Appendix A
Missouri River Watershed:
Land and Water Resources Inventory

MISSOURI RIVER WATERSHED
Comprehensive Watershed Management Plan

HoustonEngineering Inc.

MISSOURI RIVER WATERSHED Comprehensive Watershed Management Plan

Maple Grove, MN
February 14, 2018

MISSOURI RIVER WATERSHED

Land and Water Resources Inventory

MISSOURI RIVER WATERSHED LAND AND WATER RESOURCES INVENTORY

February 2018

Disclaimer: This Land and Water Resources Inventory is intended to summarize land and water resource information in the Missouri River Watershed One Watershed, One Plan planning area relevant to the One Watershed, One Plan planning process. This Inventory is not a scientific analysis or independent review of the data, but instead provides a summary of and reference to existing reports and data. It is intended to be used to provide background information and reference to land and water resource information available in the plan area.

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MISSOURI RIVER WATERSHED
Comprehensive Watershed Management Plan

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INTRODUCTION

The Missouri River Watershed (MRW), One Watershed, One Plan (1W1P) boundary encompasses portions of four (4) major watersheds in southwestern Minnesota (see **Figure 1)**:

- Upper Big Sioux River (HUC-8: 10170202);
- Lower Big Sioux River (HUC-8: 10170203);
- Rock River (HUC-8: 10170204); and
- Little Sioux River (HUC-8: 10230003).

The drainage area headwaters a portion of the greater Missouri River Basin – draining streams from Southern Minnesota downstream through other rivers and states (**Figure 2**, upper right). The MRW drains a total of 1.1 million acres of land from Minnesota and includes all or portions of 25 towns and cities (Worthington, Pipestone, Luverne, Adrian, etc.) and six (6) counties (Jackson, Nobles, Murray, Rock, Pipestone, and Lincoln). Roughly 30,000 people live within the MRW.

The four major watersheds within the MRW (Upper Big Sioux, Lower Big Sioux, Rock, and Little Sioux River Watersheds) are not true complete watersheds in the sense that only a small percentage of the overall area of each of these watersheds falls within the border of Minnesota. The Missouri River Basin drains approximately 1,783 mi^2 of southwest Minnesota. Its northern boundary is just west of Lake Benton and the Redwood Watershed and borders South Dakota to the west all the way south to the Iowa border. The eastern most edge of the basin is just west of Jackson and the Lower Des Moines Watershed, and follows the Iowa border west to the South Dakota border. Most of the eastern border of the watershed borders the Des Moines Watershed. The Upper Big Sioux, Lower Big Sioux, and the Rock River drain into the Big Sioux River, which eventually empties into the Missouri River in Sioux City, Iowa. The Little Sioux River is a direct tributary that flows south and enters the Missouri River in Little Sioux, Iowa. With the exception of the Rock River Watershed, many of the headwater streams do not connect with the mainstem river of their watershed in Minnesota (MPCA 2014b).

The Upper Big Sioux Watershed is the smallest of the four watersheds, drains 41 mi^2 of southwest Lincoln County, and is entirely in the Northern Glaciated Plains ecoregion (Omernik and Gallant 1988). The Lower Big Sioux Watershed drains 511 mi^2 of southwest Lincoln, western Pipestone, and western Rock Counties. The northern third of the watershed falls in the Northern Glaciated Plains ecoregion and the southern two-thirds falls in the Western Corn Belt Plains ecoregion (Omernik and Gallant 1988). The Rock River Watershed is the largest of the four watersheds and drains 910 mi^2 of southeast Pipestone, southwest Murray, eastern Rock, and western Nobles Counties. The northern tip of the watershed falls in the Northern Glaciated Plains ecoregion and the rest is in the Western Corn Belt Plains ecoregion (Omernik and Gallant 1988). The Little Sioux River Watershed drains 321 mi^2 of southeast Nobles and southwest Jackson Counties. The watershed falls completely in the Western Corn Belt Plains ecoregion (Omernik and Gallant 1988).

This area of Minnesota has very fertile soils and has an important agricultural economy rich in crop production and livestock operations. Wind power is another important part of the economy in southwest Minnesota. The high ground which separates the Missouri River Basin from the Minnesota River Basin is called the Buffalo Ridge and is a prime place for wind turbines. This ridge also plays a role on how streams are configured in the watersheds (MPCA, *Missouri River Basin Monitoring and Assessment Report*, Sept 2014, p. 1).

The information contained within this Land and Water Resources Inventory is largely transcribed from the Minnesota Pollution Control Agency (MPCA) *Missouri River Basin Total Maximum Daily Load: Lower Big Sioux River, Little Sioux River, and Rock River Watersheds* (MPCA 2018a), *Missouri River Basin Watersheds of Minnesota Watershed Restoration and Protection Strategies* (MPCA 2018b), *Missouri River Basin (Upper Big Sioux River, Lower Big Sioux River, Little Sioux River, and Rock River Watersheds) Monitoring and Assessment Report* (MPCA 2014b), and the individual watersheds' biotic stressor identification reports (See References for the full list). This information is provided for the purpose of providing background information on the existing water resources and physical factors affecting the water resources within the watershed for the Missouri River Watershed 1W1P.

Figure 1: Missouri River Watershed 1W1P Planning Boundary

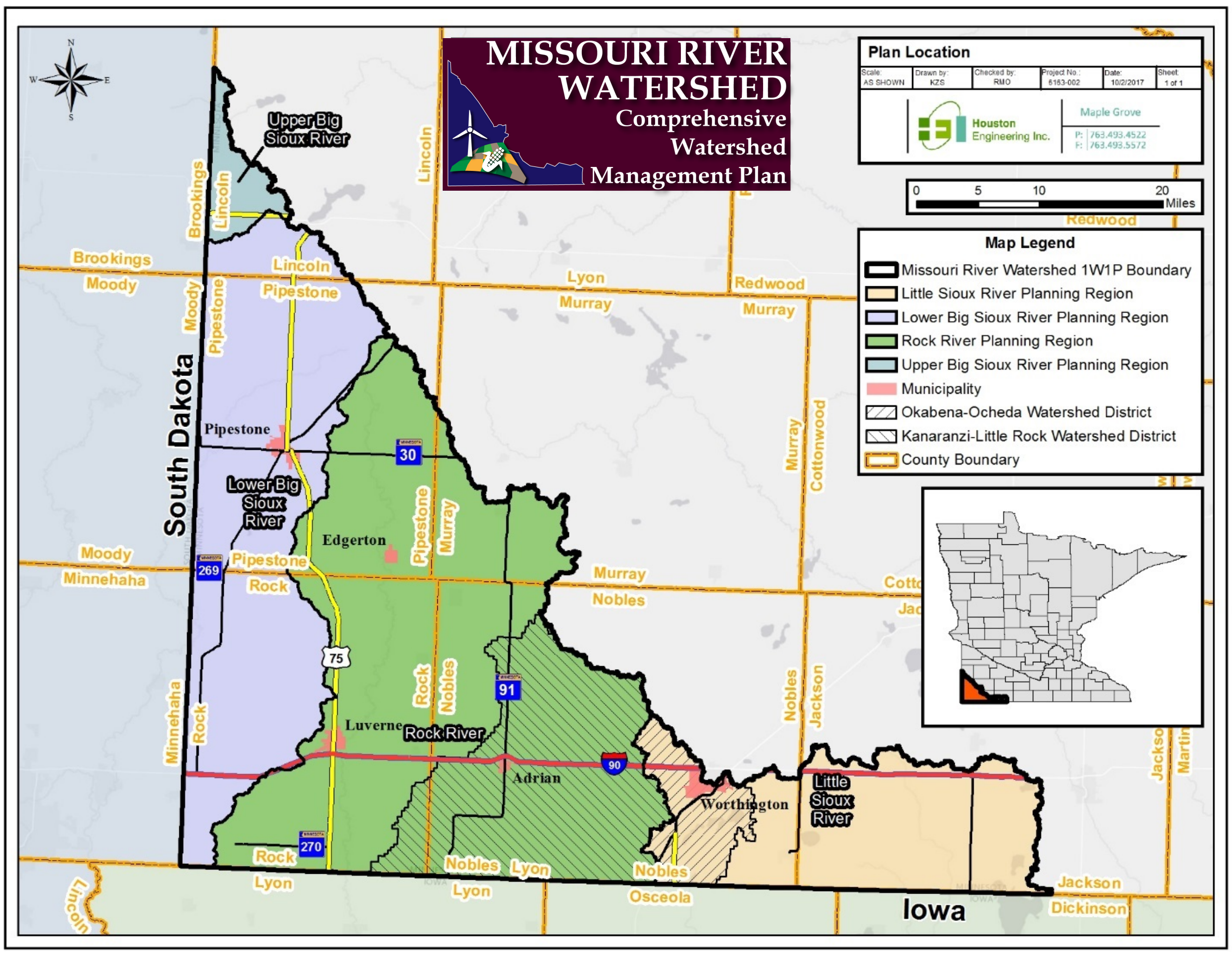
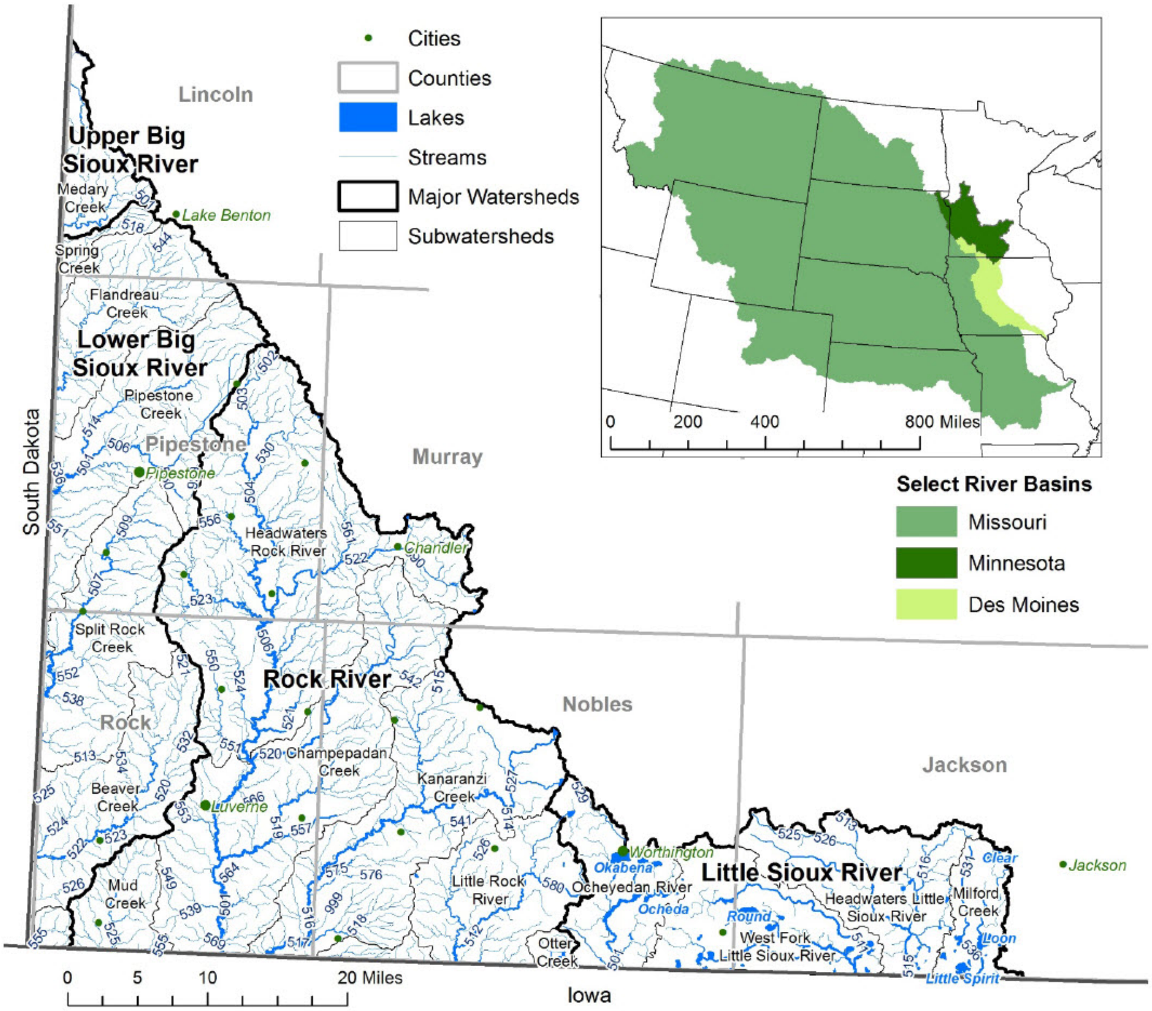


Figure 2: The Missouri River Basin Drainage Area



The Missouri River Basin drains millions of acres from 10 different states (upper right image) via the Missouri River into the Mississippi River in Missouri. The Minnesota portion of the Missouri River Basin contains portions of four (4) major watersheds. The stream line size is used to indicate the estimated average stream flow. Some of the thinnest stream lines are ephemeral or seasonal streams. Stream reaches are labeled in this image by the last three digits of the AUID (AUID-3). Source: MPCA, *Missouri River Basin Watersheds of Minnesota Watershed Restoration and Protection Strategies* (January 2018), Figure 2, p. 6.

1 TOPOGRAPHY, SOILS, & GENERAL GEOLOGY

This southwestern region of the state is predominately rolling topography incised by a dendritic network of streams. In an early 20th century history account of Rock County, Rose (1911) described the Rock County landscape as, "…the topography is gently undulating. There are no lakes and sloughs and no flat expanses of territory such as characterize some portions of southwestern Minnesota; consequently, there is no waste land from this source."

The natural, northeastern watershed boundary of the MRW is the Mississippi-Missouri Rivers drainage divide. The boundary, formed during a Wisconsin Glaciation, rises to more than 1,900 feet in the northern part of the watershed (Anderson et al., 1976). West of the divide, the topography is generally more mature and better drained than it is to the east. The land surface of northern Rock County and southern Pipestone County is characterized by bedrock outcrops of Precambrian Sioux Quartzite. Near surface unconsolidated materials are loess-covered clayey glacial drift (Anderson et al. 1976).

The MRW contains a significant geologic feature, the Coteau des Prairies. The Coteau des Prairies is a prominent highland plain that traverses the southwestern corner of Minnesota (Anderson et al. 1976). The Des Moines and James glacial lobes did not cover the Coteau during the most recent glaciation 14,000 years ago. The Coteau extends only into the far western edge of the Little Sioux River Watershed, as indicated by the elevation change (**Figure 3**). The Des Moines Lobe covered the majority of the Little Sioux River Watershed, leaving behind glacial till, a flatter landscape, natural depressions, and poorly drained soils (DNR 2017a) that are in contrast to the Upper Big Sioux, Lower Big Sioux, and Rock River Watersheds. Of the 14 lakes in the MRW, all are located in the eastern half and the majority of those are found in the flatter Little Sioux River Watershed.

