Appendix A
Land and Water Resources Inventory

Drafted by the Bois de Sioux Watershed District

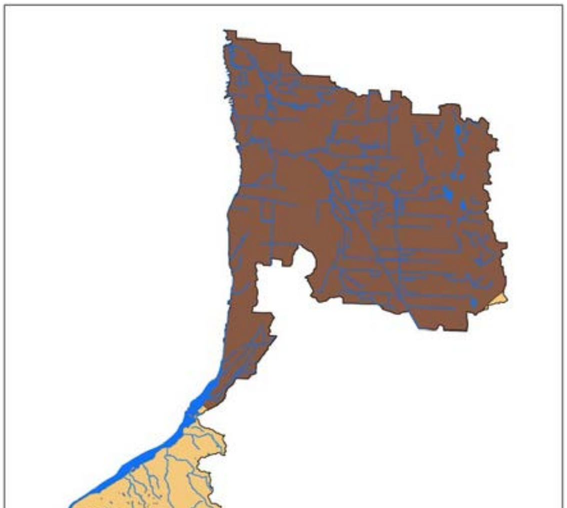
Contents

1 - ECOREGIONS

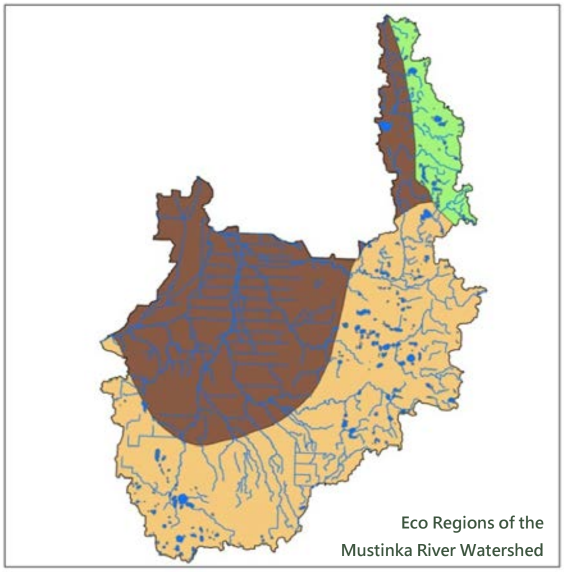
SUBREGIONS

The US Environmental Protection Agency (EPA) defines an ecoregion as "a relatively homogenous ecological area defined by similarity of climate, landform, soil, potential natural vegetation, hydrology, or other ecologically relevant variables" (EPA 2010). Due to the relative homogeneity within ecoregions, Minnesota has developed several water quality standards based on these delineations.

Ecological Subregions of the United States (1994), https://www.fs.fed.us/land/pubs/ecoregions/					
	Northern Glaciated Plains		Lake Agassiz Plain (another name for RRV ecoregion)		North Central Hardwoods
Watershed	*Bois de Sioux*	*& Mustinka*	*Bois de Sioux*	*& Mustinka*	*Mustinka*
Elevation Ranges	750 to 2,000 ft		900 to 1,250 ft		600 to 2,000 ft
Local Relief	20 to 100 ft		low; most areas are nearly level		Not Available
Abbreviation	NGP		LAP / RRV		NCHF
TP (µg/L)	130 – 250		23 – 50		23 – 50
CHLA (µg /L)	30 – 55		5 – 22		5 – 22
Secchi (ft)	1 – 3.25		5 – 10.5		5 – 10.5



Eco Regions of the Bois de Sioux River Watershed



Eco Regions of the Mustinka River Watershed

BOIS DE SIOUX RIVER WATERSHED:

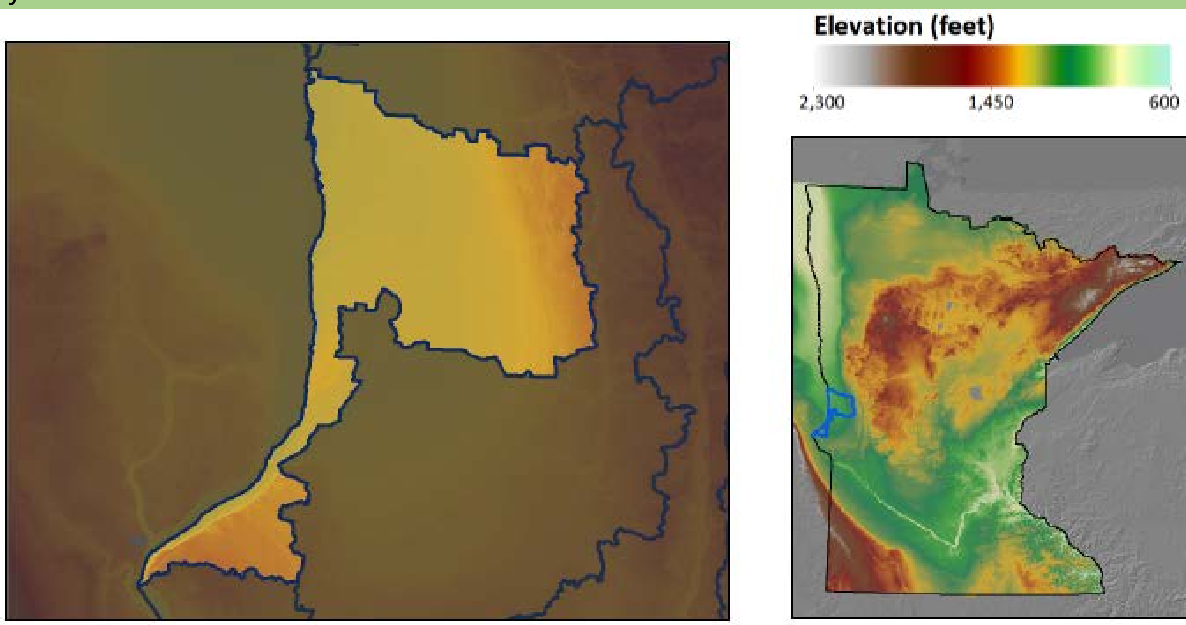
The Bois de Sioux River Watershed (718,685 acres) is split between Minnesota (361,222 acres) and North Dakota and South Dakota (357,463 acres). The Bois de Sioux River watershed includes the Lake Traverse and Bois de Sioux River drainage basins (MPCA, DRAFT Bois de Sioux River Watershed WRAPS, January 2019). The watershed's ecoregions include (MPCA, Bois de Sioux River Watershed Monitoring and Assessment Report, November 2013):

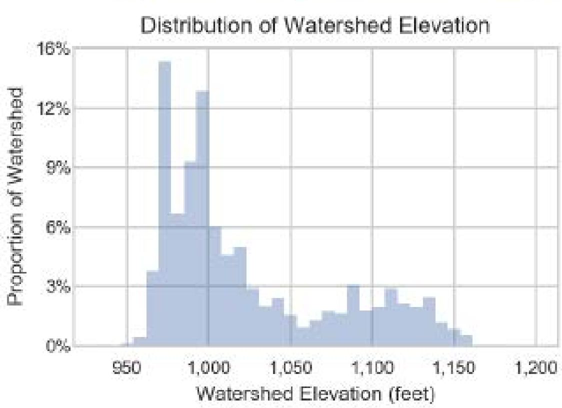
Lake Agassiz Plain

Northern Glaciated Plains

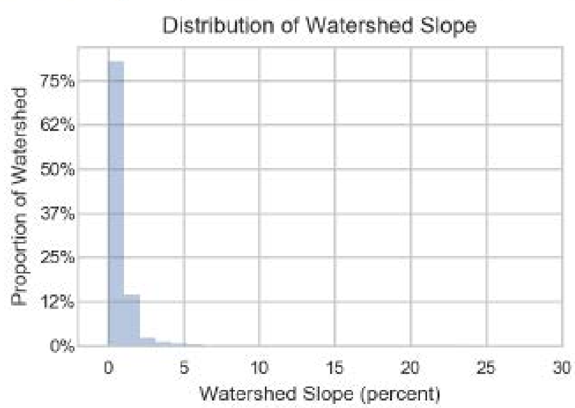
The Bois De Sioux River Watershed spans MN, ND & SD (MPCA 2013)

Physical Characteristics





The distribution of watershed area over the elevation range. Each vertical bar represents the percent of this watershed at that elevation value.



The distribution of watershed area over the range of hillslope. Each vertical bar represents the percent land area for a given slope value.

DNR Bois de Sioux River Watershed Context Report, September 2017

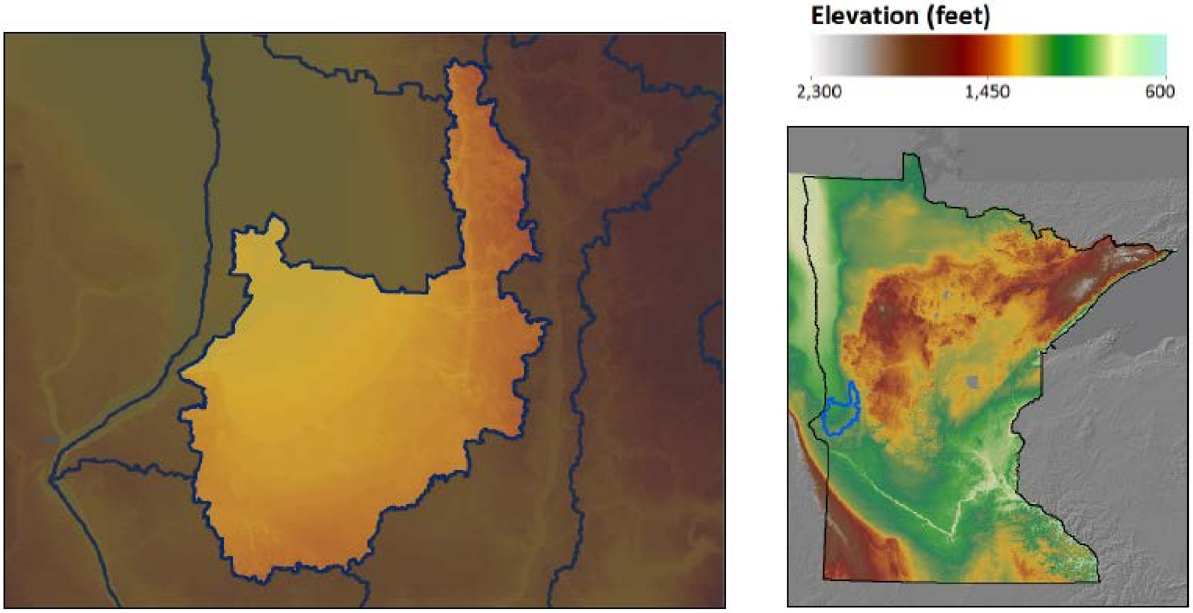
MUSTINKA RIVER WATERSHED:

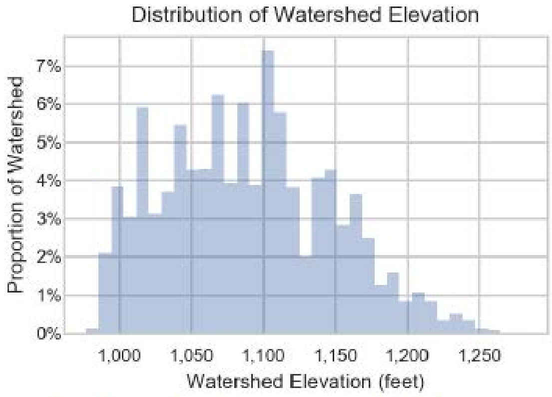
Composed of 562,112 acres the Mustinka River watershed includes the drainage basins of the Mustinka River, Stony Brook and Lightning Lakes. The watershed's ecoregions include (MPCA, Mustinka River Watershed Monitoring and Assessment Report, November 2013):

> *Lake Agassiz Plain*
> *Northern Glaciated Plains*
> *Northern Central Hardwoods*

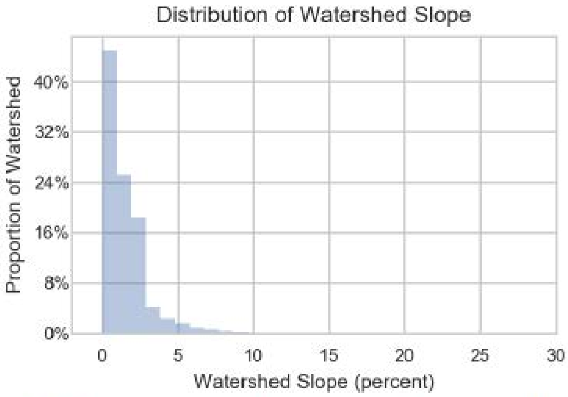
The Mustinka River Watershed (MPCA 2013)

Physical Characteristics





The distribution of watershed area over the elevation range. Each vertical bar represents the percent of this watershed at that elevation value.



The distribution of watershed area over the range of hillslope. Each vertical bar represents the percent land area for a given slope value.

DNR Mustinka River Watershed Context Report, September 2017

GEOLOGY

The watersheds are underlain by bedrock that was formed during the precambrian period of geologic time, approximately 3 billion years ago. These are igneous and metamorphic rocks, predominantly granite and gneiss. A map of bedrock elevational contours is shown in the Precambrian Bedrock Elevations Map Figure. The depth below the surface to the bedrock varies from only 14 feet near Herman to 600 feet near the southwest corner of the Bois de Sioux Watershed.

Overlying the bedrock, in most of both watersheds, are sediments that were formed when oceans covered parts of the area, during the cretaceous period, about 100 million years ago. These sedimentary deposits include layers of soft shales, sandstones, and limestone. Their thickness varies from zero in the high bedrock areas around Herman to 280 feet in the southwest corner of the watershed. A map of cretaceous bedrock elevation contours is shown in the Cretaceous Bedrock Elevations Map Figure.

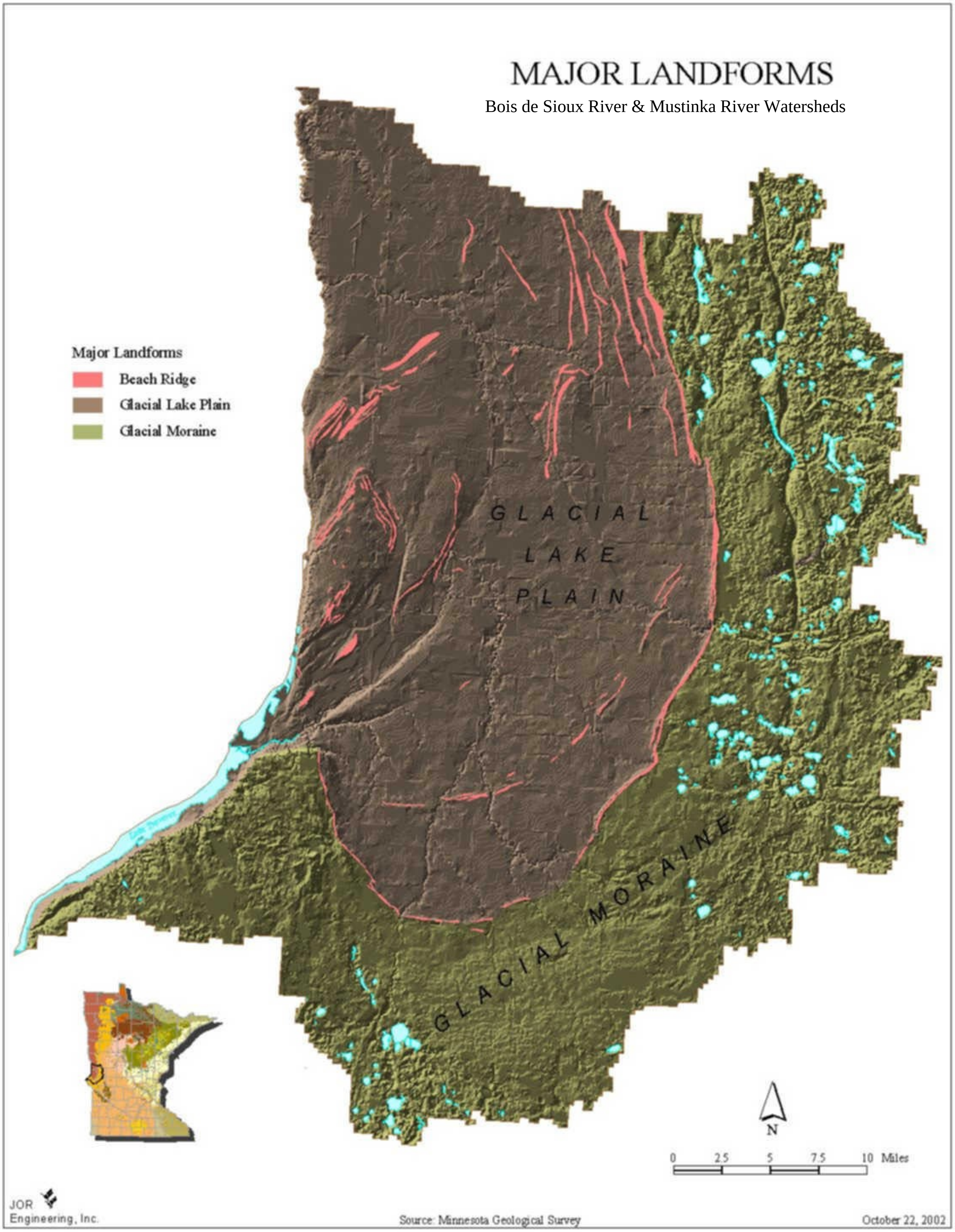
The zone above the cretaceous sediments and up to the ground surface consists of glacially transported materials called glacial drifts that were deposited during the Great Ice Age, from 2,000,000 to 12,000 years ago. Major deposits, referred to as glacial moraines, were built up and remain at the terminal extent of the more recent glaciers. Glacial moraines form the upland regions in the eastern and southern parts of the Mustinka Watershed.

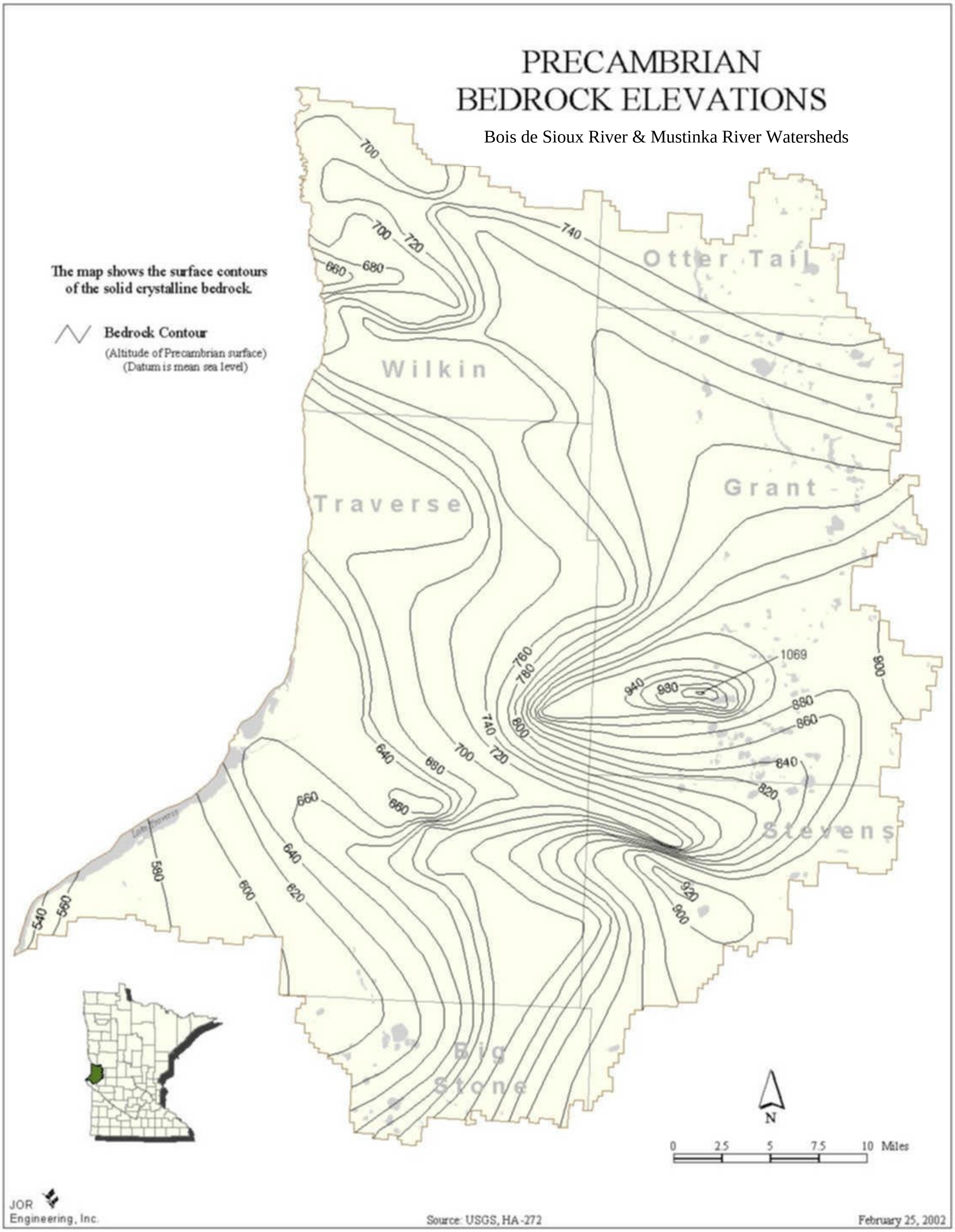
As the last glacier retreated, meltwater was trapped between the continental divide at the southwest corner of the Bois de Sioux Watershed near Browns Valley and the ice mass to the north. A huge water body was formed which is referred to as Glacial Lake Agassiz. Wave action at the margins of the lake formed the beach ridges that remain as prominent features of the landscape. In the northwestern area of the Bois de Sioux Watershed, one will find the broad, flat, glacial lake plain which was the bed of the lake. The locations of the moraine and lake plain areas are shown on the map in Major Landforms Map Figure.

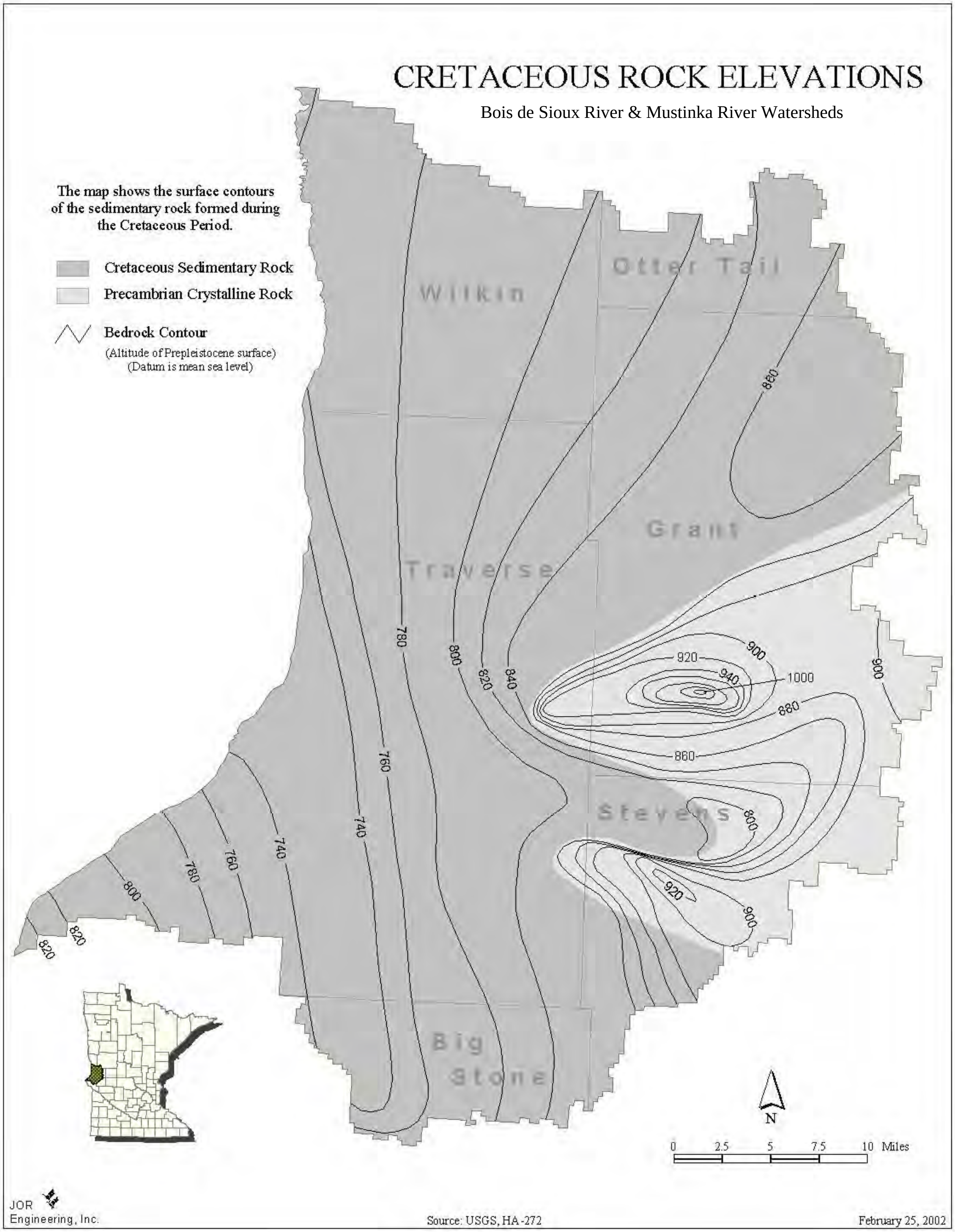
The thickness of the glacial deposits varies from 14 feet near Herman to 350 feet at Graceville. It is made up of a mix of materials, including clay, silt, sand, gravel, stones, and boulders. In some areas, the materials are very well mixed and are commonly referred to as glacial till. In other areas, they have been worked on and sorted by wind and water and redeposited as sediments of various gradations of particle size.

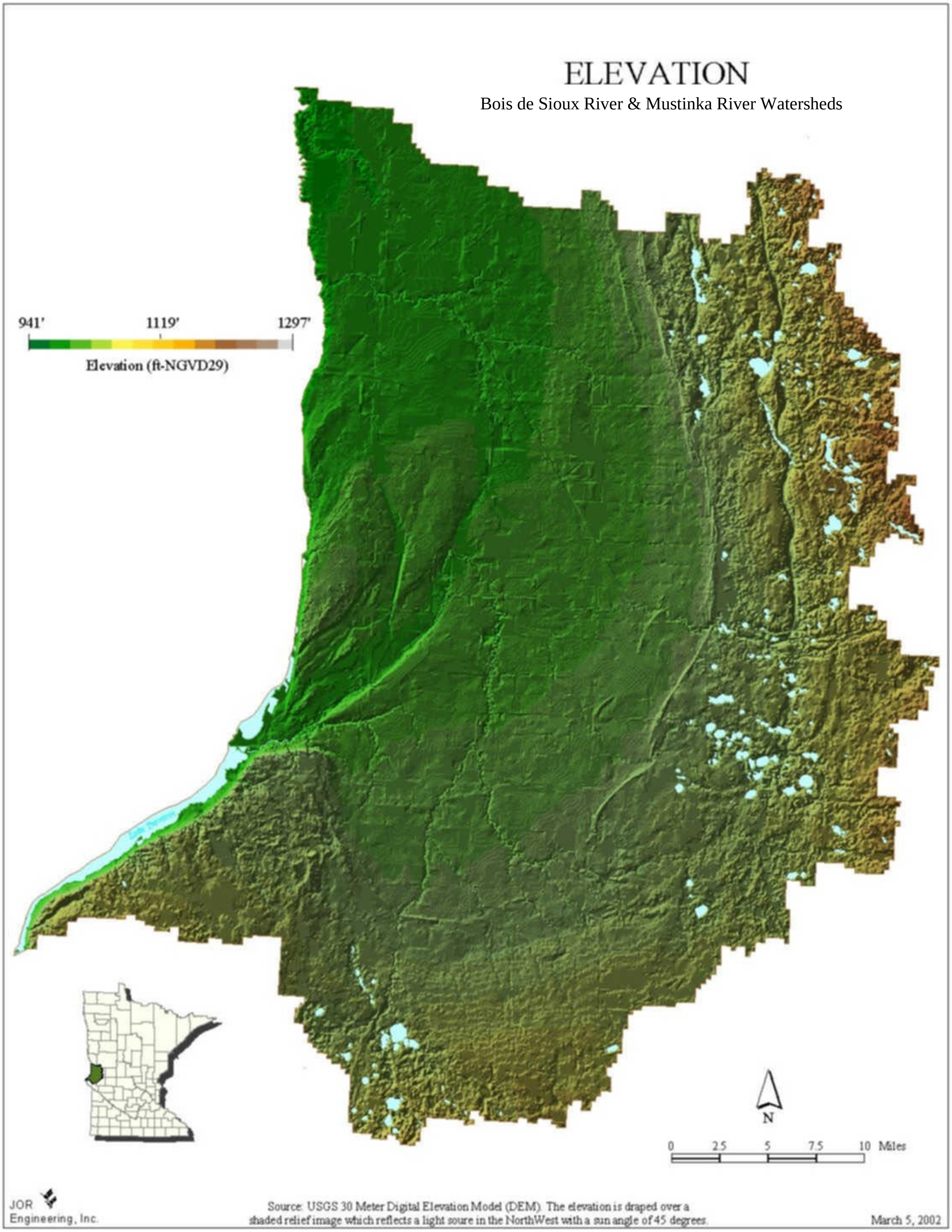
TOPOGRAPHY

The topography of the watersheds varies from gently rolling with interspersed lakes and wetlands in the morainal areas to very flat and level in the lake plain areas. Land elevations range from 1,280 feet above mean sea level northeast of Elbow Lake to 950 feet at Breckenridge. Land slopes of up to 20 percent are found in the morainal areas. In the lake plain, zero slope is not uncommon. A map of the general surface topography is shown in the Elevation Map Figure.

