, 8B
Parnell	C, 2C	Seroco	N,1A/I,9	Viborg	C, 3D
Parshall	I, 7A	Sham	N, 1D	Viking	C, 2C
Patent	N, 1D	Shambo	I, 4A	Virgelle	C, 5A
Peever	C, 2B	Sinai	C, 2B	Wabek	N,1A/I,10
Perella	C, 3B	Sinnigam	N, 1E	Wahpeton	C, 3B
Playmoor	N, 1C	Sioux	N,1A/I,10	Walsh	C, 3D
Poppleton	C, 2B	Southam	C, 2C	Waham	I, 8A
Portal	N, 1B	Spottswood	I, 6B	Wamchaska	I, 9

Rauville	C, 3B	Stady	I, 6B	Wanagan	I,6A or 6B
Reeder	N, 3C	Stirum	N, 1B	Warsing	I, 6A
Regan	C, 3B	Straw	I, 4A	Watrous	N, 3C
Regent	C, 2B	Suomi	C, 2B	Waukon	C, 3D
Renshaw	I, 6A	Sutley	I, 4A	Wayden	N, 1A
Rhame	I, 7A	Svea	C, 3D	Werner	N, 1A
Rhoades	N, 1B	Swenoda	C, 5A	Wheatville	C, 3B
Ridgelawn	C, 6B	Tally	I, 7A	Whitebird	N, 1B
Rifle	N, 1F	Tansem	I, 4A	Wildrose	C, 2B
Ringling	N,1A/I,10	Telfer	I, 4A	Williams	C, 3D
Rockwell	C, 5B	Temnick	C, 3D	Wilton	C, 3D
Rollette	C, 2B	Tiffany	C, 7B	Wolf Point	N, 1C
Rollis	C, 3B	Tinsley	N,1A/I,10	Wyard	C, 4B
Rolla	C, 2B	Toby	I, 7A	Wyndmere	C, 7B
Rondell	I, 4A	Tolna	C, 7B	Wyrene	C, 7B
Roseglen	I, 4A	Tonka	C, 2C	Yawdin	N, 1A
Rosewood	C, 8B	Totten	N, 1B	Yegen	C, 3A
Rusklyn	I, 4A	Towner	C, 5A	Yetull	I, 9
Ruso	I, 8A	Trembles	I, 7A	Zahl	N,1A/I,4A
Ryan	N, 1B	Tusler	N, 1A	Zeeland	C, 2B
Sakakawea	I, 4A	Ulen	C, 8B	Zell	N,1A/I,4A
Savage	C, 2B	Vallers	C, 3B	Zeona	I, 9

For explanation of irrigability groups, see pages - following.
N = nonirrigable, C = conditional, I = irrigable.

Irrigability Groups

In the following text, "<" means less than and ">" means greater than.

Non-Irrigable (NI)

These are soils with very severe limitations due to slope, sodicity, salinity, excessively slow permeability and/or root restrictive subsoil layering. Irrigation is strongly discouraged. Irrigation will cause soil quality to be degraded and reduce the productivity of the soils for future generations of farm producers. Different phases of each soil series will modify irrigation recommendations.

1A. Non-irrigable because of slope

Arikara
Badland
Blow-out Land
Brandenburg, slopes >5%
Buse, slopes, >5%
Cabba
Cabbart
Coe
Cohagen
Dumps
Esmond, slopes >5%
Flasher
Fleak
Kirby, slopes > 5%
Langhei, slopes >5%
Lakoa
Ringling, slopes >5%
Serden, slopes >5%
Seroco, slopes >5%
Sioux, slopes >5%
Tinsley, slopes >5%
Tusler, slopes >5%
Wabek, slopes >5%
Wayden, slopes >5%
Werner
Yawdin
Zahl, slopes >5%
Zell, slopes >5%