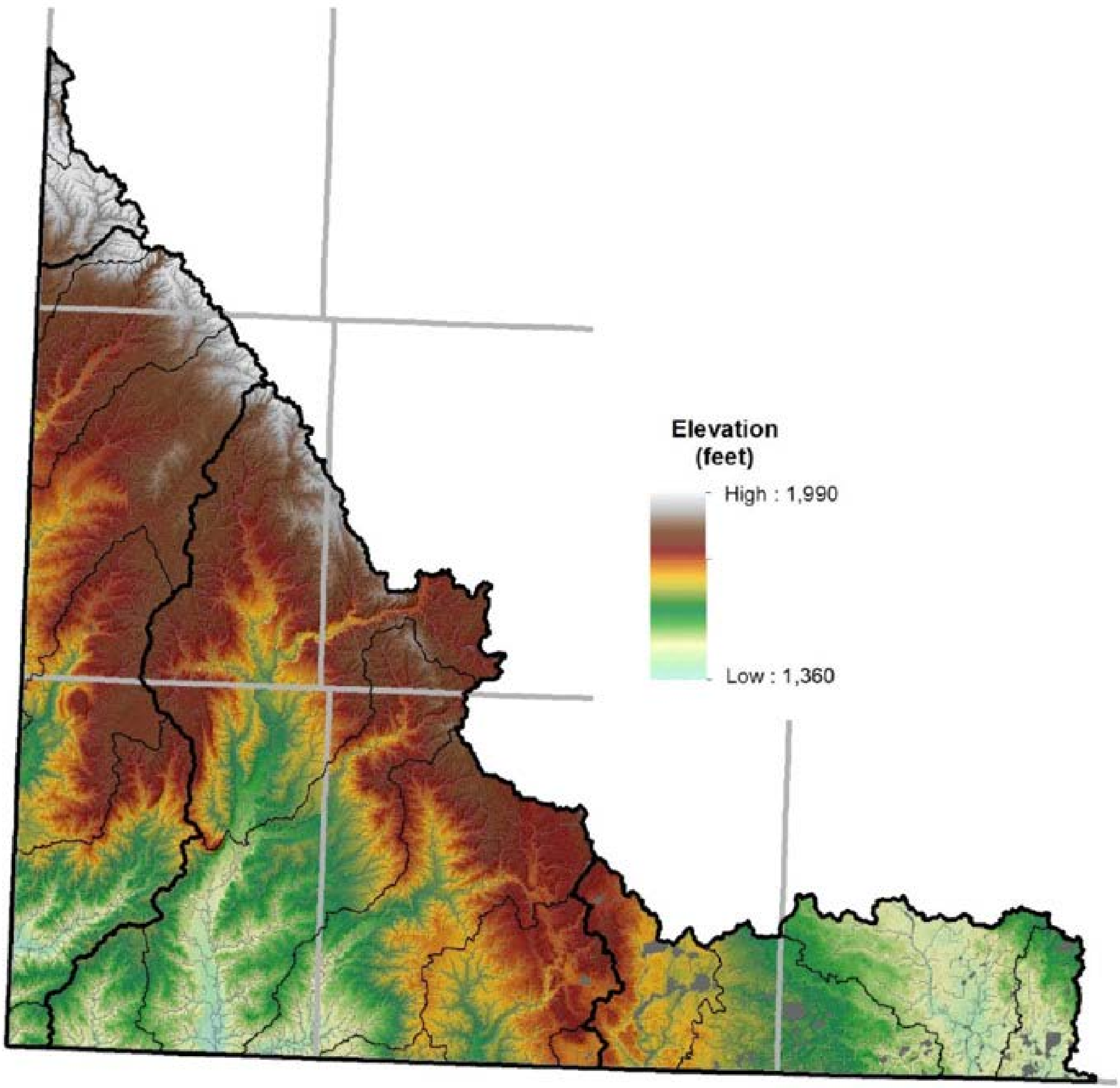
Additional information on the MRW can be found at:

- Watershed Health Assessment Framework (DNR, 2013)
- Inner Coteau Subsection and Coteau Moraines Subsection Prairie Parkland Zones (DNR, 2017)
- Water resources of the Rock River Watershed, Southwestern Minnesota (Anderson et al., 1976)

The Minnesota Geological Survey's (MGS) County Geologic Atlas Program provides a broad range of information on county geology, mineral resources (including construction materials), and natural history (MGS, 2017). At the time of authoring this Land and Water Resources Inventory, the MGS was in the process of completing the first of two County Geologic Atlas phases (Part A) for Rock and Nobles County. When available, this information should be referenced and cited to guide geology, groundwater, and surface water management related decisions during plan implementation.

Further descriptions of geology in these 4 major watersheds is integrated into the surface waters – wetlands discussion in **Section 3.3.1** of this report.

Figure 3: Missouri River Basin Topography



Source: MPCA, *Missouri River Basin Watersheds of Minnesota Watershed Restoration and Protection Strategies* (January 2018), Figure 4, p.8.

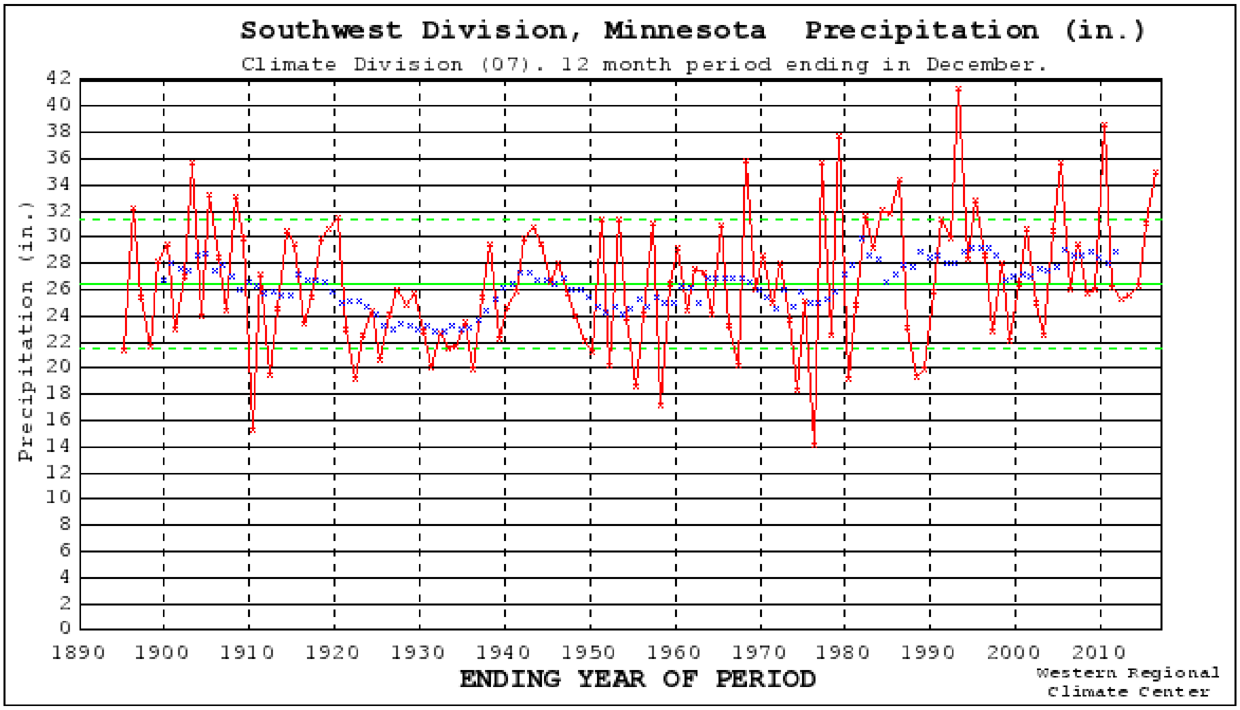
2 CLIMATE & PRECIPITATION

The MRW has a "continental climate", marked by warm summers and cold winters. The mean annual temperature for Minnesota is 4.5˚C; the mean summer temperature for the Little Sioux River Watershed is 20.0˚C; and the mean winter temperature is -8.9˚ C (Minnesota State Climatologists Office, 2003). From 1890-2017, the southwestern corner of Minnesota has experienced an average annual precipitation of 26.4 inches for a 12-month period ending in December[1]. During that period, the highest reported annual

[1] Western Regional Climate Center, Desert Research Institute, U.S.A Divisional Climate Data – Time Series Plot #1, Southwest Division, Minnesota Precipitation 1890-2017. Accessed Oct 2 2017: https://wrcc.dri.edu/spi/divplot1map.html.

precipitation was 41.3 inches in the early 1990's, with the lowest annual precipitation reported during the late 1970's with 14.1 inches (**Figure 4**).

Figure 4: Historical Precipitation Trends for a 12 month period ending in December within Southwest Minnesota (1890-2017)



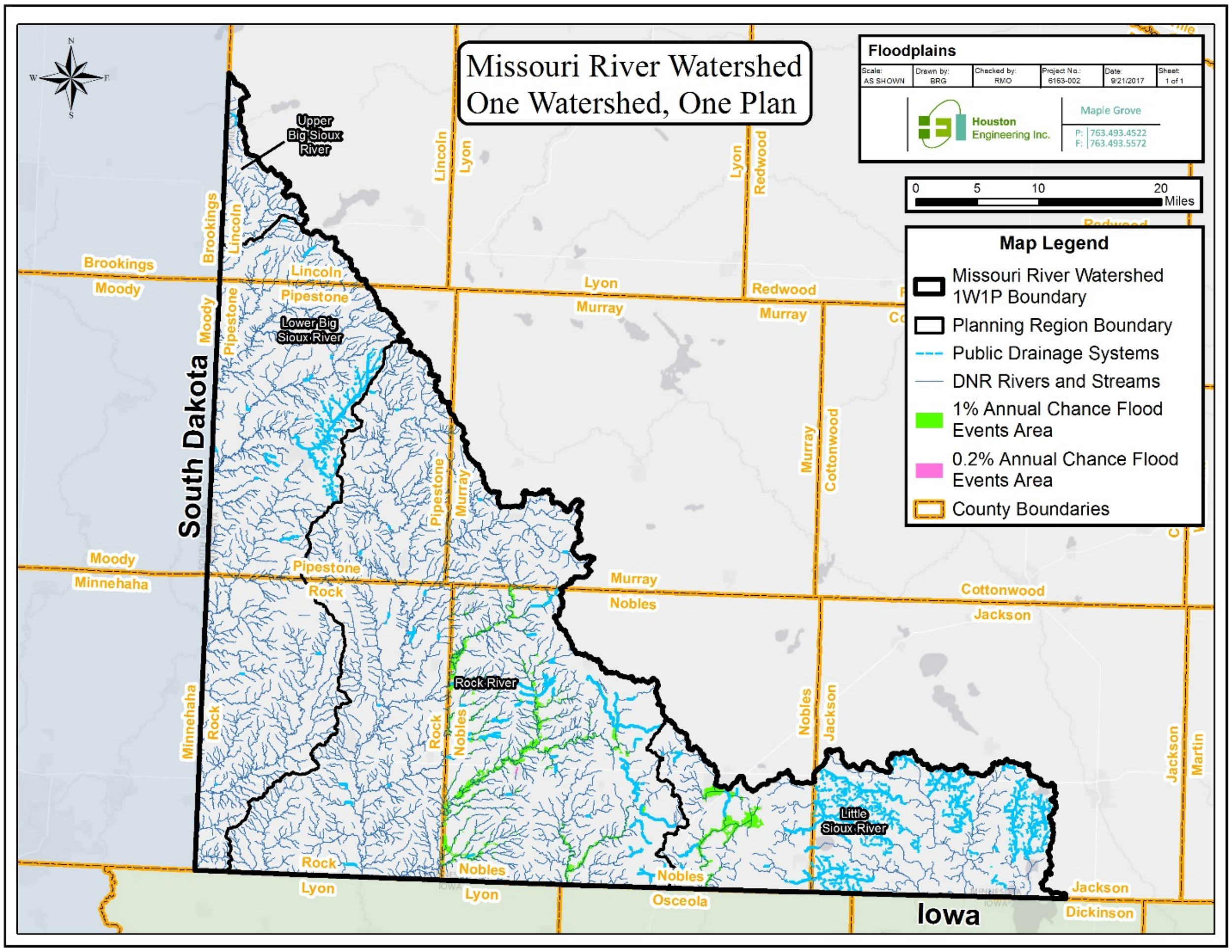
Red indicates a twelve (12) month period. Blue represents the 10-year running mean. Green shows the average (solid), +/- sigma (dashed).
Source: Western Regional Climate Center, Desert Research Institute, U.S.A Divisional Climate Data – Time Series Plot #1, Southwest Division, Minnesota Precipitation 1890-2017. Accessed October 2, 2017: https://wrcc.dri.edu/spi/divplot1map.html.

2.1 FLOODING

As recorded within the MRW WRAPs document (MPCA 2018b), it was noted by 43% of the surveyed residents within the MRW that water quantity (flooding) has impacted their property.

Figure 5 provides a map showing flood risks within the MRW. This map shows flood risk information, based on the Digital Flood Insurance Rate Map (DFIRM) Database. The primary risk classifications used in this map show flood prone areas that have a 1-percent-annual-chance flood event and a 0.2-percent-annual-chance-flood event. Under these flood conditions, land, homes, buildings, and roads within the marked areas could be inundated with excess water, causing adverse economic loss and societal consequences in the impacted community.

Figure 5: Floodplains



3 SURFACE WATER RESOURCES

This MRW 1W1P boundary headwaters a section of the greater Missouri River Basin that spans across the southwest corner of Minnesota. Many small spring-fed tributaries and runoff create all of the streams in these watersheds. The four major (8 HUC) watersheds encompassing the MRW have a few large streams and only the Little Sioux River Watershed as a direct tributary to the Missouri River. Most of the streams, with the exception of the Rock and its tributaries, flow directly west into South Dakota or south to Iowa. The largest river in the MRW is the Rock River, which flows south into the Big Sioux River in Iowa before entering the Missouri River. Lakes are not a prominent feature of the MRW and all but one (which is a reservoir) are in the Little Sioux River Watershed. Nine (9) lakes had enough information to be assessed and all nine are impaired for aquatic recreation use.[2]

The Upper Big Sioux River Watershed encompasses 154,921 acres in southwest Minnesota and 1,197,507 acres in South Dakota (**Figure 6**). This watershed includes several small streams that flow into

[2] MPCA, *Missouri River Basin Monitoring and Assessment Report*, September 2014. P. 25.

Medary Creek, a tributary to the Big Sioux River which eventually joins the Missouri River (MPCA, Upper Big Sioux River Watershed Biotic Stressor Identification Report, Jan. 2015).

The Lower Big Sioux River Watershed covers a 2,188,399 acre area[3] and there are seven major HUC-10 subwatersheds in the Lower Big Sioux River Watershed: Spring Creek, Flandreau Creek, Pipestone Creek, West Pipestone Creek, Split Rock Creek, Beaver Creek – Split Rock Creek, and Ninemile Creek – Big Sioux River (**Figure 7**). The streams and tributaries that make up these major subwatersheds generally flow in a westerly direction into South Dakota.