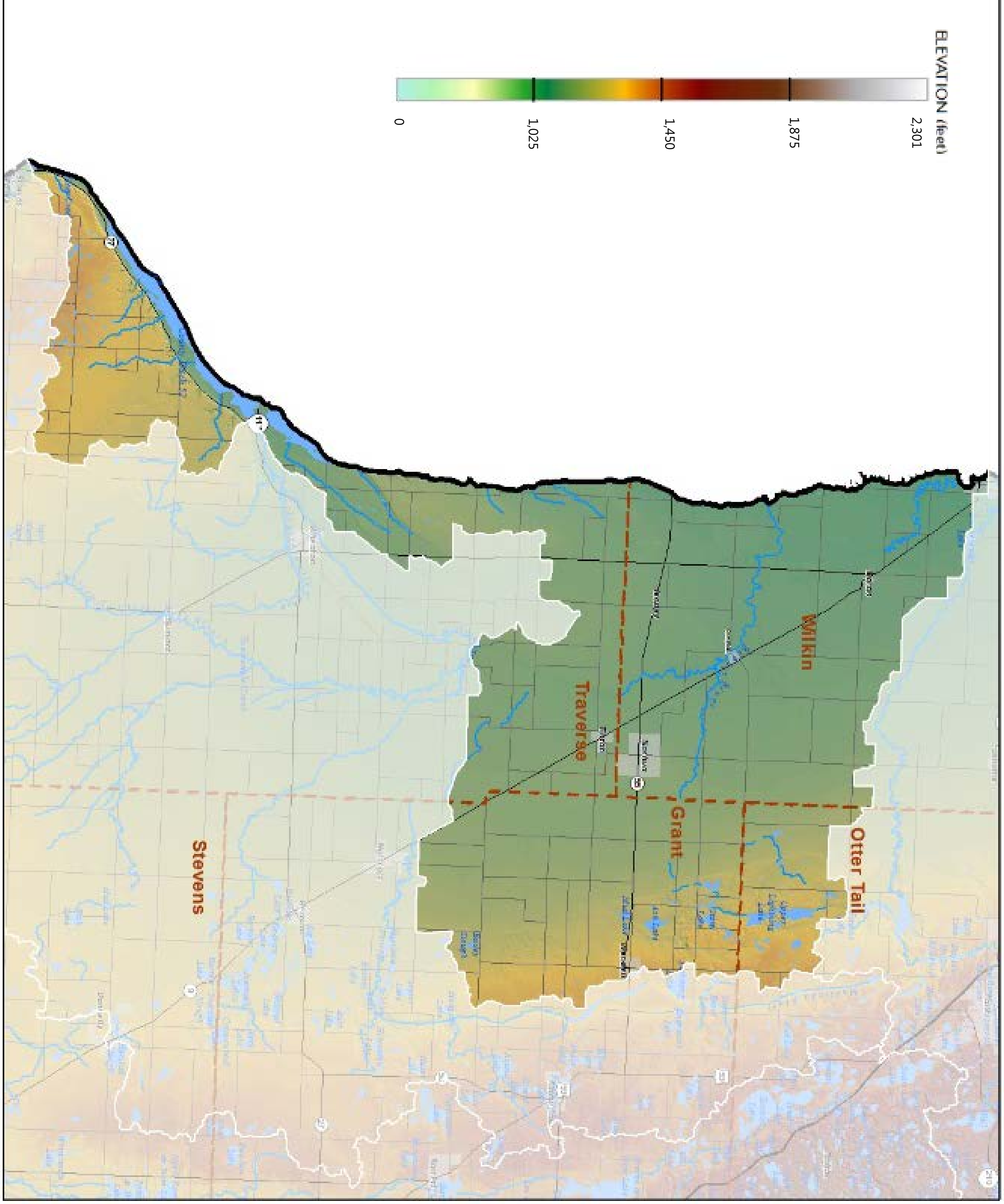

MAJOR LANDFORMS
Bois de Sioux River & Mustinka River Watersheds
Major Landforms
Beach Ridge
Glacial Lake Plain
Glacial Moraine
GLACIAL
LAKE
PLAIN
GLACIAL MORAINE
N
0 2.5 5 7.5 10 Miles
JOR
Engineering, Inc.
Source: Minnesota Geological Survey
October 22, 2002


PRECAMBRIAN
BEDROCK ELEVATIONS
Bois de Sioux River & Mustinka River Watersheds
The map shows the surface contours of the solid crystalline bedrock.
Bedrock Contour
(Altitude of Precambrian surface)
(Datum is mean sea level)
Otter Tail
Wilkin
Grant
Traverse
Stevens
Big Stone
700
720
740
680
660
640
760
780
800
1069
940
980
880
860
840
820
920
900
620
600
580
560
540
N
0 2.5 5 7.5 10 Miles
JOR Engineering, Inc.
Source: USGS, HA-272
February 25, 2002


CRETACEOUS ROCK ELEVATIONS
Bois de Sioux River & Mustinka River Watersheds
The map shows the surface contours of the sedimentary rock formed during the Cretaceous Period.
Cretaceous Sedimentary Rock
Precambrian Crystalline Rock
Bedrock Contour
(Altitude of Prepleistocene surface)
(Datum is mean sea level)
Wilkin
Otter Tail
Grant
Traverse
Stevens
Big Stone
N
0 2.5 5 7.5 10 Miles
JOR Engineering, Inc.
Source: USGS, HA-272
February 25, 2002

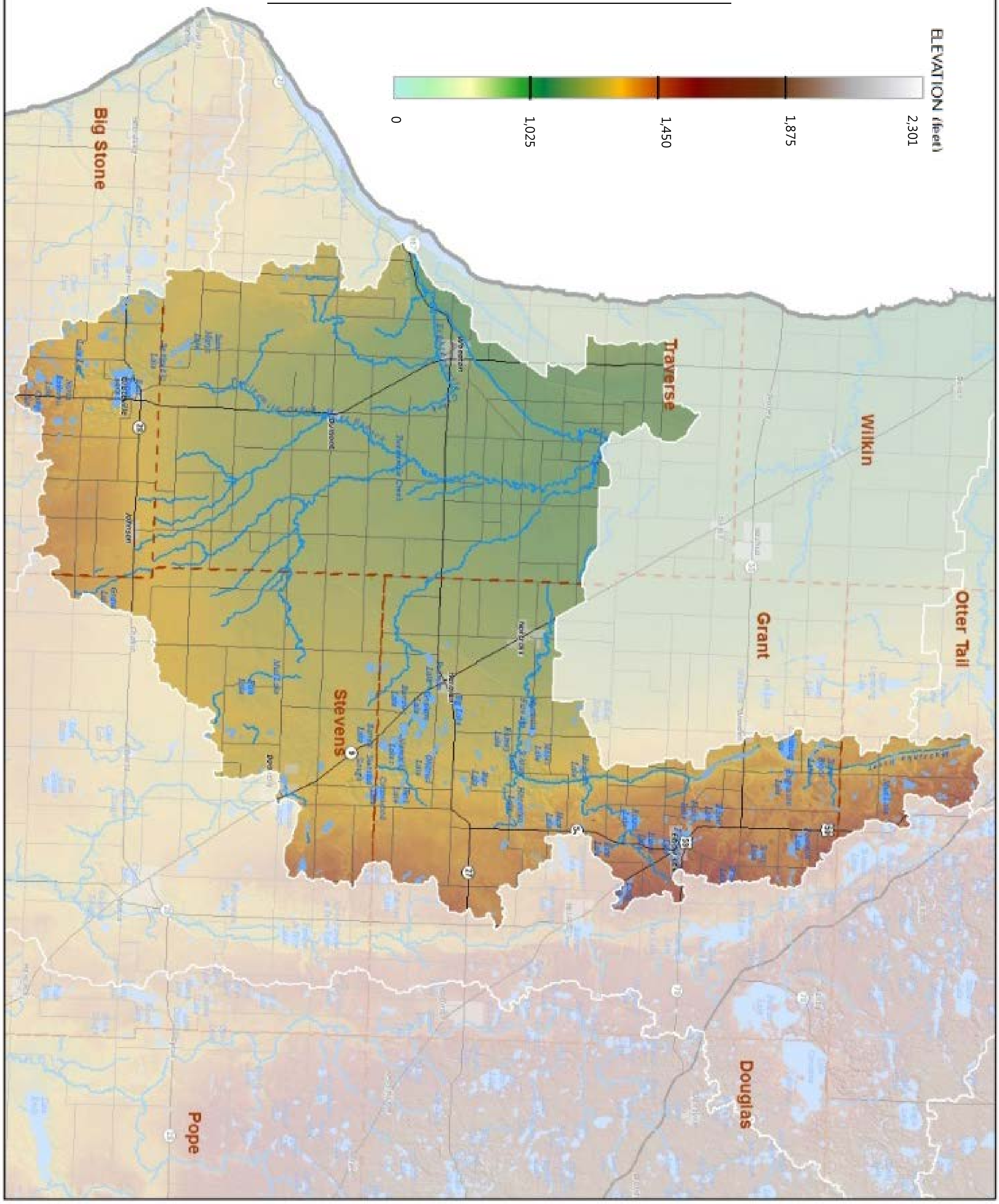

ELEVATION
Bois de Sioux River & Mustinka River Watersheds
941'
1119'
1297'
Elevation (ft-NGVD29)
N
0
2.5
5
7.5
10 Miles
JOR Engineering, Inc.
Source: USGS 30 Meter Digital Elevation Model (DEM). The elevation is draped over a shaded relief image which reflects a light soure in the NorthWest with a sun angle of 45 degrees.
March 5, 2002

ELEVATIONS IN THE BOIS DE SIOUX RIVER WATERSHED



Bois de Sioux River Watershed, https://mrbdc.mnsu.edu/mnnutrients/watersheds/bois-de-sioux

ELEVATIONS IN THE MUSTINKA RIVER WATERSHED



Mustinka River Watershed, https://mrbdc.mnsu.edu/mnnutrients/watersheds/mustinka-river-watershed

SOILS

The soils of both watersheds are all based in glacial materials. The soil texture differences depend on the sorting processes that wind and water have applied to the glacial deposits. The unsorted glacial till is a mixture of clay, silt, sand, gravel, and rock. The action of running water or waves on the till washed away the smaller particles in some areas, leaving behind the characteristic gravel pit deposits. The clay, silt and sand particles were transported by the water to more quiet areas within the streams or lake area. In general, the fine clay particles were carried farthest and deposited in the depths of the lake. The sands were the first to settle and form deposits in streambeds or near the edges of the lake where wave action further distributed them up and down the shoreline.

Topsoil development may include the addition of windborne deposits and organic remains that accumulate both above ground and within the root zone. Soils have been extensively mapped by the U.S. Department of Agriculture primarily to encourage suitable land use applications. Detailed soil surveys have been published covering each of the counties. These maps are detailed enough for land use planning on a small acreage basis.

From a water management viewpoint, soil texture is an important characteristic. Sandy soils have higher water infiltration rates but are more prone to drought and erosion than clay soils. Soil Texture Map Figure is a generalized soil landscape map of the watersheds showing the soil texture.

SOIL RUNOFF

Soil types also effect potential run-off. Hydrologic soil groups are classified in the map below by USDA as:

> *Group A—sand, loamy sand, or sandy loam soils that have low runoff potential and high infiltration rates even when thoroughly wetted.*
>
> *Group B—silt loam or loam soils that have moderate infiltration rates when thoroughly wetted.*
>
> *Group C—sandy clay loam soils that have low infiltration rates when thoroughly wetted.*
>
> *Group D—clay loam, silty clay loam, sandy clay, silty clay, or clay soils that have very low infiltration rates when thoroughly wetted. (USDA, 2014)*

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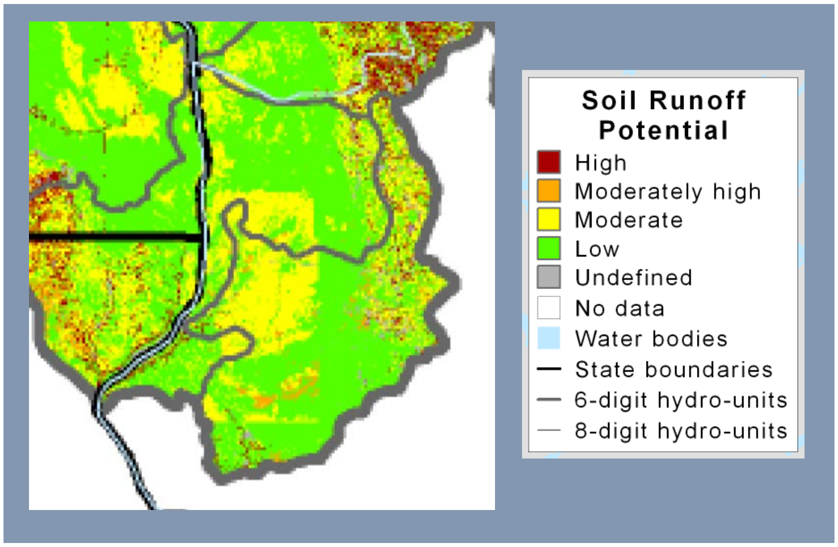
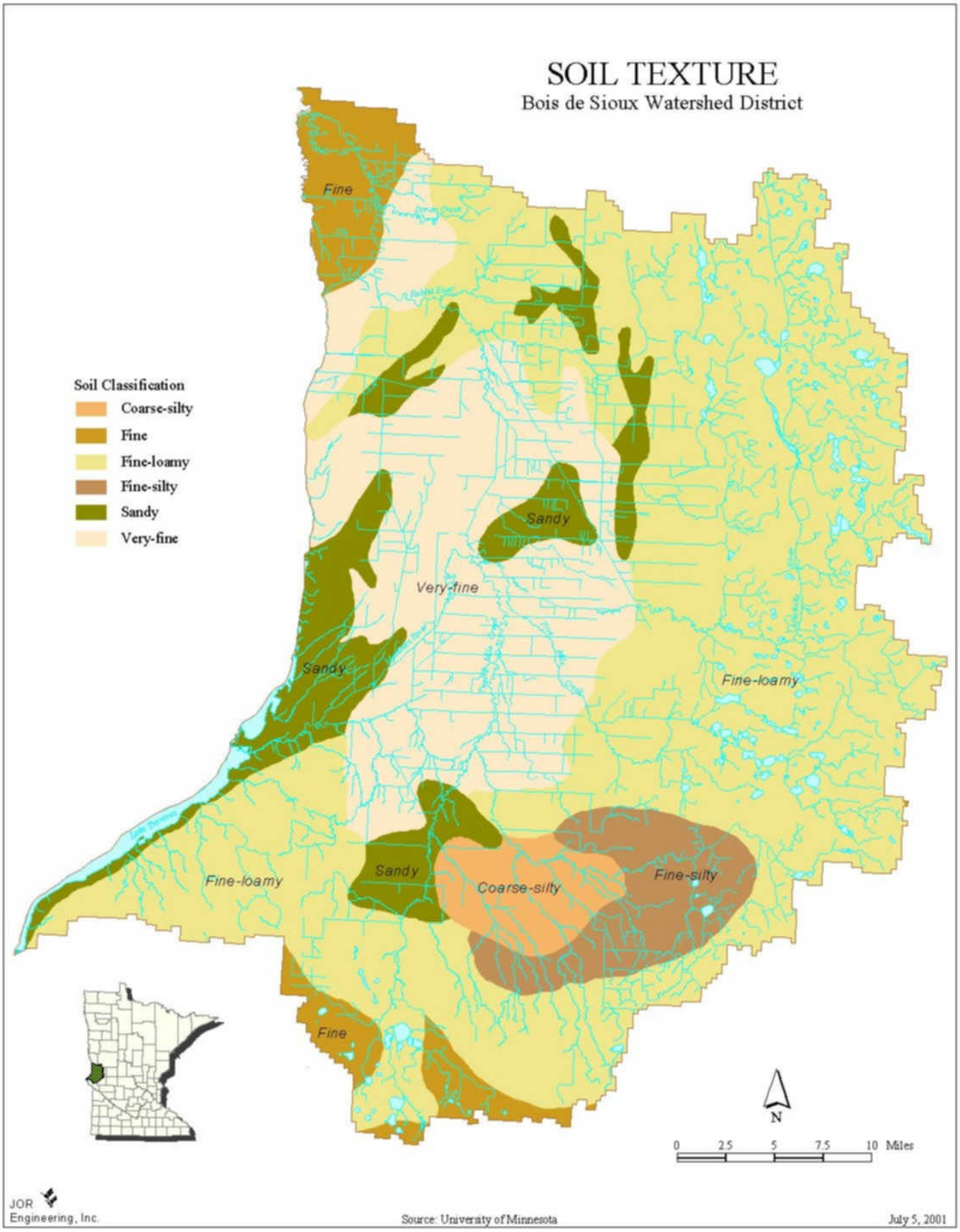


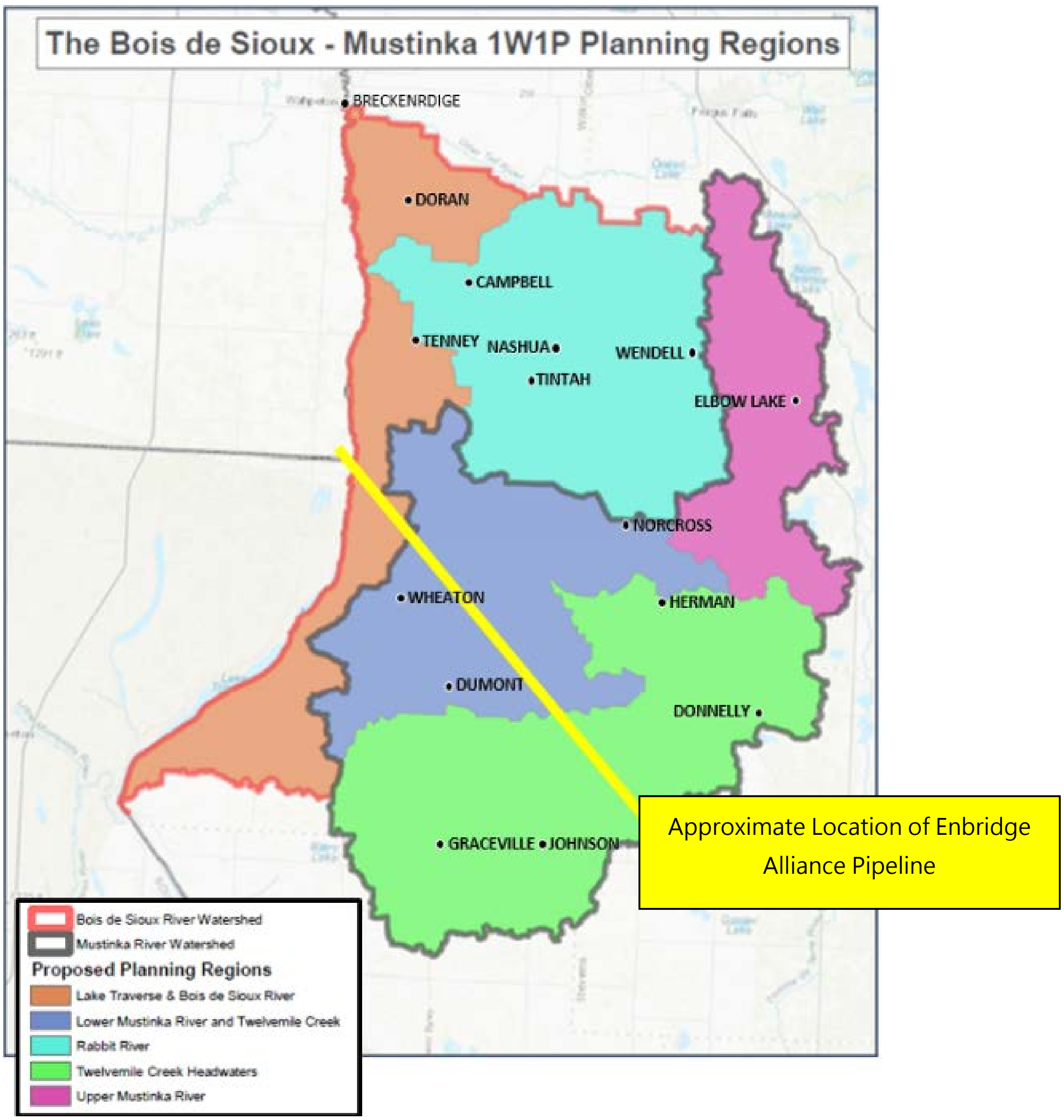

SOIL TEXTURE
Bois de Sioux Watershed District
Soil Classification
Coarse-silty
Fine
Fine-loamy
Fine-silty
Sandy
Very-fine
Fine
Sandy
Very-fine
Sandy
Fine-loamy
Fine-loamy
Sandy
Coarse-silty
Fine-silty
Fine
N
0 2.5 5 7.5 10 Miles
JOR Engineering, Inc.
Source: University of Minnesota
July 5, 2001

BELOW THE TOPSOIL

Underneath the topsoils of the Bois de Sioux and Mustinka River Watersheds, there is limited infrastructure. One noteable system is the Enbridge Natural Gas Pipeline (recently acquired by Enbridge from Alliance).

Per Enbridge (https://www.enbridge.com/map#map:infrastructure):

> *The Alliance Pipeline system consists of a 2,391-mile (3,848-kilometre) integrated U.S. and Canadian natural gas gathering and transmission pipeline system, delivering rich natural gas from the Western Canadian Sedimentary Basin and the Williston Basin to the Chicago market hub. The United States portion of the system consists of approximately 967 miles (1,556 kilometres) of infrastructure, including the 80-mile Tioga Lateral in North Dakota. Enbridge has a 50 percent ownership interest in Alliance Pipeline. The map below shows the approximate location of the pipeline in the Bois de Sioux and Mustinka River Watersheds. No cities in the watersheds are supplied with natural gas utilities.*



2 - ENVIRONMENTAL CONDITIONS

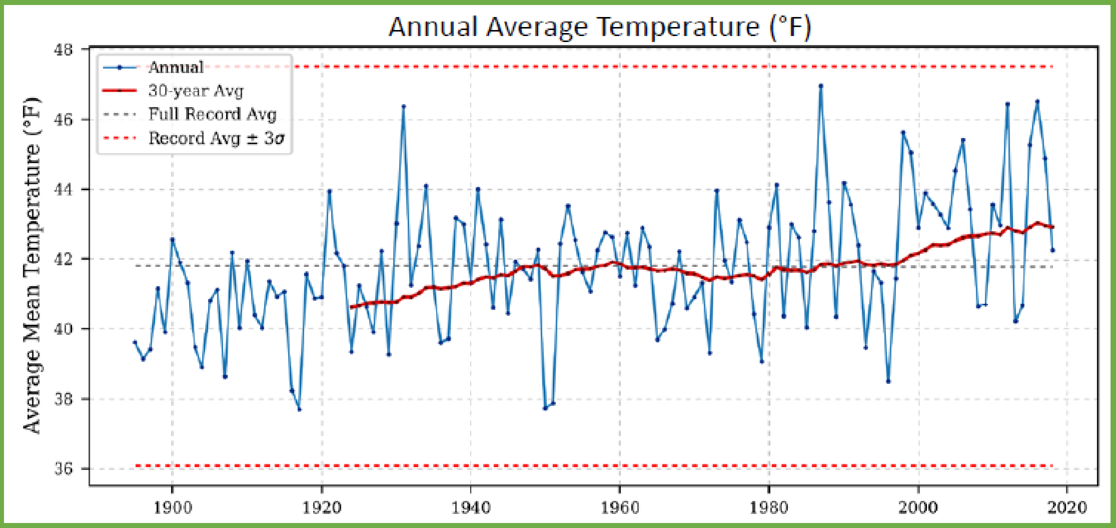
The climate of both watersheds is characterized by extreme temperature fluctuations and seasonal precipitation patterns.

Ecological Subregions of the United States (1994), https://www.fs.fed.us/land/pubs/ecoregions/			
Watershed	*Bois de Sioux & Mustinka*	*Bois de Sioux & Mustinka*	*Mustinka*
	Northern Glaciated Plains	**Lake Agassiz Plain (another name for RRV ecoregion)**	**North Central Hardwoods**
Growing Season	120 to 160 days	120 days	130 to 160 days
Precipitation averages	20 to 33 in	20 to 22 in	24 to 35 inches
Precipitation timing	50% during the growing season	40% during the growing season	Not Available
Mean annual temperatures	40 to 48 degrees F	37 to 41 degrees F	41 to 44 degrees F
Disturbance Regimes	Historically, fire was the most common natural disturbance. Floods and tornadoes also occurred. Fire suppression has allowed woodlands to develop from what was originally oak openings or brush prairies.	Fire was the most common natural disturbance, followed by floods and tornadoes. Fire frequency and intensity were reduced by natural barriers.	Not Available

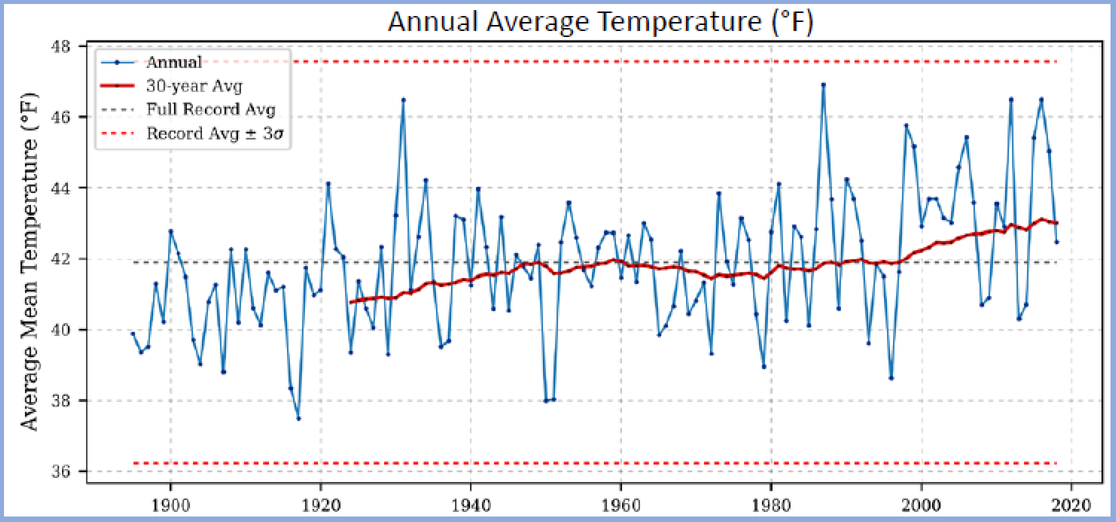
CLIMATE

How have annual average and long-term averages changed over the climate record? This figure provides annual average values (solid blue line) alongside the 30-year running average (solid red line), and the overall record average (dashed blue line). The figure allows us to compare values across three time periods and observe how recent observations compare to long-term trends.

BOIS DE SIOUX RIVER WATERSHED:



MUSTINKA RIVER WATERSHED:

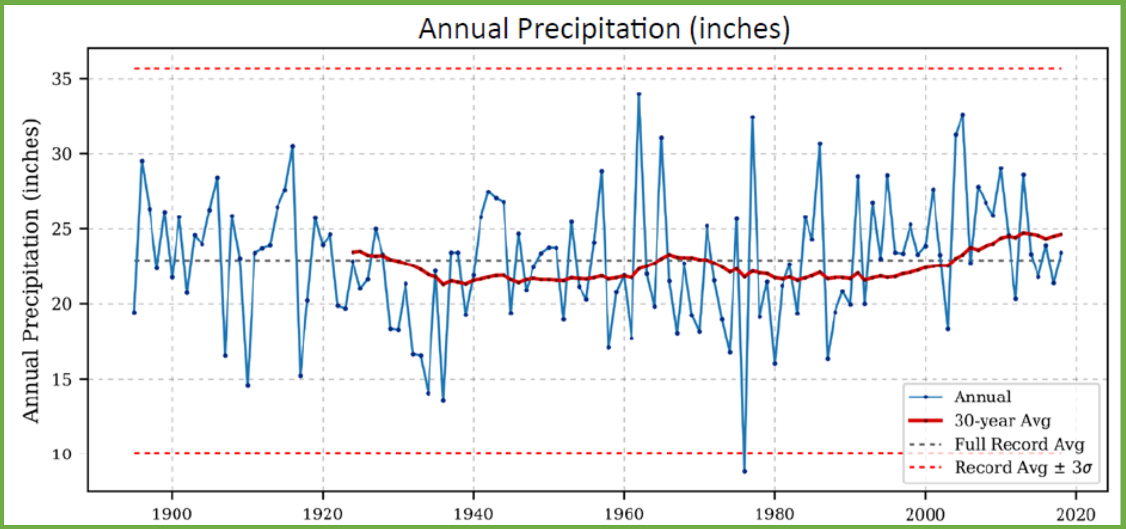


DNR Bois de Sioux River and Mustinka River Climate Summaries for Watersheds. June, 2019

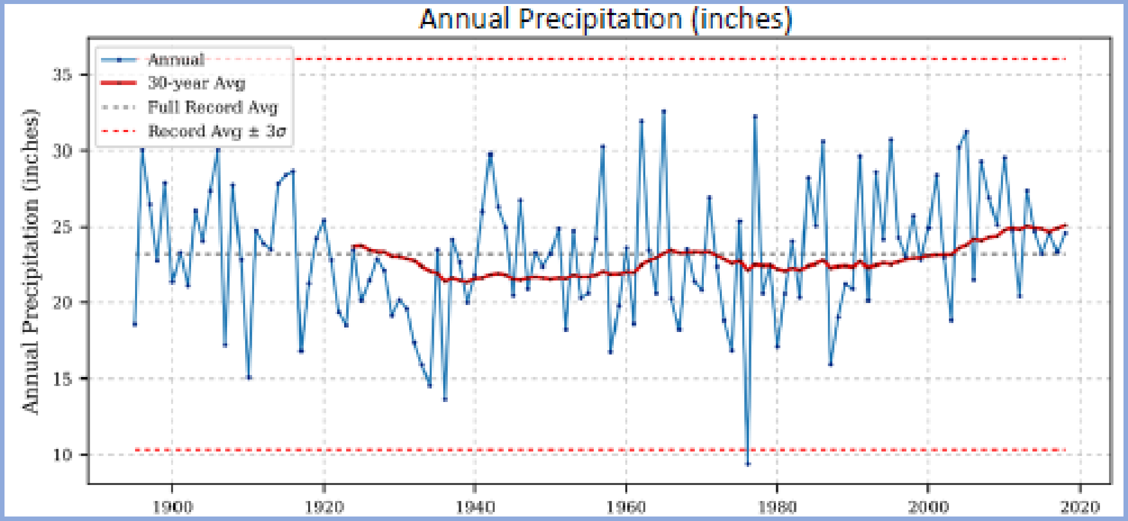
PRECIPITATION

How have annual average and long-term averages changed over the climate record? This figure provides annual average values (solid blue line) alongside the 30-year running average (solid red line) and the overall record average (dashed blue line). The figure allows us to compare values across three time periods and observe how recent observations compare to long-term trends.

BOIS DE SIOUX RIVER WATERSHED:



MUSTINKA RIVER WATERSHED:



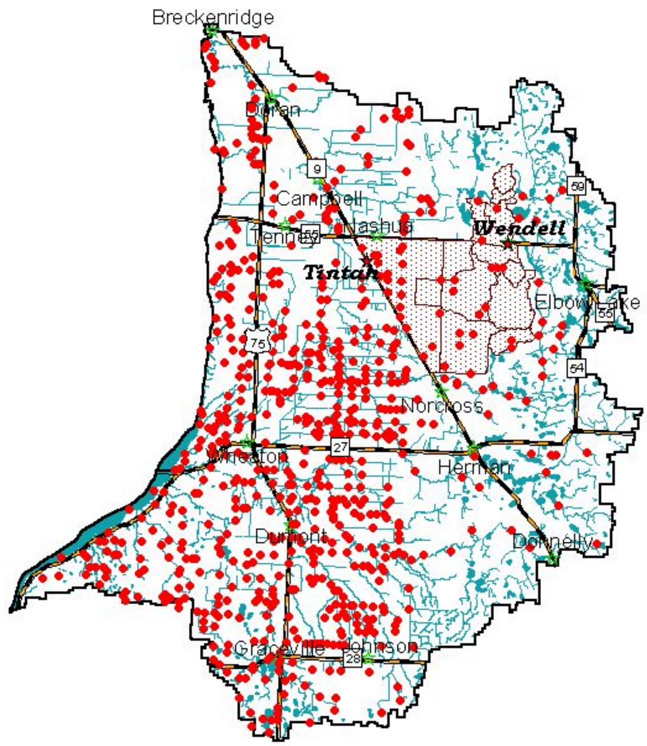
DNR Bois de Sioux River and Mustinka River Climate Summaries for Watersheds. June, 2019

SNOWMELT & FLOODING

Historically there have been tremendous problems with spring and summer flood events in both the Bois de Sioux River and Mustinka River Watersheds, and there have also been periods of excessive precipitation in the fall. Flooding causes considerable damage to public infrastructure, homes, businesses, cropland, and at times, crops. Much of the flooding problem relates to geophysical and hydrological nature of the region and the difficulty in containment by natural and artificial drainage systems. It is of utmost importance to the citizens of both watersheds that solutions to flood damage reduction be developed and implemented within a reasonable timeframe. The cooperation of counties, watershed districts, state and federal agencies and other local agencies are critical in the reduction of flood damage.

Widespread Red River Basin flooding occurred in 1882, 1883, 1893, 1897, 1916, 1943, 1947, 1948, 1950, 1952, 1965, 1966, 1969, 1975, 1978, 1979, 1989, 1993, 1997, 2001, 2006, 2009, and 2011(page 1 Leitch Krenz 2013), and most recently in 2019. Flood events occurred in the spring and summer seasons. The most severe conditions were experienced in 1997. In A River Runs North, Leitch and Krenz emphasize the importance of the 1997 flood:

> *The 1997 flood established a water level mark in the Red River Valley unseen for generations…. The 1997 flood…was the largest recorded flood…. Increased development and population in 1997 resulted in greater economic losses than in previous years.*



FEMA Sites, Flood of 1997

Total damages for the Red River region were $3.5 billion. Many flood mitigation projects were initiated and developed in response to the 1997 flood. Stricter zoning compliance requirements and flood insurance policies were also implemented.

Each flood is different, as there are a number of extenuating circumstances. When evaluating the seriousness of spring flooding, considerations are made for pre-freeze soil saturation conditions, snow depth and density, and spring warming temperatures. Because these factors will result in various flooding possibilities, collecting data is vitally important to understanding the circumstances leading up-to and contributing to flood events. As an example of the importance of applying lessons of past floods towards the shape of goals and objectives to mitigate the damages of future floods, the Flood of 1997 shows us that both surface *and* groundwater caused damages:

> *As temperatures began to warm up towards the end of March, the near-record snow-pack across Big Stone and Traverse Counties began to melt and runoff, filling up ditches, lakes, creeks, streams, and low-lying areas. The extensive amount of water inundated many county and township roads (as well as some highways). Many road sections were broken-up or washed-out. Culverts were damaged or blown-out, and some bridges were damaged or washed-out by ice chunks and high water flows. Thus, road closures occurred with rerouting taking place for school*

buses, mail carriers, farmers, ranchers, etc. Many acres of farmland and pastureland were underwater. Due to the high groundwater level, some homes were flooded by water in their basements. Total damages for the Red River region were $3.5 billion.