1B. Non-irrigable because of sodicity

Absher
Alkabo
Cavour
Daglum
Desart
Dogtooth
Ekalaka
Evridge
Exline
Harriet
Heil
Janesburg
Ladner
Lakota
Larson
Lemert
Letcher
Manfred
McKenzie
Mekinock
Miranda
Nahon
Nobe
Noonan
Oburn
Portal
Rhoades
Ryan
Slickspots
Stirum
Totten
Whitebird

1C. Non-irrigable because of salinity

Benz
Easby
Lallie
Lambeth
Ojata
Playmoor
Vanda
Wolf Point

1D. Non-irrigable because of extremely slow permeability

Bowdoin
Moreau
Patent
Sham

1E. Non-irrigable because of restrictive subsoil layering

Dilts
Dupree
Kloten
Lisam
Livona
Sinnigam

1F. Non-irrigable because of very poorly drained muck and peat soils

Cathro
Markey
Rifle
Seelyeville

2A. Non-irrigable because of high salts in the subsoil

Aberdeen
Belfield
Cathay
Cresbard
Niobell

3C. Non-irrigable because of shallow depth to bedrock and lateral seepage hazard

Amor
Boxwell
Chama
Edgeley
Lefor
Marmarth
Morton
Omio
Reeder
Sen
Watrous

Conditional Soils (C)

Conditional soils can be irrigated under a high level of management. Soil conditions which contribute to conditional status are the presence of salts, poor drainage properties, the presence of subsurface layering and the need for supplemental surface and subsurface drainage. Irrigation without high levels of management may degrade soil quality for future generations, but can be successfully irrigated if recommendations are followed. Soil phases of each soil series may modify irrigation recommendations.

2B. Fine-textured, well and moderately drained with moderately or slow permeability and high available water capacity. Classified conditional because of salinity hazard and poor internal drainage.

Acel
Bearpaw
Etheridge
Frazer
Grail
Gwinner
Hattie
Lawther
Magnus
Marias
Mondomin
Nutley
Olga
Peever
Regent
Rolette
Rolla
Savage
Sinai
Wildrose
Zeeland

Irrigation water quality

Maximum allowable EC <1000 umhos/cm
Maximum allowable SAR <6

Irrigation management

See NDSU Extension Service Circular AE-792 (revised), Irrigation Scheduling by the Checkbook Method, for irrigation scheduling information.

2C. Fine textured soils with poor and very poor drainage and slow, very slow permeability and high available water capacity

Dimmick
Doran
Dovray
Enloe
Eramosh
Fargo
Fulda
Galchutt
Grano
Hegne
Lindaas
Lohler
Ludden
McDonaldsville
Oldham
Parnell
Quam
Southam
Scorio
Tonka
Viking

Irrigation water quality
Maximum allowable EC <1000 umhos/cm
Maximum allowable SAR <6

Irrigation management
See NDSU Extension Bulletin AE-792 (revised) for irrigation scheduling information.

3A. **Medium to moderately fine textured. Well drained to moderately well drained with moderately slow permeability and high available water holding capacity. Conditional due to the hazard of salt buildup.**

Beotia
Cherry
Farland
Farnuff
Feler
Makoti
Overly

Irrigation water quality
Maximum allowable EC <1500 umhos/cm
Maximum allowable SAR <6

Irrigation management
Salinity of the root zone should be monitored every three to five years. Extra water may be required to leach out salts periodically if soil moisture conditions during the fall through early spring do not provide for water movement through the soil. Leaching should be done in the fall or early spring when crop requirements for water are low. The application of 3/4 inches of water in excess of field capacity should pass through the crop root zone.

3B. **Medium, moderately fine and fine textured, moderately well drained to poorly drained soils with slow to moderately slow permeability and high water holding capacity. Conditional because of the need for supplemental surface and subsurface drainage.**

Antler
Bearden
Big Sandy
Cashell
Colvin
Flom
Gilby
Hamerly
LaMoure
Mauvais
McKeen
Neche
Perella
Rauville
Regan
Roliss
Suomi
Vallers
Wahpeton
Wheatville

Irrigation water quality
Maximum allowable EC <1500 umhos/cm
Maximum allowable SAR <6

Irrigation management
Monitor for salinity every 3-5 years. See NDSU Extension Service Circular AE-792 (revised) for irrigation scheduling information.

