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Compatibility of North Dakota Soils for Irrigation

NDSU photo

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Irrigation increases the productivity of soils and the effectiveness and consistency of certain soil-applied herbicides and provides a stable supply of farm products for food product processors. However, irrigation can degrade the quality of soil and cause crop yields to decline, even to the point of field abandonment when soil and irrigation water are not compatible.

Examples of soil degradation and land abandonment due to improper irrigation exist throughout history. When irrigation acreage expands to new areas, determining soil and water compatibility is critical for sustaining yields at high levels.

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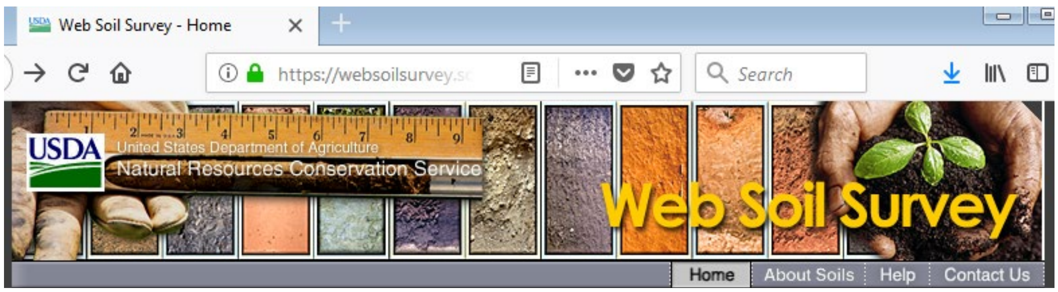
How to Use This Information

This publication is intended as a first step to help current and prospective irrigators understand the principles behind the irrigability of soils in North Dakota. **This publication should be used in combination with soil survey information for the land to be irrigated.**



Soil surveys of every county in North Dakota have been digitized and documented. Official, up-to-date soil survey information can be found only on the internet at *http://websoilsurvey.nrcs.usda.gov/*. Your local Natural Resources Conservation Service office or NDSU Extension county office can help you obtain soil survey information for the fields of interest.

Understanding the irrigability of the soil in a field begins with knowledge of the local soil series and the way they are represented on the 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 lesser extent and are called minor components. These minor components need to be considered when making irrigation management decisions.

Each soil description may have different phases of slope and other properties that modify its suitability for irrigation. We highly recommend you consult with a qualified soil scientist before making the decision to irrigate.

The photo on the cover is of a lateral-move irrigation system (sometimes called a linear-move system) at the Nesson Valley Irrigation Research Site. It is about 30 miles east of Williston on the north side of Lake Sakakawea.

(Photo by Tyler Tjelde)

Classification of Soils for Irrigation Suitability

All soil series in North Dakota have been classified for irrigation suitability. A soil series is based on distinguishing characteristics, including the number 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: nonirrigable (n), conditional (c) and irrigable (i). Nonirrigable soils should not be irrigated by any water source under any circumstances **(Table 1, Pages 4-5)**. The decision to classify a soil as nonirrigable is based on the knowledge that irrigation will not benefit the irrigator in the short term 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 generally can be irrigated from most water sources. A high level of management is advised to improve nutrient uptake and decrease collateral pollution due to excess water movement through the soil.

Some fields will contain soils that fall into two or perhaps all three irrigation categories. A qualified soil professional can assist with evaluating fields with conditional soils. An irrigation system should be designed to exclude irrigation on areas that fall into the nonirrigable category, but this may not be possible.

If most of the field falls into the irrigable category, but significant areas are conditional and nonirrigable, the soils in these categories will influence management decisions strongly.

Required management may include annual soil testing for nitrates, sodium and salts; annual addition of calcium amendments; lower nitrogen fertilizer rates; the use of no-till or reduced tillage; or other special activities. Special management methods will depend on the reason for placement into conditional or nonirrigable classes.

The special requirements for irrigating small areas of conditional or nonirrigable soils should be part of the estimate of the total irrigation investment. As site-specific farming techniques are developed, more practical methods of managing soil inclusions will become available.

Commercial center-pivot irrigation systems now have site-specific water application technology that will vary the amount of water applied to a particular area in the field. The improved water application technology, along with reduced or no-till technology, will make a big difference in how conditional soils will be irrigated.

Irrigation Water Management

Irrigation water management is recommended for all irrigation systems. Irrigation scheduling is an important part of irrigation water management. Irrigation scheduling will minimize the use of water without loss of yield. It also is important for reducing nitrate leaching from overirrigation.

Irrigation scheduling tools are available to North Dakota irrigators. They are:

- A manual method outlined in NDSU Extension publication AE792 “Irrigation Scheduling by the Checkbook Method” and a spreadsheet version of the checkbook method with a user’s manual: *www.ndsu.edu/agriculture/ag-hub/ag-topics/crop-production/irrigation-tiling-drainage/irrigation-scheduling*
- A site-specific web-based application available through the North Dakota Agricultural Weather Network (NDAWN) website: *https://ndawn.ndsu.nodak.edu*

Table 1. Alphabetical list of soil series and associated irrigability group. Irrigability groups are from 1 to 29, where "i" is for irrigable, "c" is for conditionally irrigable, and "n" is for not irrigable. Groups 1 to 7 are irrigable soils, 8 to 22 are conditional soils and 23 to 29 are nonirrigable. Irrigation group ratings listed do not address series phases such as saline, wet, flooded, drained, undrained and slope.