The effect of snowmelt and excess precipitation is not only measured in the quantity of water in the Bois de Sioux and Mustinka River Watersheds, but also snowmelt and flooding impact water quality as well. Corriveau, Chambers, and Culp found that total phosphorus and nitrogen loads "showed more variability and larger values during winter and snowmelt." (Julie Corriveau, July 2013). Rattan, Blukacz-Richards, Yates, Culp, and Chambers write:

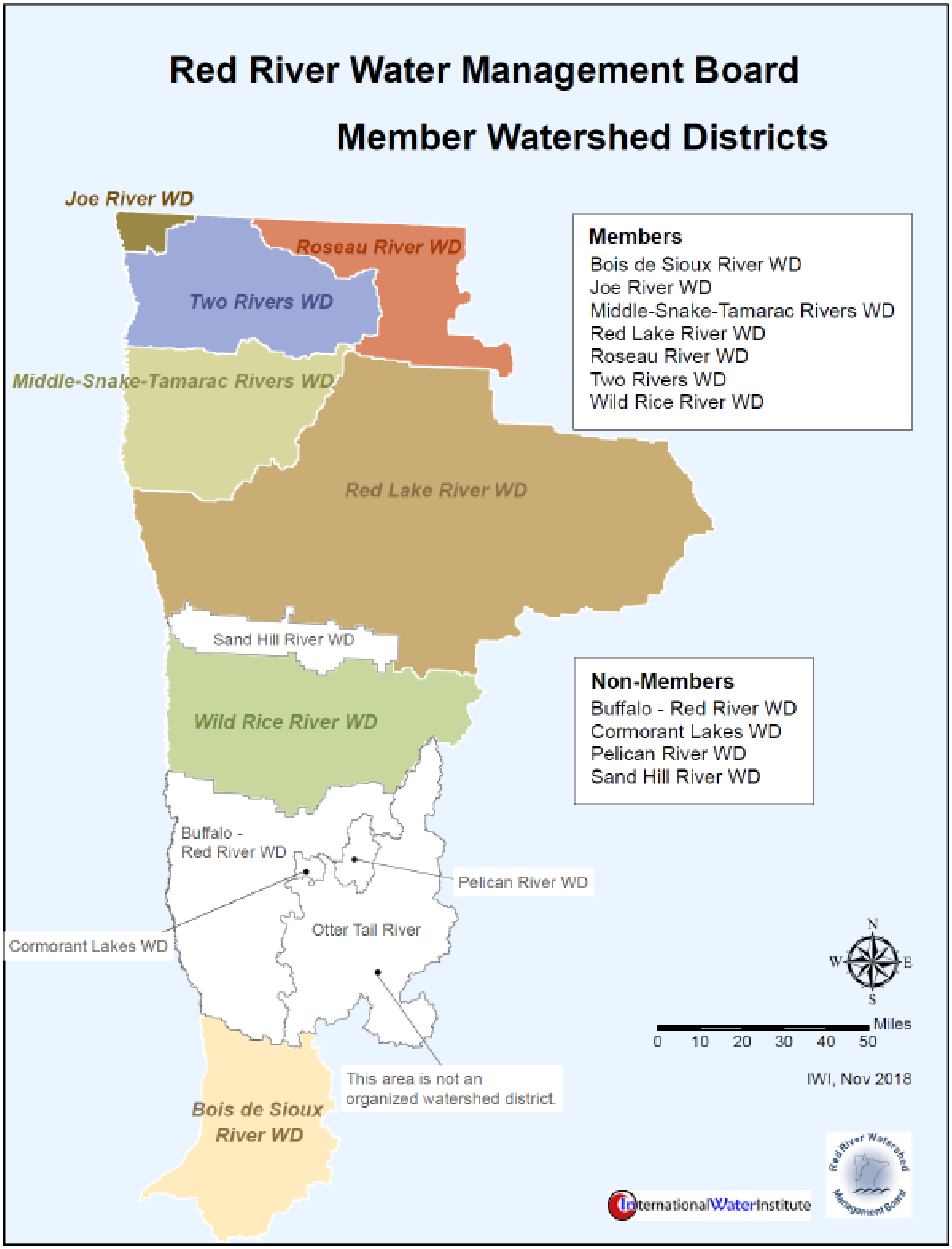
Our finding that nutrient concentrations, fractionation and export for prairie streams differs between years according to hydrological conditions has implications for water quality, particularly in response to climate change when reduced snowmelt and increased rain events are forecast to occur. During snowmelt dominated years, particulate nutrient concentrations and loads are greater and likely to result in increased water turbidity. In contrast, during years with reduced snowmelt runoff and greater rainfall, concentrations and loads of particulate N and P are lower in streams dissecting the Red River Valley." (K.J. Rattan, 2019)

RED RIVER WATER MANAGEMENT BOARD & RED RIVER BASIN MEDIATION AGREEMENT

The Bois de Sioux and Mustinka River Watersheds are part of the Red River Basin. In 1976, the Minnesota legislature created the Lower Red River Watershed Management Board (now renamed and known as the Red River Water Management Board RRWMB), an organization tasked with addressing basin-wide flooding. Prior to the formation of the Red River Water Management Board, flood control projects focused on a local scale. The RRWMB actively promotes a basin-wide perspective for water management.

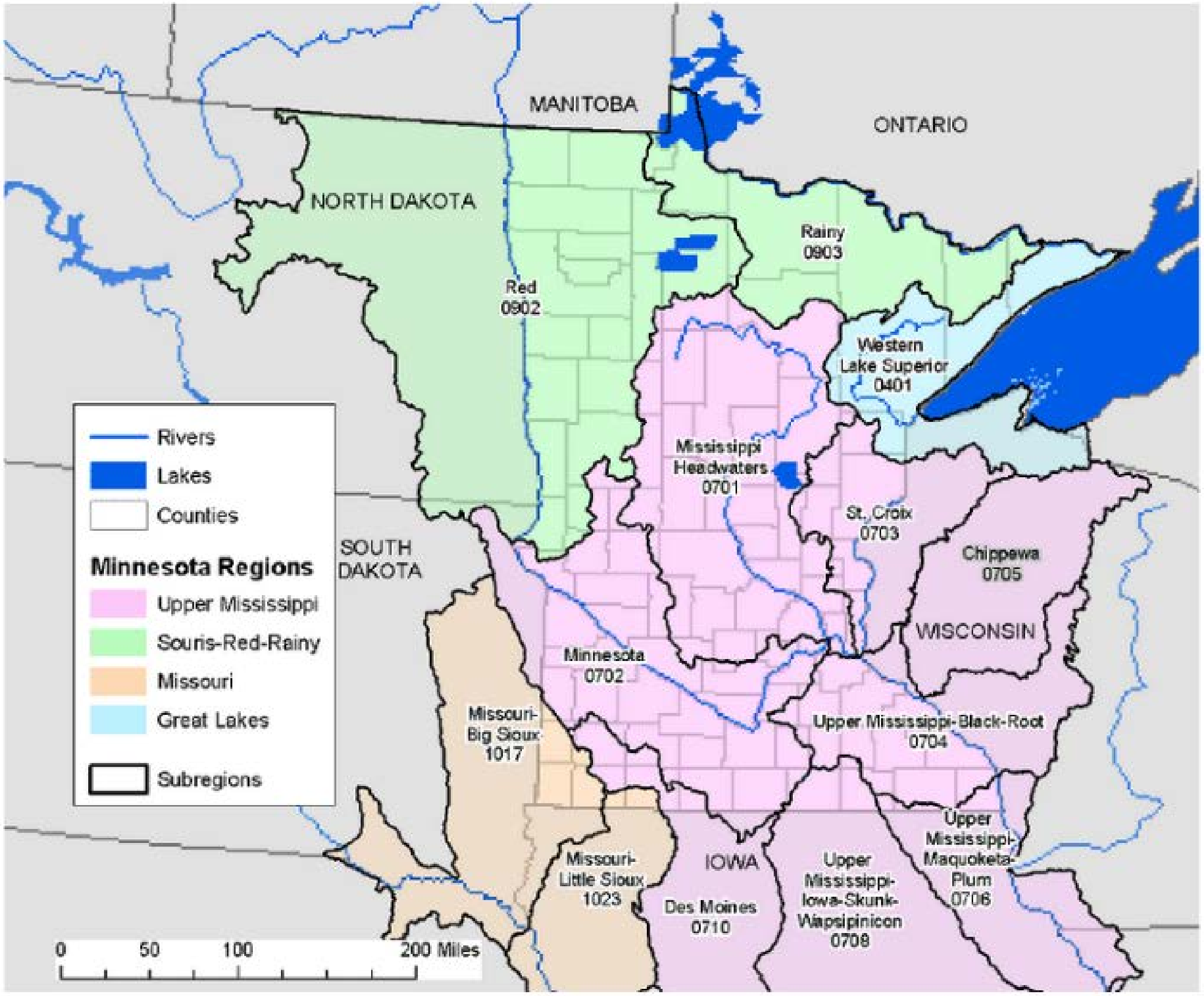
Even after the formation of the RRWMB, however, state permitting for flood control projects continued to present insurmountable barriers. As stated on page 1 of the December 9, 1998, Mediation Agreement, the Mediation Agreement fulfilled the Minnesota legislature's mandate to "resolve gridlock over state permitting of flood damage reduction projects in the Red River Basin." Stakeholders who signed the Mediation Agreement included representatives for MN Department of Natural Resources, Minnesota Board of Water and Soil Resources, Red River Watershed Management Board, National Audubon Society, Minnesota Center for Environmental Advocacy, US Army Corps of Engineers, US Fish and Wildlife, and Minnesota Pollution Control Agency.

Bois de Sioux and Mustinka River Watershed staff work within the guidelines and goals of the Mediation Agreement when developing flood damage reduction projects. Flood damage reduction strategies included in the Mediation Agreement include: wet dams, dry dams, on-stream water storage, off-stream water storage, flood storage wetlands, wetland restoration, river corridor restoration, setback levees, riparian buffer strips, dredging and channelization, flood storage easement, retirement of land, land use, best management practices, gating ditches, culvert sizing, and drainage.


Red River Water Management Board
Member Watershed Districts
Joe River WD
Roseau River WD
Two Rivers WD
Middle-Snake-Tamarac Rivers WD
Red Lake River WD
Sand Hill River WD
Wild Rice River WD
Buffalo - Red River WD
Pelican River WD
Cormorant Lakes WD
Otter Tail River
This area is not an organized watershed district.
Bois de Sioux River WD
Members
Bois de Sioux River WD
Joe River WD
Middle-Snake-Tamarac Rivers WD
Red Lake River WD
Roseau River WD
Two Rivers WD
Wild Rice River WD
Non-Members
Buffalo - Red River WD
Cormorant Lakes WD
Pelican River WD
Sand Hill River WD
N
W
E
S
Miles
0 10 20 30 40 50
IWI, Nov 2018
InternationalWaterInstitute
Red River Watershed Management Board

3 - SURFACE WATER HYDROLOGY

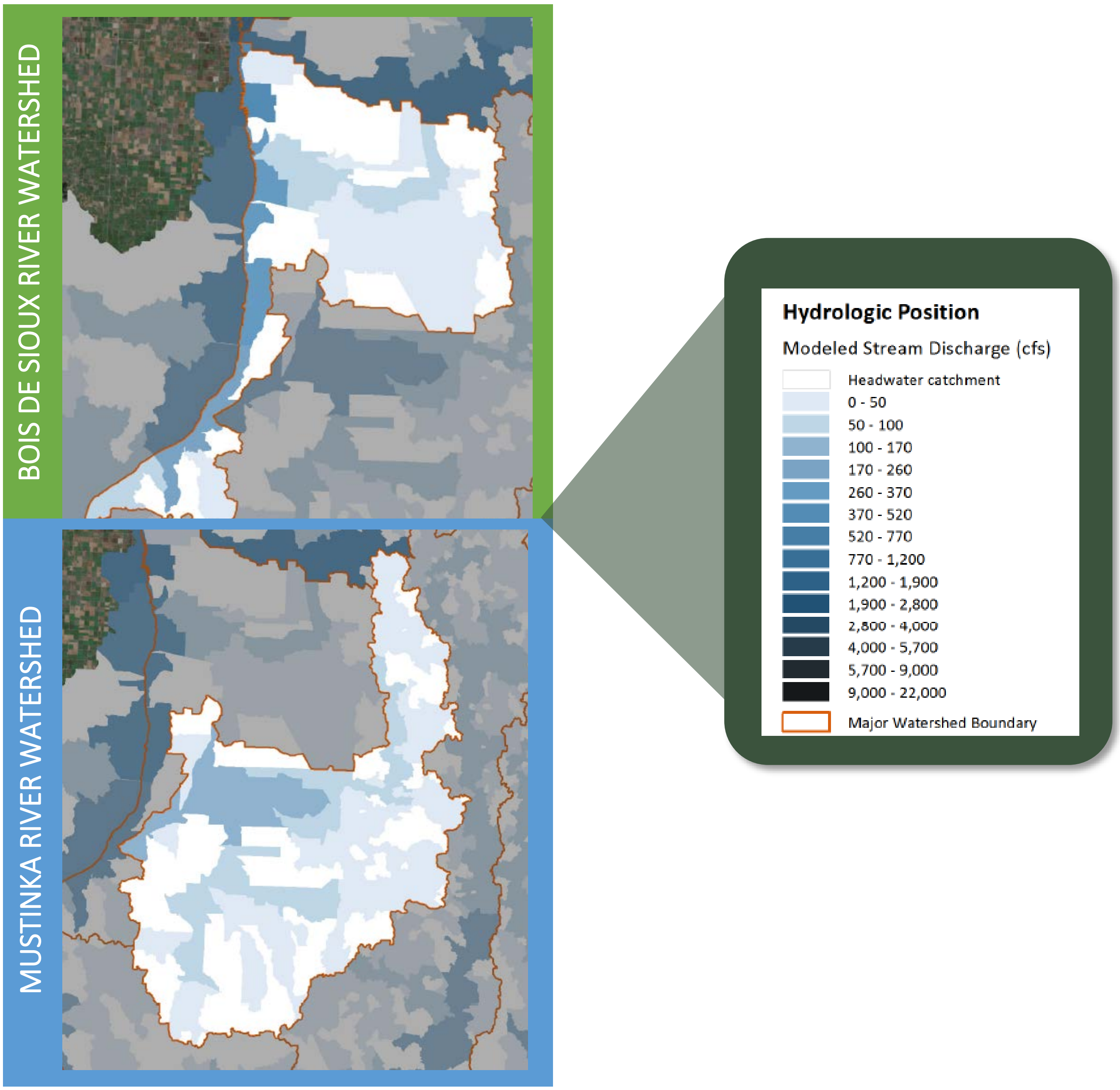
The Bois de Sioux and Mustinka River Watersheds are part of the Souris-Red-Rainy Hydrologic Subregion (4-Digit HUC) and the Upper Red Hydrologic Basin (6-Digit HUC).



(https://www.dnr.state.mn.us/watersheds/subregions.html).

HYDROLOGIC POSITION

The figures below, provided by the DNR, indicates that the majority of the acreage in the Bois de Sioux and Mustinka River Watersheds act as headwater catchments; they collect the surface water and send the water downstream. The DNR adds this footnote: "The discharge amounts in cubic feet per second (cfs) are estimates based on modeling, not actual measurements of stream flow."



SURFACE WATER QUALITY & QUANTITY

WATERSHED	RIVER MILES	LAKES > 10 ACRES	POINT SOURCES	WETLANDS & OPEN WATER
BOIS DE SIOUX	41	9	3	9%
MUSTINKA	68	188	27	9%

BOIS DE SIOUX RIVER WATERSHED

According to the MPCA's Bois de Sioux River Watershed Monitoring and Assessment and WRAPS Reports:

Rivers. *The Bois de Sioux River begins its 41 mile course at the dam on the north end of Lake Traverse. Rivers in this district are relatively shallow, and are prone to low- or no-flow during summer and fall. The river briefly flows north before entering Mud Lake. Roberts County, South Dakota lies on the west bank of the river and Traverse County, Minnesota on the east bank. The Bois de Sioux flows through White Rock Dam on the north end of Mud Lake and continues north. Eventually the river crosses into Richland County, North Dakota on its western side and Wilkin County, Minnesota on its eastern side. The Rabbit River, a major tributary, joins the Bois de Sioux River in Wilkin County. Originating near the source of the Mustinka River, the Rabbit River drains approximately 327 square miles of land and flows east to west within the Bois de Sioux River Watershed. The Bois de Sioux River continues north into the adjacent communities of Breckenridge, Minnesota and Wahpeton, North Dakota. At this location, the Otter Tail River joins with Bois de Sioux River to form the Red River of the North. Numerous small ditches and streams enter the Bois de Sioux at various locations throughout its entire course. Sections of the Bois de Sioux River have been channelized at various locations. There are four streams impaired: one impairment for Total Suspended Solids, one impairment for Low Fish-IBI Score, one impairment for mercury, two impairments for Low Dissolved Oxygen, and two impairments for E.coli. It is important to note that wildlife fecal runoff was identified as the likely dominant non-point pollutant source of bacteria to impaired streams.*

Lakes. *There are few major lakes in the watershed. The BdSRW has nine lakes with surface areas greater than ten acres. Lakes in this district have relatively shallow depths and large watersheds. Only three of these lakes has enough water quality data collected to conduct assessments (Ash, Upper Lightning, and Mud Lake, Traverse County). To be listed as impaired, a lake must not meet water quality standards for TP and either chl-a or secchi depth. Two of these lakes are considered impaired for aquatic recreation (Ash and Upper Lightning Lakes).*

Point Sources. *There are only three point sources in the watershed: Campbell Wastewater Treatment Facility (Municipal Wastewater), Hawes Piling Ground (Industrial Wastewater), Chad Hasbargen Farms (Animal Feeding Operation). All three discharge into the Rabbit River.*

Nonpoint Sources. *Nonpoint source pollution is caused by rainfall, snowmelt (moving over and through the ground), and wind erosion. Nonpoint sources are: overland runoff, wind erosion, near-stream/ditch erosion, wildlife fecal runoff, manure runoff, failing septic systems, internal loading, upstream lakes and streams. (MPCA, DRAFT Bois de Sioux River Watershed WRAPS, January 2019)*

Wetlands. *Wetlands and open water account for 9% of the Bois de Sioux River Watershed (MPCA, Bois de Sioux River Watershed Monitoring and Assessment Report, November 2013).*

Irrigation. *Surface water irrigation is currently non-existent. As of 2017, there are only 3 active permits for agricultural irrigation, and the last usage by any of the three permitees was in 1990 (DNR, Updated 09-05-2018).*

MUSTINKA RIVER WATERSHED

According to the MPCA's Mustinka River Watershed Monitoring and Assessment and WRAPS Reports:

Rivers. *Major rivers and streams include the Mustinka River, Twelve Mile Creek, Five Mile Creek and Eighteen Mile Creek. Numerous small unnamed creeks and ditches occur throughout the watershed. Rivers in this district are relatively shallow, and are prone to low- or no-flow during summer and fall. Beginning its 68 mile flow length in southwestern Ottertail County, the Mustinka River flows southward into Grant County through Lightning Lake and Stony Brook Lake (Waters 1977). The river maintains a southward course until turning west in southern Grant County. The river continues flowing west past Norcross and into Traverse County. In north-central Traverse County two main tributaries, Twelve Mile Creek and Five Mile Creek, feed into the Mustinka. Just west of the confluence of these tributaries the Mustinka River turns southwest and flows past Wheaton into Lake Traverse. There are eleven streams impaired: seven impairments for Total Suspended Solids, four impairments for Total Phosphorous, seven impairments for E. coli. It is important to note that there was a statistically significant decrease in average annual total suspended solid concentrations of 46% in the Mustinka River at Highway 75 near Wheaton from 2001 to 2011.*

Lakes. *There are 188 lakes greater than 10 acres within the Mustinka River Watershed. Lakes in this district have relatively shallow depths and large watersheds. Three of these lakes has enough water quality data collected to conduct assessments. To be listed as impaired, a lake must not meet water quality standards for TP and either chl-a or secchi depth. Three of these lakes are considered impaired for aquatic recreation (Lightning, East Toqua, and Lannon Lakes).*

Point Sources. *As of 2016, there are twenty-seven point sources in the watershed: 8 Municipal Wastewater Treatment Facilities (Big Stone Hutterite Colony, Donnelly, Dumont, Elbow Lake, Graceville, Herman, Wendell), 9 Industrial Stormwater Facilities (Aggregate Industries, City of Dumont, Elbow Lake Airport, Elbow Lake Gravel, Grant County Highway Garage, Grant County Highway Department, Grant County Norcross Highway Garage, Herman Airport, Herman Public Works).*

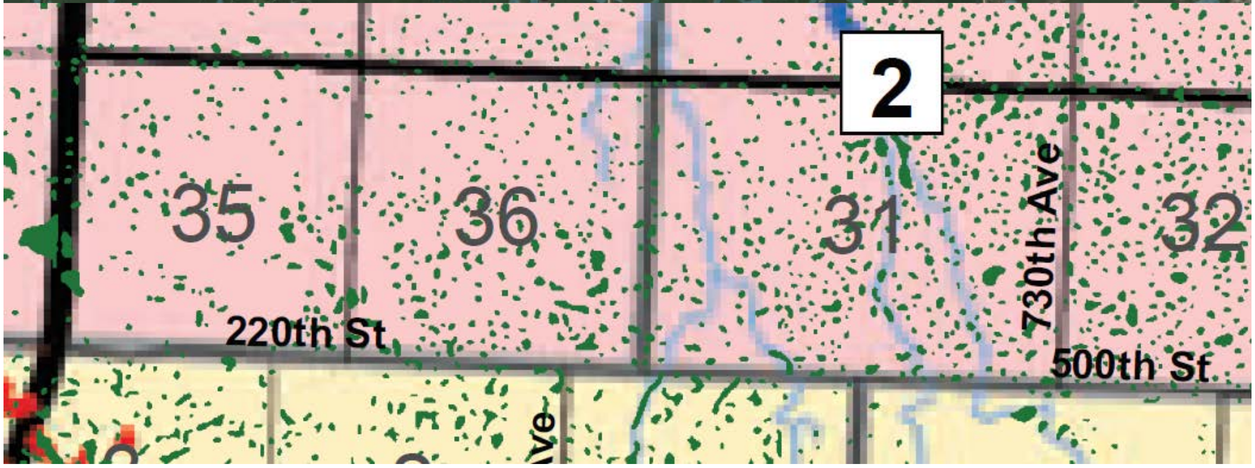
Nonpoint Sources. *Nonpoint source pollution is caused by rainfall, snowmelt (moving over and through the ground), and wind erosion. Nonpoint sources are: fertilizer and/or manure runoff, field and stream erosion, failing septic systems, internal loading, upstream lakes and streams, wildlife fecal runoff. (MPCA, Mustinka River Watershed Monitoring and Assessment Report, November 2013)*

Wetlands. *Wetlands and open water account for 9% of the Mustinka River Watershed (MPCA, Monitoring and Assessment Report, October 2016).*

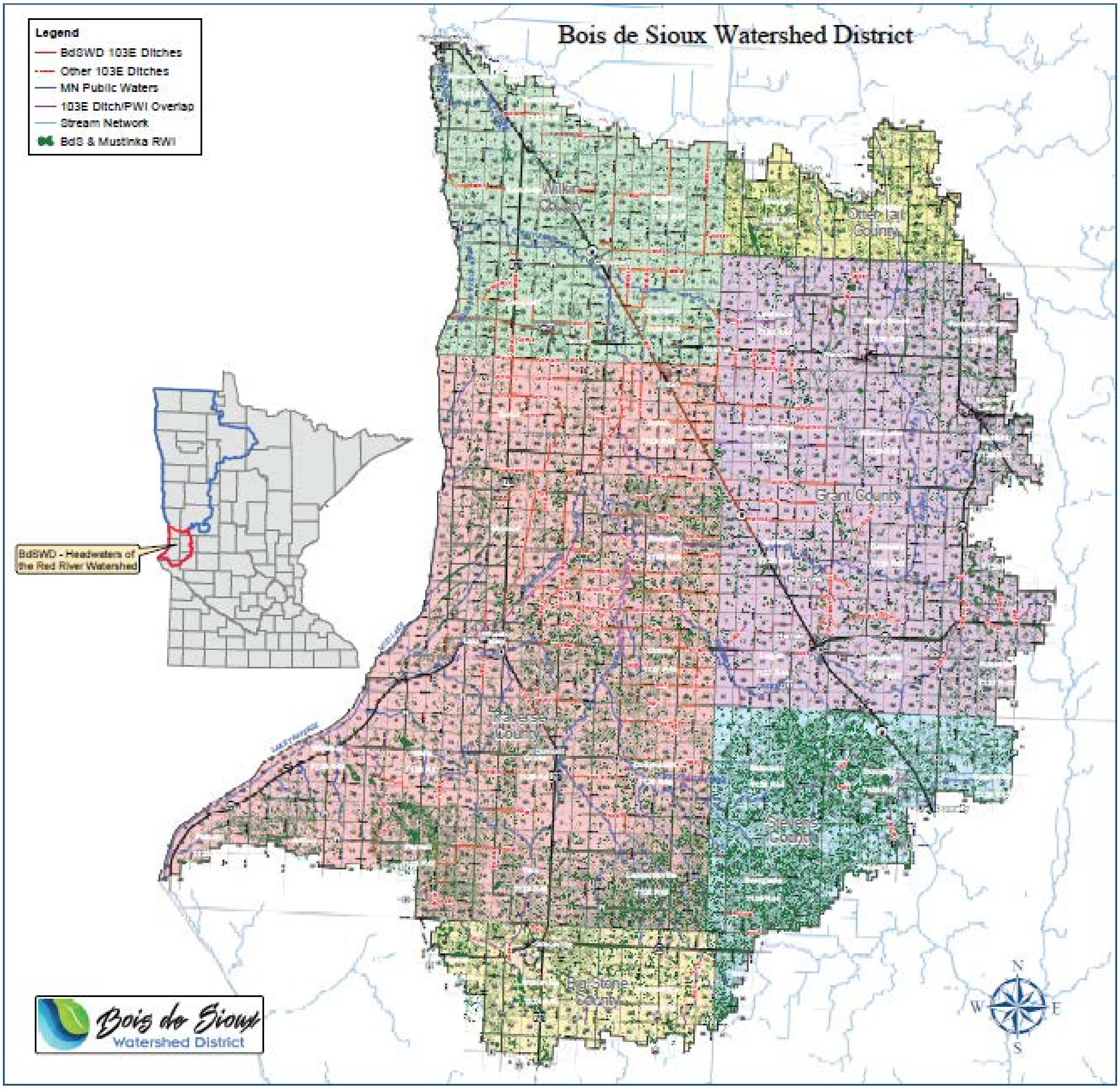
Irrigation. *Surface water irrigation is nearly non-existent. As of 2017, there are only 3 active permits for agricultural irrigation; two report no usage, and one permittee has irrigated intermittently between 1997 and 2017. The Wheaton Country Club Golf Course does utilize a Mustinka River Tributary for irrigation (DNR, Updated 09-05-2018).*

WETLANDS

The Minnesota Department of Natural Resource, using dollars from the Environment and Natural Resources Trust Funds contracted with Ducks Unlimited to inventory, map, and digitize drained restorable wetlands. This tool is used by soil and water conservation districts to evaluate potential wetland restoration sites. The map excerpts below are from Traverse County - Tara Township, Sections 35 and 36; Leonardsville Township, Sections 31 and 32.

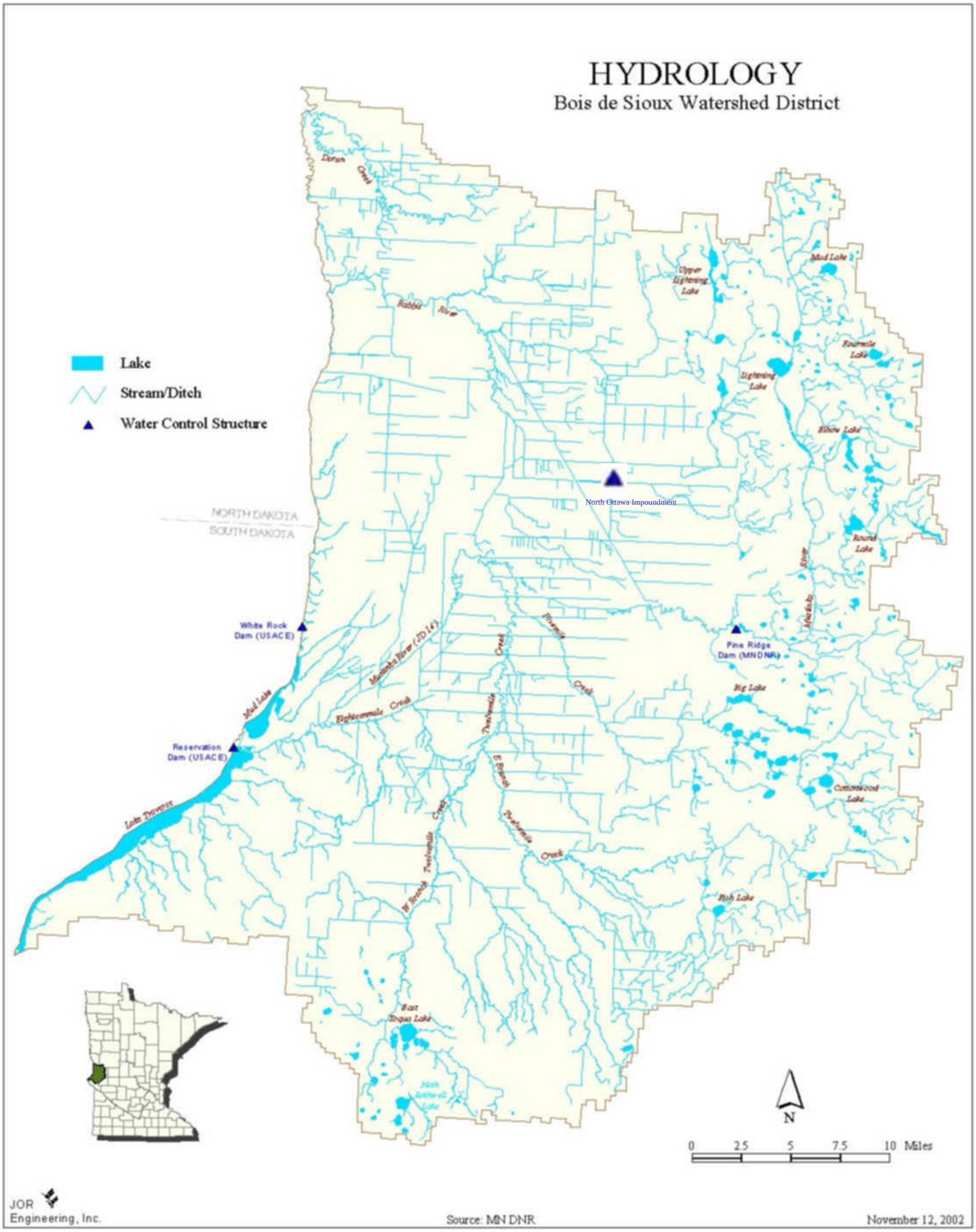


DNR-DU Restorable Wetland Inventory



WATER MANAGEMENT STRUCTURES

There are a wide variety of structures in the Bois de Sioux River and Mustinka River Watersheds – varying from large, complex systems (such as dams, drainage systems, and impoundments) to small, field-scale projects (such as ring dikes, grassed waterways, and terraces).


HYDROLOGY
Bois de Sioux Watershed District
Lake
Stream/Ditch
Water Control Structure
NORTH DAKOTA
SOUTH DAKOTA
North Ottawa Impoundment
White Rock Dam (USACE)
Reservation Dam (USACE)
Pine Ridge Dam (MNDNR)
Mud Lake
Lake Traverse
Rabbit River
Mustinka River (JD 14)
Eighteenmile Creek
Twelvemile Creek
Fivemile Creek
Big Lake
Fish Lake
Cottonwood Lake
Round Lake
Elbow Lake
Lightning Lake
Fourmile Lake
Upper Lightning Lake
N
0 2.5 5 7.5 10 Miles
JOR Engineering, Inc.
Source: MN DNR
November 12, 2002

BOIS DE SIOUX RIVER WATERSHED – LAKE TRAVERSE BOIS DE SIOUX RIVER PROJECT

The Lake Traverse Bois de Sioux River Project was constructed by the Corps of Engineers in 1941. The project consists of a flood control dam at the outlet of Mud Lake (White Rock Dam), a level control dam at the outlet of Lake Traverse (Reservation Dam), a levee at the south end of Lake Traverse (the Browns Valley Dike), and a channel improvement on the Bois de Sioux River extending 24 miles downstream. The project provides 128,520 acre-feet of flood control storage in addition to a conservation pool of 121,280 acre-feet. The flood storage capacity is equivalent to 2.2 inches of runoff from the upstream drainage area.