3D. **Medium and moderately fine textured soils, well drained with soft bedrock at 20 to 40 inches, moderate and moderately slow permeability, and high water holding capacity. These soils are conditional due to slow internal drainage and the hazard of salinity buildup.**

Aastad
Barnes
Bottineau
Bowbells
Buse, slope
Kelvin
Kittson
Forman
Hamlet
Temvik
Walsh
Waukon
Williams

Irrigation water quality
Maximum allowable EC <1800 umhos/cm
Maximum allowable SAR <6

Irrigation management
Extra water may be required for leaching if fall through spring precipitation does not provide at least 3/4 inches of water in excess of field capacity passing through the root zone.

4B. **Medium textured, somewhat poorly drained and poorly drained with moderate permeability and high water holding capacity. Conditional because of the need for supplemental surface and subsurface drainage.**

Bohnsack
Borup
Fram
Glyndon
Wyard

Irrigation water quality

Maximum allowable EC <2250 umhos/cm
Maximum allowable SAR <6

Irrigation management

See NDSU Extension Service Circular AE-792 (revised) for irrigation scheduling information.

5A. Coarse and moderately coarse textured, well to moderately drained soils with glacial till or lake sediments at 20 to 40 inches, moderately slow permeability and moderate water holding capacity. Conditional due to restricted drainage because of subsoil stratification. Salinity should be monitored every 3 to 5 years. Drain-age systems may be required for adequate drainage.

Dickey
Foldahl
Flaxton
Krem
Lanona
Livona
Swenoda
Towner
Virgelle

Irrigation water quality

Maximum allowable EC <1800 umhos/cm
Maximum allowable SAR <9

Irrigation management

See NDSU Extension Bulletin AE-792 for irrigation scheduling information.

5B. Moderately coarse textured, somewhat poorly drained and poorly drained soils with glacial till or lake sediments at 20 to 40 inches, moderately slow permeability and moderate water holding capacity.

Grimstad
Kratka
Rockwell

Irrigation water quality

Maximum allowable EC <1800 umhos/cm
Maximum allowable SAR <9

Irrigation management

Surface and subsurface drains required.

6C. Medium textured, somewhat poorly drained and poorly drained soils with coarse sand and gravel at or just below the rooting zone, moderate to moderately rapid permeability and moderate to low water holding capacity. Conditional because of rapid water movement and need for supplemental drainage.

Benoit
Divide
Marysland

Irrigation water quality

Maxiumum allowable EC <3000 umhos/cm
Maximum allowable SAR <6

Irrigation management

Surface and subsurface drains required.

7B. Medium and moderately coarse textured, somewhat poorly drained and poorly drained soils with moderately rapid permeability and low to moderate water holding capacity. Conditional because of the need for supplemental drainage.

Arveson
Tiffany
Tolna
Wyndmere
Wyrene

Irrigation water quality

Maxiumum allowable EC <3000 umhos/cm
Maximum allowable SAR <12

Irrigation management

Surface and subsurface drained required.

8B. **Coarse textured, somewhat poorly drained and poorly drained soils with rapid permeability and low water holding capacity. Conditional because of the requirement for supplemental drainage.**

Bantry
Cormant
Fossum
Hamar
Karlsruhe
Minnewaukan
Poppleton
Rosewood
Ulen
Venlo
Verendrye

Irrigation water quality

Maximum allowable EC <3000 umhos/cm
Maximum allowable SAR <12

Irrigation management

Surface and subsurface drainage required.

Irrigable Soils (I)

Irrigable soils need generally less management than conditional soils. Even though the soils are in an irrigable class, good irrigation management is essential. For example, Arnegard, Grassna and LaDelle are in the 4A irrigable class. However, in times of soil wetness, these sites may receive additional water due to surface and subsurface water flow. This additional water may increase salinity and sodicity beyond what might be expected with normal irrigation. Use of lower quality water than recommended can lower the productivity of the soils from salts and sodium. Different phases of each soil series may modify irrigation recommendations.