The Rock River (1,075,032 acres[4]) is the largest river in the Minnesota portion of the Missouri River Basin. There are seven major HUC-10 subwatersheds in the Rock River Watershed: Mud Creek – Rock River, Headwaters Rock River, Champepadan Creek – Rock River, Kanaranzi Creek, Tom Creek – Rock River, Little Rock River, and Otter Creek – Little Rock River (**Figure 8**). These subwatersheds flow south into the Big Sioux River in Iowa before entering the Missouri River.

In the Little Sioux River Watershed (1,812,406 acres[5]), there are four major HUC-10 subwatersheds: Ocheyedan River, West Fork Little Sioux River, Headwaters Little Sioux River, and Milford Creek (**Figure 9**). The streams and tributaries in these subwatersheds generally flow south toward Iowa.

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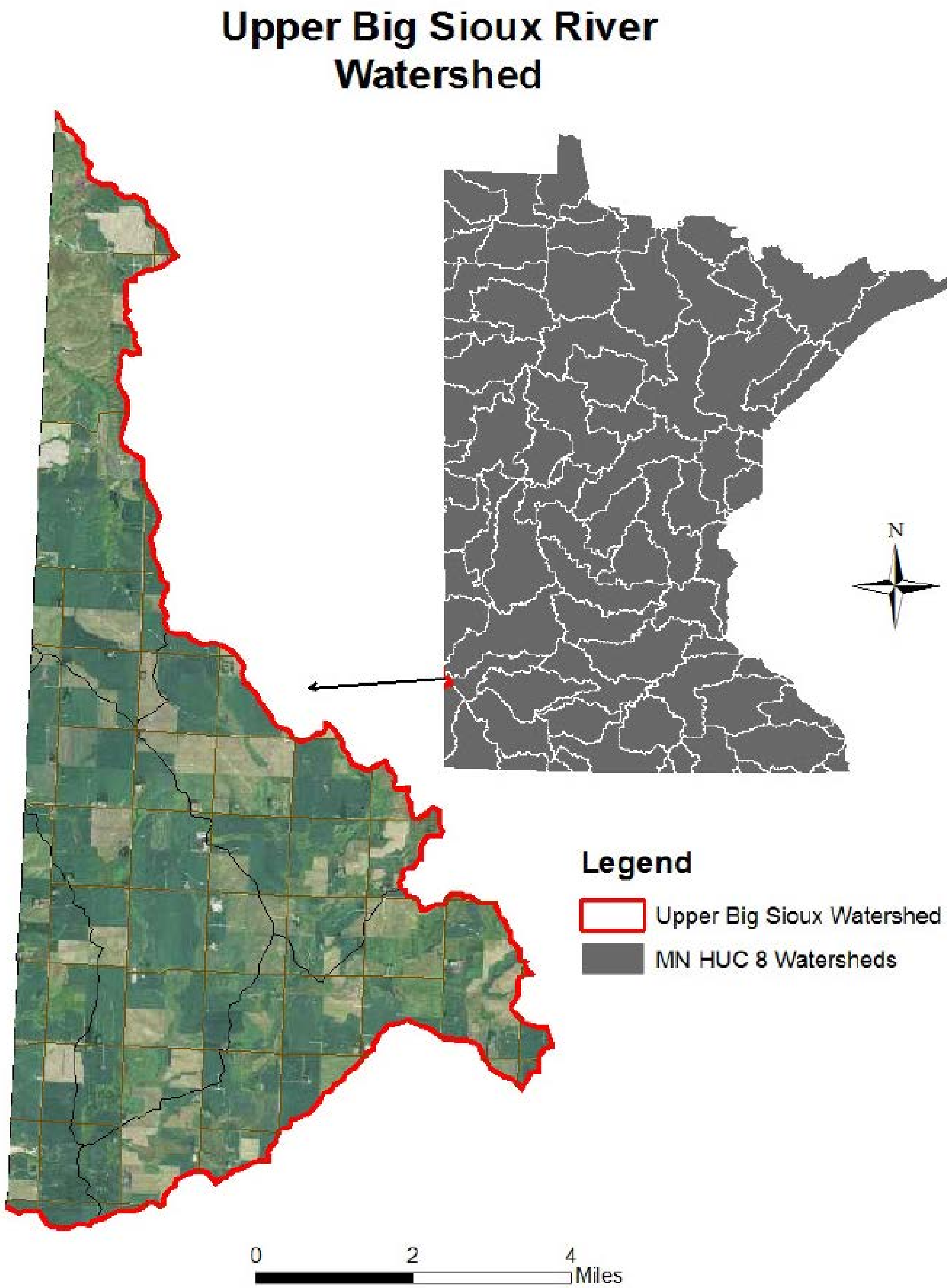
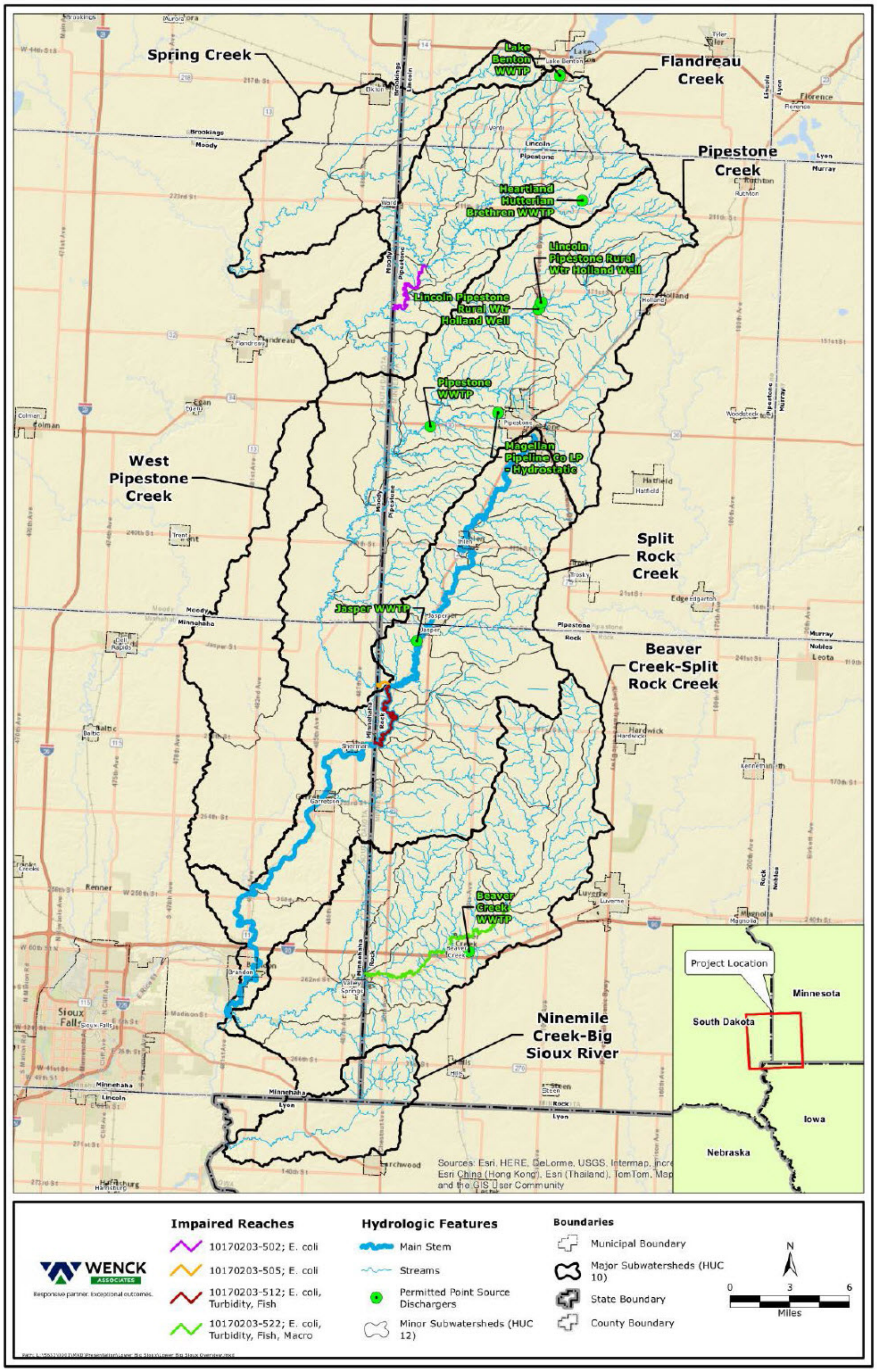
[3] Minnesota Pollution Control Agency (MPCA), Watersheds: Lower Big Sioux River, accessed Aug 29 2017: https://www.MPCA.state.mn.us/water/watersheds/lower-big-sioux-river.
[4] MPCA, Watersheds: Rock River, accessed Aug 29 2017, https://www.MPCA.state.mn.us/water/watersheds/rock-river.
[5] MPCA, Watersheds: Little Sioux River, accessed Aug 29 2017, https://www.MPCA.state.mn.us/water/watersheds/little-sioux-river.

Figure 6: Upper Big Sioux River Watershed



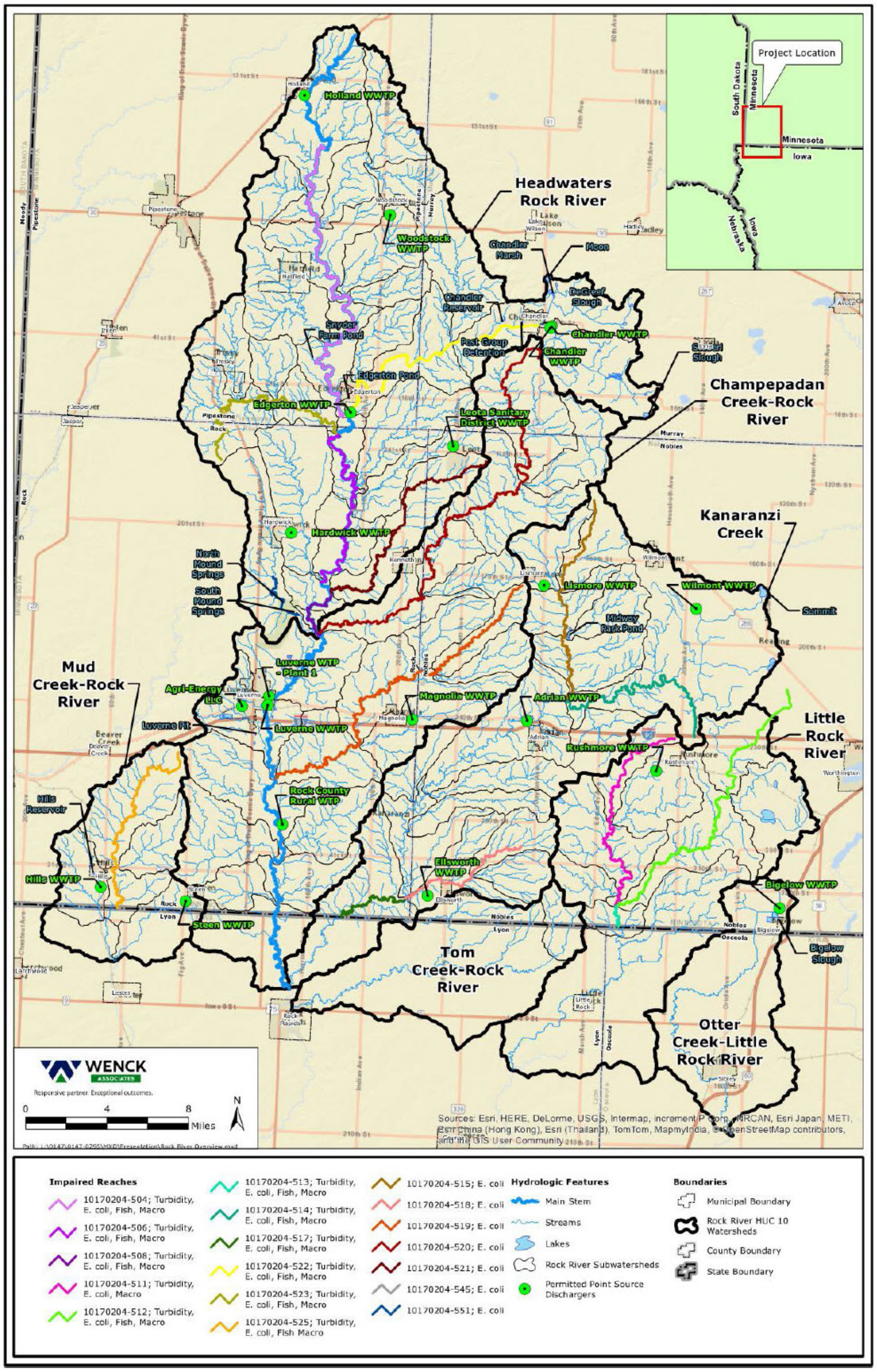
Source: MPCA, *Upper Big Sioux River Watershed Biotic Stressor Identification Report* (January 2015) Figure 1, p.2.

Figure 7: Lower Big Sioux Watershed and Impairments



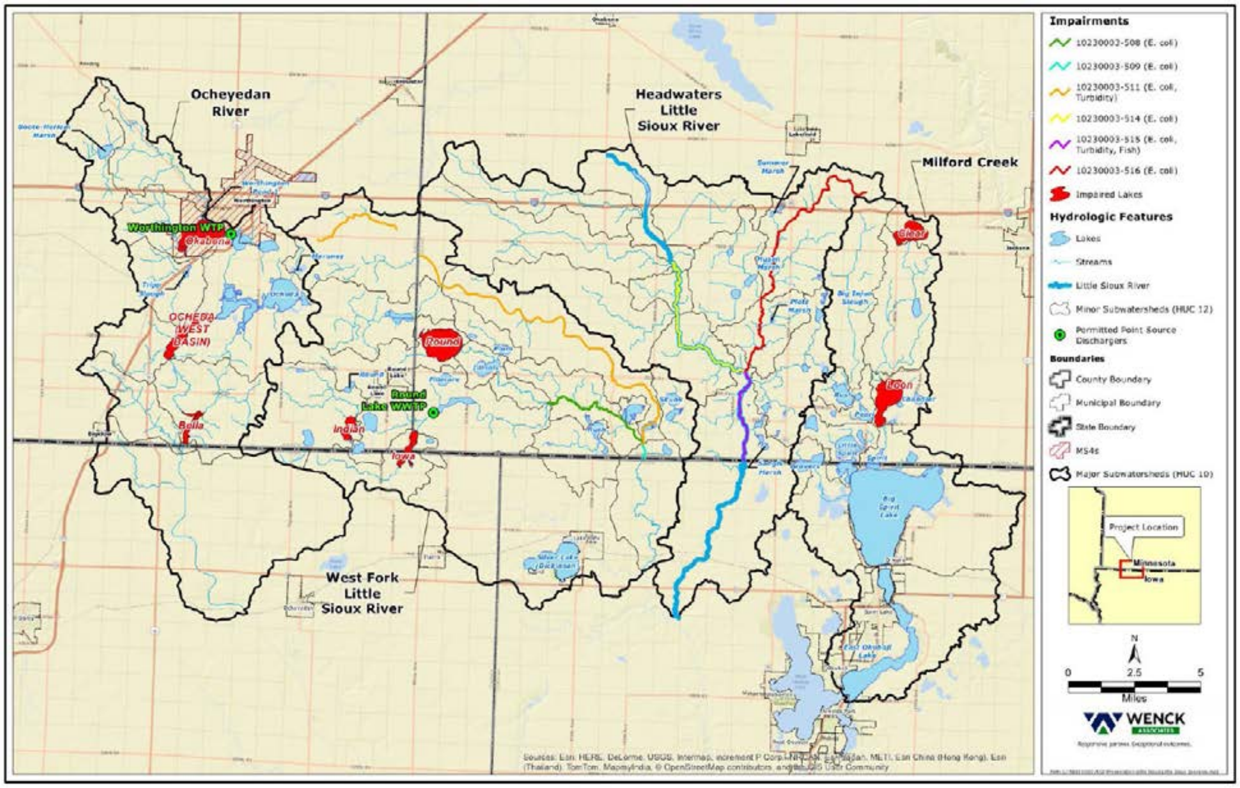
Lower Big Sioux River Watershed impairments addressed in the MPCA, *Missouri River Basin Total Maximum Daily Load – Lower Big Sioux River, Little Sioux River, and Rock River Watersheds* (January 2018). Source: MPCA, *Missouri River Basin Total Maximum Daily Load – Lower Big Sioux River, Little Sioux River, and Rock River Watersheds* (January 2018) Figure 1, p.20.