Normal operation of the dams is to control the level of Lake Traverse at about 976 feet above sea level and Mud Lake at about 972. During minor runoff events, Reservation Dam at the outlet of Lake Traverse is opened to keep the lake below 977. White Rock Dam at the outlet of Mud Lake will be closed if there is flooding potential downstream. During major floods, the level in Mud Lake will rise to equal that in Lake Traverse: the pools will rise together from 977 to 981. When the reservoir reaches 981, White Rock Dam is opened to match the inflow as best it can. In 1997, inflow was higher than outflow and pools raised to 982.25. The release of water at White Rock Dam may impact downstream drinking water due to the presence of high organic carbon, high sulfate and hardness.

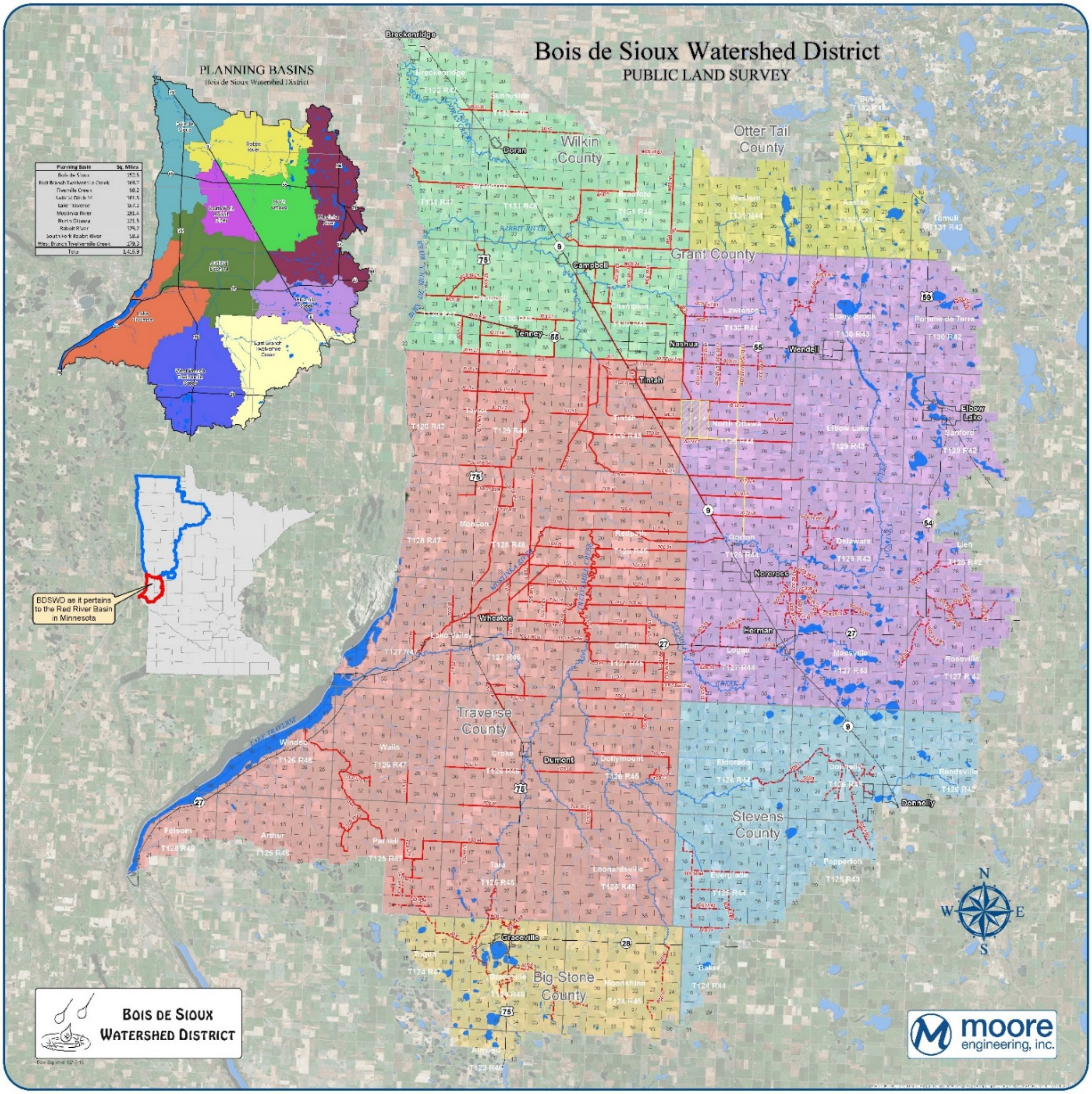
MUSTINKA RIVER WATERSHED – MUSTINKA RIVER PROJECT

The Mustinka River Project was constructed by the Corps of Engineers in 1957. It consists of 36.1 miles of channel improvement on the Mustinka River, Twelve Mile Creek, and County Ditch 42. This project was then turned over to the Local Government Unit (LGU)- Joint County Board to be managed as a Legal Drainage System under Minnesota Statute MS 103E.

DRAINAGE WATER MANAGEMENT SYSTEMS

Legal drainage ditches were constructed in 1870 and later; most of the existing ditch systems were established during the first quarter of this century. Ditches provide local relief from soil wetness conditions and minor flooding problems. The generally flat topography and predominantly heavy soils of both watersheds do not afford adequate natural drainage for efficient production of agricultural crops - however, when water is properly managed, the soils are highly productive. In addition to enhancing agricultural production, drainage ditch systems protect roads, highways, and property; landowners who deemed to receive benefit from the drainage systems were originally assessed drainage ditch construction costs. Subsequent repair, maintenance, and improvements are also assessed annually.

The public drainage systems within the Bois de Sioux and Mustinka River Watersheds that are managed by drainage authorities on behalf of the landowners receiving benefit from the drainage system. There are 581 miles of legal ditches as shown in the figure below. Of these, 414 miles are managed by the Bois de Sioux Watershed District. Big Stone, Grant, Otter Tail, Stevens and Wilkin Counties act as the drainage authority over specific drainage systems in their jurisdictions. Following the figure below is a list of local government units that serve as the drainage authority for the Bois de Sioux and Mustinka River Watershed public drainage systems.


Bois de Sioux Watershed District
PUBLIC LAND SURVEY
PLANNING BASINS
Bois de Sioux Watershed District
BDSWD as it pertains to the Red River Basin in Minnesota
Wilkin County
Otter Tail County
Grant County
Traverse County
Stevens County
Big Stone County
Breckenridge
Campbell
Tintah
Wheaton
Herman
Dumont
Graceville
Donnelly
Elbow Lake
BOIS DE SIOUX WATERSHED DISTRICT
moore engineering, inc.

BENEFITTED LAND	DITCH SYSTEM NAME	DRAINAGE AUTHORITY
Wilkin County	BdSWD #3	Bois de Sioux Watershed District
Grant County	Big Stone County Ditch #10	Big Stone County
Grant County	Big Stone County Ditch #11	Big Stone County
Grant County	Big Stone County Ditch #16	Big Stone County
Grant County	Big Stone County Ditch #8	Big Stone County
Grant County	Big Stone County Judicial Ditch #4	Big Stone County
Grant County	Grant County Ditch #15	Grant County
Grant County	Grant County Ditch #21	Grant County
Grant County	Grant County Ditch #22	Grant County
Grant County	Grant County Ditch #29	Grant County
Grant County	Grant County Ditch #3	Grant County
Grant County	Grant County Ditch #32	Grant County
Grant County	Grant County Ditch #33	Grant County
Grant County	Grant County Ditch #5	Grant County
Grant County	Grant County Ditch #6	Grant County
Grant County	Grant County Ditch #8	Grant County
Grant County	Grant County Ditch #9	Grant County
Grant County	Grant County Judicial Ditch #2	Grant County
Stevens County	Stevens County Ditch #1	Stevens County
Stevens County	Stevens County Ditch #7	Stevens County
Stevens County	Stevens County Ditch #8	Stevens County
Stevens County	Stevens County Ditch #15	Stevens County
Traverse County	Traverse County Ditch #1	Bois de Sioux Watershed District
Traverse County	Traverse County Ditch #2	Bois de Sioux Watershed District
Traverse & Grant Counties	Traverse County Ditch #4	Bois de Sioux Watershed District
Traverse County	Traverse County Ditch #7	Bois de Sioux Watershed District
Traverse & Stevens Counties	Traverse County Ditch #8	Bois de Sioux Watershed District
Traverse County	Traverse County Ditch #9	Bois de Sioux Watershed District
Traverse County	Traverse County Ditch #10	Bois de Sioux Watershed District
Traverse County	Traverse County Ditch #11	Bois de Sioux Watershed District
Traverse County	Traverse County Ditch #13	Bois de Sioux Watershed District
Traverse County	Traverse County Ditch #15	Bois de Sioux Watershed District
Traverse County	Traverse County Ditch #16	Bois de Sioux Watershed District
Traverse County	Traverse County Ditch #17	Bois de Sioux Watershed District
Traverse County	Traverse County Ditch #18	Bois de Sioux Watershed District

BENEFITTED LAND	DITCH SYSTEM NAME	DRAINAGE AUTHORITY
Traverse County	Traverse County Ditch #19	Bois de Sioux Watershed District
Traverse County	Traverse County Ditch #20	Bois de Sioux Watershed District
Traverse County	Traverse County Ditch #22	Bois de Sioux Watershed District
Traverse County	Traverse County Ditch #23	Bois de Sioux Watershed District
Traverse County	Traverse County Ditch #24	Bois de Sioux Watershed District
Traverse County	Traverse County Ditch #26	Bois de Sioux Watershed District
Traverse County	Traverse County Ditch #27	Bois de Sioux Watershed District
Traverse County	Traverse County Ditch #28	Bois de Sioux Watershed District
Traverse County	Traverse County Ditch #29	Bois de Sioux Watershed District
Traverse County	Traverse County Ditch #30	Bois de Sioux Watershed District
Traverse County	Traverse County Ditch #31	Bois de Sioux Watershed District
Traverse County	Traverse County Ditch #32	Bois de Sioux Watershed District
Traverse County	Traverse County Ditch #33	Bois de Sioux Watershed District
Traverse County	Traverse County Ditch #35	Bois de Sioux Watershed District
Traverse County	Traverse County Ditch #36	Bois de Sioux Watershed District
Traverse & Stevens Counties	Traverse County Ditch #37	Bois de Sioux Watershed District
Traverse County	Traverse County Ditch #38	Bois de Sioux Watershed District
Traverse County	Traverse County Ditch #39	Bois de Sioux Watershed District
Traverse County	Traverse County Ditch #40	Bois de Sioux Watershed District
Traverse County	Traverse County Ditch #41	Bois de Sioux Watershed District
Traverse County	Traverse County Ditch #42	Bois de Sioux Watershed District
Traverse County	Traverse County Ditch #43	Bois de Sioux Watershed District
Traverse County	Traverse County Ditch #44	Bois de Sioux Watershed District
Traverse County	Traverse County Ditch #46	Bois de Sioux Watershed District
Traverse County	Traverse County Ditch #48	Bois de Sioux Watershed District
Traverse County	Traverse County Ditch #50	Bois de Sioux Watershed District
Traverse County	Traverse County Ditch #51	Bois de Sioux Watershed District
Traverse County	Traverse County Ditch #52	Bois de Sioux Watershed District
Traverse County	Traverse County Ditch #53	Bois de Sioux Watershed District
Traverse County	Traverse County Ditch #55	Bois de Sioux Watershed District
Traverse & Grant Counties	Traverse County Judicial County Ditch #2	Bois de Sioux Watershed District
Traverse County	Traverse County Judicial County Ditch #3	Bois de Sioux Watershed District
Traverse & Wilkin Counties	Traverse County Judicial County Ditch #6	Bois de Sioux Watershed District
Traverse & Wilkin Counties	Traverse County Judicial County Ditch #7	Bois de Sioux Watershed District
Traverse & Wilkin Counties	Traverse County Judicial County Ditch #11	Bois de Sioux Watershed District

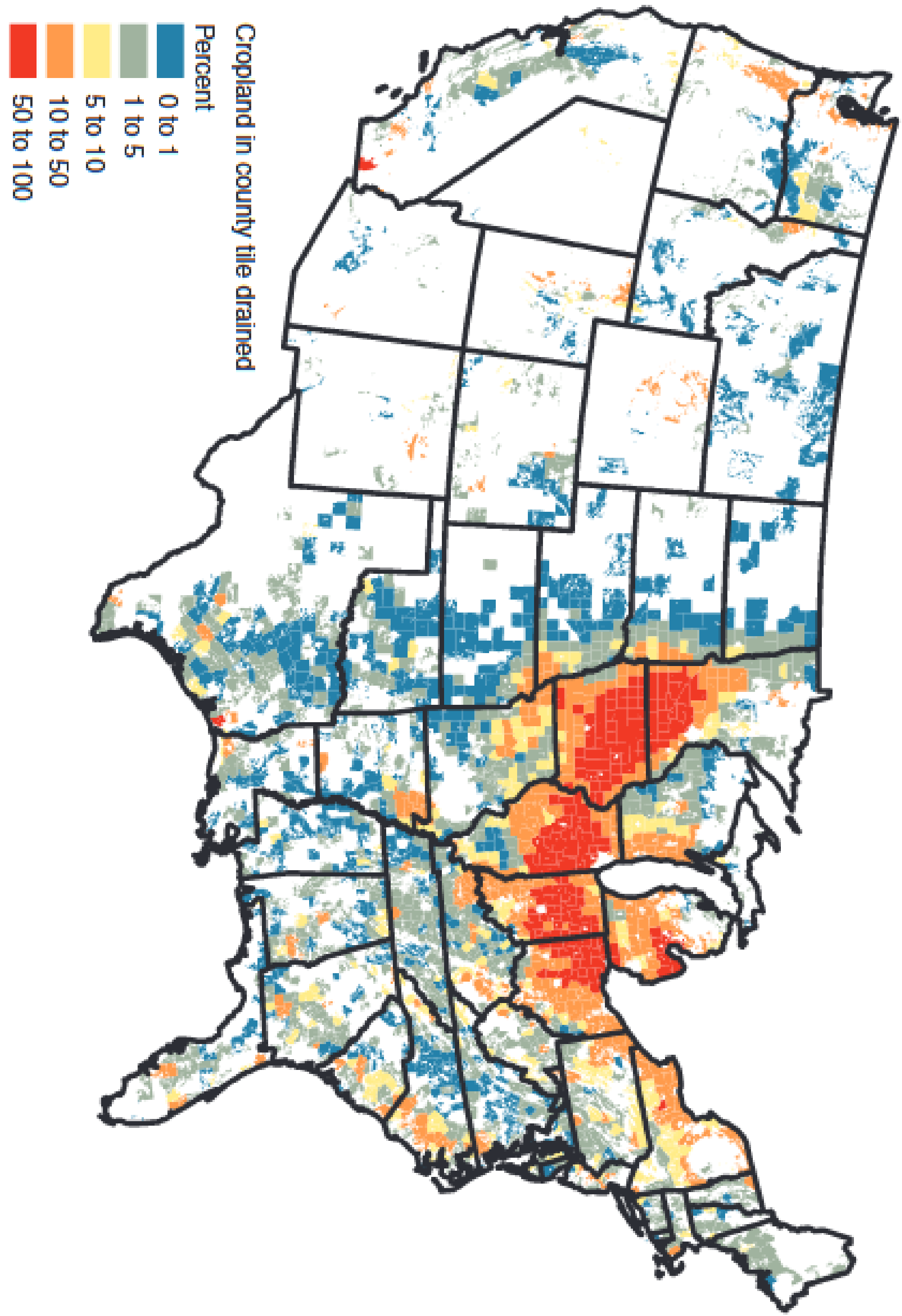
BENEFITTED LAND	DITCH SYSTEM NAME	DRAINAGE AUTHORITY
Grant, Traverse & Wilkin Counties	Traverse County Judicial County Ditch #12	Bois de Sioux Watershed District
Grant & Traverse Counties	Traverse County Judicial County Ditch #14	Bois de Sioux Watershed District
Traverse & Grant Counties	Bois de Sioux Ditch #3	Bois de Sioux Watershed District
Wilkin County	Wilkin County Ditch #Sub-1	Bois de Sioux Watershed District
Wilkin County	Wilkin County Ditch #8	Bois de Sioux Watershed District
Wilkin, Grant & Otter Tail Counties	Wilkin County Ditch #9	Bois de Sioux Watershed District
Wilkin County	Wilkin County Ditch #18	Bois de Sioux Watershed District
Wilkin County	Wilkin County Ditch #20	Bois de Sioux Watershed District
Wilkin County	Wilkin County Ditch #25	Bois de Sioux Watershed District
Wilkin County	Wilkin County Ditch #35	Bois de Sioux Watershed District
Wilkin County	Wilkin County Ditch #39	Bois de Sioux Watershed District

Public drainage systems may also act as an outlet for subsurface tile drainage, used to manage soil water levels. The Minnesota Department of Agriculture states (https://extension.umn.edu/agricultural-drainage/impact-agricultural-drainage-minnesota#drainage-water-management-1360360):

Poorly drained soils increase risks to agricultural production from excess water and high-water tables. Proper soil drainage improves agricultural production by:

> *Ensuring timely planting and field operations.*
> *Minimizing soil compaction and salt buildup.*
> *Promoting conditions for good seedbed establishment and germination.*
> *Minimizing high water table stresses to growing crops.*
> *Outyielding poorly drained soils*
> *Offering less year-to-year yield variability.*
> *Improving the opportunity to employ other conservation practices such as minimum tillage.*

Figure 3.16.4
Tile drainage is most common in regions that typically lack irrigation, 2012



Note: County boundaries are clipped to show only cropland to illustrate the relative extent of irrigation in different regions and the spatial concentration within the Western counties.
Source: USDA, Economic Research Service calculations based on data from USDA, National Agricultural Statistics Service, 2013 Census of Agriculture.

https://www.ers.usda.gov/webdocs/publications/93026/eib-208.pdf?v=9435.6

IMPOUNDMENTS

In 2012, the Bois de Sioux Watershed District Office completed a 20% Flow Reduction Strategy for the watershed. This study focused on placing seasonal flood water storage within the Bois de Sioux Watershed District. A total of 26 sites or potential projects were identified within the District. The water storage was placed in the Lake Traverse and Rabbit River basins. Site selection was based primarily on the need for local flood control as flooding problems are widespread in the Bois de Sioux Watershed District.

The Bois de Sioux Watershed District prioritizes development of specific impoundment projects based on need, local support, budget, and importance of other watershed projects and programs that require the time of district staff.

BOIS DE SIOUX RIVER WATERSHED – NORTH OTTAWA IMPOUNDMENT

The North Ottawa Impoundment is located within the Bois de Sioux Watershed District. The impoundment is southeast of Tintah, Minnesota in Sections 17, 18, 19, and 20 of North Ottawa Township in Grant County. The contributing drainage area includes about 60% of the watersheds of Judicial Ditch 2 and Judicial Ditch 12 in Grant and Ottertail Counties, which outlet into the Rabbit River about 5 miles and 10 miles downstream, respectively. The areas immediately downstream that receive local flood damage reductions are in Grant, Traverse, and Wilkin Counties. The diversion system collects water and conveys it safely to the impoundment. The primary function is to collect as much water as practical. A secondary consideration is to improve conditions within the upstream and downstream watershed areas. The existing ditches in this area are found to be inadequate. In many areas, ditches overflow on an annual basis – and, when water leaves the ditches, it flows over cultivated land which can cause severe erosion and downstream sedimentation.

An ac-ft is defined as one acre of land covered by one foot of water. There are 325,851 gallons in one ac-ft of water. Three ac-ft of water is about 1,000,000 gallons.

This project effectively controls the precipitation runoff from the 74 square mile drainage area, which is about 23% of the Rabbit River and 4% of Bois de Sioux drainage areas, respectively. The gate-controlled flood storage of 16,000 acre-feet is equivalent to 75% of the estimated 100-year spring runoff. The available summer flood storage of 12,000 acre-feet is sufficient to store all the runoff from a 100-year, 24-hour rainfall event. Floods exceeding the gate-controlled water storage capacity can also be effectively controlled with only minor discharges relative to inflows.

The North Ottawa Impoundment also provides numerous natural resource enhancements, including stream augmentation, reduction of Total Suspended Solids, and wildlife habitat. Once spring floodwaters have receded, agriculture is used in many of the interior cells. According to a study published in 2017 by the University of Minnesota conducted in the North Ottawa Impoundment, growing and harvesting a crop is a means to improve subsequent water quality – the harvested crop pulls excess phosphorous and nitrates out of the system (Guzner).

MUSTINKA RIVER WATERSHED – REDPATH IMPOUNDMENT PROJECT

The Redpath Impoundment Project, located in Redpath Twp. of Traverse County and Gorton Twp. of Grant County is a proposed floodwater impoundment facility that will bring flood risk reduction, water quality improvements, and natural resource enhancements to the Mustinka River Watershed, Rabbit River Watershed, Lake Traverse, Bois de Sioux River, and Red River of the North. This project also rehabilitates a significant reach (approximately 5 miles) of the Mustinka River which was channelized by the United States Army Corps of Engineers (USACE) in about 1950.

The project has an approximate footprint of 4 square miles, a contributing watershed of 212 square miles, a floodwater storage volume of 24,000 Ac-Ft (2.1 inches of runoff), and includes about 5 miles of rehabilitation of the Mustinka River.

FIELD-SCALE PROJECTS

There are many field-scale projects that affect the flow or quantity of surface water, or protect the quality of surface water. These improvements may be installed in-field, edge-of-field, or beyond the field. Although they may require permitting, field-scale projects may be installed and maintained by private landowners or public entities, with or without the help of soil and water conservation districts, county offices, and the watershed district office and include:

Bridges
Buffers
Channel Bank Vegetation
Clearing and Snagging
Cover Crops
Constructed Wetlands
Culverts & Culvert Traps
Diversions
Fencing
Field Borders
Field Windbreaks
Filter Strips
Grade Stabilization
Grass Waterways
Levees
Lined Waterway or Outlet
Mulching
Obstruction Removal
Pasture and Hayland Planting
Pipelines
Ponds
Private Ditches
Ring Dikes
Runoff Management System
Sediment Basins
Shelterbelts
Streambank and Shoreland Protection
Stripcropping
Subsurface Drains & Tile
Terraces
Tree/Shrub Establishment
Underground Outlets
Wastewater and Feedlot Runoff Controls
Zoning/Ordinances

PUBLIC WATER BUFFERS

For both the Bois de Sioux River and Mustinka River Watersheds, 50’ riparian buffers were made mandatory and permanent on or before November 1, 2017 by state law. Some buffers were converted from agricultural production prior to the deadline, and some were legally required by shoreland zoning ordinances implemented at the county-level.

Engineer’s Estimate of Public Waters Buffers		
	Bois de Sioux River Watershed	**Mustinka River Watershed**
Public Waters (Not Next to Roads)		
Miles	128.83	315
Width	100'	100'
Acres	1,561.6	3,821.8
Perimeter of Ponds, Lakes, Reservoirs		
Miles	378.7	69.6
Width	50'	50'
Acres	2,295.2	421.8
North Ottawa Impoundment		
Grassland Acres	484	
Wetland Acres – Sediment Sink	608	
Total Acres	**4,948.8**	**4,243.6**

PUBLIC DITCH BUFFERS

For both the Bois de Sioux River and Mustinka River Watersheds, 16.5’ riparian buffers were made mandatory and permanent by state law on or before November 1, 2018 by state law. Some buffers were converted from agricultural production prior to the deadline, and some were acquired by legal drainage authorities under the legal requirements of benefit redetermination.

Engineer’s Estimate of Public Ditch Buffers		
	Bois de Sioux River Watershed	**Mustinka River Watershed**
Public Ditch Buffers (Not Next to Roads)		
Miles	41.4	118.1
Width	33'	33'
Acres	165.6	472.4
Public Ditch Buffers (Next to Roads)		
Miles	185.3	183.9
Width	16.5'	16.5'
Acres	370.6	367.8
Total Acres	**536.2**	**840.2**

4 - HYDROGEOLOGY & GROUNDWATER

SURFICIAL AND BEDROCK GEOLOGY

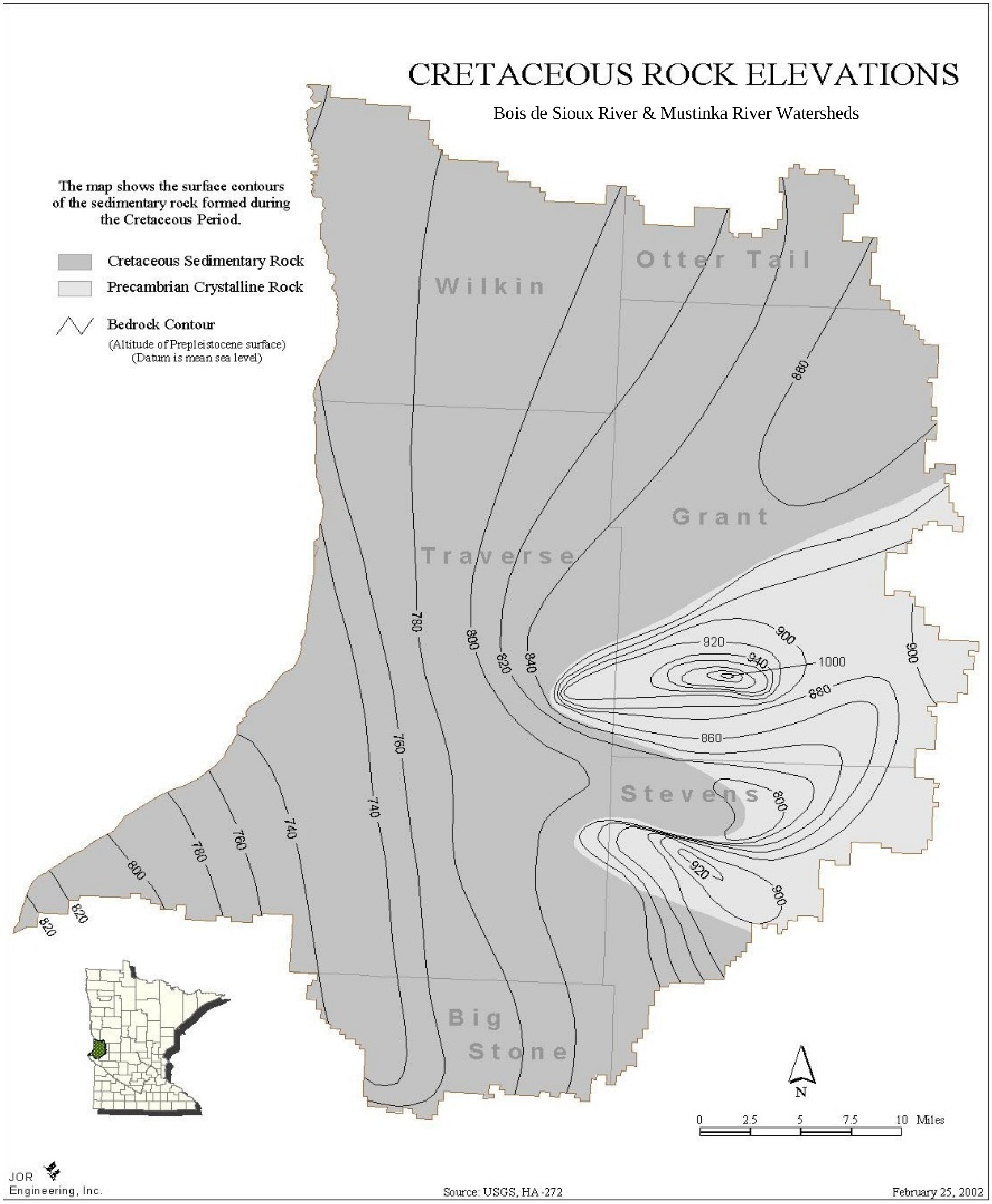
The County Geologic Atlas Program is a collaboration between MnDNR and Minnesota Geological Survey. This program will develop geology and hydrogeology maps and reports for Minnesota Counties. Atlas' have not been completed for the counties in the Bois de Sioux River or Mustinka Watersheds (with the exception of Otter Tail, who started the multi-year development process in 2019).

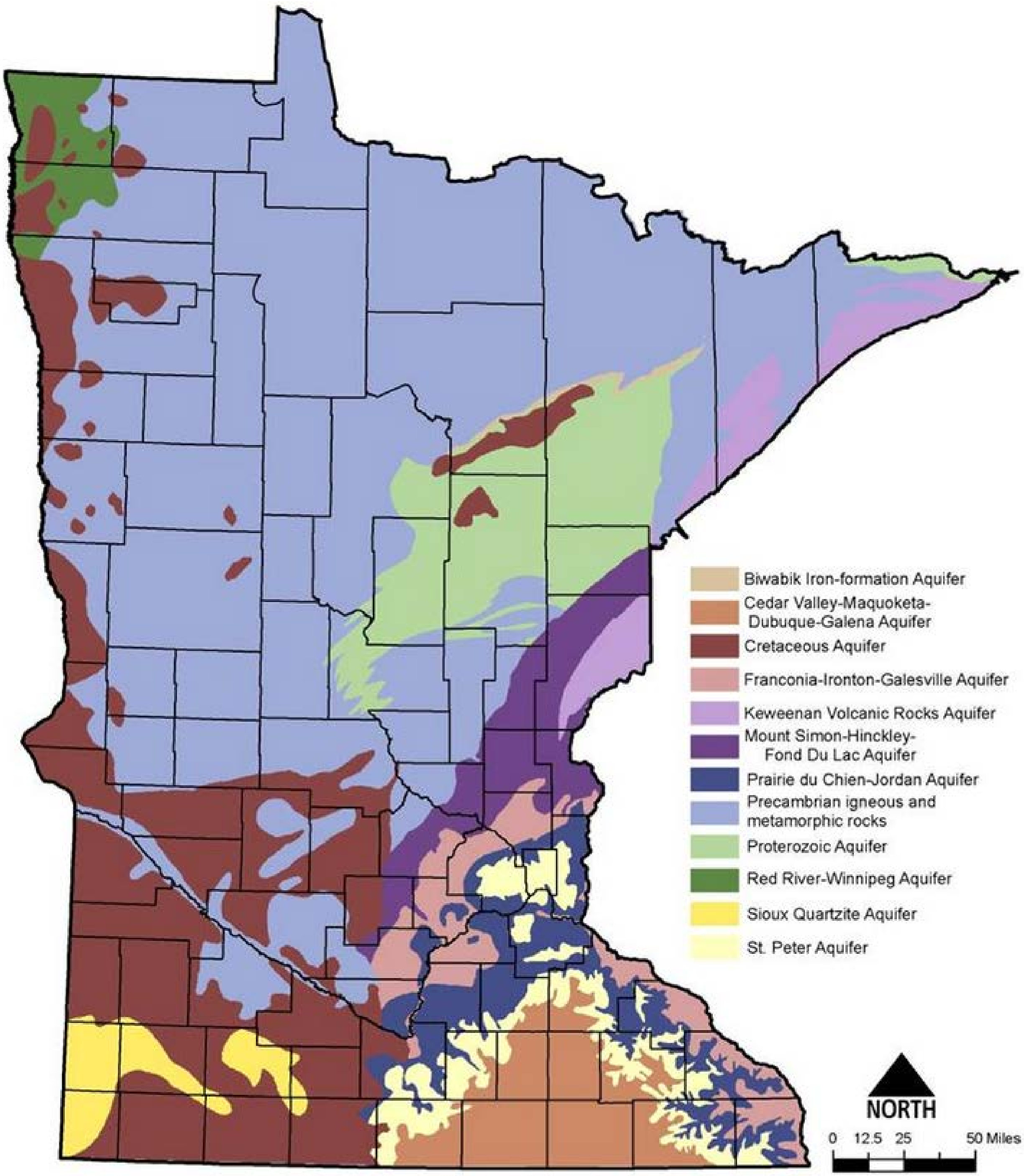
AQUIFERS & GROUNDWATER PROVINCES

Groundwater is an extremely important resource. All domestic water supplies, public and private, are drawn from groundwater, with the exception of the Breckenridge municipal water supply that uses the Otter Tail River as a backup. Groundwater has provided a reliable and relatively high-quality source of water for both domestic and livestock consumption. Irrigation has not been a major factor and significant development of irrigation is not anticipated.