4A. **Medium and moderately fine textured, well and moderately well drained soils with moderate permeability and high water holding capacity.**

Arnegard
Bryant
Darnen
Eckman
Emrick
Esmond, slope
Havre
Havrelon
Heimdal
Korchea
Korell
Mandan
Randell
Roseglen
Rusklyn
Sakakawea

Irrigation water quality

Maximum allowable EC <2250 umhos/cm
Maximum allowable SAR <6

Irrigation management

See NDSU Extension Service Circular AE-792 (revised) for irrigation scheduling information.

6A. **Medium textured, well and moderately well drained soils with coarse sand and gravel at 10 to 20 inches, moderate or moderately rapid permeability, low water holding capacity.**

Baahish
Brantford
Kensal
Lehr
Renshaw
Warsing

Irrigation water quality

Maximum allowable EC <3000 umhos/cm
Maximum allowable SAR <9

Irrigation management

See NDSU Extension Service Circular AE-792 (revised) for irrigation scheduling information.

6B. **Medium textured, well drained soils with coarse sand and gravel at 20 to 40 inches, moderate or moderately rapid permeability, and moderate or low water holding capacity.**

Bowdle
Fordville
Littlemo
Spottswood

Brisbane
Chanta
Hidatsa
Hoffmanville
Ridgelawn
Searing
Stady
Vang

Irrigation water quality

Maximum allowable EC <3000 umhos/cm
Maxiumum allowable SAR <9

Irrigation management

See NDSU Extension Service Circular AE-792 (revised) for irrigation scheduling information.

7A. Moderately coarse textured, well and moderately well drained soils with moderately rapid permeability, moderate water holding capacity.

Conditional due to underlying weathered sandstone 20 to 40 inches

Beisigl
Breien
Cozberg
Malachy
Rhame
Vebar

Completely irrigable

Chinook
Egeland
Embden
Glendive
Inkster
Velva
Mott
Parshall
Tally
Toby
Trembles

Irrigation water quality

Maximum allowable EC <3000 umhos/cm
Maximum allowable SAR <12

Irrigation management

See NDSU Extension Service Circular AE-792 (revised) for irrigation scheduling information.

8A. Moderately coarse and coarse textured, somewhat excessively to moderately well drained soils. Rapid permeability and low water holding capacity. Some shallow to gravel.

Depth to gravel in parentheses

Appan
Arvilla (12-25 inches)
Banks
Binford (12-25 inches)
Breien
Clontarf
Hanly
Hecla
Lihen
Maddock
Manning (20-40 inches)
Osakis (12-25 inches)
Ruso (20-40 inches)
Shaller
Telfer
Walum (12-25 inches)

Irrigation water quality

Maximum allowable EC <3000 umhos/cm
Maxiumum allowable SAR <12

Irrigation management

See NDSU Extension Service Circular AE-792 (revised) for irrigation scheduling information.

9A. Coarse textured soils with rapid permeability, low water holding capacity.

Alymer
Falsen
Seroco, slopes

Irrigation water quality

Maximum allowable EC <3000 umhos/cm
Maximum allowable SAR <12

Irrigation management

Frequent irrigations will be required.

10. Medium to coarse textured, excessively and well drained soils with coarse sand and gravel or porcelainite (scoria) at less than 10 inches, rapid permeability and very low water holding capacity.

(The following soils will fall into group IA if slope is

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greater than 5%.)
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Brandenburg     Kirby       Sioux      Wabek
Coe             Ringling    Tinsley
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Irrigation water quality
Maximum allowable EC <3000 umhos/cm
Maximum allowable SAR <12

Irrigation management
Light, frequent irrigations will be required. These soils may be susceptible to drought even under irrigation.

Important Topographic and Soil Properties Affecting Irrigability

Soil depth

Soil depth depends on the potential rooting depth of plants to be grown and any restrictions within the soil that may hinder rooting depth. The rooting depth of canola may only be about 3 feet, while for alfalfa the rooting depth may be over 4 feet. Discontinuities in the soil from layers of sand, gravel or bedrock may serve to physically limit rooting depth.