Figure 8: Rock River Watershed and Impairments



Rock River Watershed impairments addressed in the MPCA, *Missouri River Basin Total Maximum Daily Load – Lower Big Sioux River, Little Sioux River, and Rock River Watersheds* (January 2018)
Source: MPCA, *Missouri River Basin Total Maximum Daily Load – Lower Big Sioux River, Little Sioux River, and Rock River Watersheds* (January 2018) Figure 3, p.22.

Figure 9: Little Sioux River Watershed and Impairments



Little Sioux River Watershed impairments addressed in the MPCA, *Missouri River Basin Total Maximum Daily Load – Lower Big Sioux River, Little Sioux River, and Rock River Watersheds* (January 2018)
Source: MPCA, *Missouri River Basin Total Maximum Daily Load – Lower Big Sioux River, Little Sioux River, and Rock River Watersheds* (January 2018) Figure 2, p.21.

3.1 STREAMS

The four major watersheds (Upper Big Sioux, Lower Big Sioux, Rock, and Little Sioux) that comprise the MRW became subject to the MPCA Intensive Watershed Monitoring (IWM) process in 2011 to assess the overall health of the watershed and identify areas of interest that need to be protected or restored. The MPCA is tasked with the responsibility to monitor and assess the biology and water quality in watersheds active in the IWM process while the MNDNR provides supplementary data and conclusions for the geomorphology, hydrology, and connectivity components.

Impaired streams within the Lower Big Sioux, Rock, and Little Sioux River Watersheds portions of the MRW were assessed under the MPCA *Missouri River Basin Total Maximum Daily Load for Lower Big Sioux River, Little Sioux River, and Rock River Watersheds* (MPCA 2018a). In addition to the summaries below, please refer to the MRW WRAPs report (MPCA 2018b) for more detailed information about water quality impairments.

Within the Upper Big Sioux River Watershed there are several small streams that flow into Medary Creek, which is a tributary to the Big Sioux River which joins the Missouri River. Medary Creek was determined impaired for aquatic life due to its macroinvertebrate assemblage. For more information, please access the MPCA, *Upper Big Sioux River Biotic Stressor Identification Report* (MPCA Jan 2015).

There are four impaired reaches (listed below) in the Lower Big Sioux River Watershed (10170203) that span approximately 33 stream miles and drain over 300,000 acres of land in Minnesota and South Dakota. The impaired reach watersheds cover land in Pipestone and Rock Counties in Minnesota, and Minnehaha and Moody Counties in South Dakota. There are three reaches (-501, -514, and -527) in the Lower Big Sioux River Watershed impaired for turbidity and fecal coliform that were covered under a previous Total Maximum Daily Load (TMDL) (MPCA 2008). All three of these reaches are located in the Pipestone Creek Subwatershed, which is a major tributary to the Lower Big Sioux River.

Lower Big Sioux River Watershed (10170203) - Impaired Streams

- Flandreau Creek (10170203-502);
- Pipestone Creek (10170203-505);
- Split Rock Creek (10170203-512); and
- Beaver Creek (10170203-522);

The 18 impaired reaches in the Rock River Watershed (10170204) span approximately 294 stream miles and drain approximately 450,000 acres of land across four Minnesota counties: Pipestone, Rock, Murray, and Nobles. The two most downstream reaches of Rock River, reaches -501 and -509, along with one major tributary reach (Elk Creek reach -519) were covered as part of a previous turbidity and fecal coliform TMDL (Minnesota State University 2008).

Rock River Watershed (10170204) - Impaired Streams

- Mud Creek (10170204-525);
- Rock River, T107 R44W S30, east line to Chanarambie Cr (10170204-504);
- Chanarambie Creek (10170204-522);
- Poplar Creek (10170204-523);
- Rock River, Poplar Cr to Unnamed Cr (10170204-506);

- Unnamed Creek, Unnamed Cr to Rock R (10170204-545);
- Unnamed Creek, Headwaters to Rock R (10170204-521);
- Rock River, Unnamed Cr to Champepadan Cr (10170204-508);
- Mound Creek (10170204-551);
- Champepadan Creek (10170204-520)l
- Elk Creek (10170204-519);
- Kanaranzi Creek, Headwaters to E Br Kanaranzi Cr (10170204-515);
- Kanaranzi Creek, East Branch (10170204-514);
- Norwegian Creek (10170204-518);
- Kanaranzi Creek, Norwegian Cr to MN/IA border (10170204-517);
- Little Rock Creek (10170204-511); and
- Little Rock River, Headwaters to Little Rock Cr (10170204-512).

There are six impaired reaches in the Little Sioux River Watershed (10230003) that cover approximately 52 stream miles and drain over 140,000 acres of land across Nobles and Jackson Counties. Two of the impaired reaches (West Fork Little Sioux River (AUID -508) and West Fork Little Sioux River (-509) include watershed area in both Minnesota and Iowa. No reach impairments have been addressed in the Minnesota portions of the Little Sioux River Watersheds prior to the MPCA, *Missouri River Basin Total Maximum Daily Load for Lower Big Sioux River, Little Sioux River, and Rock River Watersheds* (MPCA 2018a) assessment.

Little Sioux River Watershed (10230003) - Impaired Streams

- West Fork Little Sioux River (10230003-508);
- Judicial Ditch 13 (Skunk Creek) (10230003-511);
- West Fork Little Sioux River (10230003-509);
- Little Sioux River (10230003-514);
- Unnamed Creek (10230003-516); and
- Little Sioux River (10230003-515).

The MDNR *Missouri River Basin Hydrology, Connectivity, and Geomorphology Assessment Report* (MDNR, 2014) analyzes the hydrology, connectivity, and geomorphology components of the MRW to find relationships that would help understand water quality and biological impairments throughout the basin. The report found that poor riparian vegetation communities and improper stream crossing sizing have an effect on geomorphic response throughout the assessed parts of the MRW. Altered hydrology, though very well documented in other watersheds as a driver of geomorphic response in rivers, was inconclusive in the MRW likely due to lack of long-term (>30 years) hydrological data. At geomorphology field sites with relatively undisturbed riparian vegetation, it appeared that geomorphic stability was much better than overgrazed reaches. Aerial photo analyses showed improper sizing of culverts and bridges also resulted in increased sediment supply and channel succession downstream (MDNR, 2014) For more information on hydrology, connectivity, and geomorphology relative to the MRW, please access the MDNR Missouri River Basin Hydrology, Connectivity, and Geomorphology Assessment Report.

3.2 LAKES

Lakes are not a prominent feature of the MRW 1W1P boundary. All the natural lakes are in the Little Sioux River Watershed.

As identified within the MPCA, *Missouri River Basin Total Maximum Daily Load for Lower Big Sioux River, Little Sioux River, and Rock River Watersheds* (MPCA 2018a), there are eight lakes in the Little Sioux River Watershed, which cover approximately 3,883 acres of open water and drain over 76,000 acres of land (**Table 1**). Three of the impaired lake watersheds (Bella, Indian and Iowa) include area in both Minnesota and Iowa. Little Spirit Lake has a completed TMDL (Iowa DNR 2004) developed by the Iowa DNR and approved by the EPA. Lake morphometry and watershed information for each impaired lake in the Little Sioux River Watershed is presented in the table below.

Table 1: Little Sioux River Watershed impaired lake watershed areas and lake morphometry

Lake Name	Surface Area [acres]	Ave. Depth [ft]	Max Depth [ft]	Volume [acre-ft]	Littoral Area [acres]	Littoral Area [%]	Direct Drainage[1] [acres]	Total Drainage[2] [acres]
Okabena Lake	780	6.6	15.0	5,150	780	100	MN: 10,011	MN: 10,011
Ocheda Lake (West Basin)	464	4.0	5.0	1,856	464	100	MN: 21,366	MN: 31,377
Bella Lake	164	5.0	14.0	820	164	100	MN: 6,839 IA: 462	MN: 38,216 IA: 462
Indian Lake	182	4.2	7.0	775	182	100	MN: 7,063 IA: 661	MN: 7,063 IA: 661
Iowa Lake	220	3.0	5.0	660	220	100	MN: 766 IA: 3,550	MN: 766 IA: 3,550
Round Lake	930	4.6	9.0	4,229	930	100	MN: 5,708	MN: 5,708
Clear Lake	434	7.2	9.0	3,116	434	100	MN: 1,343	MN: 1,343
Loon Lake	709	5.0	6.0	3,764	709	100	MN: 19,155	MN: 20,498

Source: MPCA, *Missouri River Basin Total Maximum Daily Load – Lower Big Sioux River, Little Sioux River, and Rock River Watersheds* (January 2018) Table 7, p.28.

3.3 WETLANDS

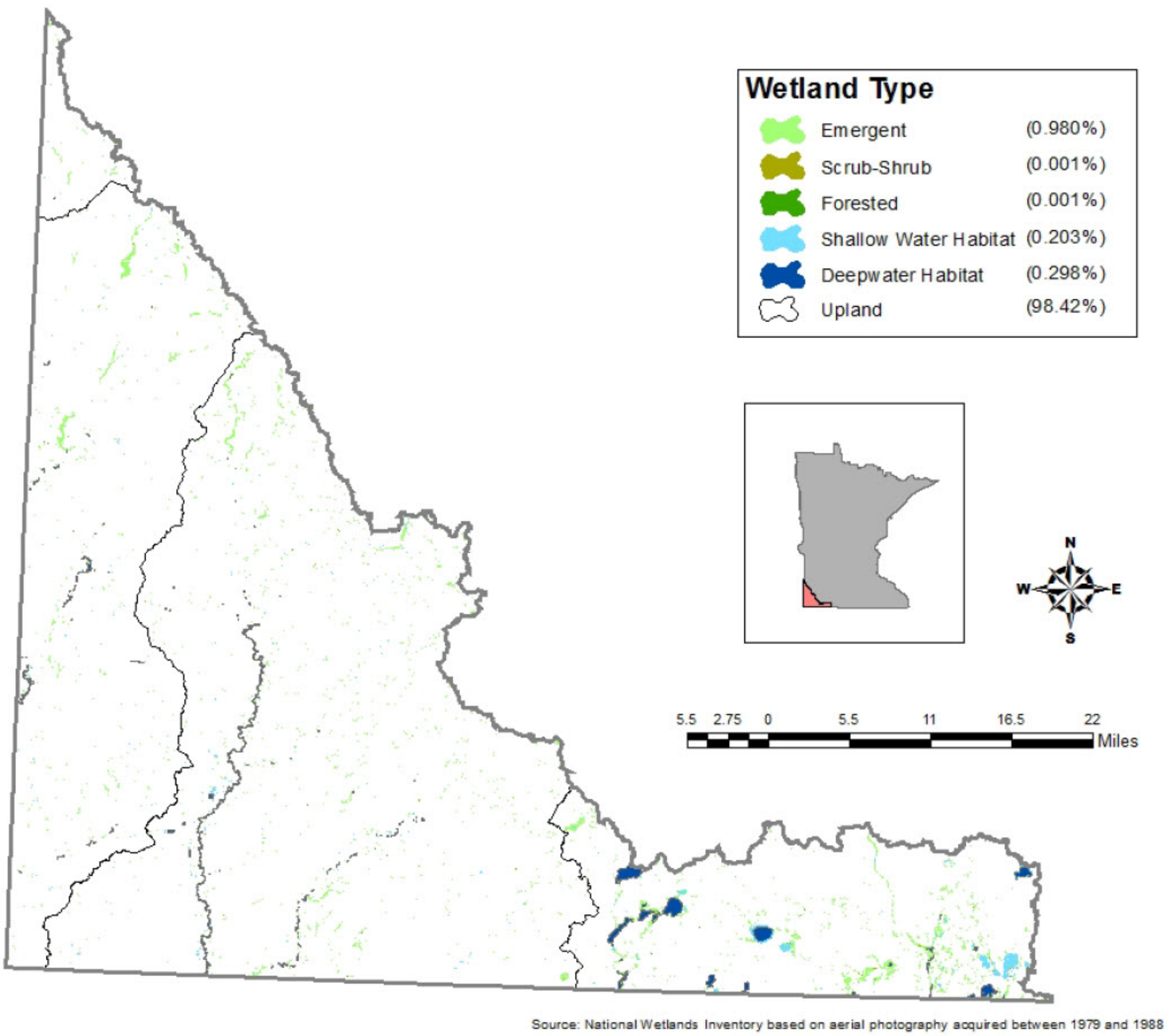
Wetlands developed in various geologic settings in this southwest corner of Minnesota. These wetlands originally provided many vital watershed functions, including slowing and retaining water, thereby providing flood reduction and pollutant treatment, and protection of downstream water quality as well as providing vital wildlife habitat (Mitsch and Gosselink 2007).

Excluding open water portions of lakes, ponds, and rivers, the four major watersheds comprising the MRW currently support approximately 22,631 acres of wetlands, which is roughly 1% of this watershed area. **Figure 10** illustrates the distribution and class of current wetlands in the MRW. Emergent wetlands are by far the most common wetland type, making up nearly 82% of the total existing wetland in the region. Emergent wetlands are typically dominated by narrow-leaved perennial emergent herbaceous plants such as grasses, sedges, bulrushes or cattails. Likely, many of these emergent wetlands are spongy wet meadows, though some probably have shallow surface water for at least part of the growing season (i.e. marshes). Roughly 17% of the current wetlands in the MRW have shallow open water (i.e. deep marshes). This wetland class is usually dominated by floating leaved and submerged leaf species such as water lilies (Nymphaea sp. and Nuphar sp.), duckweeds (Lemna sp.), coontail (Ceratophyllum sp.) and various pondweeds (Potamogeton sp.). Less than 1% of the wetland area in the MRW is forested or scrub-shrub wetlands that usually occur in close association with stream habitats. These wetland estimates represent a snapshot of the location, type, and extent of wetlands occurring in the MRW in 1980-1984, which is the period that aerial imagery was acquired in this part of Minnesota to develop the National Wetlands Inventory (NWI).