Both watersheds are classified as Western Province, with a cretaceous bedrock. In a map of Minnesota Ground Water Provinces, the DNR states:

> *Western Province: Clayey glacial drift overlying Cretaceous and Precambrian bedrock. Glacial drift and Cretaceous bedrock contain limited extent sand and sandstone aquifers, respectively.*
>
> *Cretaceous Bedrock: Sandstone layers that are interbedded with thick layers of shale are used locally as water sources. Occurs beneath glacial drift but above older bedrock.*


CRETACEOUS ROCK ELEVATIONS
Bois de Sioux River & Mustinka River Watersheds
The map shows the surface contours of the sedimentary rock formed during the Cretaceous Period.
Cretaceous Sedimentary Rock
Precambrian Crystalline Rock
Bedrock Contour
(Altitude of Prepleistocene surface)
(Datum is mean sea level)
Wilkin
Otter Tail
Grant
Traverse
Stevens
Big Stone
N
0 2.5 5 7.5 10 Miles
JOR Engineering, Inc.
Source: USGS, HA-272
February 25, 2002

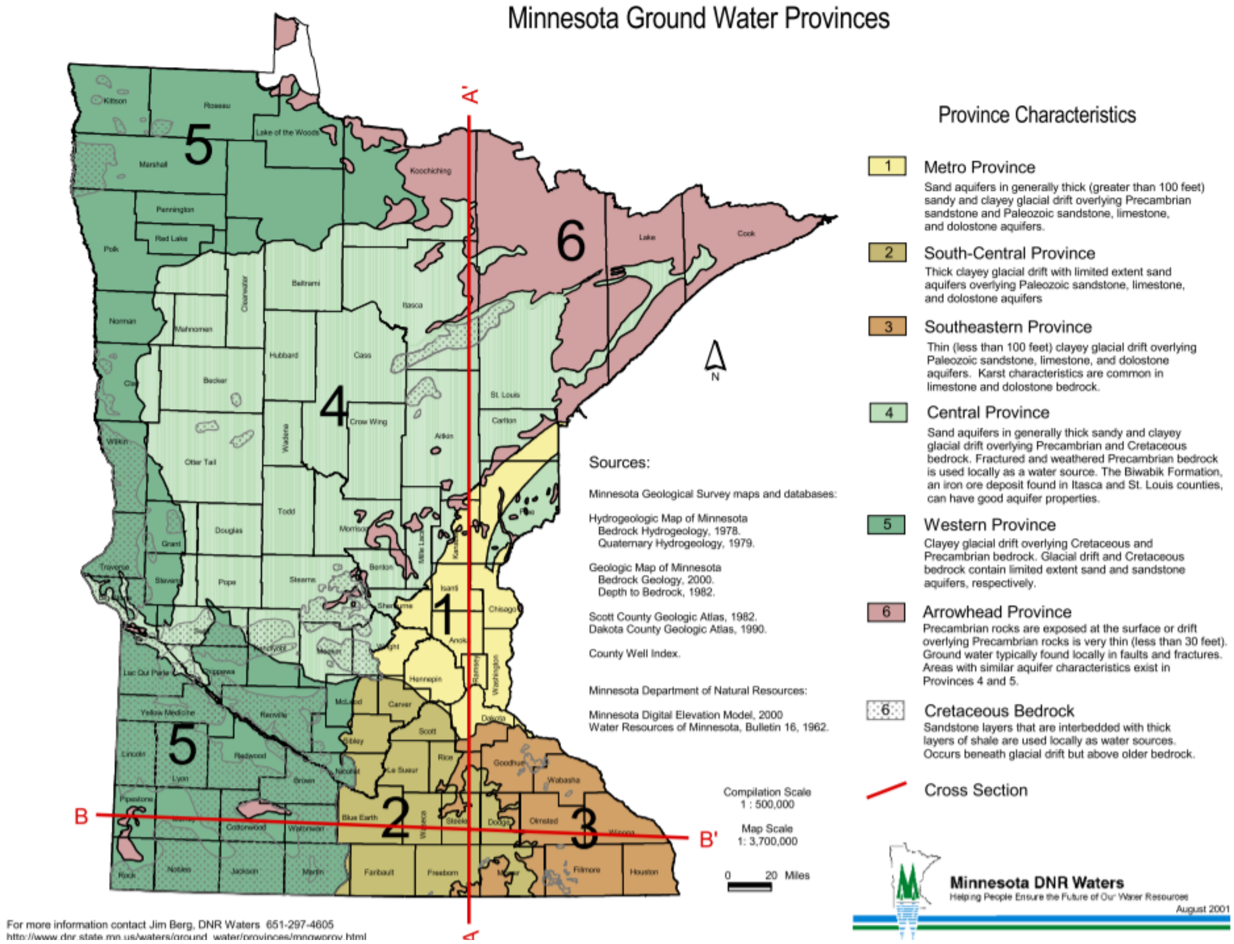


October, 2005

Sources: MGS (major aquifers from Minnesota's Bedrock Hydrogeology by Roman Kanivetsky, 1979; GIS data available at http://www.lmic.state.mn.us/chouse/metadata/hydqgeo.html), DNR (GIS data available at http://deli.dnr.state.mn.us/)

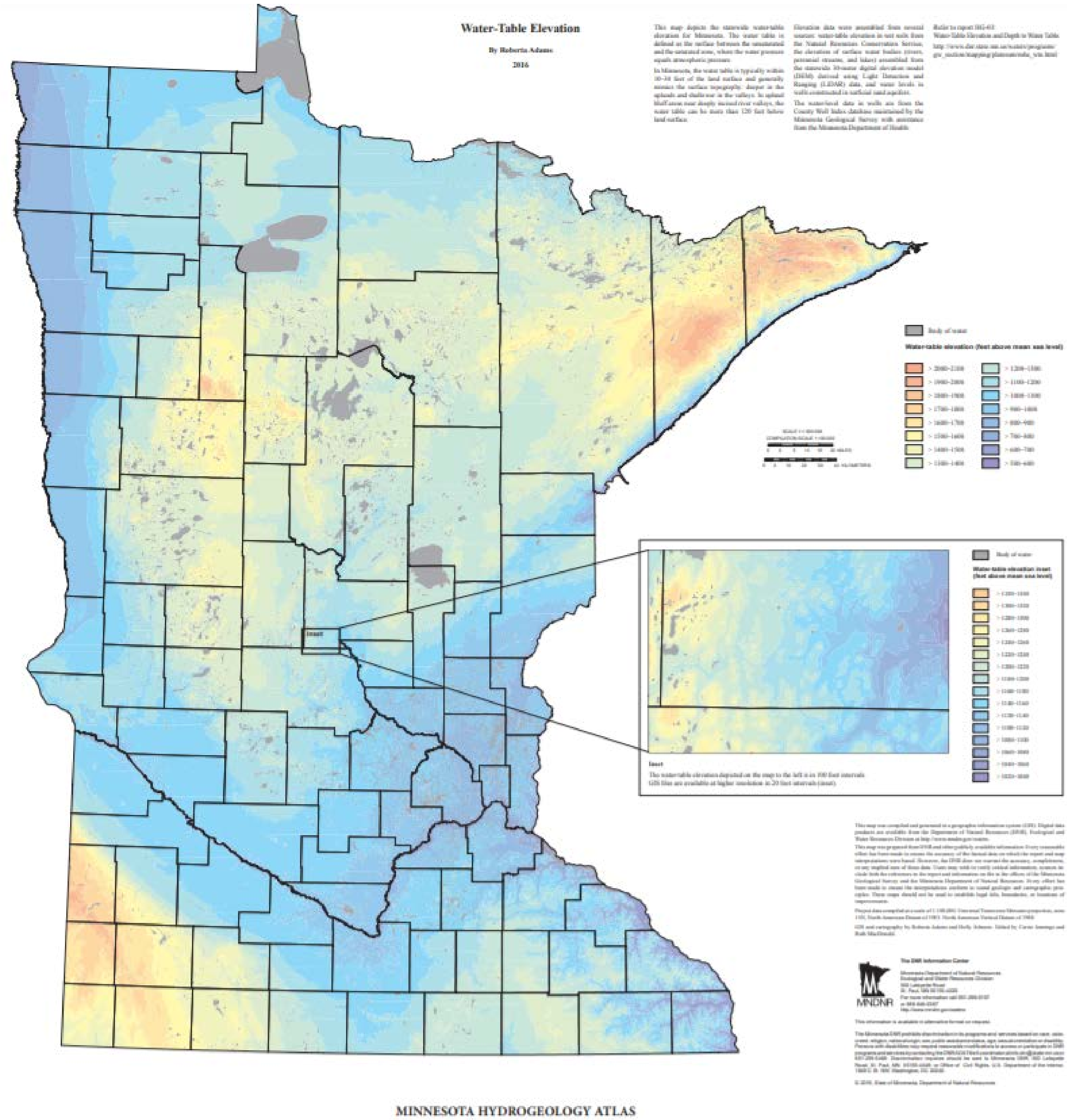
GROUNDWATER QUALITY & QUANTITY

Overall, the Western Province has moderate groundwater available in superficial sands and limited groundwater available in buried sands and bedrock.

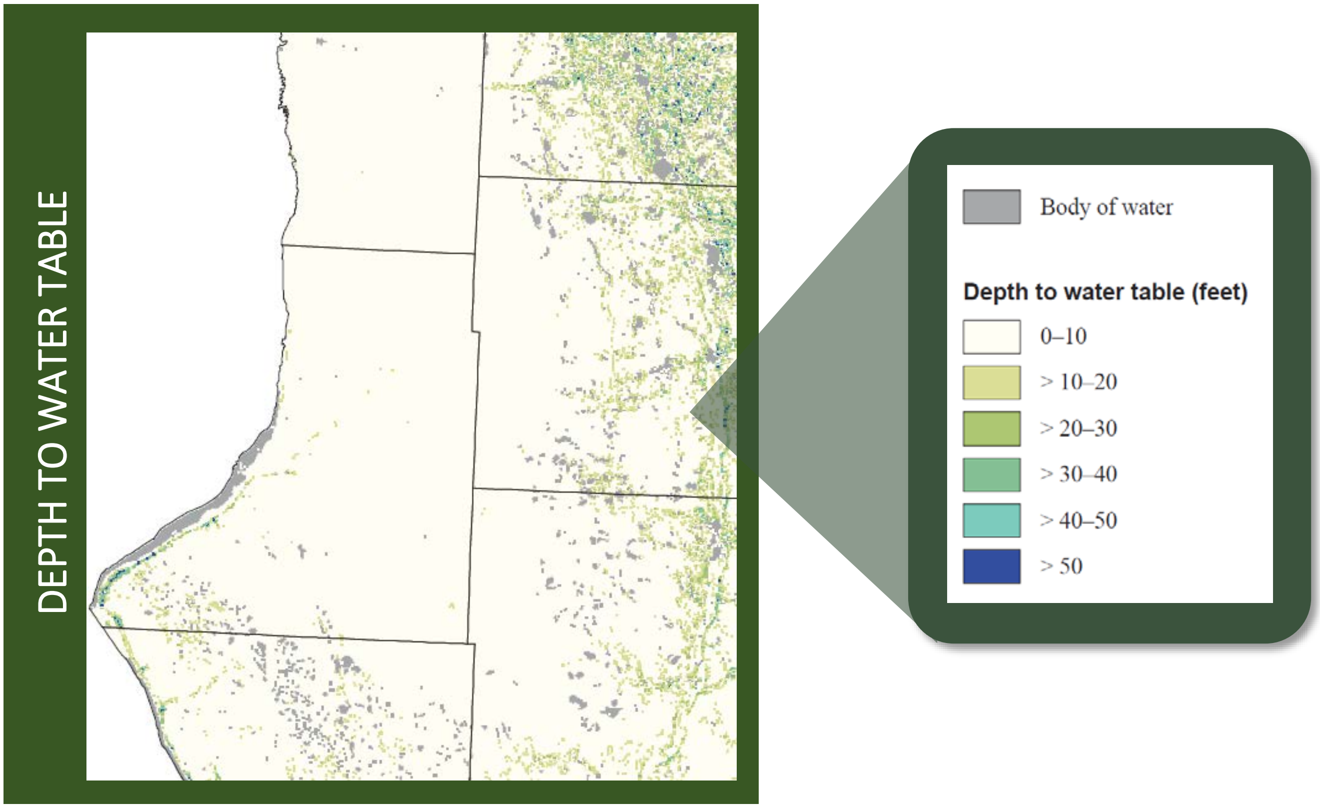


https://www.dnr.state.mn.us/groundwater/provinces/index.html

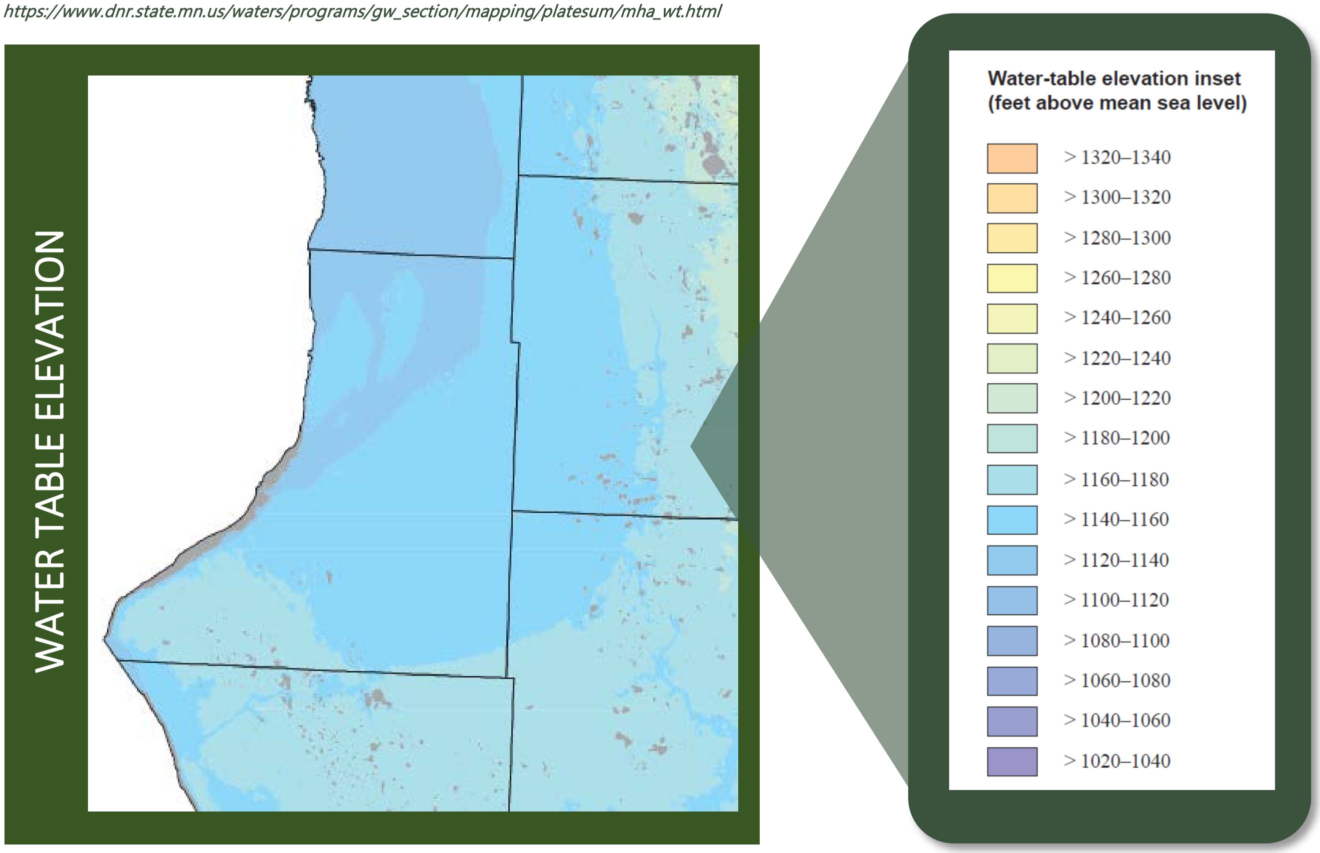
The Bois de Sioux River and Mustinka River Watersheds vary in water-table elevation from 1,100 – 1,200 feet above mean sea level. Per the DNR, "The water table is defined as the surface between the unsaturated and the saturated zone, where the water pressure equals atmospheric pressure."



https://files.dnr.state.mn.us/waters/groundwater_section/mapping/mha/hg03_plate1.pdf



https://www.dnr.state.mn.us/waters/programs/gw_section/mapping/platesum/mha_wt.html



https://www.dnr.state.mn.us/waters/programs/gw_section/mapping/platesum/mha_wt.html

Since 1944, DNR Waters has managed a statewide network of water level observation wells. Data from these wells are used to assess ground water resources, determine long term trends, interpret impacts of pumping and climate, plan for water conservation, evaluate water conflicts, and otherwise manage water resources. Number of observation wells within each watershed is shown below. Locations, reports, and current activity can be found at: https://www.dnr.state.mn.us/waters/cgm/index.html

WATERSHED	BIG STONE	GRANT	OTTER TAIL	STEVENS	TRAVERSE	WILKIN
BOIS DE SIOUX	0	2	0	0	2	2
MUSTINKA	0	4	1	1	0	0

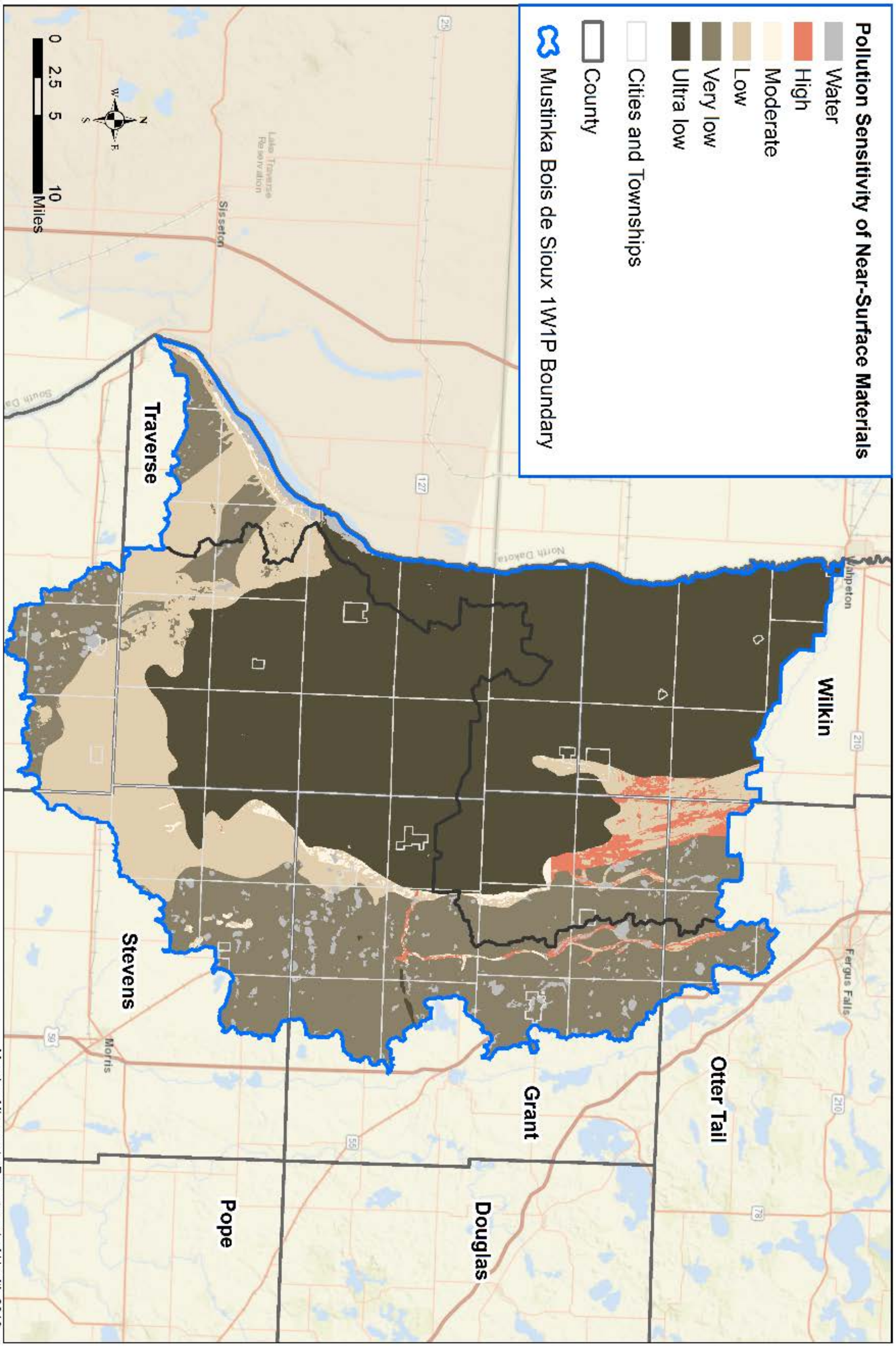
The Minnesota Department of Health monitors groundwater for arsenic levels. In a letter to the Bois de Sioux Watershed District dated March 26, 2019, the Minnesota Department of Health reported:

> *Approximately thirty percent of the 106 arsenic samples taken from wells in the Bois de Sioux-Mustinka Watershed have levels of arsenic higher than the Safe Drinking Water Act (SDWA) standard of 10 micrograms per liter (µg/L). Arsenic occurs naturally in rocks and soil and can dissolve into groundwater. Consuming water with low levels of arsenic over a long time (chronic exposure) is associated with diabetes and increased risk of cancers of the bladder, lungs, liver and other organs. The SDWA standard for arsenic in drinking water is 10 µg/L; however, drinking water with arsenic at levels lower than the SDWA standard over many years can still increase the risk of cancer. The EPA has set a goal of 0 µg/L for arsenic in drinking water because there is no safe level of arsenic in drinking water.*

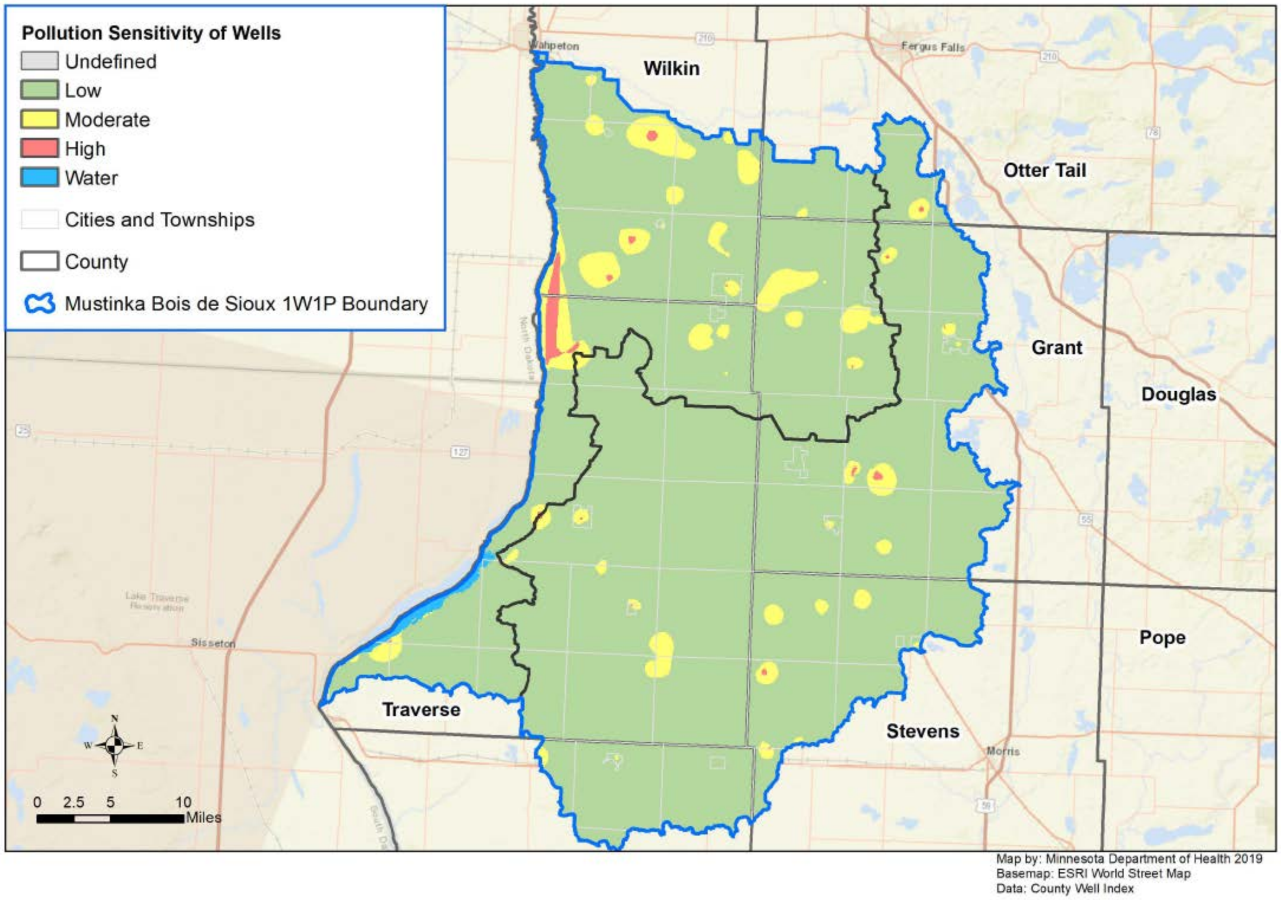
PRIVATE WELLS - ARSENIC (2008 - 2018) – (includes areas outside of Bois de Sioux and Mustinka Watersheds)

COUNTY	# OF WELLS TESTED	# OF WELLS > 2ug/L	% OF WELLS > 2ug/L	# OF WELLS > 10ug/L	% OF WELLS > 10ug/L	MEDIAN ARSENIC VALUE
BIG STONE	116	38	32.8	17	14.7	≤ 2.0
GRANT	187	138	73.8	64	34.2	5.9
OTTER TAIL	3368	1990	59.1	692	20.5	3
STEVENS	162	119	73.5	55	34	5.5
TRAVERSE	84	48	57.1	25	29.8	4.7
WILKIN	129	68	52.7	32	24.8	2.2

https://mndatamaps.web.health.state.mn.us/interactive/wells.html

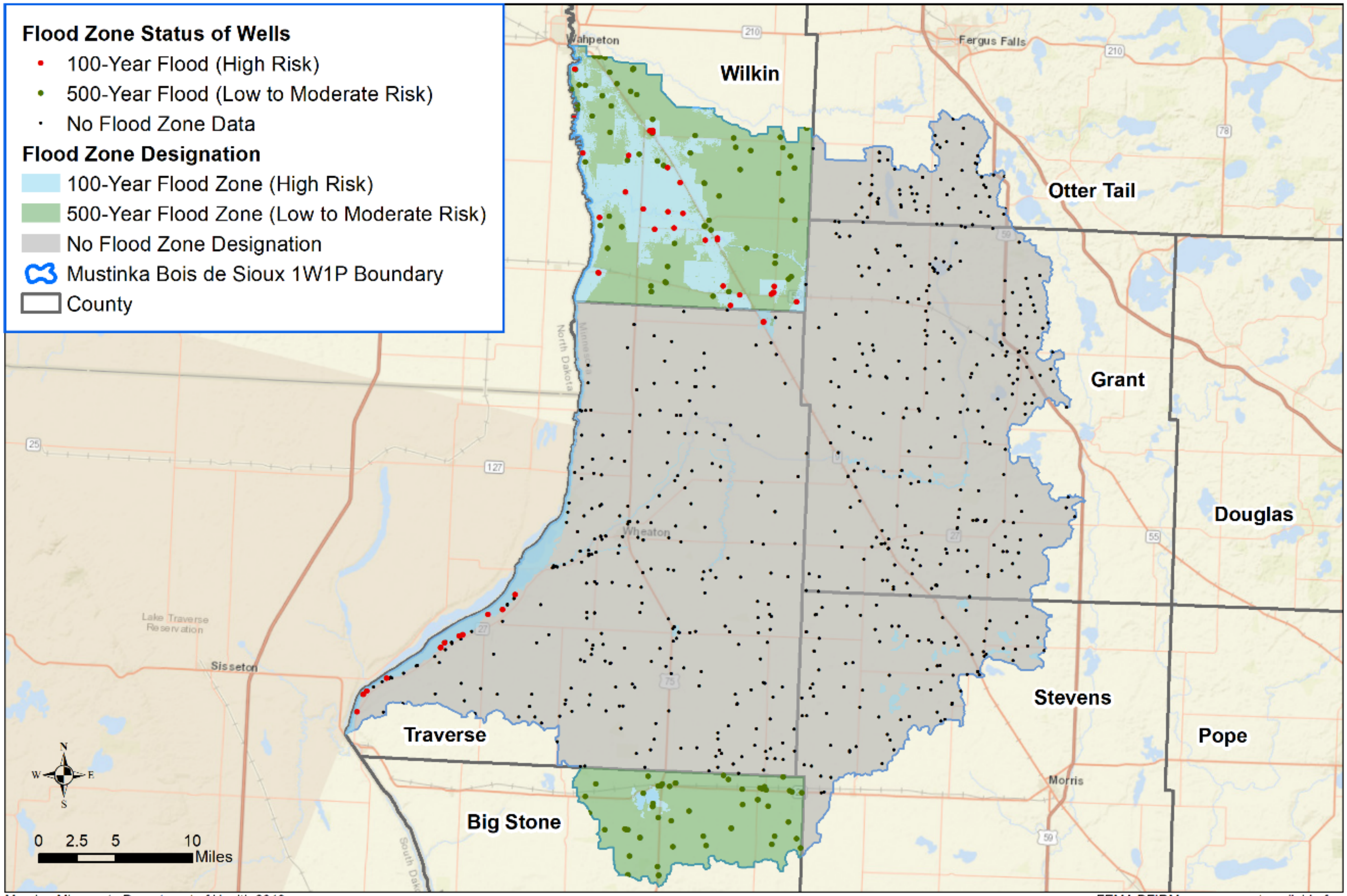


Map by: Minnesota Department of Health 2019
Basemap: ESRI World Street Map
Data: MNDNR Pollution Sensitivity



For a significant portion of the Bois de Sioux River and Mustinka Watersheds, the estimated vertical travel time of near-surface materials is more than a year, and could be a decade or more, due to thick, glacial Lake Agassiz sediment deposits. The DNR classifies groundwater pollution sensitivity for the Bois de Sioux River and Mustinka River Watersheds as "ultra low." The clay-rich soil types protect groundwater resources from surface-level activities.

There are two primary concerns for groundwater contamination: abandoned and unsealed wells, and failing individual sewage treatment systems. Unsealed wells can act as a direct route to deep aquifers. Contaminants can also enter an aquifer through a buried well casing. The average cost of sealing an abandoned well is around $500.00. Failing sewage systems have the potential to transport harmful contaminants to shallow wells. Landowners are able to participate in cost-share opportunities to seal abandoned and unsealed wells.



Map by: Minnesota Department of Health 2019
Basemap: ESRI World Street Map
Data: County Well Index, FEMA Digital Flood Insurance Rate Map (DFIRM) Database

FEMA DFIRM maps are not available for Otter Tail, Grant, Stevens, and Traverse Counties. Any flood zone designations for these areas are based on unmodernized data.

The Minnesota Department of Health's assessment of drinking water wells and flood risk is limited by completed flood zone designations.

The Minnesota Department of Health oversees the protection of municipal drinking water resources, and has determined that the Drinking Water Supply Management Areas (DWSMAs) in both the Bois de Sioux River and Mustinka River Watersheds are at low vulnerability. Two jurisdictions (Graceville and Johnson) will begin their Well Head Protection Plan process after 2020.