Soil texture

The percentage of sand, silt and clay sized particles in the soil is the soil texture. Texture influences other properties such as water holding capacity, infiltration rate and internal drainage.

Soil structure

Soil particles are arranged into aggregates through the action of weather, organic matter attraction, soil mineral composition, time and outside physical forces such as compaction, root growth and animal activities. Soils containing aggregates unstable under irrigation may require special management. Movement of water into and within soils is partially dependent on soil structure.

Water holding capacity

Water holding capacity is defined as the soil water retained between a suction of 0.1-0.5 bars (field capacity) and 15 bars (permanent wilting point). Water held between these two suction values is regarded as plant available water. A silt loam soil holds about 2.25-2.5 inches of water per foot of soil, while a sandy loam can hold only about 1 inch of water per foot. Soils with higher organic matter generally hold more water than a soil with lower organic matter.

Slope

Slope is important in determining the water runoff potential from a field. Water and soil losses from runoff reduce both short-term and long-term economic returns. Generally, more run-off will occur on fine textured soils compared to coarser textured soils on similar slope.

Infiltration rate

Infiltration rate is the relative rate that water penetrates and moves into the soil. A faster infiltration rate allows less runoff than soil with slower rates.

Internal drainage

Internal drainage describes the degree and persistence of soil wetness and is influenced by slope, soil infiltration rate, soil texture (percent gravel,sand, silt and clay), depth to water table and depth to impermeable layers. Excessively drained soils often have crop production problems related to lack of water and nutrients due to rapid movement of water through the soil profile. On the other hand, soils with poor internal drainage that remain wet may increase disease potential to crops, cause denitrification losses of nitrogen fertilizer or cause accumulation of salts. Soils with good internal drainage respond well to irrigation. Irrigation water is retained for use by crops, while allowing sufficient movement of water within the soil to minimize saturation of pore space.

Salinity

High levels of soil salts usually result from a water table near the soil surface. High salt levels may reduce crop yields and increase the water requirement of plants. Irrigation may decrease the depth to water table over time in some soils, increasing the risk of salinization. Irrigation water containing high salt levels may also increase the risk of salinization. As salinity increases, crop productivity will decrease. Salinity is a soil property that changes relatively quickly with time compared to other properties such as texture. 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.

Sodicity

Sodium (Na) affects the physical condition of the soil by dispersing aggregates. The soil becomes pasty when wet and develops a condition called "puddling", where water remains on the surface for an extended period. The soil becomes hard when dry, and its permeability to water and air is reduced. If irrigation causes sodium salts to accumulate near the soil surface, increased sodium levels may cause yield reduction. Sodium buildup usually occurs slowly and may not be easily detected from one year to the next. Regular soil testing is recommended to determine long-term trends in sodium accumulation. Sodium buildup is one of the most serious long term dangers to productivity decline due to irrigating some soils. Water management becomes difficult, seed germination may be poor and roots cannot penetrate well into the soil.

Other More Technical Information

Important chemical characteristics of water affecting irigability of North Dakota soils

Salinity—The salt content of irrigation water is important for the long-term irrigability of many soils. The allowable salt content depends on permeability of the soil, beginning soil salt content, depth to the water table, drainage and texture.

Salts are detected by measuring the flow of electrical current through a sample of soil or water. The more salts in a sample, the less resistance to electrical current and greater the electrical conductivity (EC). Most labs in North Dakota measure conductivity on a 1:1 by weight soil to water slurry. Soils with electrical conductivity greater than 1 dS/cm in the slurry method can decrease the yield potential of some crop plants.

Modification of the water table may be neccessary before irrigation is performed. In areas where salinity is increasing, fertilizer additions should be reduced. Salt problems may be serious enough to discourage irrigation of some fields. See NDSU Extension Service Circular SF-1087, Managing Saline Soils in North Dakota, and EB-57, Salinity and Sodicity in North Dakota Soils, for more information regarding saline soil development and management.