Changes to wetlands have likely occurred in these watersheds since the early 1980s, though the NWI remains the best data available to estimate current wetland extent. Minnesota natural resource agencies are cooperating to update the state NWI over a 10-year schedule which is slated for completion in 2019.

Digital soils data can be used to estimate the extent of wetlands prior to European homesteading and settlement prior to conversion of significant amounts of wetlands in much of Minnesota. Analysis of Natural Resources Conservation Service (NRCS) digital soil survey map (SSURGO) units classed as “Poorly Drained” and “Very Poorly Drained” was used here to estimate the extent of historic wetlands. Based on soil survey drainage class an estimated 326,300 acres of wetland or 17% of the MRW occurred prior to settlement. Comparing the area of hydric SSURGO map units with contemporary national wetland inventory data for these watersheds suggests that approximately 7% of the historic wetland area remains as wetland in Minnesota’s portion of the Missouri River Basin. In other words, 93% of the historic wetland in the MRW has been lost to improve agricultural cropping practices and other development enterprises, including transportation and municipal development. (MPCA, *Missouri River Basin Monitoring and Assessment Report*, Sept 2014, p. 30)

Figure 10: Contemporary distribution of wetlands by National Wetland Inventory wetland type within the Missouri River Watershed



Source: MPCA, *Missouri River Basin Monitoring and Assessment Report* (Sept 2014) Figure 22, p.30.

3.3.1 HISTORIC WETLAND EXTENT

Rate of historic wetland loss was not consistent across the four major watersheds of the MRW 1W1P boundary. This section presents estimated loss rates by subwatershed in each major watershed.

The surface geology in the Middle Big Sioux subwatershed (101700202) in the northwest part of Minnesota's Missouri River Basin is almost entirely composed of coarse sorted till as part of an end moraine. Coarse moraine till is particularly well suited to producing seepage meadow type wetlands on slopes, toes of slopes or along streams in the valleys. Soil drainage class map units suggest extensive historic wetlands were closely associated with streams and slopes. Grass and sedge dominated meadow type wetlands were likely the most common wetland type. Estimates of historic, current and percent wetland area converted to non-wetland in the two 12-digit subwatersheds of the Middle Big Sioux subwatershed drainage is presented in Table 1 of the *Missouri River Basin Monitoring and Assessment Report* (Sept 2014). The Deer Creek subwatershed has the distinction of having the lowest percentage loss of historic wetland (62%) extent among all 29, 12-digit subwatersheds located in Minnesota's portion of the Missouri River Basin (MCPA, 2014b).

Surface geology in the Lower Big Sioux Watershed (10170203) is dominated by much older gray drift that was left from earlier glacial periods. This more weathered area resulted in significant wetland resources occurring in topographic depressions and flats, as well as along upper reaches of the stream drainage network. Wetland area and loss percent estimates for each aggregated 12-digit subwatershed on the Minnesota side of the Lower Big Sioux Watershed is presented in Table 2 of the *Missouri River Basin Monitoring and Assessment Report* (Sept 2014). Extent of historic wetland loss was roughly 10% lower in the four northern most 12-digit subwatersheds compared with the four southern subwatersheds which are estimated to have lost 94-98% of their historic wetlands. On the east side of Rose Dell Township, about five miles southwest of Jasper in the western lobe of the Upper Split Rock Creek subwatershed, is a large round flat area with hydric soils which is a very prominent feature on the SSURGO drainage class data. Like many wetlands in the area, this large wetland appears to have been effectively drained in the early part of the 20th century. A July 1936 aerial photo shows well developed row crop agriculture growing in the bed of this historic wetland. Personal communication with the MDNR area hydrologist confirmed that Rock County spent $800,000 in 2013 to improve the ditch system to more effectively drain soils in this historic wetland area (MPCA 2014b).

In the Rock River Watershed, the surface geology is comparatively complex including moraine till along the eastern third, gray drift with the historic Rock River outwash plain dividing the western third, and shale bearing loess in the center third (MPCA 2014b). This geology mosaic developed a rich array of wetlands, both hydrologically isolated wetlands in flatter areas as well as wetlands more closely associated with the stream network. Many of the historic Rock River Watershed wetlands were associated with slopes. Estimated current wetland areas and percent drained historic wetland extent in the fourteen subwatersheds of the Minnesota's portion of the Rock River Watershed is presented in Table 3 of the *Missouri River Basin Monitoring and Assessment Report* (Sept 2014). The Rock River subwatersheds have sustained some of the greatest extent of wetland conversion and loss compared with the other major watersheds in the MRW. The upper reaches of Chanarambie Creek, Champepadan Creek, Kanaranzi Creek, East Branch of Kanaranzi Creek, and Upper Little Rock Creek which start up on the Coteau des Prairies were historically particularly rich in wetlands. Based on existing wetland class extent these same subwatersheds retain some of the highest acreages of current wetlands (MPCA 2014b).

In comparison with historic estimates of emergent and shallow open water wetlands, these wetland types provide many important water quality and habitat benefits.

In the Minnesota portion of the Little Sioux Watershed, the terrain flattens out and the surface geology is dominated by three distinct types of moraine (end, ground, and stagnation moraine complexes), each of which provided ideal conditions to support development of large wetland complexes and shallow lakes. This watershed represents the southernmost reach of the important Prairie Pothole region in Minnesota. Wetland extent and loss for the Little Sioux Minnesota Watershed by 12-digit subwatersheds is presented in Table 4 of the *Missouri River Basin Monitoring and Assessment Report* (Sept 2014).

3.3.2 WETLAND CONDITION

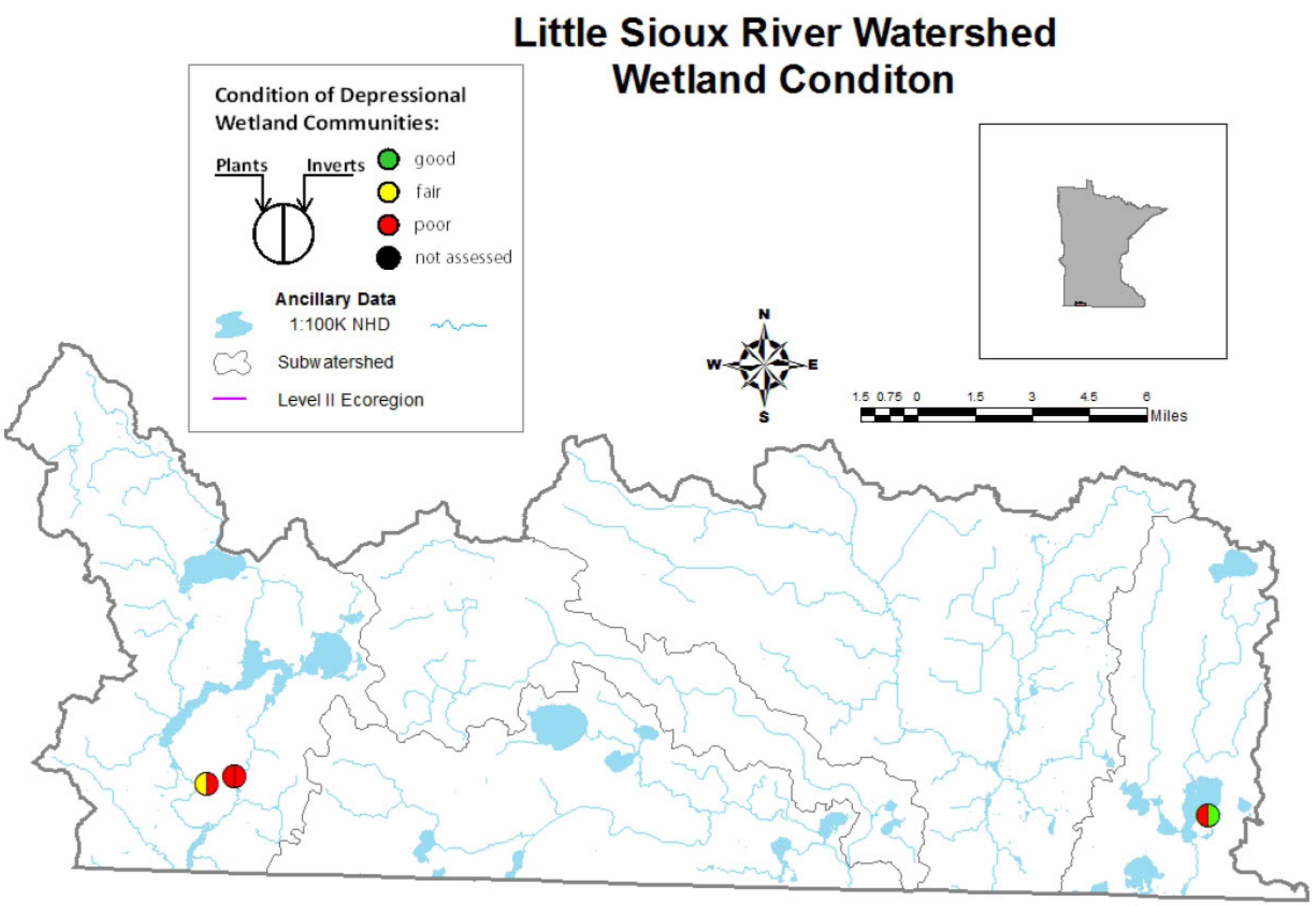
The MPCA began biological monitoring of wetlands in the early 1990s, focusing on wetlands with emergent vegetation in a depressional geomorphic setting (i.e., marshes). This work resulted in the development of plant and macroinvertebrate (aquatic bugs, snails, leeches, & crustaceans) indices of biological integrity (IBIs) to evaluate biological condition or "health" of depressional wetlands. Recently the MPCA wetland monitoring program has begun transitioning toward greater use of Floristic Quality Assessment (FQA) to assess wetland condition based on the plant community. Future watershed wetland assessment reports will begin to use FQA wetland assessment approaches. One advantage to the FQA approach is the methods have been developed to apply to all Minnesota wetland types.
Both the invertebrate and plant IBIs are scored on a 0 to 100 scale with higher scores indicating better condition. These indicators have been used in surveys of wetland condition where results can be summarized statewide and for Minnesota's three Level II Ecoregions (Genet 2012). Minnesota's portion of the Missouri River Basin occurs entirely within the Temperate Prairie Ecoregion that is characteristic of the upper Midwest.

Statewide estimates have found depressional wetlands in the Temperate Prairies Ecoregion to typically be in poor condition when compared to regional reference sites. The wetland plant community integrity results suggest 17% of the depressional wetlands in this ecoregion are estimated to be in good condition, 28% are in fair condition and 54% are in poor condition. Invasive plants, particularly narrow-leaved (*Typha angustifolia*) and hybrid cattail (*Typha* X *glauca*) as well as reed canary grass (*Phalaris arundinacea*) are important wetland stressors and can respond strongly to disturbed watershed conditions including nutrient enrichment, hydrologic alterations and toxic pollutants such as chloride loading (Galatowitsch 2012). Unfortunately, cattails and reed canary grass are very common, often dominating marshes within this region of the state and are detrimental to plant community health (Genet 2012). Survey condition estimates of depressional wetland condition in the Temperate Prairies Ecoregion based on the macroinvertebrate IBI reported 33% of the wetlands in this region are in good condition, 20% in fair condition and 47% are recognized as being in poor condition.

In the last 10 years MPCA ambient wetland biological condition data has been collected at only three natural depressional wetlands in the MRW. All three of these sites were in the Little Sioux Watershed. Invertebrate and plant biological condition results for these sites are presented in **Figure 11**. These sites were sampled as part of a probabilistic survey of the Temperate Prairie Ecoregion. Invertebrate community IBI scores at these three sites ranged from 45 to 72 (0 to 100 scale with 100 being high integrity). Based on the macroinvertebrate IBI, two of these sites were found to be in 'Poor' condition and one was in 'Good' condition. The difference between Good and Fair is set at the 25th percentile of IBI scores within a set of Ecoregion least disturbed reference sites (Genet 2012). The plant communities at these same three wetlands were similarly sampled for biological assessment endpoints. Two of the wetlands scored as 'Poor' condition and one of them were rated as 'Fair' condition. The two wetlands in poor condition each were dominated by invasive plants including cattails and reed canary grass.

Three wetlands sampled in only one part of the MRW is a very small data set and was not intended to represent the Missouri drainage area. Considering both indicators, this small dataset however demonstrates that there is a range of wetland conditions in this region of Minnesota, though additional assertions cannot be made. (MPCA, *Missouri River Basin Monitoring and Assessment Report*, Sept 2014, pp. 29-34).

Figure 11: Depressional wetland IBI results (invertebrate and plant community indices) for the MPCA wetland biological study sites located in Little Sioux Watershed as part of the Missouri drainage

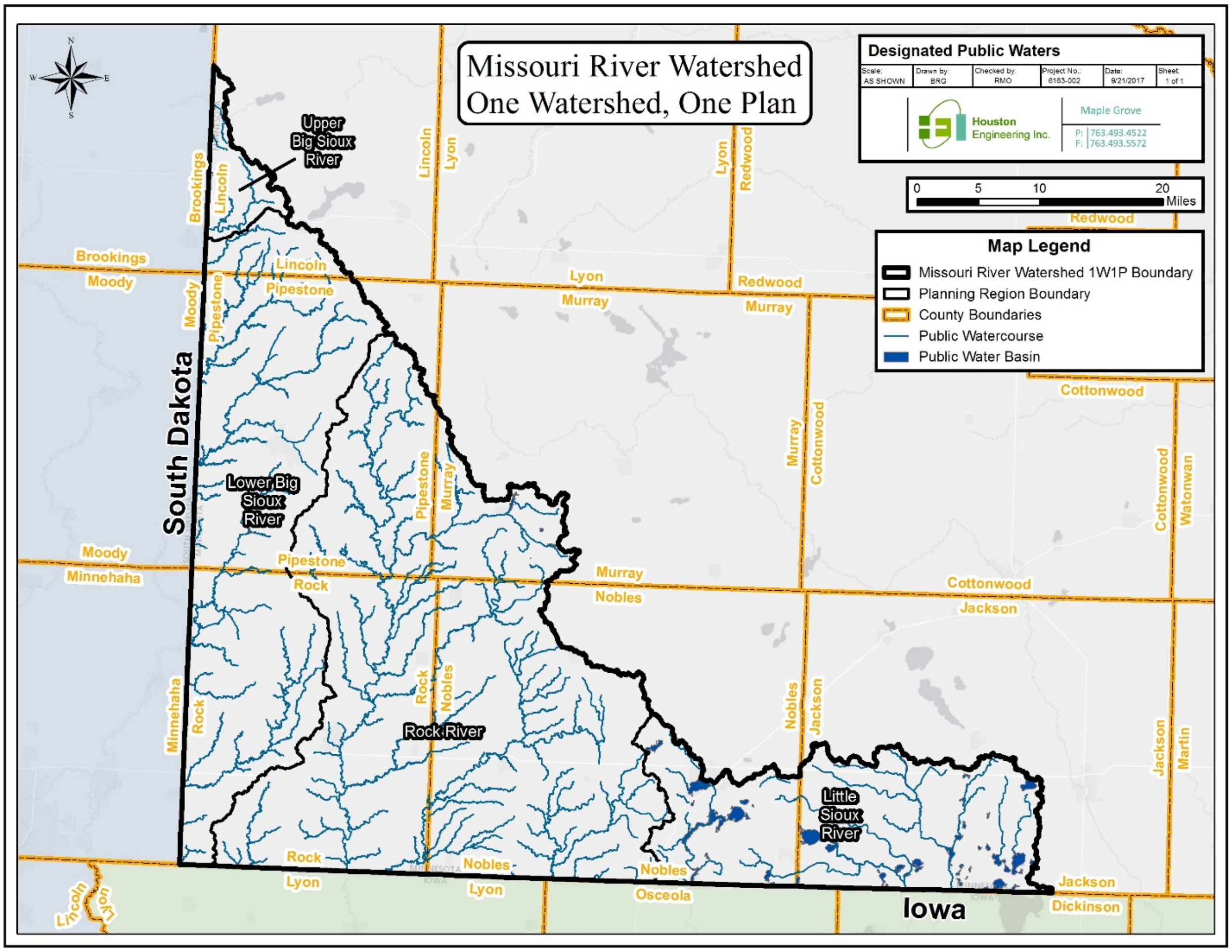


Source: MPCA, *Missouri River Basin Monitoring and Assessment Report* (Sept 2014) Figure 23, p.34.