Soil Series	Group
AASTAD	8c
AAZDAHL	8c
ABOR	24n
ABERDEEN	11c
ABSHER	24n
ADGER	24n
ALKABO	11c
AMOR	12c
ANTLER	15c
APPAM	3i
AQUENTS	27n
ARCHIN	24n
ARIKARA	23n
ARNEGARD	7i
ARVESON	19c
ARVILLA	3i
AUGSBERG	15c
AYLMER	2i
BAAHISH	5i
BADLAND	24n
BAINVILLE	26n
BALATON	9c
BANKS	3i
BANTRY	18c
BARNES	8c
BARKOF	24n
BEARDEN	15c
BEARPAW	10c
BECKTON	24n
BEISIGL	13c
BELFIELD	11c
BENZ	25n
BEOTIA	7i
BINFORD	3i
BLACKSHEEP	26n
BLANCHARD	2i
BOHNSACK	17c
BORUP	17c
BOTTINEAU	10c
BOWBELLS	8c
BOWDLE	6i
BOXCUT	12c
BOXWELL	12c
BRANDENBURG	1i
BRANTFORD	5i
BREIEN	4i
BRISBANE	6i
BRUSHTON	8c
BRYANT	8c
BULLOCK	24n
BULLTOP	6i
BUSE	9c
BURGRAFF	12c
CABBA	26n
CABBART	26n
CAMBERT	12c
CAMTOWN	11c
CASHEL	15c
CATHAY	11c
CAVOUR	24n
CEDAR PAN	26n
CHAMA	12c
CHANTA	6i
CHERRY	9c
CHINOOK	4i
CLAIRE	2i
CLEARWATER	22c
CLONTARF	3i
COE	1i
COHAGEN	23n
COLEHARBOR	12c
COLVIN	15c
CORLISS	2i
CORMANT	18c
COZBERG	3i
CRESBARD	11c
CUBDEN	15c
DAGLUM	24n
DARNEN	8c
DELAMERE	19c
DESART	24n
DICKEY	14c
DILTS	26n
DIMMICK	27n
DIVIDE	16c
DOGIECREEK	27n
DOGTOOTH	24n
DOOLEY	14c
DORAN	15c
DOVRAY	22c
DRAGLINE	22c
DUPREE	26n
EAPA	8c
EASBY	25n
ECKMAN	7i
EDGELEY	12c
EGELAND	4i
EKALAKA	24n
ELMVILLE	17c
EMBDEN	4i
EMRICK	7i
ENLOE	22c
ERAMOSH	27n
ESMOND	9c
ESPELIE	20c
ETHRIDGE	10c
EVRIDGE	24n
EXLINE	24n
FAIRDALE	9c
FALKIRK	8c
FALSEN	2i
FARFELD	26n
FARGO	22c
FARLAND	8c
FARNUF	8c
FELOR	8c
FERNEY	24n
FLAMING	2i
FLASHER	23n
FLAXTON	14c
FLEAK	26n
FLOM	15c
FLOWEREE	8c
FOLDAHL	14c
FORDVILLE	6i
FORMAN	8c
FOSSUM	18c
FRAM	17c
FULDA	22c
GALCHUTT	15c
GARBORG	18c
GARDENA	7i
GERDA	24n
GILBY	15c
GLENDIVE	4i
GLYNDON	17c
GOLVA	8c
GRAIL	10c
GRANO	22c
GRASSNA	8c
GREAT BEND	8c
GREENWAY	15c
GRIMSTAD	20c
GWINNER	21c
HAMAR	18c
HAMERLY	15c
HAMLET	8c
HANLY	3i2i
HARMONY	8c
HARRIET	24n
HATTIE	21c
HAVRE	9c
HAVRELON	9c
HAYDRAW	9c
HECLA	3i
HEGNE	22c
HEIL	24n
HEIMDAL	7i
HIDATSA	5i
HILAIRE	3i
HOFFMANVILLE	21c
HOKANS	8c
INKSTER	4i
JANESBURG	24n
KARLSRUHE	18c
KELVIN	10c
KENSAL	5i
KINDRED	15c
KIRBY	1i
KLOTEN	26n
KNIFERIVER	12c
KORCHEA	9c
KORELL	8c
KRANZBURG	8c
KRATKA	20c
KREM	14c
KREMLIN	7i
LA PRAIRIE	8c
LADELLE	8c
LADNER	24n