The United States Salinity Laboratory rates salinity in terms of a scale from C1-C4. The definitions of the scale are described below.

Salinity designations of irrigation water:

C1 — (Low-salinity water) Little likelihood that soil salinity will develop. Some leaching may be required, but not more than normal leaching from standard irrigation practices unless the soils are extremely low in permeability.

C2 — (Medium-salinity water) Water can be used if a moderate amount of leaching is used. Plants with moderate tolerance to salinity can be grown without special practices for salinity control.

C3 — (High-salinity water) Cannot be used on soils with restricted drainage. Special management is required even with good drainage. Plants with good salt tolerance must be selected.

C4 — (Very high-salinity water) Not suitable for irrigation except under very special conditions which include permeable soils, adequate drainage, excess water for leaching and very salt-tolerant crops.

Sodicity—The sodium level in the soil in relation to calcium and magnesium, as well as the sodium content of the irrigation water is important to the long-term productivity and health of the soil. Sodium disperses clay particles, causing randomization of clay sheets. Aggregation is poor, resulting in poor water infiltration (ponding) and poor root penetration. Less water and nutrients are available for plant growth.

The amount of sodium in the soil and in irrigation water are also factors which influence sodification. The use of high sodium water depends on the level of salinity and sodicity in the soil and water as described in Figure 1.

Figure 1. Classification of irrigation water (from *Agriculture Handbook No. 60, USDA Salinity Laboratory, Riverside, CA*).

The influence of sodium on soil properties depends on the relative amount of sodium with respect to calcium and magnesium. The most accepted method of comparing sodium to calcium and magnesium is by calculating the sodium adsorption ratio (SAR). The SAR may be determined on a soil extract or irrigation water. The calcium, magnesium and sodium content of the sample must first be measured by a laboratory. After analysis, the SAR can then be calculated using the following formula:

SAR = Na+ /(((Ca (squared+) + Mg (squared+))/2)

where:
Na+ is the concentration of sodium in milliequivalents per liter of soil extract or meq/liter of irrigation water.
Ca2+ and Mg2+ are the concentrations of calcium and magnesium, respectively in meq/liter of soil extract or irrigation water.

A soil extract from a saturated soil with an SAR of greater than 13 is usually an indication of sodium problems and not generally recommended for irrigation.

The SAR, however, is not the only factor to be considered when managing sodicity. The type of anion (chloride or sulfate) in the soil affects the amount of Ca2+ and Mg2+ effective in the soil. The free sulfate in soils high in sulfate may combine with Ca2+ so that the Ca2+ is not available to replace sodium from the soil cation exchange complex. Although an SAR in a sulfate system might suggest a relatively low sodium threat, the effective SAR would be higher. The bicarbonate (HCO3-) or carbonate (CO32-) content of irrigation water or soil may also cause precipitation of calcium and magnesium carbonates and increase the SAR of the soil.

Texture also modifies the effect of SAR as a management guide. Although an SAR of 13 indicates significant clay dispersion in both a clay loam and sandy loam soil, the actual effect of the dispersion on soil properties is less in the sandy loam. Soils with a relatively low SAR may become dispersed depending on the amount of clay particles held together in part by the attraction of calcium to other clay particles and the dispersing action of sodium which counteracts the aggregation process. See NDSU Extension Service Circulars EB-57 and SF-1087 for more information on sodic soil development and management.

The U.S. Salinity Laboratory defines sodicity in terms of a scale from S1-S4. The definitions of each class are described below.

Sodium designations of irrigation water:

S1 — (Low sodium water) Can be used on nearly all soils with little danger of sodium buildup to the soil, although levels may still be high enough to injure sodium sensitive plants.

S2 — (Medium sodium water) May present a potential sodium buildup on fine-textured soils with low permeability especially if soil free calcium levels are low.

S3 — (high sodium water) May cause sodium buildup in most soils and requires special management, including good drainage, excess water for leaching and organic matter addition. Soils with very high levels of free calcium may not develop problems. Chemical additions (calcium bearing minerals) may be required to replace soil sodium. Chemical additions may not be practical if salinity of irrigation water is high.