3.4 PUBLIC WATERS

Public waters are designated to indicate which lakes, wetlands, and watercourses the MDNR has regulatory jurisdiction (**Figure 12**). The statutory definition of public waters includes public waters and public water wetlands. Public water wetlands include all types 3, 4, and 5 wetlands as defined in United States Fish and Wildlife Service (USFWS) Circular No. 39 (1971 edition), not included within the definition of public waters, that are ten (10) or more acres in size in unincorporated areas or 2.5 acres or more in incorporated areas. The MDNR is the LGU for all Protected Water Wetlands unless the MDNR waives the authority to the local LGU.

Figure 12: Public Waters Inventory (PWI)

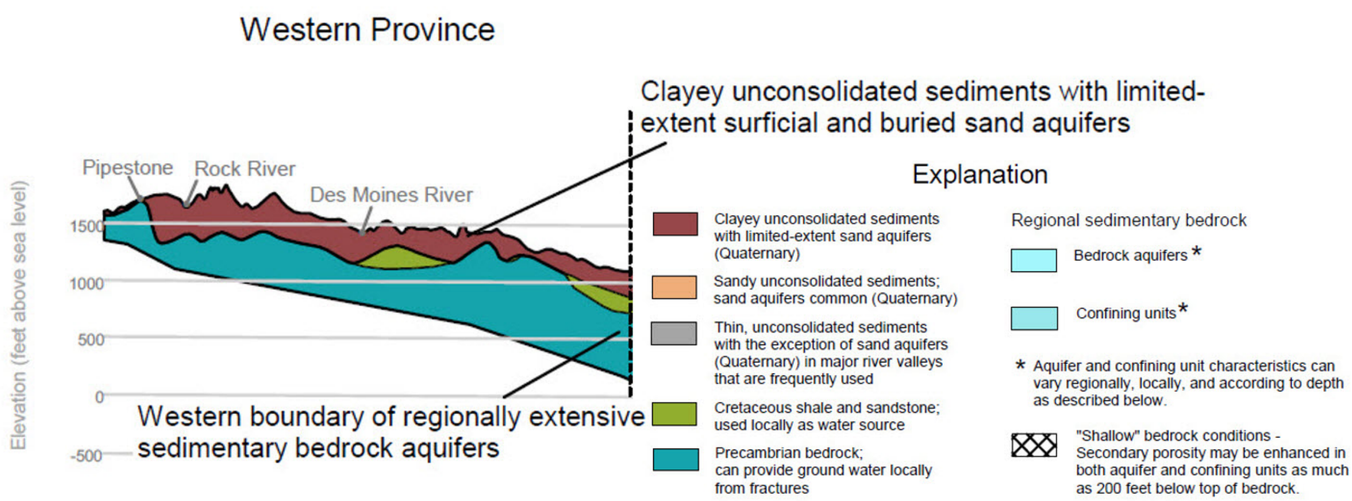


4 GROUNDWATER RESOURCES

4.1 GEOLOGY & HYDROGEOLOGY

The four watersheds of the MRW reside within Minnesota's Western Groundwater Province as defined by the MDNR. This hydrogeologic region is characterized by "clayey glacial drift overlying Cretaceous and Precambrian bedrock" (see **Figure 13**). The glacial drift and Cretaceous bedrock contain sand and sandstone aquifers that are used locally as water sources but are of limited extent. (MDNR, 2001).

Figure 13: Western Province Generalized Cross Section (Source: MDNR, 2001)

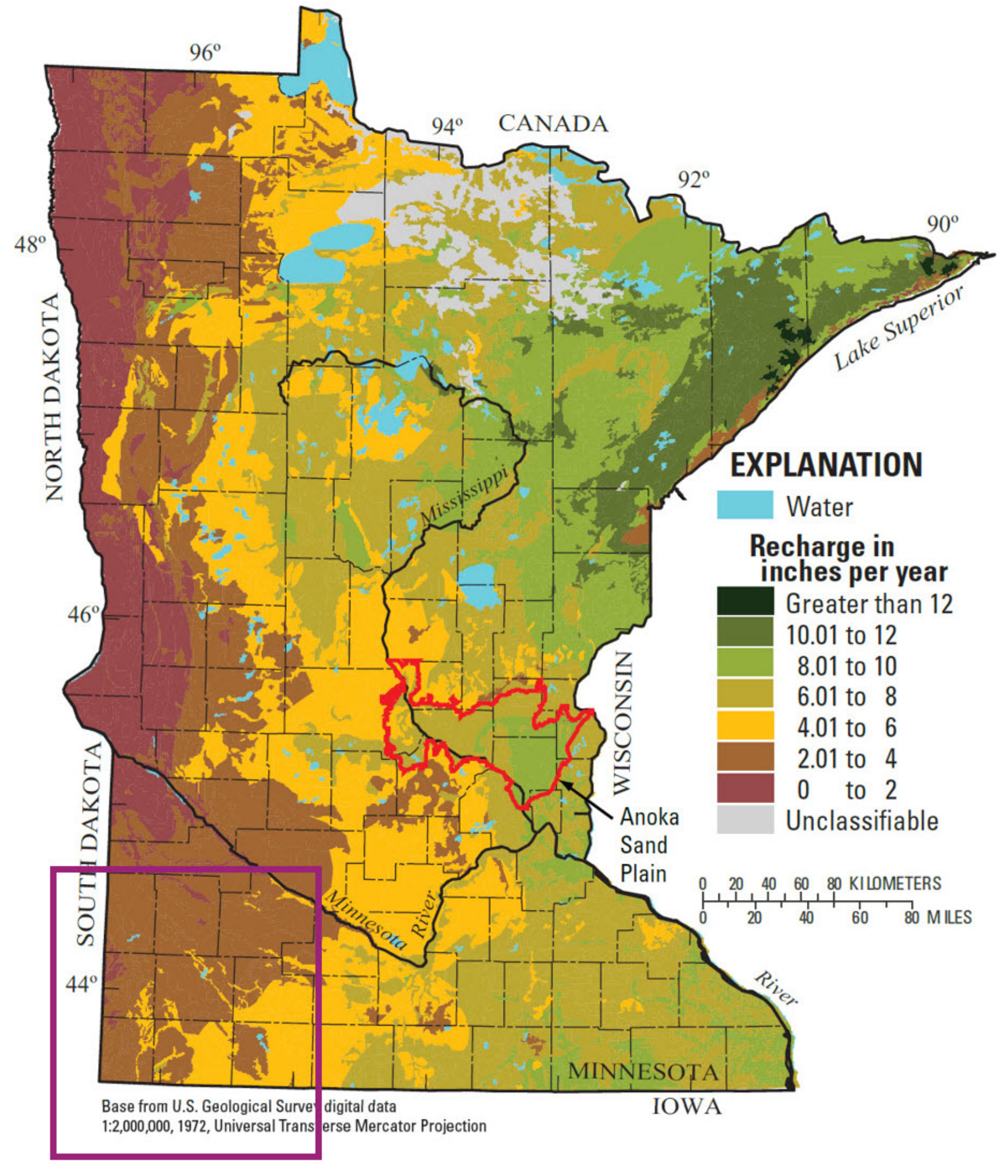


Note: Only 3 layers from "Explanation" present in Western Province cross section: 1) Clayey unconsolidated sediments with limited-extent sand aquifers; 2) Cretaceous shale and sandstone; and 3) Precambrian bedrock. Source: Jim Berg, MDNR, *Minnesota Ground Water Provinces – Generalized Cross Sections* (Nov 2001), available Online: http://files.dnr.state.mn.us/natural_resources/water/groundwater/provinces/gwprvxsec.pdf.

As a region, southwest Minnesota has four types of aquifers present: the buried sand and gravel, surficial sand and gravel, Precambrian, and Cretaceous aquifers. The majority of wells in this region of Minnesota draw from the buried sand and gravel aquifers, which include the Quaternary Buried Artesian Aquifer (QBAA), the Quaternary Buried Unconfined Aquifer (QBUA), and the Quaternary Buried Undifferentiated Aquifer (QBUU) (MPCA, 1998). The surficial sand and gravel aquifers - the Quaternary Water Table Aquifer (QWTA) and the Quaternary Undifferentiated Unconfined Aquifer (QUUU) - are important groundwater sources in the region. These are comprised of well-sorted outwash deposits left behind from the Des Moines glacial lobe. The Cretaceous aquifers underlie the majority of southwest Minnesota and are only absent where Precambrian bedrock surfaces. Cretaceous deposits include interbedded shale, siltstone and sandstone that can range from 300 to 500 feet. The Precambrian bedrock underlies the entire southwest region, making it the oldest, lowermost bedrock type in southwest Minnesota. The Precambrian aquifers include the Sioux Quartzite and Crystalline aquifers, which are nearly impermeable and as a result, very few wells draw from this layer.

Recharge of these aquifers is important and limited to areas located at topographic highs, those areas with surficial sand and gravel deposits, and those along the bedrock/surficial deposit interface. Typically, recharge rates in unconfined aquifers are estimated at 20 to 25% of precipitation received, but can be less than 10% of precipitation where glacial clays or till are present (USGS, 2007). In southwest Minnesota, the average annual recharge rate to surficial materials ranges from near zero up to six inches per year (**Figure 14**) (MPCA, *Missouri River Basin Monitoring and Assessment Report* (Sept 2014), p. 28-29).

Figure 14: Average annual recharge rate to surficial materials in Minnesota (1971-2000) (Source: USGS 2007)



Source: MPCA, *Missouri River Basin Monitoring and Assessment Report* (Sept 2014) Figure 21, p.29.

The County Geologic Atlas Program provides information essential to sustainable management of ground water resources, and defines aquifer properties and boundaries. At the time of authoring this Land and Water Resources Inventory, the MGS was in the process of completing the first of two County Geologic Atlas phases (Part A) for Rock and Nobles County, which includes the water well database and geologic maps showing properties and distribution of sediments and rocks in the subsurface (MGS, 2017). The second phase, or Part B is constructed by the MDNR, which includes maps of water levels in aquifers, direction of groundwater flow, water chemistry, and sensitivity to pollution (MGS, 2017). When available, this information should be referenced and cited to guide groundwater management related decisions during plan implementation.

4.2 GROUNDWATER & SURFACE WATER CONNECTIVITY

The major watersheds comprising the MRW are home to the Topeka shiner. The Topeka shiner is a federally endangered fish species, found with some frequency throughout MPCA sampling in the MRW (MPCA, 2014b). Research has found that favorable habitat for these species are off-channel habitat (OCHs- ponds and meander cut-offs), which have moderate to strong surface water to groundwater connections (MDNR, 2004). To protect the habitat of these species, regional boundaries, base elevation, water-table elevation, and saturated thickness of the Rock River valley alluvial aquifer were described.

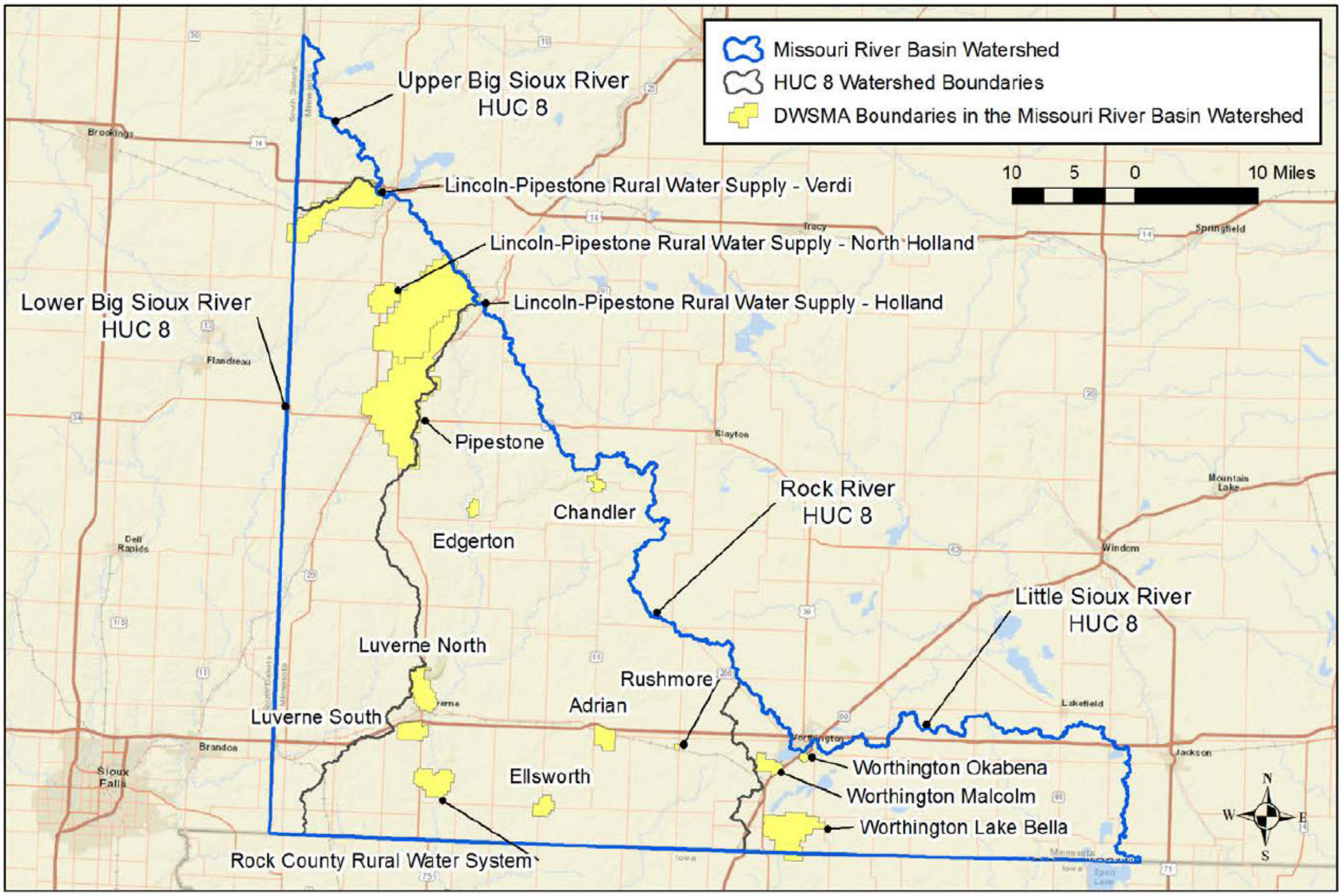
The Rock River valley alluvial aquifer shows a fairly regular pattern of aquifer thickness laterally across the aquifer with thicker portions existing in the center of the Rock River valley. The northern portion of the Rock River valley aquifer, especially around Edgerton, has a greater maximum thickness range (approximately 60-80 feet) than the maximum thickness range (approximately 40-50 feet) of the southern portion of the aquifer (MDNR, 2004). The Rock River portion also appears to be significantly thicker than the aquifer beneath the major tributaries. Therefore, the OCHs in the tributary areas would be more vulnerable than most of the OCHs in the Rock River valley. Any of the identified OCHs and others that have not yet been identified, could be affected by adjacent, large-capacity pumping activities (MDNR, 2004). For more information on saturated thickness in the Rock River valley and its impact on the Topeka shiner habitat, please access Hydrogeology of the Rock River Watershed, Minnesota, and Associated Off-Channel Habitats of the Topeka Shiner.