DRINKING WATER SUPPLY MANAGEMENT AREAS					
NAME	COUNTY	WATERSHED	SUBWATERSHED	WELL HEAD PROTECTION PLAN?	VULNERABILITY
CAMPBELL	WILKIN	BOIS DE SIOUX RIVER	RABBIT RIVER	YES	LOW
TINTAH	TRAVERSE	BOIS DE SIOUX RIVER	JD 12	YES	LOW
WENDELL	GRANT	BOIS DE SIOUX RIVER	ASH LAKE	YES	LOW
DONNELLY*	STEVENS	MUSTINKA RIVER	UPPER E BRANCH TWELVE MILE CREEK	YES	LOW
DUMONT	TRAVERSE	MUSTINKA RIVER	W BRANCH TWELVE MILE CREEK	YES	LOW
GRACEVILLE	BIG STONE	MUSTINKA RIVER	CO DITCH 44 & W BRANCH TWELVE MILE CREEK	AFTER 2020	LOW
HERMAN	GRANT	MUSTINKA RIVER	NIEMACKL LAKES	YES	LOW
JOHNSON	BIG STONE	MUSTINKA RIVER	COUNTY DITCH 38	AFTER 2020	LOW
NORCROSS	GRANT	MUSTINKA RIVER	MUSTINKA RIVER DITCH	YES	LOW
WHEATON	TRAVERSE	MUSTINKA RIVER	EIGHTEEN MILE CREEK	YES	LOW

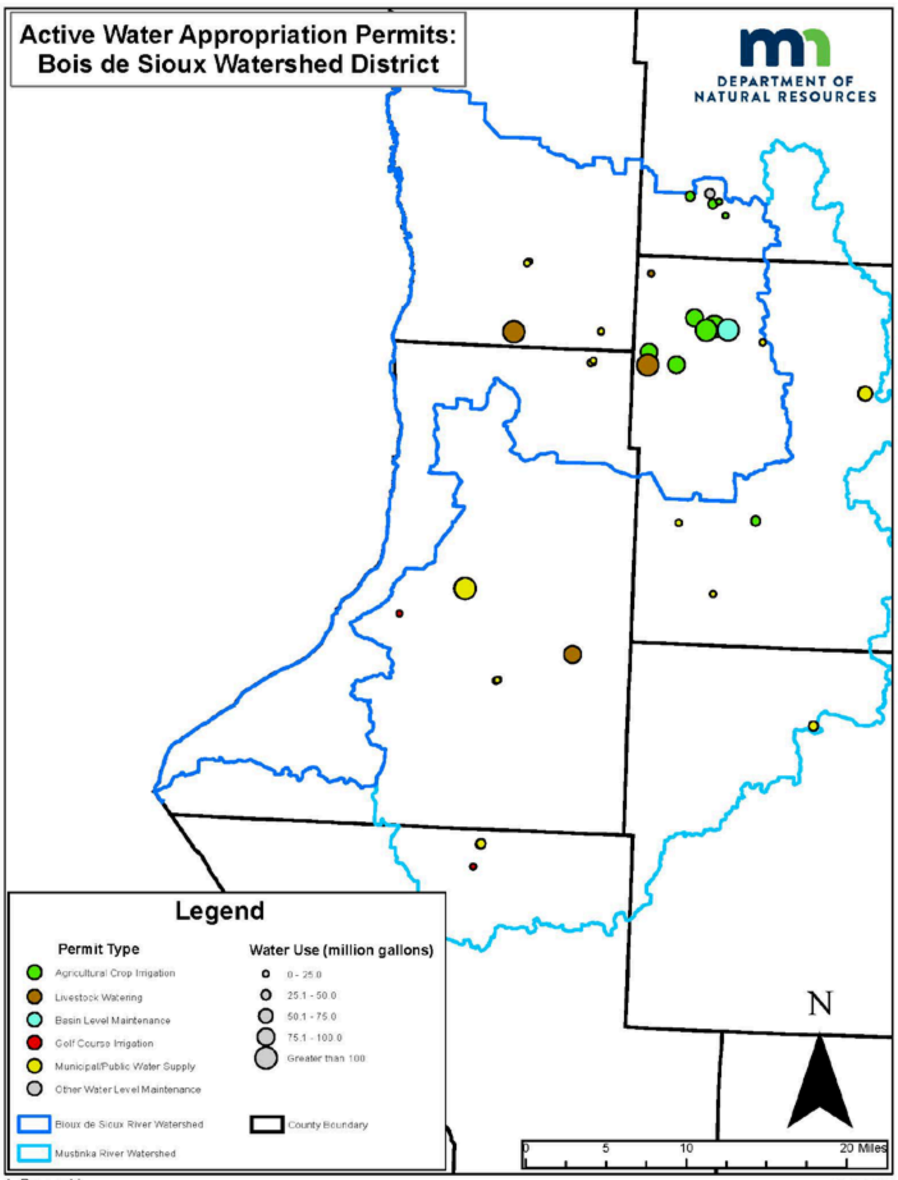
*PARTIALLY OUTSIDE WATERSHED

GROUNDWATER RECHARGE

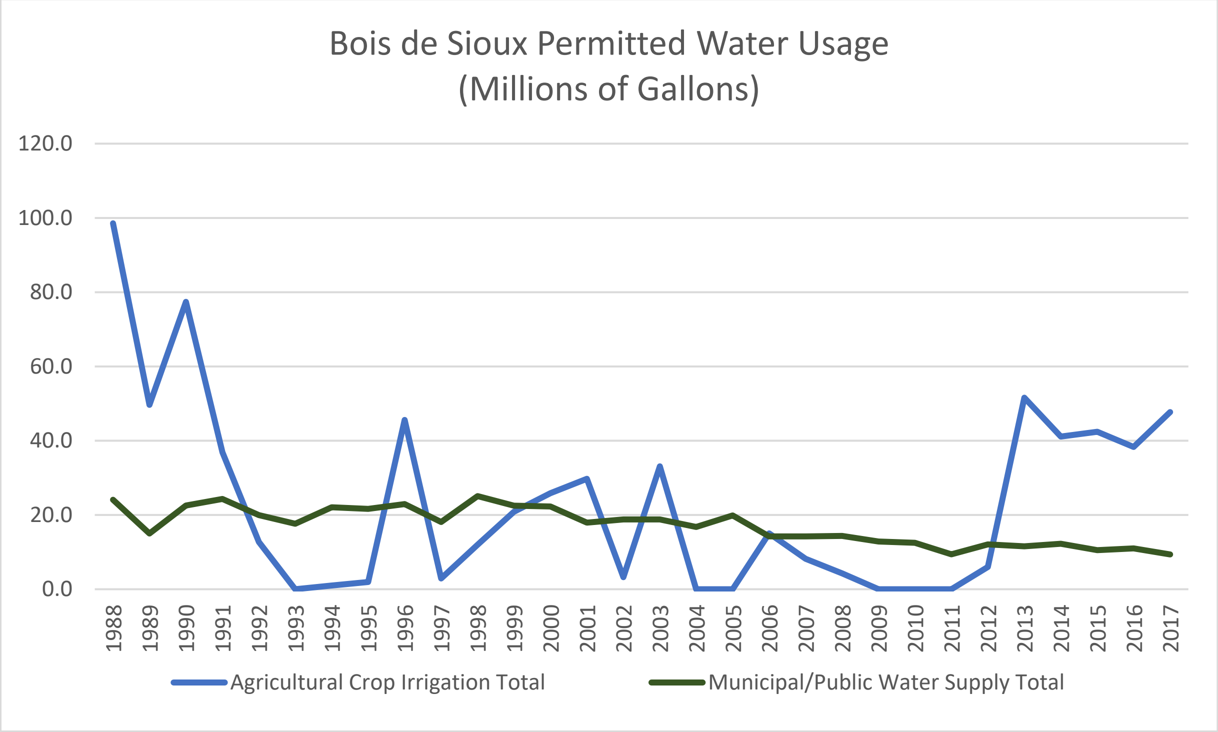
In general, groundwater recharge occurs normally in the morainal areas and discharge occurs in the lake plain area. This is evidenced by a number of flowing wells in the lake plain and by the numerous springs that feed Lake Traverse.

Prepared in cooperation with MPCA, USGS developed a report entitled, "Potential Groundwater Recharge for the State of Minnesota Using the Soil-Water-Balance Model, 1996–2010." Continuous streamflow data was used from thirty-four Minnesota watersheds for the time period 1996−2010; this data was used for calibration of the Soil-Water-Balance (SWB) model. None of the thirty-four watersheds were located on the Red River. Authors evaluating the simulation state that:

> *Some of the lowest potential recharge rates for the simulation period (generally between 1.0 and 1.5 in/yr) were in the Red River of the North Basin of northwestern Minnesota. Not only is this the driest part of the State based on mean annual gross precipitation, but this area also has thick, clayey soils that are restrictive to infiltration… (Westenbroek, 2015).*



J. Prososki 8/7/2019

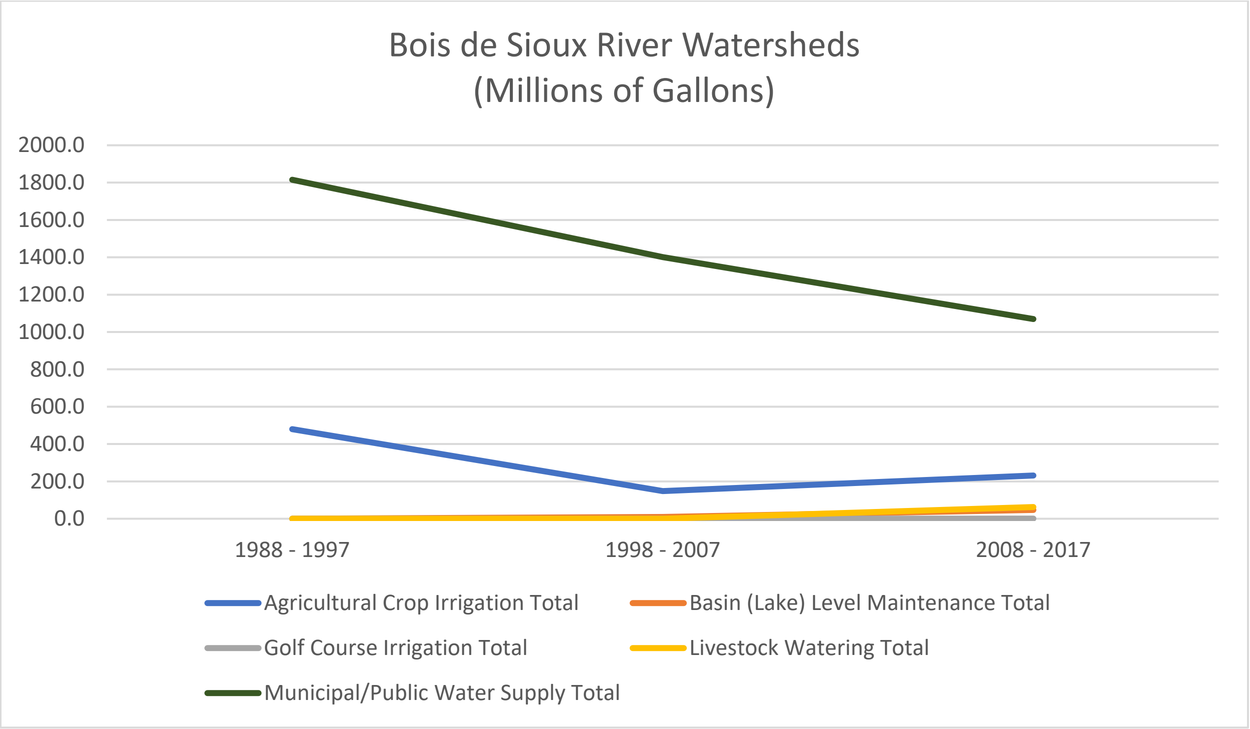


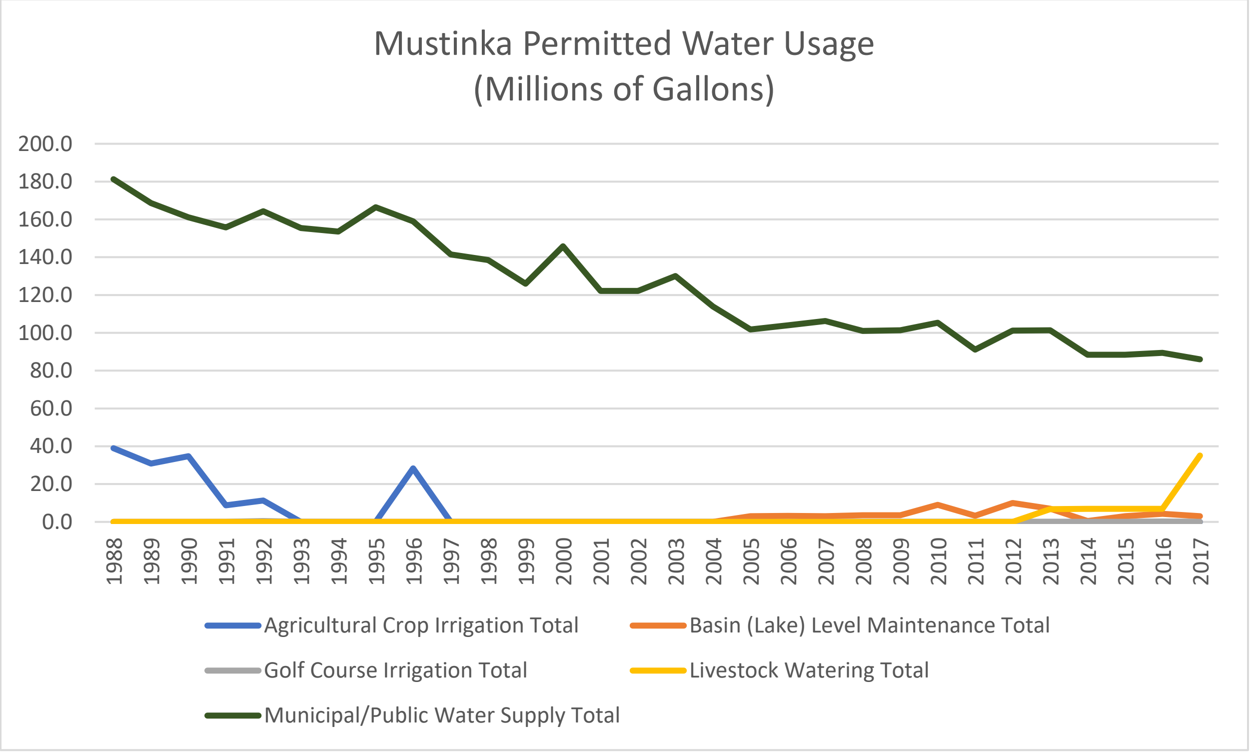
https://files.dnr.state.mn.us/waters/watermgmt_section/appropriations/mpars_index_permits_installations.xlsx, September 5, 2018

USE TYPE IN MILLIONS OF GALLONS	1988 – 1997	1998 - 2007	2008 - 2017
Agricultural Crop Irrigation	479.7	148.1	231.4
Basin (Lake) Level Maintenance	0.0	9.2	47.1
Golf Course Irrigation	0.5	0.0	0.7
Livestock Watering	0.0	0.0	62.6
Municipal/Public Water Supply	1,815.3	1,401.1	1,069.4

For both watersheds, based on DNR Groundwater Appropriations data:

> *Municipal/Public Water Supply water use has decreased 41%. Municipal systems include: Campbell, Nashua, Tintah, Wendell (Bois de Sioux River Watershed); Donnelly, Elbow Lake, Wheaton, Dumont, Herman, Graceville, Norcross (Mustinka River Watershed).*
> *Agricultural Crop Irrigation water use has decreased 52%.*
> *For 2017, there was only one livestock permit, granted in 2013.*


Bois de Sioux River Watersheds
(Millions of Gallons)
2000.0
1800.0
1600.0
1400.0
1200.0
1000.0
800.0
600.0
400.0
200.0
0.0
1988 - 1997
1998 - 2007
2008 - 2017
Agricultural Crop Irrigation Total
Basin (Lake) Level Maintenance Total
Golf Course Irrigation Total
Livestock Watering Total
Municipal/Public Water Supply Total


Mustinka Permitted Water Usage
(Millions of Gallons)
200.0
180.0
160.0
140.0
120.0
100.0
80.0
60.0
40.0
20.0
0.0
1988
1989
1990
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
2017
Agricultural Crop Irrigation Total
Basin (Lake) Level Maintenance Total
Golf Course Irrigation Total
Livestock Watering Total
Municipal/Public Water Supply Total

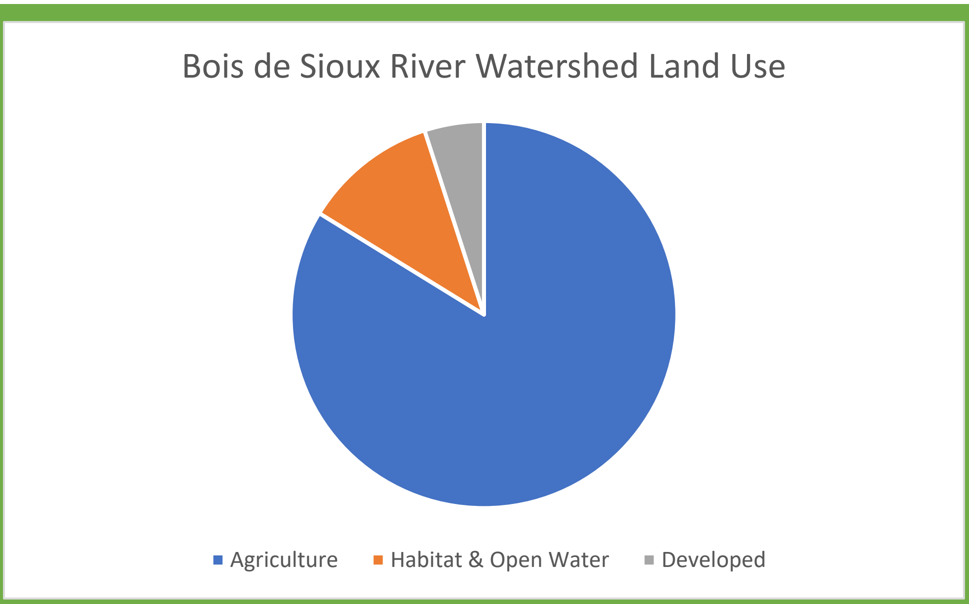
5 - LAND & OCCUPANTS

LAND USE

Land in the Bois de Sioux River and Mustinka River Watersheds is primarily used for agricultural purposes; economies are centered around agricultural products and services. The two watersheds are similar in cropping systems and land use mixes.

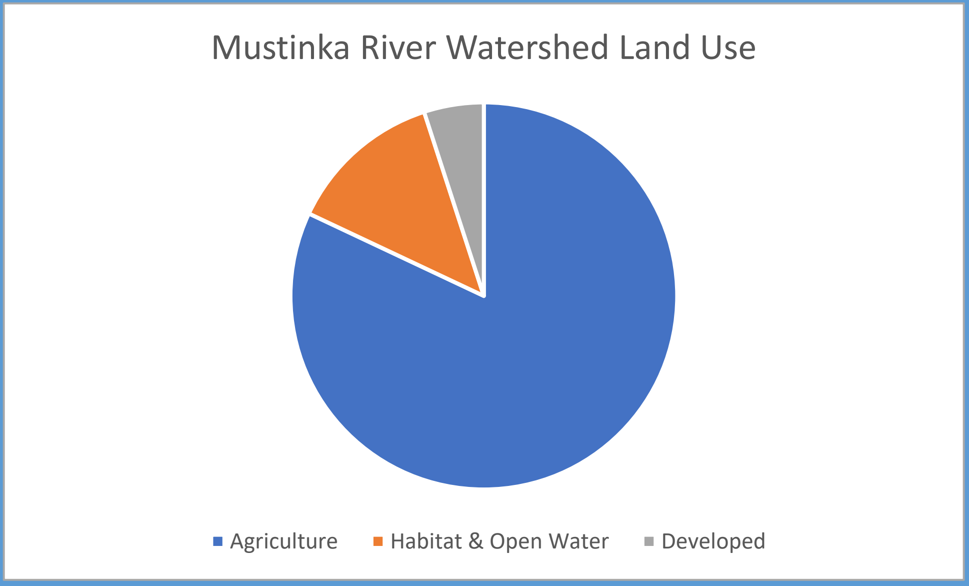
BOIS DE SIOUX RIVER WATERSHED

For 2015 - 2018, 84% of the Bois de Sioux River Watershed land was used for agricultural purposes (297,956 acres); urban development accounted for 5% of land use (17,683 acres); wetlands, grasslands, forests, and open water composed the remaining 11% (40,018 acres) (Service, 2019).



MUSTINKA RIVER WATERSHED

For 2015 - 2018, 82% of the Mustinka River Watershed land was used for agricultural purposes (451,226 acres); urban development accounted for 5% of land use (26,987 acres); wetlands, grasslands, forests, and open water composed the remaining 13% (72,217 acres). (Service, 2019).



AGRICULTURAL CROPS BY WATERSHED

BOIS DE SIOUX RIVER WATERSHED

The USDA provides annual crop data that can be narrowed to a specific region. Using the boundaries of the Bois de Sioux River Watershed resulted in data shown in the following pages; however, data was only available beginning 2006 (Service, 2019).

NOTEWORTHY:

> *Field corn production increased to 105,747 acres in 2013, and from that point through 2018, has remained above the average of 84,471 acres for years 2006 – 2012.*
>
> *Wheat production has decreased from 61,382 acres in 2006 to 33,928 acres in 2018.*
>
> *Sugarbeet production was down to 19,577 acres in 2017 & 19,020 acres in 2018 from a high of 29,578 acres during 2006 - 2018. No information for 2019 is available yet.*
>
> *"Grass/Pasture" decreased by 16,590 acres in 2011, but "Herbaceous Wetlands" increased by 15,302 acres.*

MUSTINKA RIVER WATERSHED

The USDA provides annual crop data that can be narrowed to a specific region. Using the boundaries of the Mustinka River Watershed resulted in data shown in the following pages; however, data was only available beginning 2006 (Service, 2019).

NOTEWORTHY:

> *Wheat production has decreased from 33,609 acres in 2006 to 18,501 acres in 2018.*
>
> *Sugarbeet production was down 2017 & 2018. No information for 2019 is available yet.*
>
> *"Grass/Pasture" decreased by 30,989 acres in 2011, but "Herbaceous Wetlands" increased by 28,402 acres.*

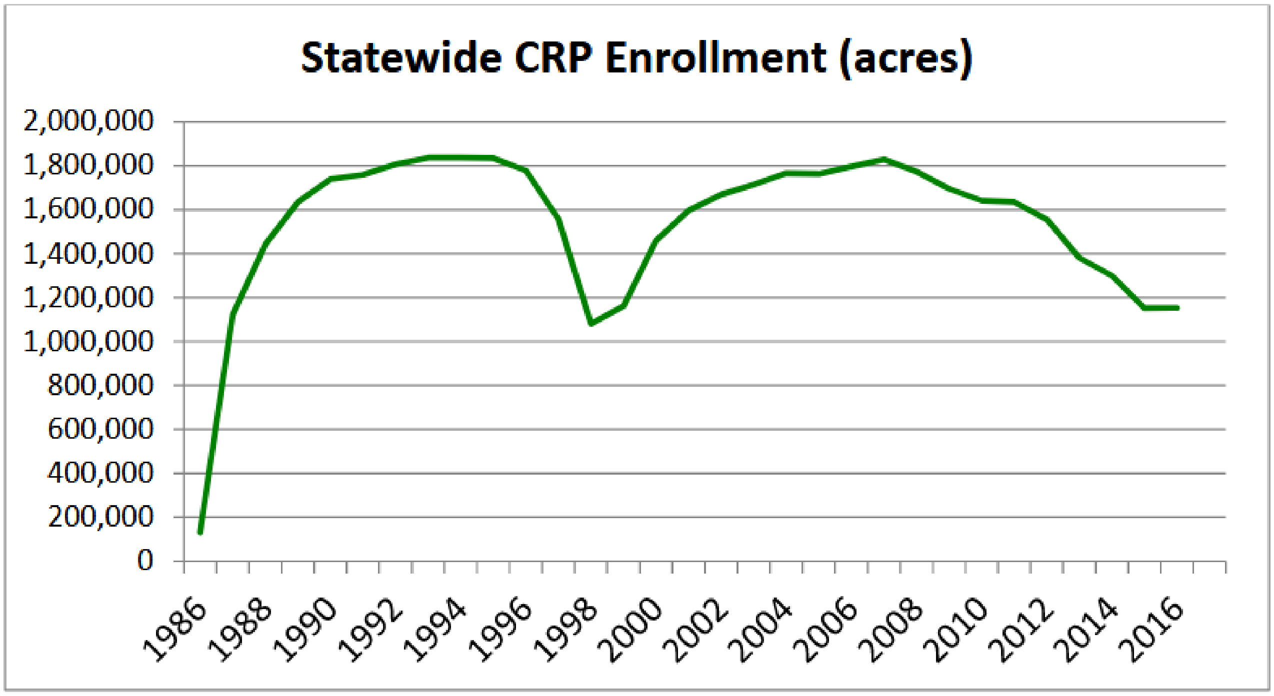
	BOIS DE SIOUX WATERSHED												
	2006 Acreage	2007 Acreage	2008 Acreage	2009 Acreage	2010 Acreage	2011 Acreage	2012 Acreage	2013 Acreage	2014 Acreage	2015 Acreage	2016 Acreage	2017 Acreage	2018 Acreage
1 - Corn	75,718.4	92,858.9	84,833.3	72,877.4	82,081.2	83,199.4	99,732.0	105,747.1	85,819.9	90,645.2	110,858.8	105,070.8	104,472.1
5 - Soybeans	122,197.4	114,738.0	120,165.8	128,708.9	128,821.0	136,490.0	119,077.7	122,276.4	145,689.8	135,618.7	120,753.2	136,663.7	136,621.0
6 - Sunflowers	578.1	265.0	1,184.9	3,333.5	2,337.8	214.6	273.1	346.0	231.1	1,387.3	1,202.0	1,762.5	1,796.9
21 - Barley	219.3	85.2	577.3	1,052.8	706.1		36.7	710.8	24.9	1,963.7	1,299.0	616.7	45.8
12, 21 - Sweet Corn	0.0	0.0	0.0	144.6	0.0	378.3	383.0	108.3	0.0	0.0	0.0	0.0	0.0
22, 23, 24 - Durum, Spring & Winter Wheat	61,382.4	55,090.7	62,873.5	54,325.7	48,834.4	49,227.1	44,400.4	34,499.8	35,764.2	39,096.8	34,853.0	31,109.2	33,928.1
27 - Rye		0.8	1.8	1.3	3.3			0.9		4.0	515.3	2.4	29.4
28 - Oats	7.7	9.3	11.3	15.6	16.7	6.9	14.2	7.6	2.7	221.7	13.6	22.0	70.1
29 - Millet	0.8						0.2			15.8		1.3	0.2
31 - Canola	5.4	1.5				0.2					2.7	0.7	53.8
32 - Flaxseed		0.8	0.2			0.2	0.9						0.2
36, 37 - Alfalfa & Other Hay/Non Alfalfa	1,374.7	1,127.5	999.6	1,022.4	962.0	1,383.9	1,372.6	1,073.2	1,628.6	1,139.8	2,103.2	2,150.1	1,774.5
39 - Buckwheat				28.5			0.9				1.6	10.0	4.2
4 - Sorghum		0.8	0.2	1.6			4.2		0.4				
41 - Sugarbeets	25,560.0	20,643.9	25,373.0	27,709.3	27,306.3	22,753.0	26,769.9	29,578.7	25,830.0	27,162.2	25,429.7	19,577.4	19,020.3
42 - Dry Beans	359.6	95.3	388.3	1,019.7	825.1	158.3	1,978.0	249.3	126.5	79.6	383.0	612.3	101.0
43 - Potatoes			0.4	3.6			1.6	1.3		0.4	0.9	0.2	
44 - Other Crops	0.8			8.0	2.2	0.4		0.7	0.2			11.3	13.3
53 - Peas	3.9	7.7						0.2	139.0	190.4	199.3	122.3	25.1
241 - Dbl Crop Corn/Soybeans			4.4		0.2								
TOTAL CROPPED ACRES	287,408.5	284,925.4	296,414.0	290,252.9	291,896.3	293,812.3	294,045.4	294,600.3	295,257.3	297,525.6	297,615.3	297,732.9	297,956.0
PERCENTAGE CROPPED	81%	80%	83%	82%	82%	83%	83%	83%	83%	84%	84%	84%	84%
58 - Clover/Wildflowers		0.8	0.2		0.2		23.8		0.2				0.9
59 - Sod/Grass Seed			2.7	19.1	0.2	1.6		10.7	4.9	0.2	7.1	6.0	2.7
60 - Switchgrass								0.2				12.0	0.9
61 - Fallow/Idle Cropland		229.4	499.5	3,713.3	95.9	4.7	16.7	7.1	159.2	81.8	19.3	336.7	138.3
63 - Forest		0.8			9.8								
70 - Christmas Trees		0.8											
87 - Wetlands	533.9	674.2			667.2								
111 - Open Water	10,810.9	10,845.8	10,502.8	10,723.0	11,057.9	10,931.8	11,060.1	11,193.3	11,347.2	11,238.5	10,855.7	10,424.3	10,901.1
131 - Barren	21.7	124.8	12.0	75.8	38.5	20.2	87.4	65.2	42.0	25.8	24.9	16.2	74.5
141 - Deciduous Forest	2,892.0	3,755.3	2,727.9	2,769.9	2,827.7	2,696.8	2,656.1	2,535.1	3,283.2	3,612.6	3,778.0	3,966.2	2,458.1
142 - Evergreen Forest	7.7	2.3	10.7	2.4	7.8	12.2	1.3	10.5	9.1	0.2	22.9	4.0	20.2
143 - Mixed Forest	0.8	0.8		0.7									0.7
152 - Shrubland	3.1	7.0	7.8	4.2	1.1	2.9	7.3	0.4	10.7	2.0	0.2	1.1	30.7
176 - Grass/Pasture	11,123.2	3,591.0	12,093.6	13,551.2	19,311.9	2,721.7	2,327.4	1,768.3	2,607.1	3,351.3	3,360.8	2,968.5	3,674.2
190 - Woody Wetlands	1,215.1	779.6	800.4	768.6	768.8	920.0	1,027.9	1,094.4	941.4	1,219.2	722.8	854.7	1,027.0
195 - Herbaceous Wetlands	15,696.0	23,488.7	14,571.3	16,073.4	11,293.4	26,595.5	26,328.0	26,191.0	23,771.3	20,656.5	21,428.6	21,810.5	21,689.0
TOTAL HABITAT ACRES	42,304.4	43,501.3	41,228.9	47,701.6	46,080.4	43,907.4	43,536.0	42,876.2	42,176.3	40,188.1	40,220.3	40,400.2	40,018.3
PERCENTAGE HABITAT	12%	12%	12%	13%	13%	12%	12%	12%	12%	11%	11%	11%	11%
82 - Developed	1.5												
121 - Developed/Open Space	23,578.5	24,893.6	15,689.3	15,337.7	15,240.7	15,984.8	15,750.7	16,114.9	15,787.6	15,938.1	15,523.6	15,333.7	15,326.8
122 - Developed/Low Intensity	2,162.8	2,048.1	2,013.8	2,028.2	2,137.7	1,667.3	2,010.4	1,774.9	2,016.0	1,651.1	1,915.0	1,781.2	1,993.3
123 - Developed/Medium Intensity	218.5	291.4	270.7	297.8	268.7	256.6	284.2	260.4	373.0	299.1	320.2	373.2	306.0
124 - Developed/High Intensity	8.5	23.2	36.0	34.9	33.4	28.5	30.5	30.2	46.7	55.2	62.5	35.8	56.5
TOTAL DEVELOPED ACRES	25,969.8	27,256.3	18,009.8	17,698.6	17,680.5	17,937.2	18,075.8	18,180.4	18,223.3	17,943.5	17,821.3	17,523.9	17,682.6
PERCENTAGE DEVELOPED	7%	8%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%
TOTAL ACRES	355,682.7	355,683.0	355,652.7	355,653.1	355,657.2	355,656.9	355,657.2	355,656.9	355,656.9	355,657.2	355,656.9	355,657.0	355,656.9