Soil Series	Group
LAKEPARK	15c
LAKOA	8c
LAKOTA	24n
LALLIE	22c
LAMBERT	9c
LAMOURE	15c
LANGHEI	9c
LANKIN	8c
LANONA	14c
LANTRY	12c
LARSON	24n
LAWTHER	21c
LEFOR	13c
LEHR	5i
LEMERT	24n
LETCHER	24n
LIHEN	3i
LINDAAS	22c
LINTON	7i
LISAM	26n
LISMORE	8c
LITTLEHORN	12c
LITTLEMO	6i
LIVONA	14c
LOHLER	28n 21c
LOHNES	2i
LONNA	9c
LOWE	15c
LUDDEN	22c
MADDOCK	3i
MAGNUS	21c
MAKOTI	8c
MALTESE	24n
MANDAN	7i
MANFRED	24n
MANNING	3i
MANTADOR	19c
MARIAS	21c
MARKEY	27n
MARMARTH	12c
MARYSLAND	16c
MASCHETAH	9c
MAUVAIS	15c 25n
MAX	8c
MCDONALDSVILLE	22c
MCKEEN	15c 27n
MCKENZIE	22c
MEHURIN	10c
MEKINOCK	24n
METIGOSHE	3i
MIDWAY	26n
MINNEWAUKAN	18c
MINOT	10c
MIRANDA	24n
MONDAMIN	21c 10c
MOREAU	12c
MORITZ	15c
MORTON	12c
MOTT	4i
MUSTINKA	22c
NAHON	24n
NECHE	15c
NIOBELL	11c
NOONAN	24n
NORTHCOTE	22c
NORTHWOOD	27n
NUTLEY	21c
OBURN	24n
OJATA	25n
OLGA	21c
OMIO	12c
ORTONVILLE	19c
OSAKIS	3i
OVERLY	8c
PARNELL	22c
PARSHALL	4i
PATENT	9c
PEEVER	21c
PERELLA	15c
PETA	15c
PLAYMOOR	28n
POPPLETON	18c
PORTAL	24n
QUAM	15c
RADIUM	2i
RALPH	12c
RANSLO	24n
RAUVILLE	15c 27n
REEDER	12c
REGAN	15c
REGENT	12c
REIS	22c
RENSHAW	5i
RHAME	13c
RHOADES	24n
RIDGELAWN	6i
RIFLE	27n
RINGLING	1i
ROCKWELL	20c
ROLETTE	21c
ROLISS	15c
ROLLA	21c
RONDELL	9c
ROSEGLEN	7i
ROSEWOOD	18c
RUSKLYN	9c
RUSO	3i
RYAN	24n
SAKAKAWEA	9c
SANDBERG	2i
SCAIRT	24n
SCHALLER	3i
SCORIO	21c
SEARING	12c
SEELYEVILLE	27n
SEN	12c
SERDEN	2i
SEROCO	2i
SHAM	25n
SHAMBO	7i
SHIBAH	5i
SINAI	21c
SINNIGAM	26n
SIOUX	1i
SISSETON	9c
SOUTHAM	22c
SPOTTSWOOD	6i
SQUARE BUTTE	12c
STADY	6i
STIRUM	24n
STRAW	7i
SUOMI	22c
SUTLEY	9c
SVEA	8c
SVERDRUP	3i
SWENODA	14c
SYRENE	15c
TALLY	4i
TANNA	10c
TANSEM	7i
TELFER	3i
TEMVIK	8c
THIEFRIVER	22c
TIFFANY	20c 19c
TINSLEY	1i
TOLNA	19c
TONKA	22c
TOTTEN	24n
TOWNER	14c
TREMBLES	4i
TUSLER	13c
ULEN	18c
URANDA	24n
VALLERS	15c
VANDA	25n
VANG	6i
VEBAR	13c
VELVA	4i
VENLO	18c
VERENDRYE	18c
VIDA	9c
VIKING	22c
VIRGELLE	14c
WABEK	1i
WAHPETON	21c
WALSH	8c
WALUM	3i
WAMDUSKA	1i
WANAGAN	5i
WARSING	5i
WATROUS	12c
WAUKON	10c
WAYDEN	26n
WERNER	23n
WHEATVILLE	15c
WHITEBIRD	24n
WIBAUX	1i
WILDROSE	21c
WILLIAMS	8c
WILTON	8c
WINGER	15c
WOLF POINT	21c
WYARD	15c
WYNDMERE	20c 19c
WYOLA	10c
WYRENE	20c 18c
YAMACALL	9c
YAWDIM	26n
YEGEN	14c
YECROSS	2i
YETULL	2i
ZAHILL	9c
ZAHL	9c
ZEELAND	10c
ZELL	9c
ZEONA	2i

Soil Texture Abbreviations

Abbreviations for soil texture, from coarse to fine, used in this publication:

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

Irrigability Groups

In the following text,

< = less than

> = greater than

dS/m = deciSiemens per meter

EC = electrical conductivity (measurement of soluble salts)

SAR = sodium absorption ratio

Irrigable Soils (i)

Irrigable soils generally require less management than conditional soils. Even though the soils are in an irrigable class, good irrigation management is essential. Attention to the allowable irrigation water quality is important. The 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.

1i. Brandenburg, Coe, Kirby, Ringling, Sioux, Tinsley, Wabek, Wamduska, Wibaux

Drainage: excessively drained

Surface texture: L, SL

Substratum texture: sand and gravel

Surface intake rate for sprinkler irrigation: 0.5 – 0.7 inch/hour for slopes < 6%

Limiting permeability within 40 inches: 0.6 to 2 inches/hour in the upper part and > 6 inches/hour in the lower part

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

Depth to lime: 0 – 10 inches

Surface pH: 6.6 – 8.4

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

SAR – (maximum within 40 inches): 0

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

Depth	Average Cumulative Available Water Capacity
1 foot	1.5 inches
2 feet	2 inches
3 feet	2.5 inches
4 feet	3 inches
5 feet	3 inches

Irrigation Water Quality
Maximum allowable EC < 3 dS/M; maximum allowable SAR <12

Water Management Practices
Water management on these soils is critical because of low available water capacity and nutrient leaching hazard.