When completed, the Nobles and Rock County Geologic Atlas will define the connection of aquifers to the land surface and to surface water resources (MGS, 2017). When available, this information should be referenced and cited to guide geology and groundwater management related decisions during plan implementation.

The Minnesota Department of Health (MDH) was preparing a Groundwater Restoration and Protection Strategies report (GRAPs) for the MRW simultaneously to the development of this Land and Water Resources Inventory. The report was completed in January 2018 (MDH 2018). Reference to this report is for the purpose of providing additional (future) informational resources for this planning area.

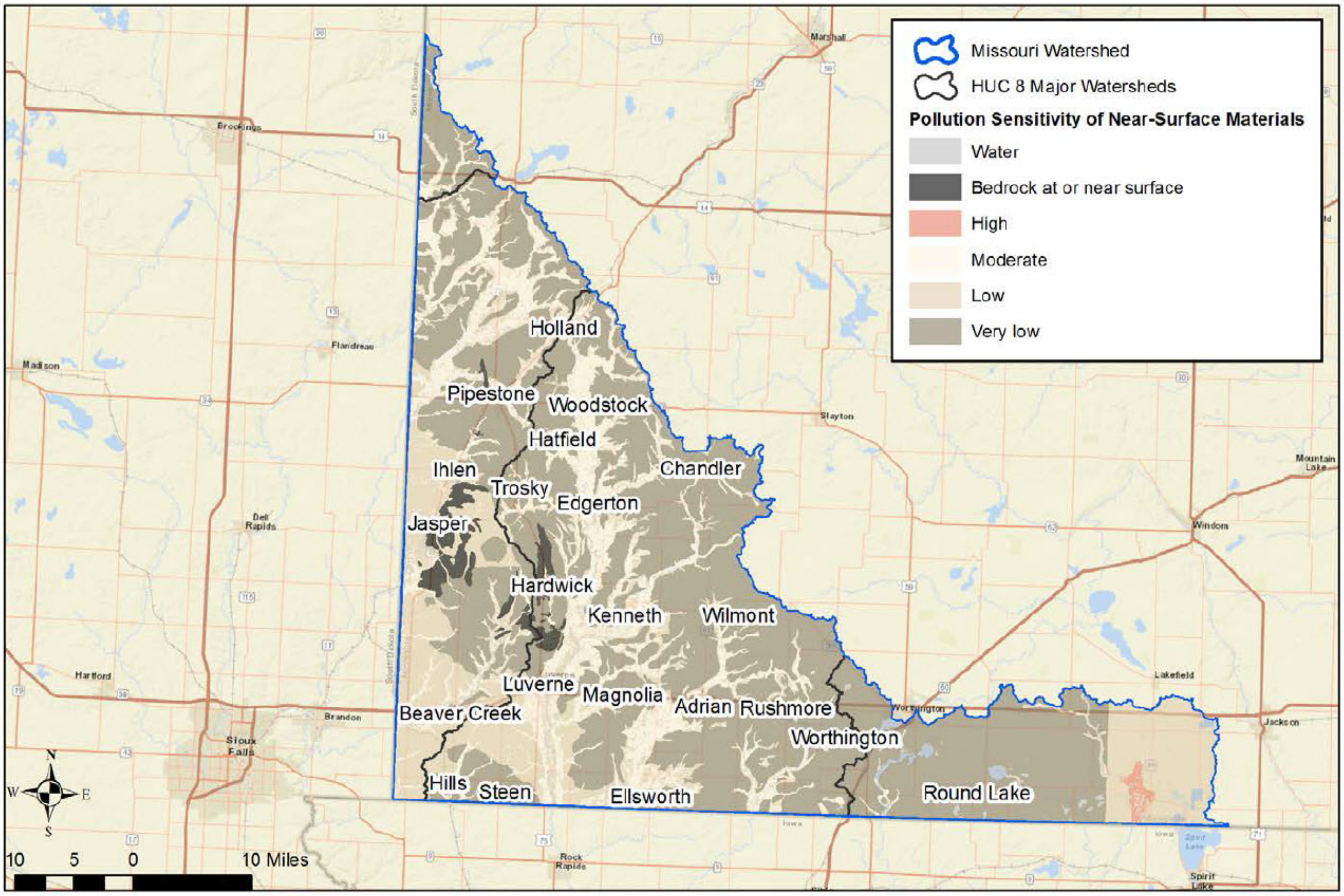
The purpose of the MDH GRAPs documents are to translate ongoing groundwater and drinking water programs and data to the watershed scale and work with other agencies to develop watershed scale groundwater and drinking water management strategies to integrate into local water management plans. Draft documents were provided to MRW planning committees by MDH on July 26, 2017 and are shown below. They include drinking water supply management areas (DWSMAs) (**Figure 15**), pollution sensitivity to aquifers (**Figure 16**), pollution sensitivity of wells (**Figure 17**), pollution sensitivity of wells and nitrate results (**Figure 18**), and arsenic results (**Figure 19).** These were the types of data and issues that were assessed in more detail in the report (MDH 2018). These figures, in draft form, were considered during MRW 1W1P plan development. As such they were subject to change. Refer to the completed GRAPs document (MDH 2018) for more information.

Figure 15: Drinking Water Supply Management Areas (DWSMAs) in the Missouri River Watershed



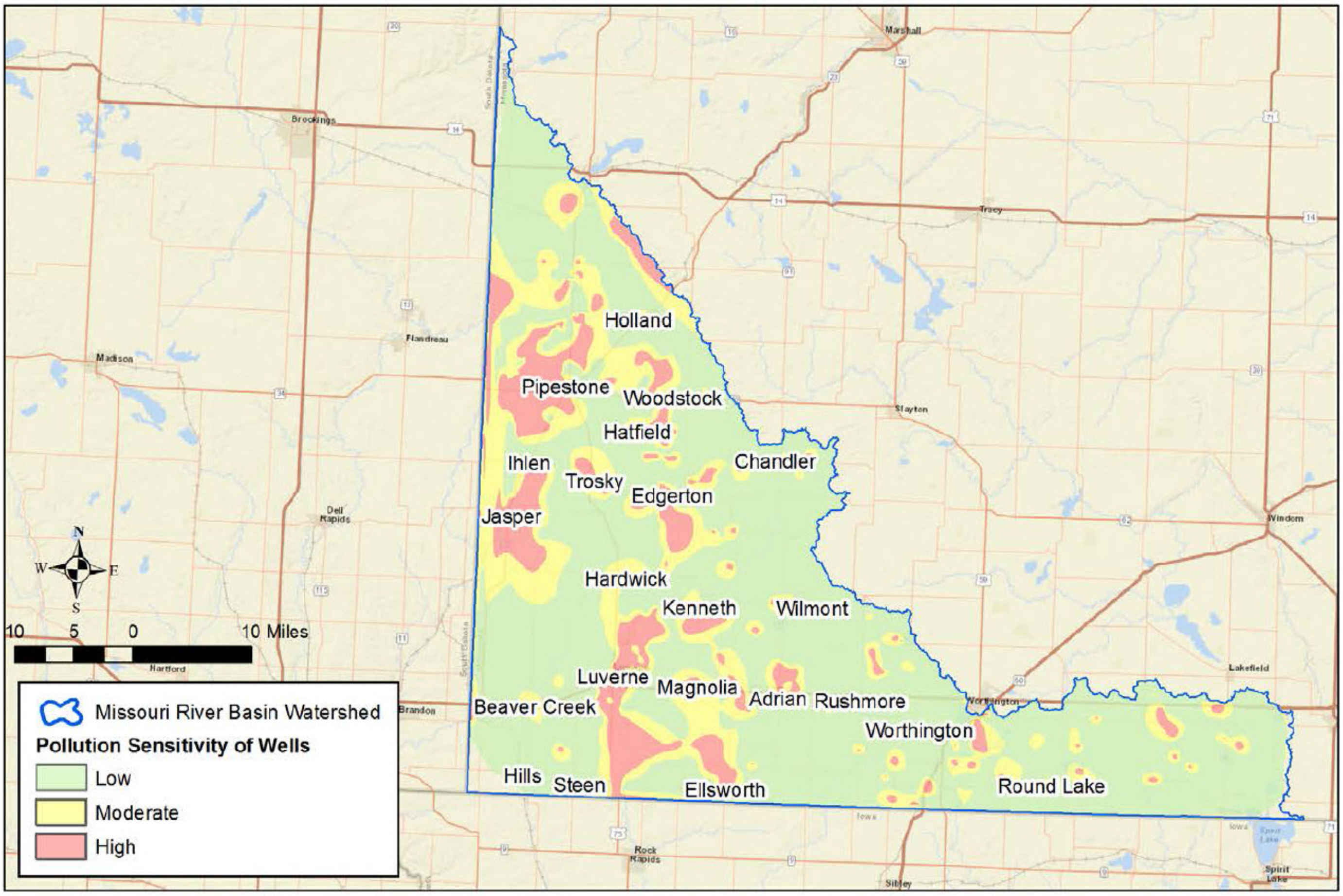
MDH data on Drinking Water Supply Management Area Boundaries
Source: MDH, *Initial 1W1P Comment Letter*, Received July 26, 2017

Figure 16: Missouri River Watershed - Pollution Sensitivity of Uppermost Aquifers



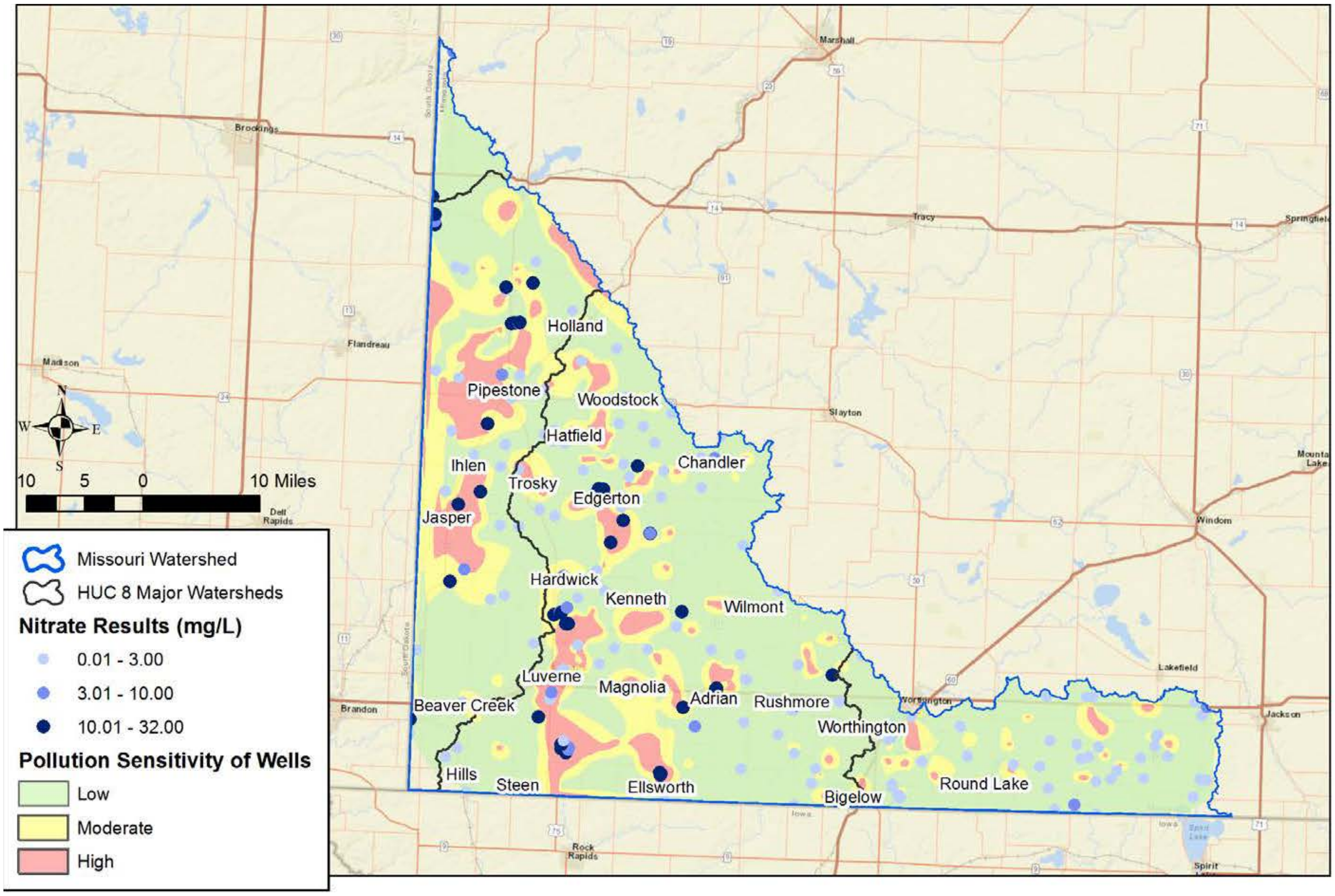
MDNR dataset that estimates the time of travel through the unsaturated zone to the water table. Figure shows the vulnerability of the uppermost aquifers based on the top ten feet of surficial geomorphology.
Source: MDH, *Initial 1W1P Comment Letter*, Received July 26, 2017