	MUSTINKA WATERSHED												
	2006 Acreage	2007 Acreage	2008 Acreage	2009 Acreage	2010 Acreage	2011 Acreage	2012 Acreage	2013 Acreage	2014 Acreage	2015 Acreage	2016 Acreage	2017 Acreage	2018 Acreage
1 - Corn	186,125.4	225,134.2	185,618.4	188,848.4	185,092.2	192,972.5	216,997.1	234,915.7	187,361.7	199,332.8	210,629.1	204,380.2	195,477.3
4 - Sorghum				2.0			0.2	1.3	4.0				1.1
5 - Soybeans	206,734.4	166,474.1	216,416.0	195,452.4	207,403.5	220,159.1	190,750.6	185,701.1	229,044.2	213,115.5	203,740.0	215,827.1	220,982.9
6 - Sunflowers	990.4	698.2	1,478.9	4,938.1	6,878.0	142.1	1,937.9	1,259.9	1,795.2	3,895.7	3,922.8	1,778.9	1,095.3
12 - Sweet Corn			0.2	0.7	0.2	13.6	5.6	2.0	0.7	12.5			
21 - Barley	115.5	0.8	16.7	168.8	117.4	106.7	707.7	9.8	58.5	72.9	133.0	77.6	86.7
22, 23, 24 - Durum, Spring & Winter Wheat	39,609.9	28,661.3	35,175.0	37,840.2	29,052.9	23,734.0	17,850.2	11,999.7	17,026.8	19,401.2	17,730.5	14,211.2	18,501.0
27 - Rye	2.3	2.3	0.2	2.2	0.9		5.8		0.4		47.4	21.8	188.4
28 - Oats	33.3	23.2	20.7	50.3	28.5	6.9	19.3	5.1	174.8	147.0	38.7	66.5	100.1
29 - Millet										0.2		18.9	0.7
31 - Canola	1.5	0.8			0.7		5.3				3.3		28.2
32 - Flaxseed							29.8						
36, 37 - Alfalfa & Other Hay/Non Alfalfa	3,683.2	3,439.9	3,318.5	3,171.8	2,437.2	3,673.3	2,349.6	2,626.0	3,216.8	2,639.1	3,819.0	4,578.5	4,733.7
39 - Buckwheat			0.9	13.8			0.2	0.4	3.6		4.2	18.0	8.7
41 - Sugarbeets	9,152.6	7,041.7	6,831.7	8,129.6	7,144.2	4,351.2	10,375.6	8,155.0	7,374.4	9,235.8	8,586.7	7,180.2	8,554.4
42 - Dry Beans	1,499.5	619.9	1,732.7	2,064.7	3,101.5	443.9	3,299.0	1,578.3	1,362.4	2,351.8	2,684.3	2,764.4	1,388.9
43 - Potatoes		24.0	0.9	10.9			1.3	1.8	1.3	5.8		0.7	
44 - Other Crops			2.0	21.8	2.2	0.4	1.3	4.4	0.2	1.3		1.8	62.9
47 - Misc Vegs & Fruits	1.5	2.3											
53 - Peas	12.4	9.3	0.2				16.0	2.7	281.1	6.4	17.3	3.3	6.4
241 - Dbl Crop Corn/Soybeans			20.7		64.5								
205 - Triticale (Hybrid of Wheat & Rye)													8.9
TOTAL CROPPED ACRES	441,961.9	432,132.0	450,633.7	440,715.7	441,323.9	445,603.7	444,352.5	446,263.2	447,706.1	450,218.0	451,356.3	450,929.1	451,225.6
PERCENTAGE CROPPED	80%	79%	82%	80%	80%	81%	81%	81%	81%	82%	82%	82%	82%
57 - Herbs						0.7							
58 - Clover/Wildflowers	0.8						3.8	2.7					2.7
59 - Sod/Grass Seed			3.6	4.4	0.4	1.1	2.2	0.9		0.2	0.7	2.4	2.9
60 - Switchgrass									4.9			11.8	1.3
61 - Fallow/Idle Cropland		128.6	18.2	871.8	265.3	13.8	65.2	64.3	108.3	459.0	4.4	1,015.2	870.5
63 - Forest		11.6			89.6								
70 - Christmas Trees	9.3	3.1											
87 - Wetlands	544.8	1,151.5			2,398.7								
111 - Open Water	17,372.2	17,944.9	16,987.6	17,039.2	17,334.8	17,685.7	17,177.3	17,077.0	17,843.6	18,314.2	17,322.1	17,172.4	17,650.6
131 - Barren	22.5	97.6	74.1	102.7	79.0	38.7	164.1	157.0	84.5	91.4	65.2	56.5	109.2
141 - Deciduous Forest	5,054.0	6,421.0	4,977.0	4,895.1	5,122.6	5,028.1	5,129.3	4,930.0	5,153.1	5,424.0	5,459.6	5,673.1	4,708.8
142 - Evergreen Forest	26.3	10.8	24.5	21.8	19.8	7.3	14.5	31.6	10.9	1.8	6.7	3.6	42.5
143 - Mixed Forest	4.6	2.3			1.1	0.2	2.4	0.7	6.0		0.2		0.2
152 - Shrubland	10.8	13.2	5.3	14.7	2.0	6.4	9.3	3.8	2.9	17.3	2.4	1.8	21.8
176 - Grass/Pasture	19,320.4	5,827.4	20,042.7	24,442.5	35,195.3	4,206.1	4,346.5	3,539.9	4,911.6	4,399.9	3,899.9	3,862.1	4,773.7
190 - Woody Wetlands	882.6	431.6	317.1	419.2	342.3	431.0	375.2	452.6	330.0	420.5	406.1	315.8	431.0
195 - Herbaceous Wetlands	25,698.7	44,789.7	29,977.2	36,027.2	21,461.1	49,863.3	51,254.2	50,334.4	46,517.0	43,695.7	44,730.7	44,613.0	43,601.4
TOTAL HABITAT ACRES	68,947.0	76,833.3	72,427.3	82,838.6	82,312.0	77,282.4	78,544.0	76,594.9	74,972.8	72,824.0	71,898.0	72,727.7	72,216.6
PERCENTAGE HABITAT	13%	14%	13%	15%	15%	14%	14%	14%	14%	13%	13%	13%	13%
121 - Developed/Open Space	36,385.7	38,435.3	24,709.4	24,143.6	23,805.1	25,091.2	24,897.1	25,001.2	24,741.2	24,838.4	24,350.4	23,971.3	24,152.9
122 - Developed/Low Intensity	2,625.4	2,362.0	1,906.8	2,013.1	2,320.0	1,894.4	2,005.6	1,956.2	2,171.2	1,837.9	2,069.6	1,975.8	2,045.6
123 - Developed/Medium Intensity	424.7	533.9	638.9	644.9	546.9	450.3	520.6	507.9	703.2	590.7	610.0	700.1	652.5
124 - Developed/High Intensity	68.2	116.2	115.6	75.8	121.4	107.2	109.4	106.1	135.0	120.3	145.2	125.4	136.3
TOTAL DEVELOPED ACRES	39,504.0	41,447.4	27,370.7	26,877.4	26,793.4	27,543.1	27,532.7	27,571.4	27,750.6	27,387.3	27,175.2	26,772.6	26,987.3
PERCENTAGE DEVELOPED	7%	8%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%
TOTAL ACRES	550,412.9	550,412.7	550,431.7	550,431.7	550,429.3	550,429.2	550,429.2	550,429.5	550,429.5	550,429.3	550,429.5	550,429.4	550,429.5

FEDERAL CONSERVATION PROGRAMS

The USDA offers a variety of voluntary conservation programs, focusing on agricultural lands and practices. The programs are described in the 2019 Agricultural Resources and Environmental Indicators Report:

The **Conservation Reserve Program (CRP)** generally provides 10- to 15-year contracts to remove land from agricultural production. The latest acreage cap under the 2014 Farm Act for this program is 24 million acres. Most of the land enrolled in the CRP was in crop production prior to CRP enrollment and is now planted to grass or trees. Historically, a large majority of CRP contracts enrolled whole fields or whole farms. Increasingly, however, CRP contracts fund high-priority, partial-field practices such as filter strips and grass waterways, rather than whole-field or whole-farm enrollments. Up to 2 million acres of the 24 million acre CRP cap can be used for a specific grasslands enrollment where each landowner agrees to keep the land in grazing use rather than tilling it for crop production or converting it to any other use.



http://www.mncorn.org/wp-content/uploads/2018/02/Corn_History_BMPs_report-Final.pdf

The **Agricultural Conservation Easement Program (ACEP)** provides long-term or permanent easements for preservation of wetlands and the protection of agricultural land (cropland, grazing land, etc.) from commercial or residential development.

The **Environmental Quality Incentives Program (EQIP)** provides financial assistance to farmers who adopt or install conservation practices on land in agricultural production. Common practices include nutrient management, cover crops, conservation tillage, field-edge filter strips, and fences to exclude live-stock from streams. Sixty percent of program funds are targeted to livestock-related practices and at least 5 percent are targeted to wildlife-related practices.

The **Conservation Stewardship Program (CSP)** supports ongoing and new conservation efforts for producers who meet stewardship requirements on working agricultural and forest lands. Farmers and ranchers must demonstrate a high level of stewardship to be eligible for the program and must agree to further improve environment performance over the life of the CSP contract (up to 10 years). Participants receive financial assistance for adopting new conservation practices and for stewardship, based on previously adopted practices and the ongoing maintenance of those practices.

The **Regional Conservation Partnership Program (RCPP)** is designed to coordinate conservation program assistance with partners to solve problems on a regional or watershed scale. Financial assistance is coordinated through RCPP but provided to producers largely through "covered" programs: EQIP, CSP, ACEP, and the Healthy Forests Reserve Program. Up to 7 percent of the dollars or acres available/eligible under each of these programs is allocated through RCPP.

Finally, through **Conservation Technical Assistance (CTA),** USDA provides ongoing technical assistance to agricultural producers who seek to improve the environmental performance of their farms.

MINNESOTA STATE CONSERVATION PROGRAMS

Re-Invest in Minnesota (RIM) Easement Program began in 1986, is intended to protect water quality, help fund the restoration of land and the retirement of land from agricultural production, and enhance critical habitats of fish and wildlife. The program matches private donations of land and money with state funds. The program has many arms that are administered through the Department of Natural Resources (DNR) and Board of Water and Soil Resources (BWSR). Eligible lands include riparian lands, sensitive groundwater areas, wetlands, marginal croplands, and snow fence lands. Below is a list of the different arms involved in conservation easements.

Conservation Reserve Enhancement Program (CREP) is an offshoot of the Conservation Reserve Program (CRP), the country's largest private-land conservation program. Administered by the Farm Service Agency (FSA), CREP targets high-priority conservation issues identified by local, state, or tribal governments or non-governmental organizations. In exchange for removing environmentally sensitive land from production and introducing conservation practices, farmers, ranchers, and agricultural land owners are paid an annual rental rate. Participation is voluntary, and the contract period is typically 10–15 years, along with other federal and state incentives as applicable per each CREP agreement.

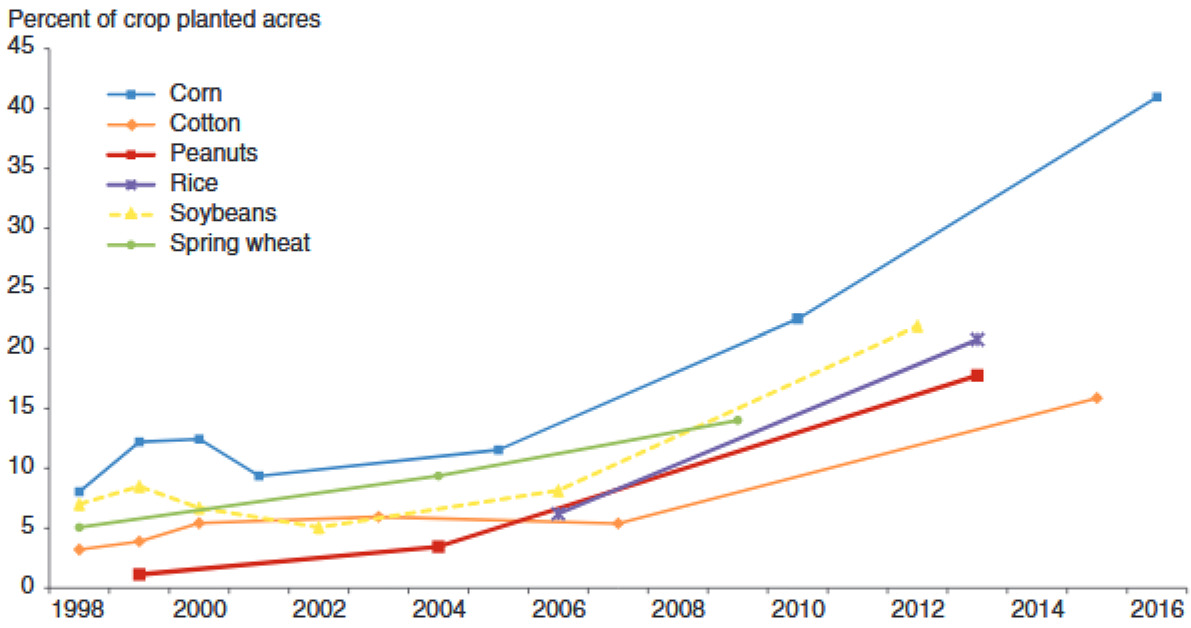
Conservation Easements involve the acquisition of limited rights in land for conservation purposes. Landowners who offer the state a conservation easement receive a payment to stop cropping and/or grazing the land, and in turn the landowners establish conservation practices such as native grass and forbs, trees or wetland restorations. The easement is recorded on the land title with the county recorder and transfers with the land when the parcel is sold.

EVOLVING AGRICULTURAL PRACTICES

Since the mid-1990's, precision agriculture has become mainstream, implemented by individual growers and by regional agricultural service co-operatives and agribusinesses. Precision agriculture uses digital mapping, global positioning systems (GPS), and sensors integrated with a variety of farm implements to collect data and vary seed planting populations and crop fertilizer and herbicide treatments. Specific technologies include yield monitors, yield maps, soil GPS maps, guidance systems, and variable rate technology. "Precision technologies are associated with increased use of soil conservation tillage, erosion reduction, and nutrient control practices." (https://www.ers.usda.gov/webdocs/publications/93026/eib-208.pdf?v=9435.6)

Variable rate technology is one agricultural development that notably reduces environmental risk to water quality. Fertilizer and pesticide applications can be increased or decreased on a 1' x 1' scale – rather than set at one setting, broadcast on an entire field. More closely matching plant needs with fertilizer and pesticide applications reduces possibilities for excess nutrients and runoff.

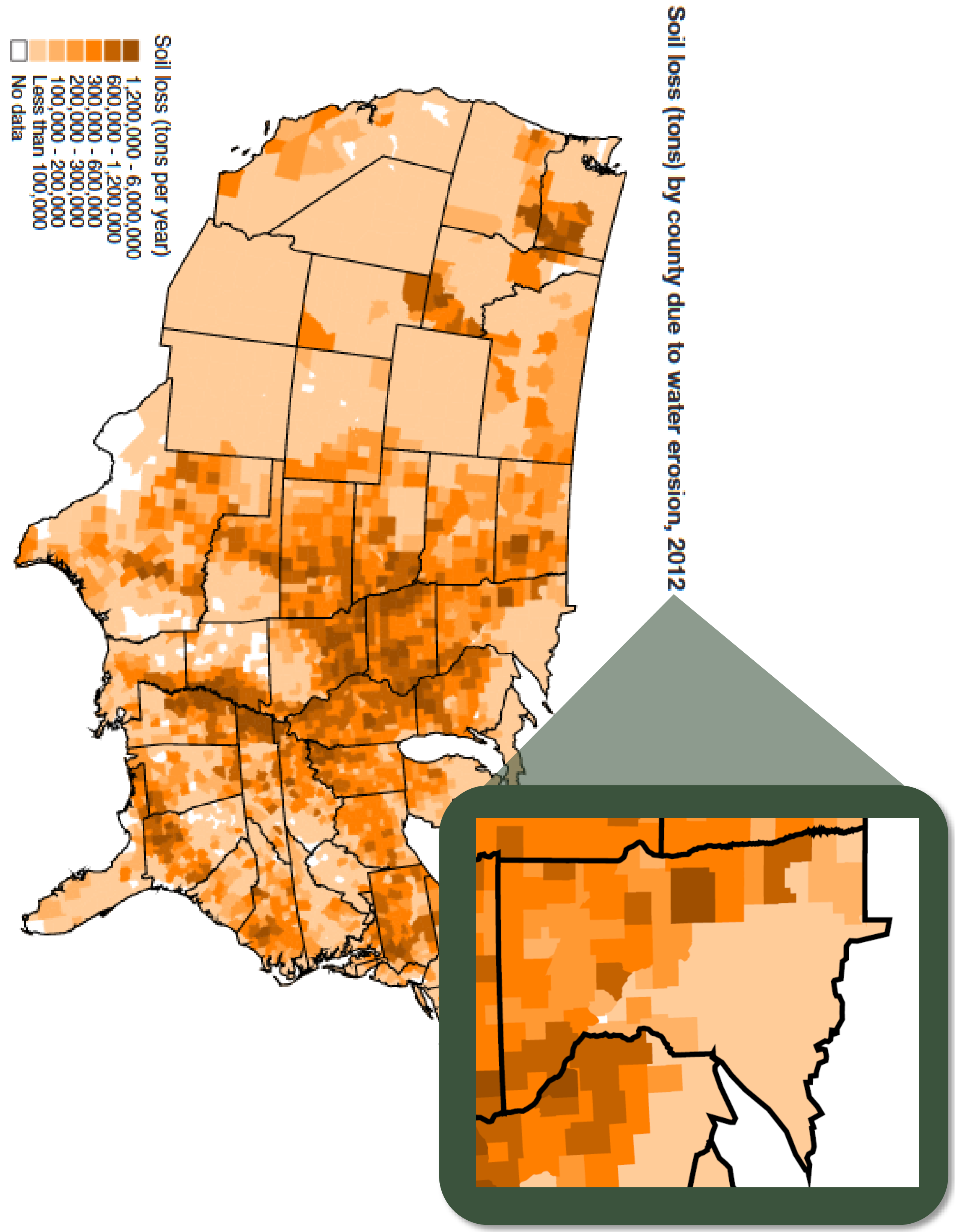
Adoption of variable-rate technology (VRT) by crop, 1998-2016



Note: Line markers indicate survey years for each crop.
Source: USDA, Economic Research Service (ERS) estimates using data from ERS and USDA, National Agricultural Statistics Service, Agricultural Resource Management Survey, Phase II.

AGRICULTURAL PRACTICES AFFECT SEDIMENT

Sediment is a source of watershed water quality impairments. Erosion has declined due to improved cropping practices (such as conservation tillage), implemented in the 1980's and 1990's (Daniel Hellerstein, 2019).



Source: USDA, Economic Research Service using data from the 2012 National Resources Inventory (USDA, 2012b).

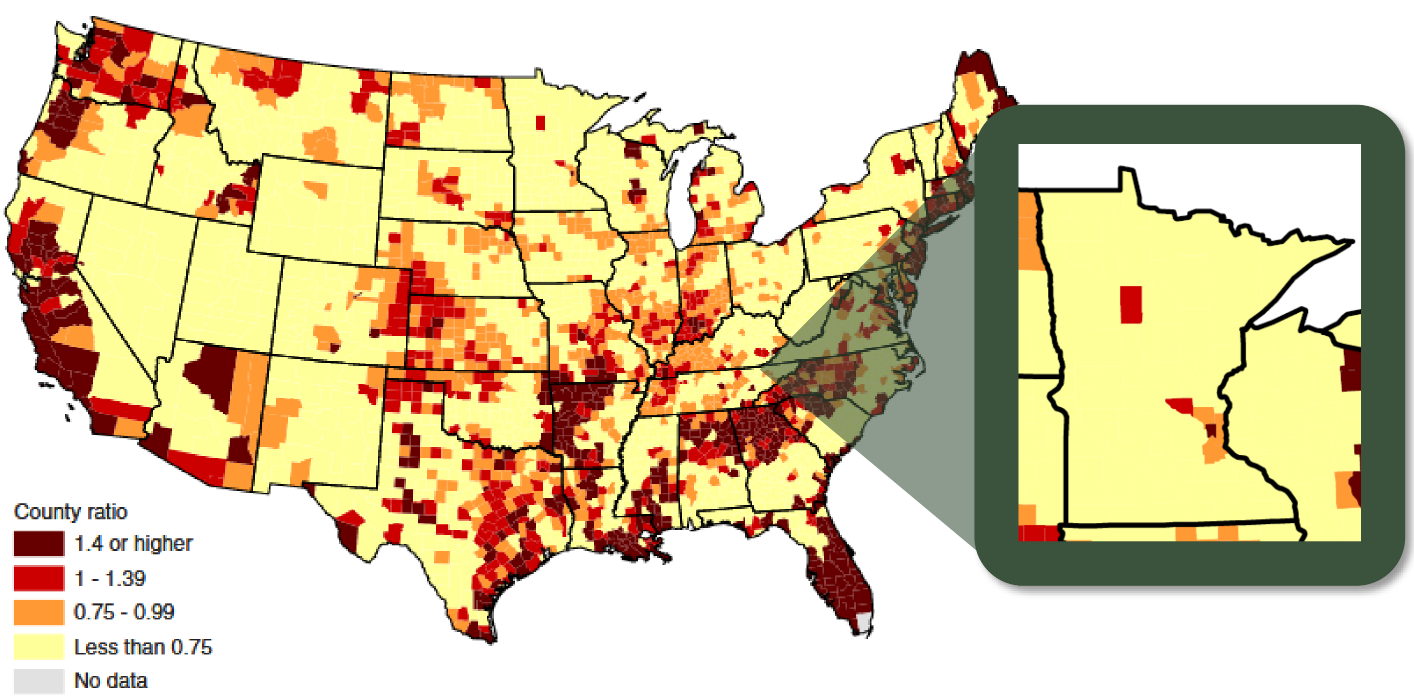
Nitrates are not a primary concern in either the Bois de Sioux or Mustinka River Watersheds, but there are both nonpoint and point sources of nitrates in both the Bois de Sioux and Mustinka River Watersheds. With regard to nonpoint agricultural sources, fall application of nitrogen fertilizer is an uncommon practice, and data from the USDA suggests that the ratio of commercial fertilizers applied in watershed counties is below the amount required by county crops.

One of the considerations for an aquatic recreation impairment for lakes is total phosphorus. Phosphorus, which does not have a toxic effect, is used by Minnesota Pollution Control Agency as an indicator; elevated phosphorus levels lead to eutrophication, which results in reduced oxygen concentrations. There are both nonpoint and point sources of phosphorous in both the Bois de Sioux and Mustinka River Watersheds. With regard to nonpoint agricultural sources, phosphorous loss is influenced by tillage systems, application details (rate, time and method), and field-specific soil chemistry (https://extension.umn.edu/phosphorus-and-potassium/agronomic-and-environmental-management-phosphorus#tillage-systems-572911)

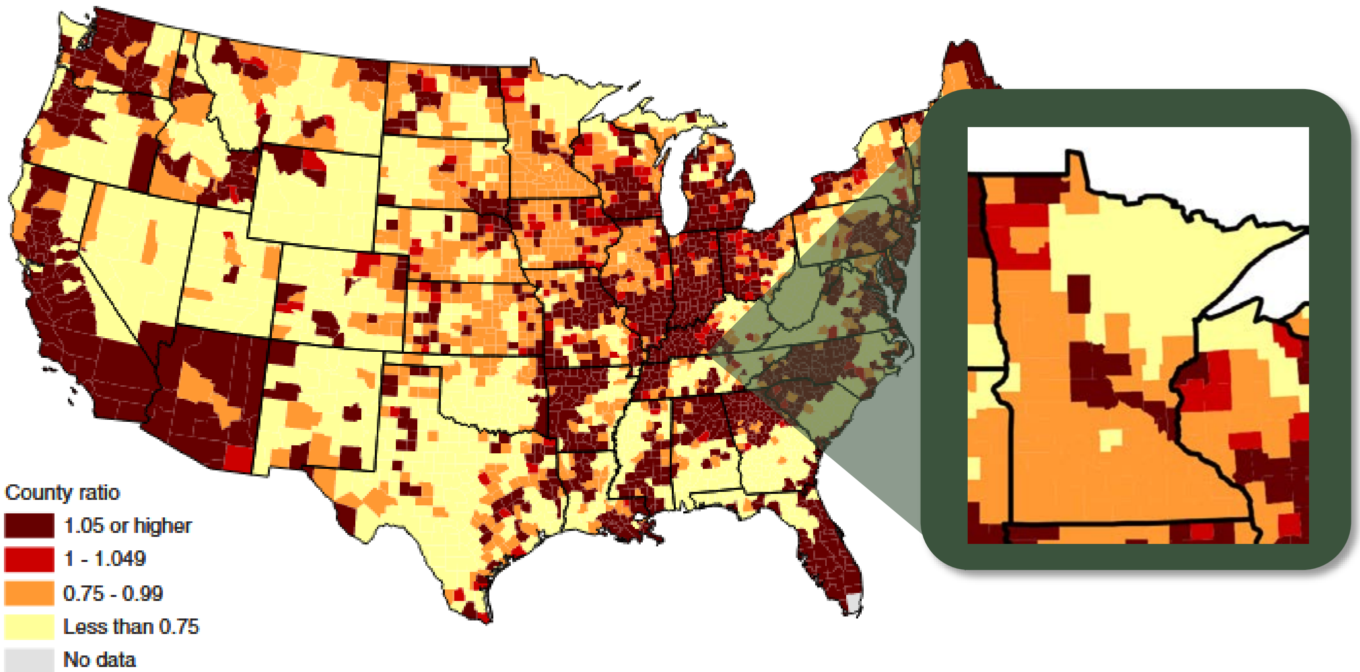
In their 2019 Agricultural Resources and Environmental Indicators Report, the USDA writes that the maps below show:

> *...the ratio of the county-wide amount of available nutrients to the agronomically appropriate nutrient requirements for crops and pasture. Available nutrients include the amount of manure nutrients recoverable for later application to crops and pasture plus purchased commercial fertilizer. Values of the ratio greater than one suggest that farms within that county use more manure and fertilizer nutrients than are being taking up by crops and pastures, and therefore these counties exhibit a higher risk of nutrient runoff or leaching.*

Ratio of nitrogen from commercial fertilizer and manure to crop/pasture uptake by county, 2012



Ratio of phosphorus from commercial fertilizer and manure to crop/pasture uptake by county, 2012

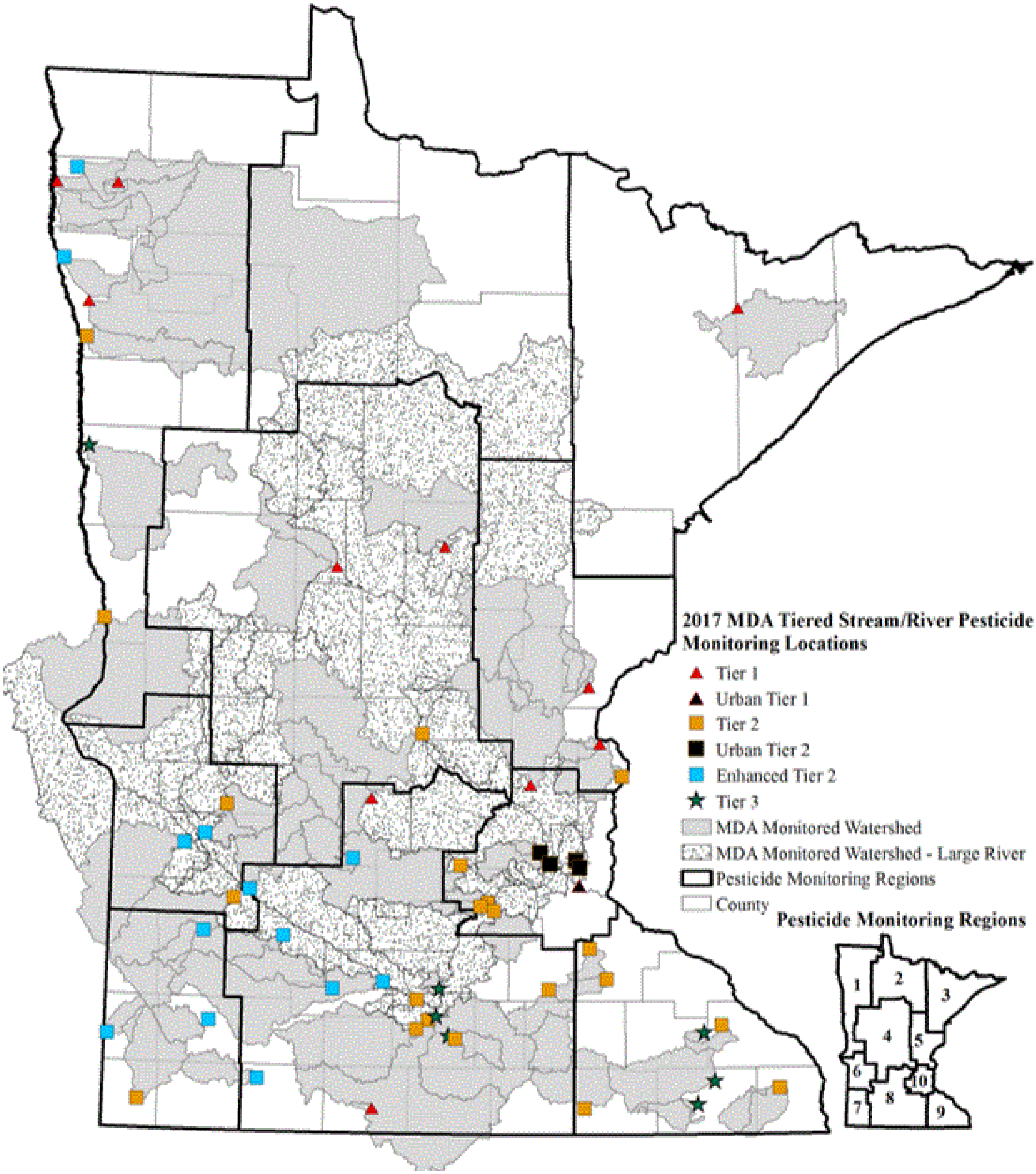


AGRICULTURAL PRACTICES AFFECT PESTICIDES

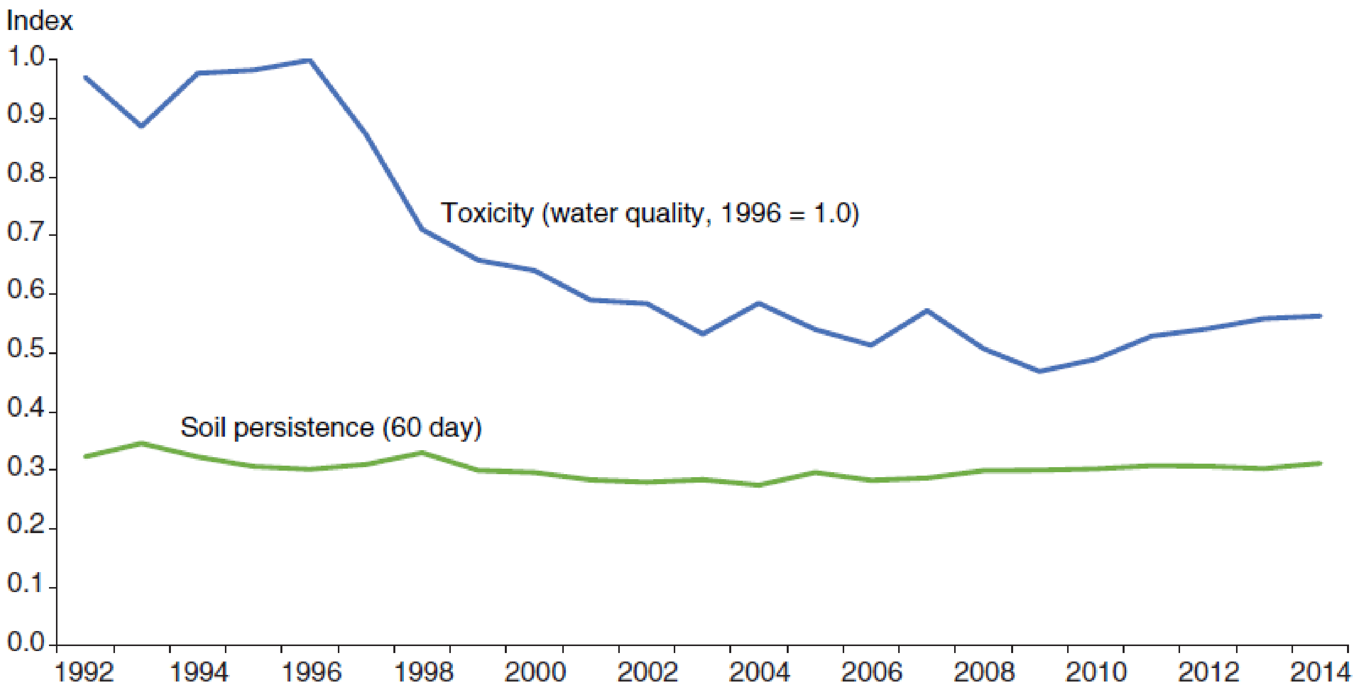
Farmers apply pesticides primarily to control insects, weeds, and fungus. The Minnesota Department of Agriculture monitors surface and groundwater exposure to pesticides. Bois de Sioux and Mustinka River farmers apply pesticides primarily to control insects, weeds, and fungus. The Minnesota Department of Agriculture monitors surface and groundwater exposure to pesticides. The Bois de Sioux and Mustinka River Watersheds do not have a designated or proposed impairment for currently registered pesticides.