2i. Aylmer, Banks, Blanchard, Claire, Corliss, Falsen, Flaming, Lohnes, Radium Sandberg, Serden, Seroco, Yetull, Yecross, Zeona

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 inch/hour for slopes < 9%

Limiting permeability within 40 inches: 6 – 20 inches/hour

Profile characteristics: sandy and moderately coarse-textured material

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

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

Depth	Average Cumulative Available Water Capacity
1 foot	1 inch
2 feet	2 inches
3 feet	2.5 inches
4 feet	3 inches
5 feet	4 inches

Irrigation Water Quality
Maximum allowable EC < 3 dS/m; maximum allowable SAR < 12

Water Management Practices

Water management on these soils is critical because of low available water-holding capacity and nutrient leaching hazard.

3i. Appam, Arvilla, Binford, Clontarf, Cozberg, Hanly, Hecla, Hilaire, Lihen, Maddock, Manning, Metigoshe, Osakis, Ruso, Schaller, Sverdrup, Telfer, Walum

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 inches/hour for slopes < 6%

Limiting permeability within 40 inches: 2 – 20 inches/hour in the upper part and > 6 inches/hour in the lower part

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

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

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

Depth	Average Cumulative Available Water Capacity
1 foot	1.5 inches
2 feet	3 inches
3 feet	3.5 inches
4 feet	4.5 inches
5 feet	5.5 inches

Irrigation Water Quality
Maximum allowable EC < 3 dS/m; maximum allowable SAR < 12

Water Management Practices
An irrigation scheduling system must be used.

4i. Breien, Chinook, Egland, Embden, Glendive, Inkster, Mott, Parshall, Tally, Trembles, Velva

Drainage: well and moderately well drained

Surface texture: SL, FSL, L

Subsoil texture: SL, FSL, L

Surface intake rate for sprinkler irrigation: .5 – 1 inch/hour for slopes < 6%

Limiting permeability within 40 inches: 0.6 – 6 inches/hour

Profile characteristics: moderately coarse and medium-textured material

Depth to lime: Typically, at 10 – 20 inches but may extend to the surface

Surface pH: 6.1 – 8.4

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

SAR – (maximum within 40 inches): 0

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

Depth	Average Cumulative Available Water Capacity
1 foot	2 inches
2 feet	4 inches
3 feet	5.5 inches
4 feet	7 inches
5 feet	9 inches

Irrigation Water Quality
Maximum allowable EC < 3 dS/m; maximum allowable SAR < 12

Water Management Practices
An irrigation scheduling system must be used.

5i. Baahish, Brantford, Hidatsa, Kensal, Lehr, Renshaw, Shibah, Wanagan, Warsing

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 inch/hour for slopes < 6%

Permeability within 40 inches: 0.6 – 2 inches/hour in the upper part and > 6 inches/hour in the lower part

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

Depth to lime: 10 – 20 inches

Surface pH: 6.1 – 7.8

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

SAR – (maximum within 40 inches): 0

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

Depth	Average Cumulative Available Water Capacity
1 foot	2 inches
2 feet	3 inches
3 feet	3.5 inches
4 feet	4 inches
5 feet	4.5 inches

Irrigation Water Quality
Maximum allowable EC < 3 dS/m; maximum allowable SAR < 9

Water Management Practices
An irrigation scheduling system must be used.

6i. Bowdle, Brisbane, Bulltop, Chanta, Fordville, Littlemo, Ridgelawn, Spottswood, Stady, Vang

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 inch/hour for slopes < 6%

Limiting permeability within 40 inches: 0.6 – 2 inches/hour in the upper part and > 6 inches/hour in the lower part

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

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

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

Depth	Average Cumulative Available Water Capacity
1 foot	2.5 inches
2 feet	4.5 inches
3 feet	5.5 inches
4 feet	6 inches
5 feet	6.5 inches

Irrigation Water Quality
Maximum allowable EC < 3 dS/m: maximum allowable SAR < 9

Water Management Practices
An irrigation scheduling system must be used.

7i. Arnegard, Beotia, Eckman, Emrick, Gardena, Heimdal, Kremlin, Linton, Mandan, Roseglen, Shambo, Straw, Tansem

Drainage: moderately well and well drained

Surface textures: VFSL, SIL, L

Subsoil texture: VFSL, SIL, L, SICL

Surface intake rate for sprinkler irrigation: 0.1 – 0.5 inch/hour for slopes < 3%

Limiting permeability within 40 inches: 0.2 – 2 inches/hour

Profile characteristics: medium and moderately fine-textured material

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

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

Depth	Average Cumulative Available Water Capacity
1 foot	2.5 inches
2 feet	5 inches
3 feet	7 inches
4 feet	9 inches
5 feet	11.5 inches

Irrigation Water Quality
Maximum allowable EC < 2.25 dS/m; maximum allowable SAR < 6

Water Management Practices
An irrigation scheduling system must be used.

Conditional Soils (c)

Conditional soils can be irrigated under a high level of management. Soil conditions that 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 the soil quality for future generations but can be irrigated successfully if recommendations are followed. Soil phases of each soil series may modify irrigation recommendations.

8c. Aastad, Aazdahl, Barnes, Bowbells, Brushton, Bryant, Eapa, Falkirk, Farland, Farnuf, Felor, Floweree, Forman, Golva, Grassna, Great Bend, Hamlet, Harmony, Hokans, Korell, Kranzburg, La Prairie, LaDelle, Lakoa, Lankin, Lismore, Makoti, Max, Overly, Svea, Temvik, Walsh, Williams, Wilton

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 inch/hour for slopes < 3%

Limiting permeability within 40 inches: 0.2 – 2 inches/hour

Profile characteristics: medium and moderately fine-textured material

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

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

Depth	Average Cumulative Available Water Capacity
1 foot	2.5 inches
2 feet	4.5 inches
3 feet	6.5 inches
4 feet	8.5 inches
5 feet	10 inches

Irrigation Water Quality
Maximum allowable EC < 1.5 dS/m; 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

three- to five-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.