S4 — (very high sodium water) Unsuitable for irrigation water except if the water is low or medium salinity (C1 or C2). Under low irrigation salinity, addition of gypsum or calcium chloride may make use of S4 water possible.

Boron—Accumulation of boron has not been documented as an irrigation problem in North Dakota. In a few western states, boron can sometimes be a concern. High levels of boron are toxic to crop plants. Irrigation water should be tested for boron when the well source is originally tested. If the boron level is less than 2 ppm, then boron should not be a problem. If higher than 2 ppm, periodic soil testing every four years would be a good way to monitor boron levels. Water from most North Dakota aquifers is not expected to have high boron levels.

Countering sodium buildup from the use of high SAR irrigation water

The laboratory derived SAR may not be a clear indicator of the actual dispersion of clay particles due to increased sodium levels or decreased soluble calcium in a soil. A quick field test of suspected problem areas may help direct the need for an amendment. Place a one-half cup of surface soil in a clear glass quart jar, add one pint of distilled water and shake well. Leave the jar undisturbed for 12 hours. If the water has not cleared in that time, the clay has become dispersed and an amendment may be required to keep the surface soil productive.

Sodium accumulation and clay dispersion may be countered by the addition of soluble calcium compounds that replace more weakly held sodium on clay and organic matter surfaces and increase flocculation. Free sodium can then be leached from the soil surface to below the root zone where it will not interfere with plant growth. The hazard of sodium accumulation from irrigation water is illustrated in Figure 1 (USDA, 1954).

The sodicity buildup hazard for irrigation water is dependent on both its SAR and its salinity. As the salt content of the water increases sodicity hazard also increases. This means that lower SARs may cause significant sodium buildup in the soil. The reason for an increased sodicity hazard with greater salinity is simply the greater number of sodium ions to replace calcium in the soil.

The effective use of calcium amendments is related to the salinity and SAR of the irrigation water and the soil mineral content. Addition of calcium amendments to irrigation water may be most helpful with irrigation water classes C1-S3, C1-S4, and C2-S4. The sodicity hazard of irrigation water classes C1-S3 and C1-S4 may be reduced with the addition of calcium amendments to irrigation water. Application of soluble calcium amendments may be most useful with soils irrigated with water in classes C2-S3 and C3-S2.

Calcium amendments for soil and irrigation water

Gypsum, which is the common name for calcium sulfate ($CaSO_4$), has been used successfully as a reclamation amendment when the soil was not already saturated with gypsum. In areas with low soil salt content, gypsum is the preferred method of reclaiming high sodium soils. Gypsum dissolves in the soil and calcium ions replace sodium ions on clay and organic matter surfaces. Water moving through the soil then leaches the sodium out of the root zone. However, in many North Dakota soils, sodium and calcium levels are high together. Addition of gypsum in soils already high in gypsum will not result in a replacement of sodium, since greater amounts of gypsum will not increase the number of free calcium ions in solution. Other amendments may be more useful.

In soils with high levels of calcium carbonate and low levels of gypsum, application of elemental sulfur is sometimes used to produce gypsum. Sulfur is oxidized in soils by sulfur bacteria. The resulting sulfuric acid reacts with calcium carbonate to produce gypsum.

In some soils, subsurface gypsum layers can be incorporated into surface soils with high sodium levels through deep tillage. Mixing gypsum into high sodium soils may be a practical way to reclaim some soils. Before tillage, soil sampling surface and deep layers with respect to sodium and gypsum levels will be necessary. If excess gypsum is not present in the subsurface layers, deep tillage may not be helpful.

More soluble calcium amendments, such as calcium chloride, may be more useful in replacing sodium ions in sulfatic systems. Calcium chloride is more soluble in sulfatic systems than gypsum. The economics of reclamation and effectiveness of amendments in reclaiming sodic soils or countering sodium accumulation should be evaluated before deciding to use a soluble calcium amendment.

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