The USDA states:

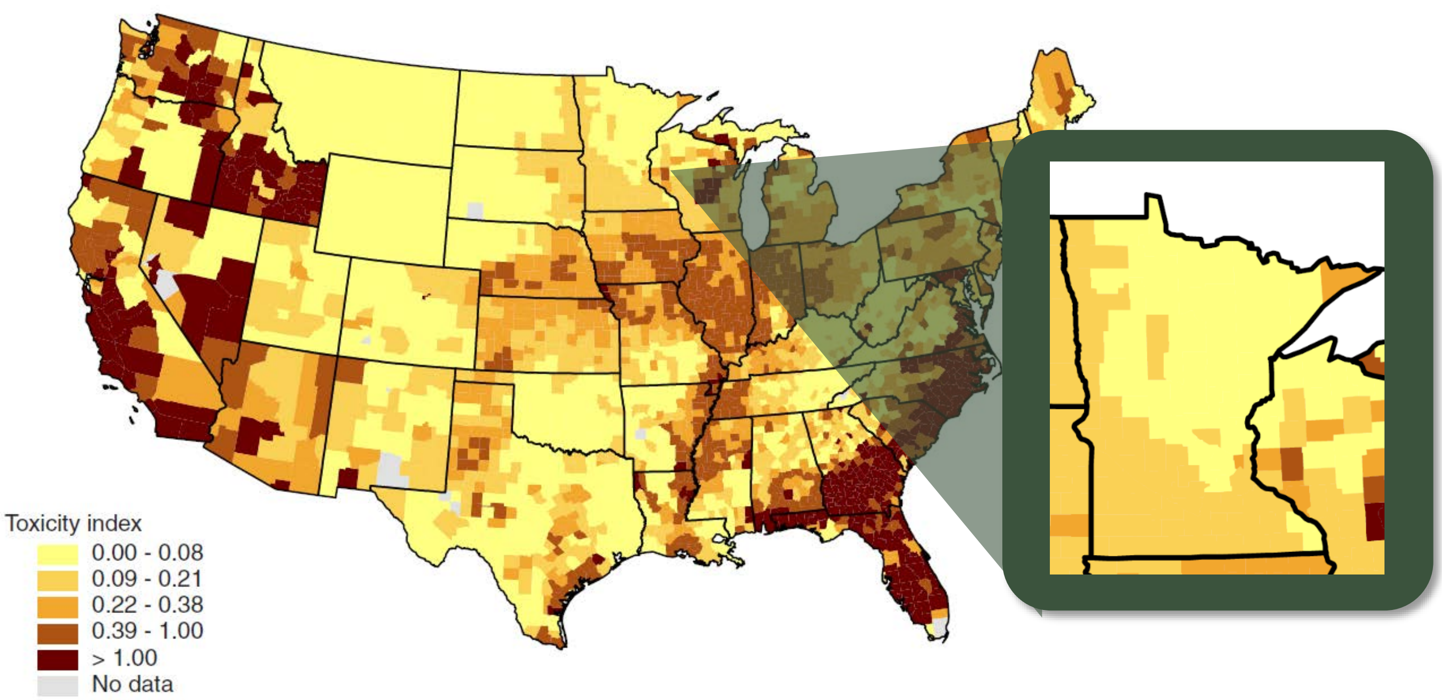
> *Once applied, pesticides can remain in the soil for weeks, months, or years. On average about 30 percent of the pesticides applied remain in the soil after 60 days (figure below). Persistent pesticides, with long half-lives, can travel off the field and into waterways where they may harm fish and other aquatic life. Pesticides may also contaminate ground water and well water.*


2017 MDA Tiered Stream/River Pesticide Monitoring Locations
Tier 1
Urban Tier 1
Tier 2
Urban Tier 2
Enhanced Tier 2
Tier 3
MDA Monitored Watershed
MDA Monitored Watershed - Large River
Pesticide Monitoring Regions
County
Pesticide Monitoring Regions
1
2
3
4
5
6
7
8
9
10

Agricultural pesticide toxicity indexes using water quality thresholds and 60-day soil persistence, 1992-2014



Agricultural pesticide toxicity index using water quality thresholds by county, 2014



Although the predominant land use in both the Bois de Sioux and Mustinka River Watersheds is agriculture, it is important to remember that agricultural impacts to water quality are affected by natural, weather-related events:

> *The difference in nutrient export between snowmelt versus snow + rain dominated years may require changes or adaptations to current BMPs in order to control nutrient losses under a future climate change scenario. While measures to reduce nutrient loss such as crop rotation (Liu et al., 2013) and placement and timing of fertilizer application (Flaten, 2011) have been implemented, additional actions may be needed to address the variability in nutrient (particularly P) loss between snowmelt-dominated and snowmelt + rain dominated years. In particular, actions may be need to address the difference in seasonality of nutrient loss between snowmelt-dominated years (when snowmelt and spring losses predominate) compared to snowmelt + rain dominated year (when losses occur during snowmelt, spring and summer).*

AGRICULTURAL LIVESTOCK BY WATERSHED

Livestock operations are sparsely located in parts of each watershed, but animal units are increasing. Since 2013, three new dairies have been constructed (two in the Bois de Sioux and one in the Mustinka River Watersheds). Operators are able to participate in trough/tank water facility and wastewater/feedlot runoff cost-share opportunities through soil and water conservation districts.

BOIS DE SIOUX RIVER WATERSHED								
HUC-12	Issued Active Registered Sites/Permitted Sites	Bovine	Goat/Sheep	Horses	Swine	Geese/Ducks	Chicken	Totals by HUC-12
LAKE TRAVERSE & BOIS DE SIOUX RIVER PLANNING REGION								
County Ditch No 52	3	87.7	3.0					90.7
Doran Creek (no animal units)	1							0.0
Lower Lake Traverse	1	180.0						180.0
Mud Lake	8	122.4		7.0	390.0	0.1		519.5
Clubhouse Lake-Bois de Sioux River	4	721.0						721.0
County Ditch No 26-Bois de Sioux River	1				10.0		0.5	10.5
Upper Lake Traverse	3	96.5			3.0			99.5
RABBIT RIVER PLANNING REGION								
Ash Lake	1	58.0						58.0
County Ditch No 20-Rabbit River	4	226.0			2,880.0			3,106.0
Judicial Ditch No 12	2	42.0						42.0
Judicial Ditch No 2	1	11,000.0						11,000.0
N. Fork Rabbit River (no animal units)	1							0.0
Upper Lightning Lake	1				1,440.0			1,440.0
BOIS DE SIOUX RIVER WATERSHED TOTAL	**31**	**12,533.6**	**3**	**7**	**4,723**	**0.12**	**0.45**	**17,267.17**

MUSTINKA RIVER WATERSHED

HUC-12	Issued Active Registered Sites/Permitted Sites	Bovine	Deer /Elk	Goat /Sheep	Horses	Swine	Geese /Ducks	Chicken	Turkey	Totals by HUC-12
LOWER MUSTINKA AND TWELVEMILE CREEK PLANNING REGION										
County Drain No 27	1					3,073.4				3,073.4
Eighteen Mile Creek	6	474.0		6.5						480.5
Lower East Branch Twelvemile Creek	7	9,482.0			2.0	1,275.0				10,759.0
Mustinka River (no animal units)	0									0.0
Old Channel-Mustinka River	2	1,450.0		26.5						1,476.5
Twelvemile Creek	5	510.0		80.0		781.8		150.1		1,521.9
West Branch Twelvemile Creek	2	44.2								44.2
TWELVEMILE CREEK PLANNING REGION										
County Ditch No 38	12	100.0				2,115.0				2,215.0
County Ditch No 44-West Branch Twelvemil	4	939.0		35.0	3.0	900.0		0.1		1,877.1
East Fork Twelvemile Creek	4	16.2				1,370.0				1,386.2
Fivemile Creek	5	493.0		500.0	16.0	80.0				1,089.0
Middle East Branch Twelvemile Creek	2	33.0				300.0				333.0
Niemackl Lakes	7	737.8		4.8				0.3		742.9
South Fork Rabbit River	3	9,710.0		40.0	3.0	3,030.0				12,783.0
Toqua Lakes	4	10.2		0.9		4,176.1	5.0	12.8	1,469.4	5,674.4
Town of Collis-West Branch Twelvemile Cr	3	99.0	3.5		2.0					104.5
Upper East Branch Twelvemile Creek	8	1,177.4		52.5		1,027.2		1.3		2,258.4
West Fork Twelvemile Creek	6	823.9		0.6		1,764.3		0.6		2,589.4
UPPER MUSTINKA PLANNING REGION										
Elbow Lake-Mustinka River (no animal units)	1									0.0
Fridhem Cemetery*	1	44.5				900.0				944.5
Headwaters Mustinka River	3	113.0			2.0					115.0
Mustinka Flowage-Mustinka River	4	250.0								250.0
Round Lake	1			6.0						6.0
MUSTINKA RIVER WATERSHED TOTAL	**153**	**26,507.2**	**3.5**	**752.8**	**28.0**	**20,792.8**	**5.0**	**165.2**	**1,469.4**	**49,723.9**

Active Registered and Permitted Sites Animal Units, per MPCA on July 18, 2019

PRAIRIE HABITAT

The DNR classifies all, or portions, of 50 of 87 Minnesota counties as part of their "Prairie Planning Section." Based on the Minnesota Prairie Conservation Plan, authored and mapped by The Nature Conservancy, the DNR further specifies a permanent prairie goal, in acres, for each watershed.

For the Bois de Sioux River Watershed, the DNR calculates a shortage of 9,302 acres of permanent prairie; for the Mustinka River Watershed, the DNR calculates a goal shortage of 12,496 acres of permanent prairie. In its calculations, the DNR does not recognize additional habitat acres including: DNR-mapped permanent drainage system buffers, DNR-mapped permanent public waters buffers, or grassland areas of DNR-permitted flood impoundments, or road right-of-ways.

CALCEROUS FENS

Two calcerous fens have been identified by the Minnesota DNR, at following locations, in the Mustinka River Watershed (*https://files.dnr.state.mn.us/eco/wetlands/calcareous_fen_list.pdf*):

Fen ID # 28155: Aastad Township, Section 25. T131N-R43W-SENE25 (Erlandson WMA)
Fen ID #28156: Aastad Township, Section 23. T131N-R43W-SWSW23

According to a fact sheet from the Board of Water and Soil Resources, "Calcareous fens are rare and distinctive wetlands characterized by a substrate of non-acidic peat and dependent on a constant supply of cold, oxygen-poor groundwater rich in calcium and magnesium bicarbonates. This calcium-rich environment supports a plant community dominated by "calciphiles," or calcium-loving species" (*http://www.bwsr.state.mn.us/wetlands/Calc_fen-factsheet.pdf*). BWSR highlights the following plant species, stating that the species indicated with an (*) are exclusively found in calcerous fens:

*Carex sterilis**	*Sterile sedge*	*State threatened*
*Cladium mariscoides**	*Twig-rush*	*State special concern*
*Rhynchospora capillacea**	*Fen beak-rush*	*State threatened*
*Fimbristylis puberula**	*Hairy fimbristylis*	*State endangered*
Scleria verticillate	*Nut-rush*	*State threatened*
Eleocharis rostellata	*Beaked spike-rush*	*State threatened*
Valeriana edulis	*Valerian*	*State threatened*
Cypripedium candidum	*Small white lady's slipper*	*State special concern*

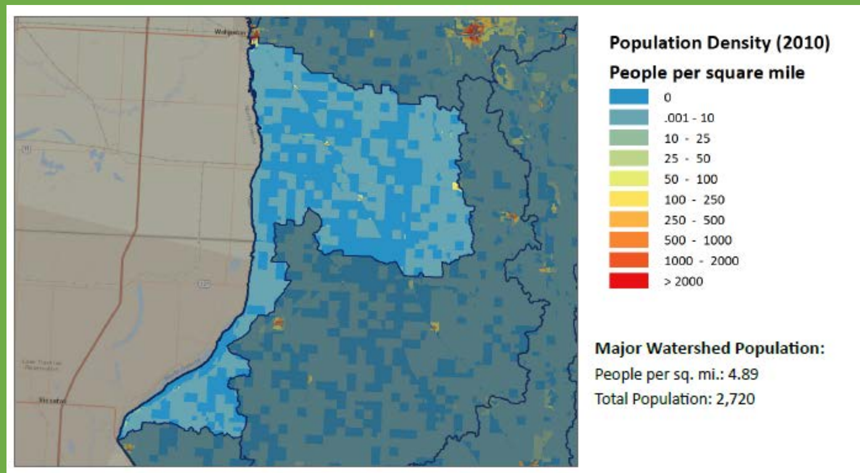
RECREATIONAL AREAS

The DNR maintains a list of statewide Wildlife Management Areas that provide recreation for hunters and trappers, and wildlife watching opportunities (*https://www.dnr.state.mn.us/wmas/index.html*).

6 - PEOPLE

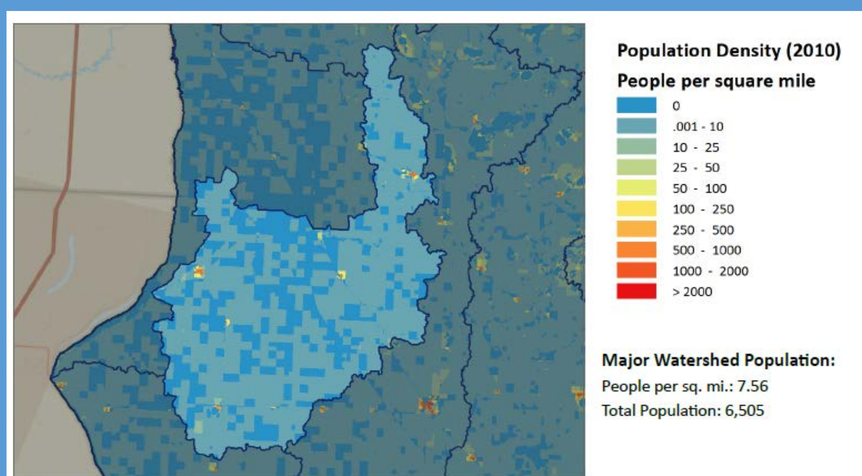
BOIS DE SIOUX RIVER WATERSHED: POPULATION ESTIMATE 2,720

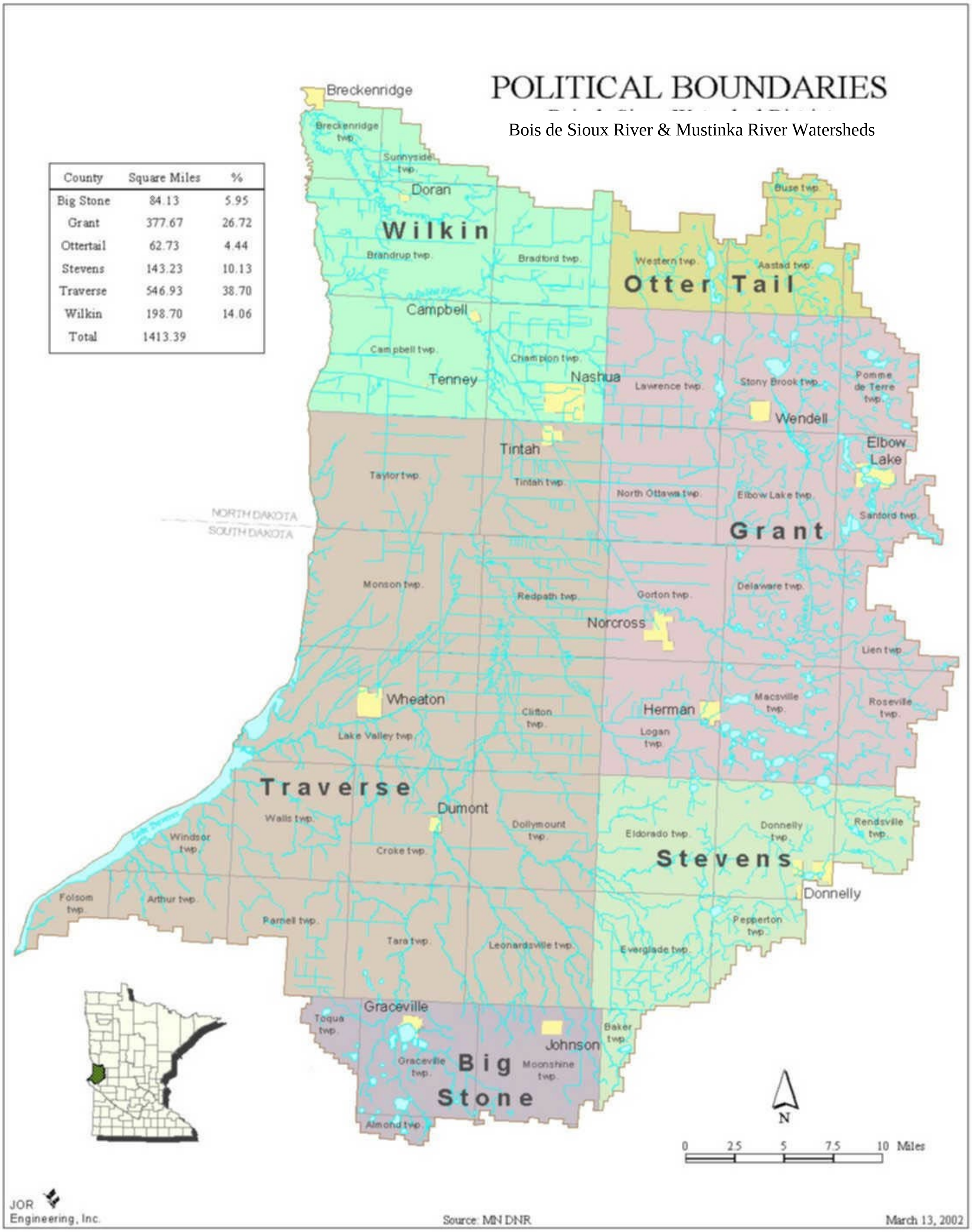
Cities and towns within the Bois de Sioux River Watershed in Minnesota include Breckenridge (the portion of town south of the railroad tracks and east of the Bois de Sioux River), Campbell, Nashua, Tintah, and Wendell. Cities and towns within the Bois de Sioux River Watershed in North and South Dakota include: Blackmer, Fairmount, LaMars, New Effington, Rosholt, and Tyler.



MUSTINKA RIVER WATERSHED: POPULATION ESTIMATE 6,505

Cities and towns within the Mustinka River Watershed include: Donnelly, Elbow Lake, Graceville, Herman, Norcross, Wendell, and Wheaton.




POLITICAL BOUNDARIES
Bois de Sioux River & Mustinka River Watersheds
County | Square Miles | %
Big Stone | 84.13 | 5.95
Grant | 377.67 | 26.72
Ottertail | 62.73 | 4.44
Stevens | 143.23 | 10.13
Traverse | 546.93 | 38.70
Wilkin | 198.70 | 14.06
Total | 1413.39
Wilkin
Otter Tail
Grant
Traverse
Stevens
Big Stone
Breckenridge
Doran
Campbell
Tenney
Nashua
Tintah
Wendell
Elbow Lake
Norcross
Herman
Wheaton
Dumont
Donnelly
Graceville
Johnson
NORTH DAKOTA
SOUTH DAKOTA
N
0 2.5 5 7.5 10 Miles
JOR Engineering, Inc.
Source: MN DNR
March 13, 2002

RURAL POPULATIONS

Comparing overall data from the 2000 & 2010 Census, populations in the Bois de Sioux River and Mustinka River Watersheds have declined. In their "Reclamation, Managing Water in the West. Final Report on Red River Valley Water Needs and Options," the US Department of the Interior includes information that compared 2050 projections for three counties with portions in the Bois de Sioux River & Mustinka Watersheds. The data projects a decline for Wilkin and Traverse Counties, and an increase for Otter Tail County, although it is impossible to tell if these changes will happen within parts of the counties inside or outside of the Bois de Sioux and Mustinka River Watersheds.

COUNTY	2000 CENSUS DATA	RECLAMATION 2050 POPULATION PROJECTION	NORTHWEST 2050 POPULATION PROJECTION
Otter Tail	57,222	81,700	69,845
Traverse	4,119	2,800	3,180
Wilkin	7,133	4,900	6,587

https://www.usbr.gov/gp/dkao/redriver/rrvwsp/Report/Report.pdf

POPULATION TRENDS

The 2000 & 2010 U.S. Census data is collected by county, township, and city. Looking at population by township, most townships have declined in population for both the Bois de Sioux River and Mustinka River watersheds from 2000 to 2010.

TOWNSHIP	2000 POPULATION	2010 POPULATION	CHANGE
Aastad township	187	213	14%
Almond township*	190	110	-42%
Arthur township*	109	81	-26%
Baker township*	114	265	132%
Bradford township*	119	91	-24%
Brandrup township	172	158	-8%
Breckenridge township*	234	255	9%
Buse township*	690	491	-29%
Campbell township	99	57	-42%
Champion township	73	53	-27%
Clifton township	92	75	-18%
Croke township	84	75	-11%
Delaware township	119	102	-14%
Dollymount township	83	77	-7%
Donnelly township*	113	100	-12%
Elbow Lake township	157	141	-10%
Eldorado township	109	94	-14%
Everglade township*	128	108	-16%
Folsom township*	149	128	-14%
Gorton township	64	49	-23%
Graceville township	205	197	-4%
Lake Valley township	276	237	-14%
Lawrence township	96	84	-13%
Leonardsville township	150	107	-29%

TOWNSHIP	2000 POPULATION	2010 POPULATION	CHANGE
Lien township*	117	111	-5%
Logan township	115	93	-19%
Macsville township	128	114	-11%
Monson township	162	133	-18%
Moonshine township*	150	131	-13%
North Ottawa township	69	50	-28%
Parnell township*	62	60	-3%
Pepperton township*	148	134	-9%
Pomme de Terre townsh	165	133	-19%
Redpath township	35	48	37%
Rendsville township*	177	161	-9%
Roseville township*	154	124	-19%
Sanford township*	169	153	-9%
Stony Brook township	164	133	-19%
Sunnyside township*	143	136	-5%
Tara township	126	92	-27%
Taylor township	108	105	-3%
Tintah township	53	33	-38%
Toqua township*	87	53	-39%
Tumuli township*	434	449	3%
Walls township	81	65	-20%
Western township*	142	129	-9%
Windsor township	54	66	22%

*These townships have portions located outside of the Bois de Sioux and Mustinka River Watersheds.

Looking at population by city, it can be noted that most cities in the Bois de Sioux River and Mustinka River Watersheds have declined from 2000 to 2010. Because Wendell is split between the two watersheds, and Breckenridge is only partially included in the Bois de Sioux River Watershed, it is not possible to decipher the total population change for urban residents in each watershed.

Mustinka River Watershed	2000 Population	2010 Population	Change
Donnelly city, Stevens County	254	241	-5%
Elbow Lake city, Grant County	1,275	1,176	-8%
Graceville city, Big Stone County	605	577	-5%
Herman city, Grant County	452	437	-3%
Norcross city, Grant County	59	70	19%
Wendell city, Grant County**	177	167	-6%
Wheaton city, Traverse County	1,619	1,424	-12%

Bois de Sioux River Watershed	2000 Population	2010 Population	Change
Breckenridge city, Wilkin County*	3,559	3,386	-5%
Campbell city, Wilkin County	241	158	-34%
Nashua city, Wilkin County	69	68	-1%
Tintah city, Traverse County	79	63	-20%
Wendell city, Grant County**	177	167	-6%

*Wendell should be split between watersheds
**Only a portion of Breckenridge is within the Bois de Sioux Watershed

7 - FISH & WILDLIFE

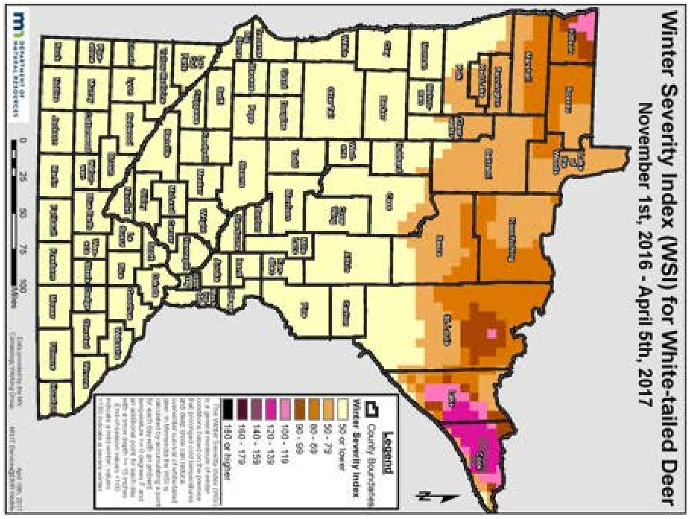
Fish and wildlife are important natural resources of the area. Fishing and hunting provide recreation for residents and are also significant to the local economy. Duck, goose, pheasant, Hungarian partridge, fox, and whitetail deer are commonly hunted species. Walleye, northern pike, panfish, bullhead, and roughfish species are fished, both for recreation and commercially.

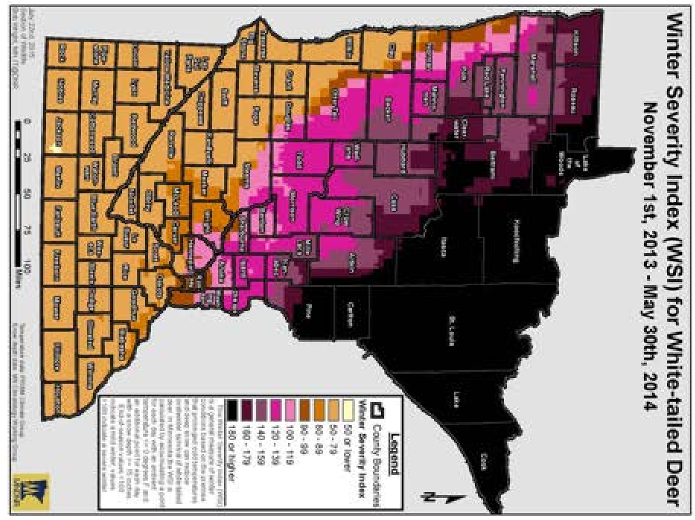
The watersheds lay along a major flyway for migratory birds. Species that migrate through the area include the bald eagle and peregrine falcon both of which are on the endangered species list.

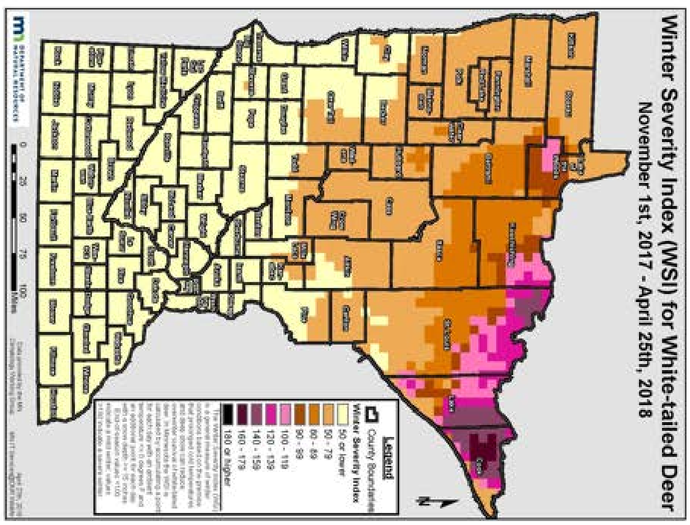
According to information by the DNR, another native resident of the Bois de Sioux and Mustinka River Watersheds - the burrowing owl - was added to the endangered species.

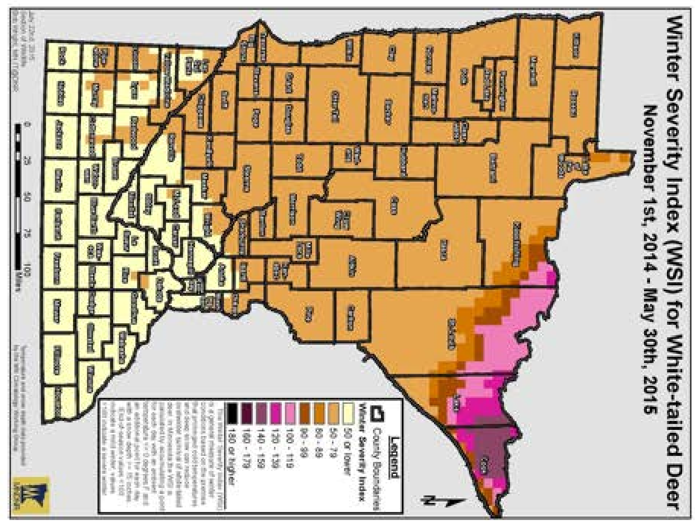
> *"The Minnesota Biological Survey continues to target this species as surveys are completed in the prairie region of the state. Burrowing owls were observed in western Minnesota in 1999, 2002, and 2004-2007. Nesting was confirmed in Norman County in 2006 and in Polk and Pipestone counties in 2007. These records represent the first documented nesting of burrowing owls in Minnesota since 1990."*
>
> https://www.dnr.state.mn.us/rsg/profile.html?action=elementDetail&selectedElement=ABNSB10010

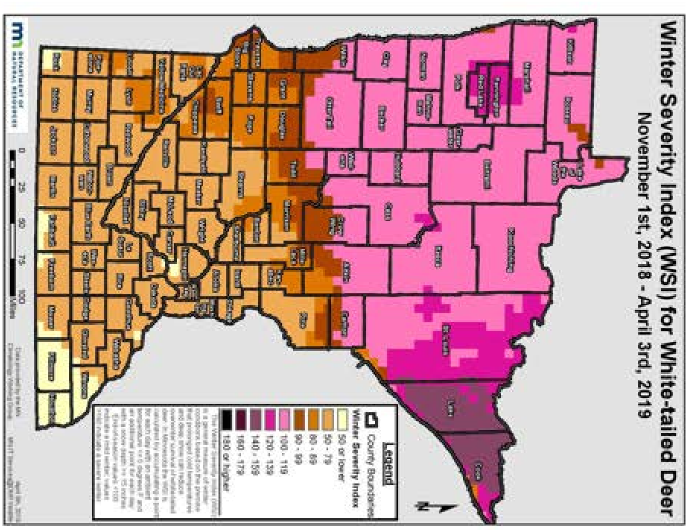
Winter weather impacts wildlife populations, and this is evidenced by white-tailed deer, which are plentiful in both watersheds. The Minnesota DNR rates the severity of winter conditions for deer. For three of the past six years, both Bois de Sioux and Mustinka River Watersheds were evaluated to have the least severe winter weather conditions for white-tailed deer.

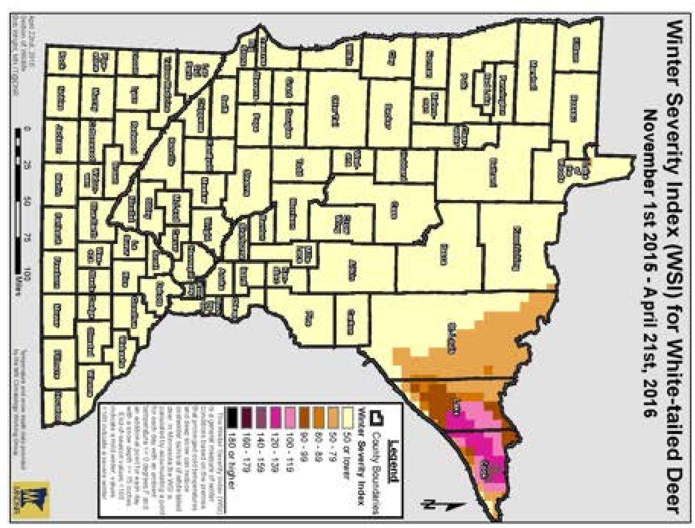

Winter Severity Index (WSI) for White-tailed Deer
November 1st, 2016 - April 5th, 2017
Legend
County Boundaries
Winter Severity Index
50 or lower
50 - 79
80 - 89
90 - 99
100 - 119
120 - 139
140 - 159
160 - 179
180 or higher


Winter Severity Index (WSI) for White-tailed Deer
November 1st, 2013 - May 30th, 2014


Winter Severity Index (WSI) for White-tailed Deer
November 1st, 2017 - April 25th, 2018


Winter Severity Index (WSI) for White-tailed Deer
November 1st, 2014 - May 30th, 2015


Winter Severity Index (WSI) for White-tailed Deer
November 1st, 2018 - April 3rd, 2019


Winter Severity Index (WSI) for White-tailed Deer
November 1st 2016 - April 21st, 2016