9c. Balaton, Buse, Cherry, Esmond, Fairdale, Havre, Havrelon, Haydraw, Korchea, Lambert, Langhei, Lonna, Maschetah, Rondell, Rusklyn, Sakakawea, Sisseton, Sutley, Vida, Yamacall, Zahill, Zahl, Zell

Drainage: moderately well and well drained

Surface texture: VFSL, FSL, SL, L, SIL, CL, SICL

Subsoil texture: L, SIL, CL, SICL

Surface intake rate for sprinkler irrigation: 0.5 – 0.7 inch/hour for slopes < 3%

Limiting permeability within 40 inches: 0.6 – 2 inches/hour

Profile characteristics: calcareous/medium and moderately fine-textured materials

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

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

Depth	Average Cumulative Available Water Capacity
1 foot	2.5 inches
2 feet	4.5 inches
3 feet	6.5 inches
4 feet	8.5 inches
5 feet	10 inches

Irrigation Water Quality
Maximum allowable EC < 1.8 dS/m; 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 three- to five-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.

10c. Bearpaw, Bottineau, Ethridge, Grail, Kelvin, Mehurin, Minot, Mondamin, Tanna, Waukon, Wyola, Zeeland

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 inch/hour for slopes < 3%

Limiting permeability within 40 inches: 0.06 – 0.6 inch/hour

Profile characteristics: moderately fine to fine-textured material

Depth to lime: 15 – 40 inches

Surface pH: 6.1 – 7.8

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

SAR – (maximum within 40 inches): < 4

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

Depth	Average Cumulative Available Water Capacity
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

Irrigation Water Quality
Maximum allowable EC < 1 dS/m; 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 three- to five-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. Subsurface drainage may be required for continued irrigation. An irrigation scheduling system must be used.

11c. Aberdeen, Alkabo, Belfield, Camtown, Cathay, Cresbard, Niobell

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 inch/hour for slopes < 3%

Limiting permeability within 40 inches: 0.06 – 0.2 inch/hour

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

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 – 15

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

Depth	Average Cumulative Available Water Capacity
1 foot	2.5 inches
2 feet	4.5 inches
3 feet	6 inches
4 feet	8 inches
5 feet	10 inches

Irrigation Water Quality
Maximum allowable EC < 1.5 dS/m; maximum allowable SAR < 4

Water Management Practices
These soils are marginal for irrigation, and irrigation of extensive areas should be avoided. Continued irrigation potentially could cause restricted water intake and permanent soil damage. Salinity of the root zone should be monitored on a three- to five-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. Subsurface drainage may be required for continued irrigation.

12c. Amor, Boxcut, Boxwell, Burgraff, Cambert, Chama, Coleharbor, Edgeley, Kniferiver, Lantry, Little Horn, Marmarth, Moreau, Morton, Omio, Ralph, Reeder, Regent, Searing, Sen, Square Butte, Watrous

Drainage: well drained

Surface texture: L, SIL, SICL

Subsoil texture: L, SIL, SICL

Surface intake rate for sprinkler irrigation: 0.1 – 0.5 inch/hour for slopes < 3%

Limiting permeability within 40 inches: 0.0 – 0.6 inch/hour depending on texture of soft weathered bedrock

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

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

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

Depth	Average Cumulative Available Water Capacity
1 foot	2.5 inches
2 feet	4.5 inches
3 feet	6.5 inches
4 feet	0.08 inch
5 feet	0.08 inch

Irrigation Water Quality
Maximum allowable EC < 1.8 dS/m; 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 three- to five-year basis or more frequently if plant growth is restricted. An irrigation scheduling system must be used.

13c. Beisigl, Lefor, Rhame, Tusler, Vebar

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 inches/hour for slopes < 3%

Limiting permeability within 40 inches: 0.0 – 0.6 inch/hour

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

Depth to lime: Typically, 10 – 20 inches, some may extend to the surface

Surface pH: 6.1 – 7.8

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

SAR – (maximum within 40 inches): 0

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

Depth	Average Cumulative Available Water Capacity
1 foot	1.5 inches
2 feet	3 inches
3 feet	3.5 inches
4 feet	0.08 inch
5 feet	0.08 inch

Irrigation Water Quality
Maximum allowable EC < 1.8 dS/m; 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 three- to five-year basis or more frequently if plant growth is restricted. An irrigation scheduling system must be used.

14c. Dickey, Flaxton, Krem, Lanona, Livona, Swenoda, Towner, Virgelle, Yegen

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 inches/hour for slopes < 3%

Limiting permeability within 40 inches: 0.2 – 0.6 inch/hour

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

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

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

Depth	Average Cumulative Available Water Capacity
1 foot	1.5 inches
2 feet	3 inches
3 feet	4.5 inches
4 feet	6.5 inches
5 feet	8 inches

Irrigation Water Quality
Maximum allowable EC < 1.8 dS/m; maximum allowable SAR < 9

Water Management Practices
These soils are conditional for irrigation due to the subsoil's moderately slow permeability and potential for increased salinity. Salinity in the root zone should be monitored on a three- to five-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.

15c. Antler, Augsberg, Bearden, Cashel, Colvin, Cubden, Doran, Flom, Galchutt, Gilby, Greenway, Hamerly, Lakepark, LaMoure, Lowe, McKeen, Moritz, Neche, Perella, Quam, Rauville, Regan, Roliss, Styrene, Vallers, Wheatville, Winger, Wyard

Drainage: somewhat poorly and poorly drained

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

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

Surface intake rate for sprinkler irrigation: 0.1 – 0.7 inch/hour for slopes < 3%

Limiting permeability within 40 inches: 0.2 – 0.6 inch/hour

Profile characteristics: medium to fine-textured materials

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

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

Depth	Average Cumulative Available Water Capacity
1 foot	2.5 inches
2 feet	4.5 inches
3 feet	7 inches
4 feet	9 inches
5 feet	10 inches

Irrigation Water Quality
Maximum allowable EC < 1.5 dS/m; 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 three- to five-year basis or more frequently if plant growth is restricted. An irrigation scheduling system must be used.

16c. Divide, Marysland

Drainage: somewhat poorly and poorly drained

Surface texture: L, CL, SIL

Subsoil texture: L, CL

Surface intake rate for sprinkler irrigation: 0.1 – 0.5 inch/hour for slopes < 3%

Limiting permeability within 40 inches: 0.6 – 2 inches/hour in the upper part and > 6 inches/hour in the lower part

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

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

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

Depth	Average Cumulative Available Water Capacity
1 foot	2.5 inches
2 feet	4.5 inches
3 feet	5 inches
4 feet	5.5 inches
5 feet	6 inches

Irrigation Water Quality
Maximum allowable EC < 3 dS/m; 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 three- to five-year basis or more frequently if plant growth is restricted. An irrigation scheduling system must be used.

17c. Bohnsack, Borup, Elmville, Fram, Glyndon

Drainage: somewhat poorly and poorly drained

Surface texture: FSL, SIL, L

Subsoil texture: FSL, SIL, L

Surface intake rate for sprinkler irrigation: 0.5 – 1 inch/hour for slopes < 3%

Limiting permeability within 40 inches: 0.6 – 2 inches/hour

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

Depth to lime: 0 – 10 inches

Surface pH: 7.4 – 8.4

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

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

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

Depth	Average Cumulative Available Water Capacity
1 foot	2.5 inches
2 feet	4.5 inches
3 feet	6 inches
4 feet	8.5 inches
5 feet	10.5 inches

Irrigation Water Quality
Maximum allowable EC < 2.25 dS/m; 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 three- to five-year basis or more frequently if plant growth is restricted. An irrigation scheduling system must be used.

18c. Banks (variant), Bantry, Cormant, Fossum, Garborg, Hamar, Karlsruhe, Minnewaukan, Poppleton, Rosewood, Ulen, Venlo, Verendrye, Wyrene

Drainage: somewhat poorly and poorly drained

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

Subsoil texture: LFS, LS, S, FS

Surface intake rate for sprinkler irrigation: 0.5 – 1.5 inches/hour for slopes < 3%

Limiting permeability within 40 inches: 2 – 20 inches/hour

Profile characteristics: coarse and moderately coarse-textured material

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

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

Depth	Average Cumulative Available Water Capacity
1 foot	1.5 inches
2 feet	2.5 inches
3 feet	3 inches
4 feet	4 inches
5 feet	5 inches

Irrigation Water Quality
Maximum allowable EC < 3 dS/m; 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 three- to five-year basis or more frequently if plant growth is restricted. An irrigation scheduling system must be used.

19c. Arveson, Delamere, Fossum, Mantador, Ortonville, Tiffany, Tolna, Wyndmere, Wyrene

Drainage: somewhat poorly and poorly drained

Surface texture: VFSL, FSL, SL

Subsoil texture: VFSL, FSL, SL

Surface intake rate for sprinkler irrigation: 0.5 – 1.25 inches/hour for slopes < 3%

Limiting permeability within 40 inches: 2 – 6 inches/hour

Profile characteristics: moderately coarse and medium-textured material

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

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

Depth	Average Cumulative Available Water Capacity
1 foot	2 inches
2 feet	3.5 inches
3 feet	5 inches
4 feet	6.5 inches
5 feet	7.5 inches

Irrigation Water Quality
Maximum allowable EC < 3 dS/m; 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 three- to five-year basis or more frequently if plant growth is restricted. An irrigation scheduling system must be used.

20c. Espelie, Grimstad, Kratka, Rockwell, Tiffany, Wyndmere

Drainage: somewhat poorly and poorly drained

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

Subsoil texture: SL, SIL, L, CL

Surface intake rate for sprinkler irrigation: 0.5 – 1.5 inches/hour for slopes < 3%

Limiting permeability within 40 inches: 0.2 – 2 inches/hour

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

Depth to lime: 0 – 10 Inches

Surface pH: 7.4 – 8.4

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

SAR – (maximum within 40 inches): < 2

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

Depth	Average Cumulative Available Water Capacity
1 foot	1.5 inches
2 feet	3 inches
3 feet	4.5 inches
4 feet	6.5 inches
5 feet	8 inches

Irrigation Water Quality
Maximum allowable EC < 1.8 dS/; 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 three- to five-year basis or more frequently if plant growth is restricted. An irrigation scheduling system must be used.

21c. Gwinner, Hattie, Hoffmanville, Lawther, Lohler, Magnus, Marias, Nutley, Olga, Peever, Rolette, Rolla, Scorio, Sinai, Wahpeton, Wildrose, Wolf Point

Drainage: moderately well and well drained

Surface texture: SIC, C

Subsoil texture: SIC, C

Surface intake rate for sprinkler irrigation: 0.1 – 0.2 inch/hour for slopes < 3%

Limiting permeability within 40 inches: 0.06 – 0.2 inch/hour

Profile characteristics: fine-textured material

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

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

Depth	Average Cumulative Available Water Capacity
1 foot	2.5 inches
2 feet	4.5 inches
3 feet	6 inches
4 feet	8 inches
5 feet	10 inches

Irrigation Water Quality
Maximum allowable EC < 1 dS/m; 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 three- to five-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. Subsurface drainage may be required for continued irrigation. An irrigation scheduling system must be used.

22c. Dimmick, Dovray, Clearwater, Dragline, Enloe, Fargo, Fulda, Grano, Hegne, Lallie, Lindaas, Ludden, McDonaldsville, McKenzie, Northcote, Parnell, Reis, Southam, Suomi, Thief River, Tonka, Viking

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 inch/hour for slopes < 3%

Limiting permeability within 40 inches: 0.06 – 0.2 inch/hour

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

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

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

Depth	Average Cumulative Available Water Capacity
1 foot	2 inches
2 feet	4 inches
3 feet	6 inches
4 feet	7.5 inches
5 feet	9.5 inches

Irrigation Water Quality
Maximum allowable EC < 1 dS/m; maximum allowable SAR < 6

Water Management Practices
These soils are conditional for irrigation due to slow permeability, wetness and a potential for salinity increase. Salinity of the root zone should be monitored on a three- to five-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.

Nonirrigable (n)

These are soils with very severe limitations to irrigation because of one or more of the following: slope, sodicity, salinity, excessively slow permeability, 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.

23n. Nonirrigable because of relief (slopes > 6%), depth or root restrictive substrata

Arikara, Buse, Cabba, Cohagen, Dumps, Dune Land, Flasher, Sioux, Werner

24n. Nonirrigable because of relief (slopes > 6%), sodicity (SAR > 13 within 40 inches), salinity (EC > 4 dS/m), slow or very slow permeability, or root restrictive subsoil

Abor, Absher, Adger, Archin, Badland, Barkof, Barkof, Beckton, Bullock, Cavour, Daglum, Desart, Dogtooth, Ekalaka, Evridge, Exline, Ferney, Gerda, Harriet, Heil, Janesburg, Ladner, Lakota, Larson, Lemert, Letcher, Maltese, Manfred, Mekinock, Miranda, Nahon, Noonan, Oburn, Portal, Ranslo, Rhoades, Ryan, Scairt, Stirum, Totten, Uranda, Whitebird

25n. Nonirrigable because of salinity (EC > 8 dS/m) and slopes < 6%

Antler, Arnegard, Arveson, Bearden, Belfield, Benz, Borup, Colvin, Divide, Easby, Elmville, Fargo, Fossum, Fram, Gilby, Glyndon, Grano, Grassna, Hamerly, Hegne, Ladelle, Lallie, LaMoure, Lohler, Ludden, Mandador, Moreau, Ojata, Overly, Parshall, Patent, Playmoor, Regan, Savage, Scorio, Sham, Vallers, Vanda, Velva, Wyndmere.

These soils may be classified in other groups without salinity.

26n. Nonirrigable due to shallow depth of root restrictive substrata (slopes < 6%)

Bainville, Blacksheep, Cabba, Cabbart, Cedarpan, Dilts, Dupree, Farfeld, Fleak, Kloten, Lisam, Midway, Sinnigam, Wayden, Yawdim

27n. Nonirrigable because of seasonal or semipermanant ponding. Slopes < 1%

Very poorly drained Arveson, Borup, Colvin, Dimmick, Dogiecreek, Fargo, Fossum, Hegne, Lallie, Ludden, Marysland, McKeen, Neche, Northwood, Parnell, Rauville, Regan, Roliss, Rosewood, Southam, Venlo.

Peat and Muck soils: Eramosh, Markey, Rifle, Seelyeville.

These soils may be classified in other groups but are poorly drained.

28n. Nonirrigable because of frequent flooding (> 50% chance of flooding)

Banks, Breien, Cashel, Colvin, Divide, Fairdale, Glendive, Hanly, Havre, Havrelon, Korchea, Korell, La Prairie, LaDelle, Lallie, LaMoure, Lohler, Ludden, Magnus, Marysland, Minnewaukan, Neche, Ojata, Patent, Playmoor, Rauville, Regan, Rhoades, Scorio, Straw, Svea and Trembles, Velva, Wolfpoint.

These soils may be classified in other groups with a lower chance of flooding.

29n. NonIrrigable due to numerous surface stones or boulders

Amor, Barnes, Beisigl, Boxwell, Buse, Cabba, Cabbart, Forman, Marmarth, Max, Morton, Reeder, Ringling, Sioux, Svea, Vallers, Vebar, Wabek, Wamduska, Williams, Zahl.

These soils may be classified in other groups because they have less surface stones.

Important Topographic and Soil Properties Affecting Irrigability

Soil Depth

Soil depth depends on the potential rooting depth of the plants to be grown and any restrictions within the soil that may hinder root growth. The rooting depth of potatoes may be only 18 to 24 inches, while alfalfa has a rooting depth of more than 4 feet. Discontinuities in the soil from layers of sand, gravel or bedrock may serve to physically limit the depth of root penetration.

Soil Texture

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

Soil Structure

Movement of water into and within soils is partially dependent on soil structure. Soil structure refers to how sand, silt and clay particles are arranged in the soil. Particles aggregate via organic matter and associated biological activity, roots, soil mineral composition, freeze-thaw cycles, wet/dry cycles and time. Outside forces can impact aggregation and soil structure, such as compaction. Soils containing aggregates are unstable under irrigation and may require special management.

Water-holding Capacity

Water-holding capacity is defined as the soil water retained between a suction of 0.1 to 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 to 2.5 inches of water per foot of soil. A sandy loam can hold only about 1 inch of water per foot. Soil with high organic matter can hold more water than a soil with similar texture and lower organic matter.

Slope

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

Infiltration Rate
(also called intake rate)

The infiltration rate is the relative rate that water penetrates and moves into the soil after a rain or irrigation event. The rate of infiltration is dependent on soil texture and structure but primarily is controlled by the surface conditions such as slope, roughness, residue and soil moisture. At the beginning of a rain or irrigation event, a dry soil surface will absorb more water than a wet surface, thus affecting the amount of potential runoff. 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) and depth to the water table or 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, or cause denitrification losses of nitrogen fertilizer or the accumulation of salts. Soils with good internal drainage respond well to irrigation. Soil retains irrigation water for crops to use while allowing sufficient movement of water within the soil to minimize saturation of pore space.

Salinity

High levels of soluble salts at or near the surface usually are the result of a high-water table but also can accumulate through the years from dissolved salts in the irrigation water. High salt levels may reduce crop yields and increase the water requirement of plants. Irrigation may decrease the depth to the water table through time in some soils, thus increasing the risk of salinization. As salinity increases, crop productivity will decrease. Salinity is a soil property that changes relatively quickly with time, compared with other properties such as texture. Soil testing for salts is necessary to not only follow possible increases through time in irrigated fields but also determine if irrigation should be attempted in the first place.

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). There are several methods to measure EC. The 1:1 method (one-part deionized water to one part soil) has become popular because it provides very fast results. However, all EC ratings in this publication were derived from the saturated paste laboratory method.

Sodicity (sodium buildup in soil)

Sodium (Na) affects the physical condition of the soil by dispersing soil 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, yields may be reduced. Sodium buildup usually occurs slowly and may not be detected easily from year to year. Excess sodium accumulation in the root zone is a major threat to good productivity on some soils. Include the sodium absorption ratio in your regular soil testing checklist every three to five years to determine long-term trends in sodium accumulation.

Quality of Irrigation Water

The quality of some water sources is not suitable for irrigating crops. Irrigation water must be compatible with the crops and soils to which it will be applied. The Soil and Water Environment Laboratory at NDSU provides soil water compatibility analysis and recommendations for irrigation. Lab personnel need an analysis of the water to be used for irrigation and a legal description of the land to make a recommendation.

Salinity and Sodicity of Irrigation Water

The salt (or mineral) content of irrigation water is important for the long-term irrigability of many soils. Irrigation water with large concentrations of salts, when applied to the soil, increases the salt content in the soil because the water is taken up by the plant or evaporates while the salt remains.

To determine the salt content in water, measure the flow of electrical current through a sample of the water. The more dissolved minerals in the water sample, the more easily it conducts electricity, which produces a high electrical conductivity (EC) number.

Distilled water has very high resistance and thus a very low EC, but when the salt content increases, the resistance decreases. The EC has units of deci-Siemens per meter (dS/m), millimhos per centimeter (mmhos/cm) or micromhos per centimeter (umhos/cm). Here is how to convert from one to the others:

Here is how to convert from one to the others:

1 dS/m = 1 mmho/cm = 1,000 umhos/cm

The sodium level in the soil in relation to the calcium and magnesium, as well as sodium content in the irrigation water, are important for the long-term productivity and health of the soil. The use of high-sodium water for irrigation depends on the level of salinity (EC) and sodicity in the soil and water.

The measure of the sodium impact is the sodium absorption ratio (SAR), whose units are dimensionless. It is the ratio of sodium concentration to the concentration of calcium and magnesium in soil or water. Generally, soil and water with SARs of less than 6 are acceptable.

Countering Sodium Buildup From the Use of High-SAR Irrigation Water

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

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 and magnesium in a soil. A quick field test of suspected areas may help. Place ½ cup of surface soil in a clear glass quart jar, add 1 pint of distilled water and shake well. Leave for an hour undisturbed. If the water has not cleared in that time, the clay has become dispersed and an amendment may need to be applied to keep the surface soil productive.

Calcium Amendments for Soil and Irrigation Water

Sodium accumulation and clay dispersion may be countered by the addition of soluble calcium amendments that replace more weakly held sodium on clay and organic-matter surfaces and increase flocculation (clay particles aggregate into clotlike masses or precipitate into small lumps). Free sodium then can be leached from the soil surface to below the root zone, where it will not interfere with plant growth.

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. The addition of gypsum to soils already high in gypsum will not result in a replacement of sodium because greater amounts of gypsum will not increase the number of free calcium ions in solution. Other amendments may be more useful.

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

On a few soil series, 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 for 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 soluble calcium and magnesium amendments.

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