Figure 17: Missouri River Watershed - Pollution Sensitivity of Wells



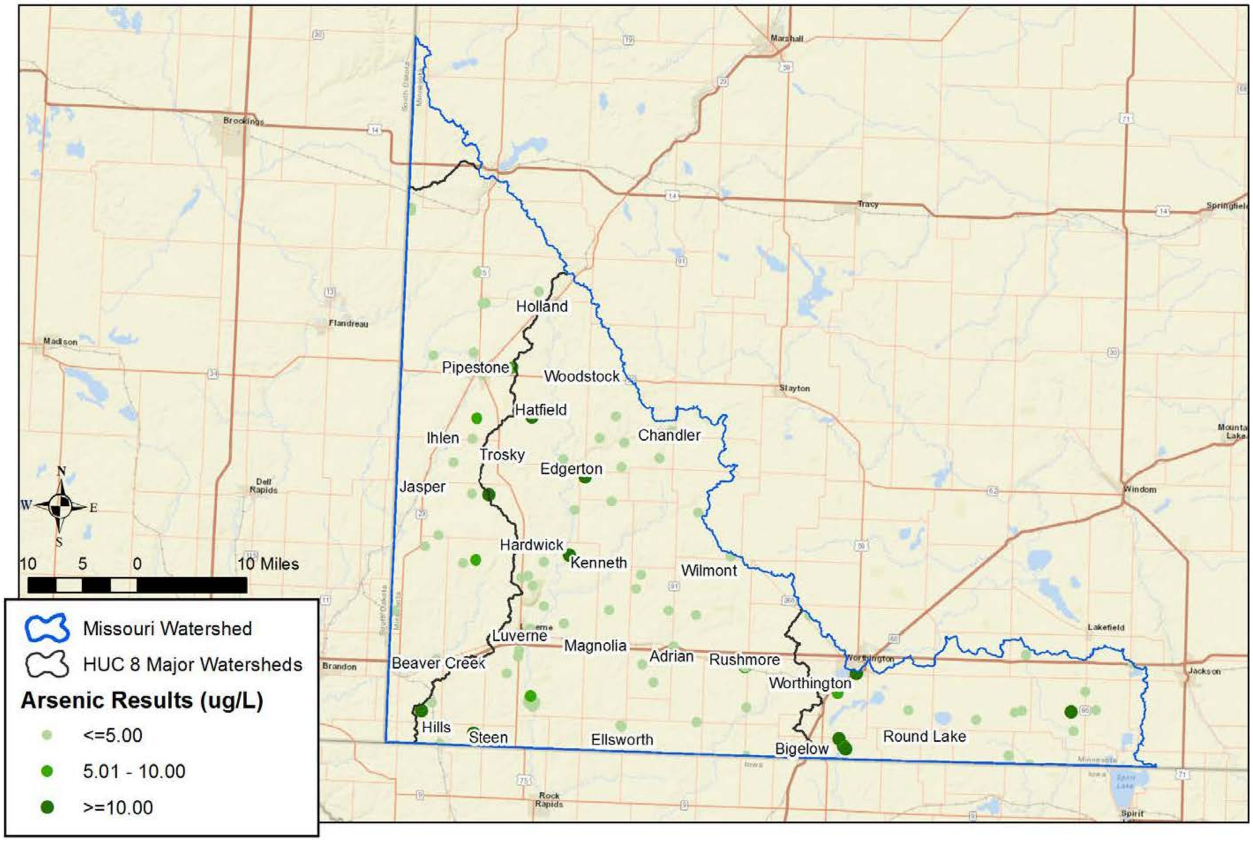
The figure depicts a gradient of the geologic sensitivity of wells across the watershed. The geologic sensitivity as determined by characteristics recorded at the time of well drilling, such as the thickness and type of material overlaying the aquifer. In comparison to the Pollution Sensitivity of Uppermost Aquifers figure, which shows the vulnerability of the uppermost aquifers based on the top ten feet of surficial geomorphology, this figure reflects vulnerability of aquifers based on the subsurface.
Source: MDH, *Initial 1W1P Comment Letter*, Received July 26, 2017.

Figure 18: Missouri River Watershed - Pollution Sensitivity of Wells and Nitrate Results



Pollution Sensitivity of Wells is shown as the backdrop to MDH water chemistry database nitrate results from public and private wells. Results were divided into three categories. The highest test result was used when well was tested multiple times.
Source: MDH, *Initial 1W1P Comment Letter*, Received July 26, 2017

Figure 19: Missouri River Watershed - Arsenic Results



MDH water chemistry database arsenic results from public and private wells. Results are divided into three categories. The highest test result was used when well was tested multiple times.
Source: MDH, *Initial 1W1P Comment Letter*, Received July 26, 2017

5 WATER QUALITY & QUANTITY

5.1 WATER QUALITY CONDITIONS

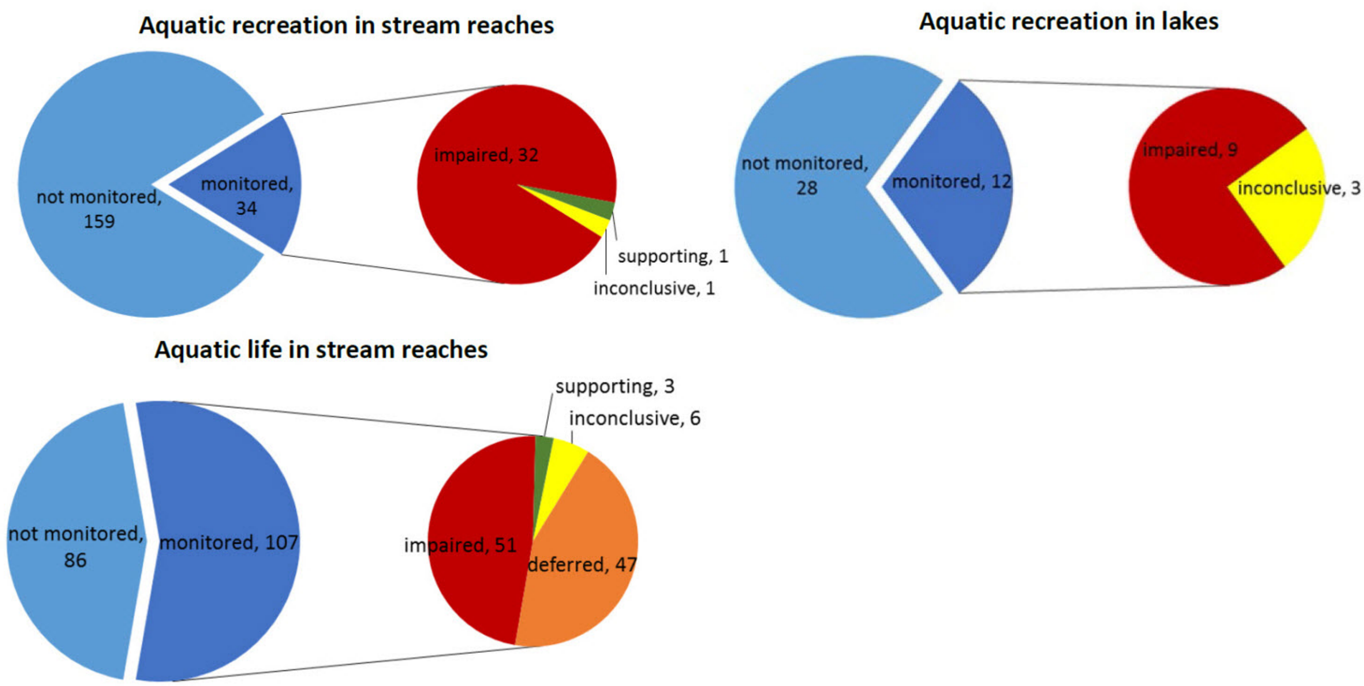
The “condition” of a water body refers to the water bodies’ ability to support fishable and swimmable water quality standards. Water quality data and associated impairments are discussed within this section. For water bodies found unable to support fishable, swimmable standards, the reason for these poor conditions – the pollutants and/or stressors – are identified. The MPCA, *Missouri River Basin Watersheds of Minnesota Watershed Restoration and Protection Strategies* (MPCA 2018b), Appendix 4.1 provides a table of all impairments, pollutants, and stressors by stream reach. More information on individual streams and lakes, including water quality data and trends can be reviewed on the *Environmental Data Application* (MPCA, 2015a).

The MRW WRAPS document covered only impairments to aquatic recreation and aquatic life. Several lakes and stream reaches are impaired for aquatic consumption due to mercury and polychlorinated biphenyls (PCBs). The state-wide mercury TMDL (MPCA, 2015b) has been published and Fish Consumption Advice (MDH, 2013) is available from the Minnesota Department of Health.

5.1.1 CONDITIONS OVERVIEW

A breakdown of the total number of water bodies (monitored and not monitored in blue) and the assessment results (impaired, supporting, inconclusive, or deferred) are presented in **Figure 20**. Refer to the MRW WRAPs, Appendix 4.1 for a table of monitoring and assessment results by stream reach.

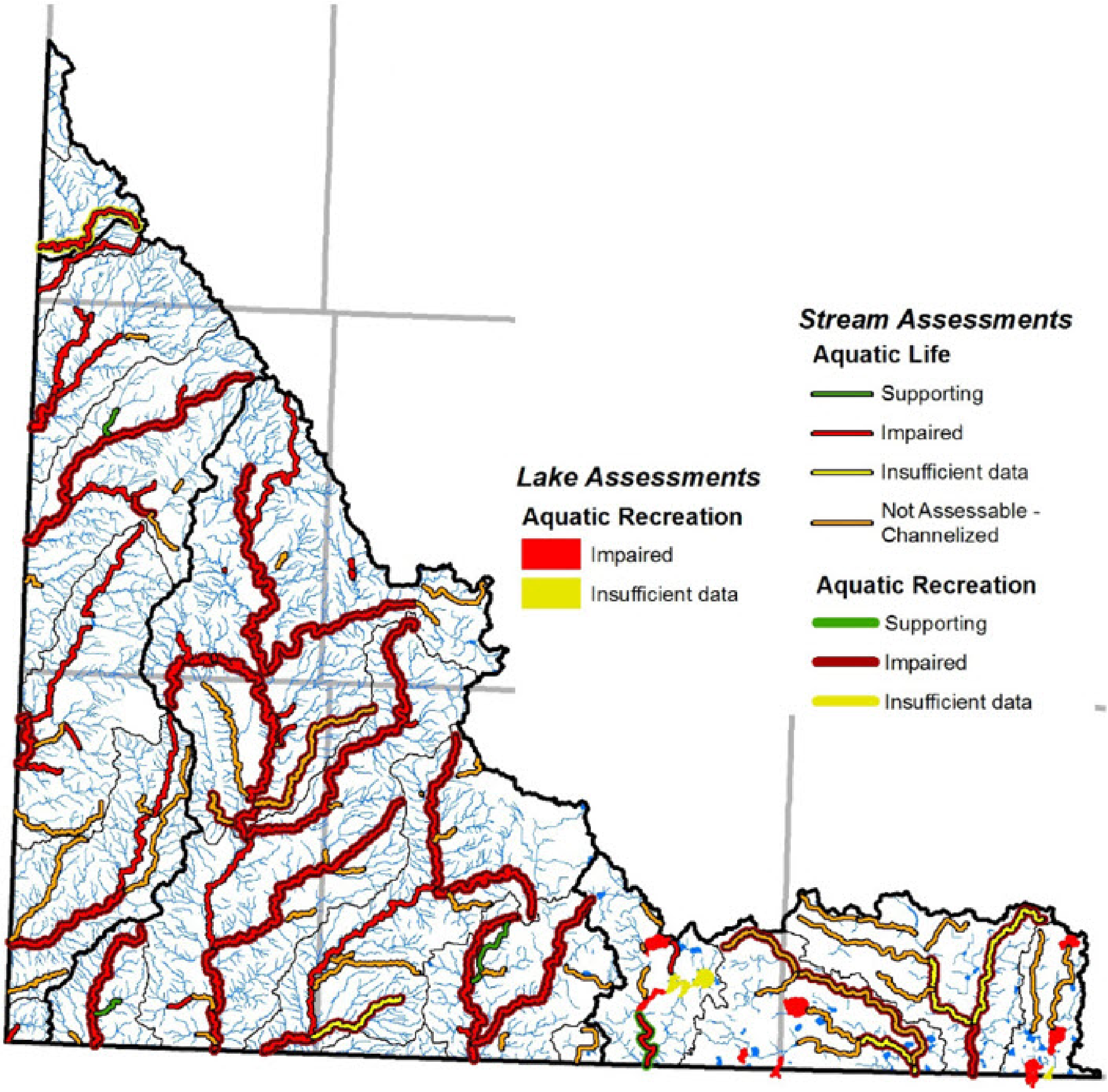
Figure 20: Water Quality Conditions within the Missouri River Watershed



Water bodies are monitored for specific parameters to make an assessment. For aquatic recreation assessment, streams are monitored for bacteria and lakes are monitored for clarity and algae-fueling phosphorus. For aquatic life assessment, streams are monitored for both aquatic life populations and pollutants that are harmful to these populations. When monitored parameters (bacteria, phosphorus, fish populations, etc.) do not meet the water quality standards, the water body is impaired.
Source: MPCA, *Missouri River Basin Watersheds of Minnesota Watershed Restoration and Protection Strategies* (January 2018), Figure 6, p.11.

Many of the monitored stream reaches and lakes are impaired for aquatic recreation (swimming) and/or aquatic life (fish and macroinvertebrates) as illustrated in **Figure 21** (in red), below. Only three (3) stream reaches are fully supporting aquatic life, one (1) stream reach is supporting aquatic recreation, and no lakes are supporting aquatic recreation (shown green in **Figure 21**). Assessments on channelized streams were deferred (**Figure 21**, orange) because tiered aquatic life use framework (TALU; MPCA, 2015e) was under development at the time of the MRW's WRAPS assessment. These channelized streams will be assessed during the next iteration of the Minnesota Watershed Approach. The specific pollutants and/or stressors that are causing the impairments are identified in the MRW WRAPS, Section 2.2.

Figure 21: Missouri River Watershed Impairments



Only one assessed stream reach was found healthy enough to safely support aquatic recreation and three (3) assessed stream reaches were healthy enough to support an appropriate fish and macroinvertebrate community (green). Impairments (red) were found across the MRW. Some streams were deferred for assessment due to channelization (orange). Several lakes and streams need more data to make a conclusive finding (yellow). Many smaller stream reaches and lakes have not been assessed (blue).
Source: MPCA, *Missouri River Basin Watersheds of Minnesota Watershed Restoration and Protection Strategies* (January 2018), Figure 7, p.12.

Several stream reaches with an aquatic life impairment were impaired due to low or imbalanced fish or macroinvertebrate populations, which are referred to as "bio-impaired". The causes, or "stressors", of these bio-impairments were identified in the stressor identification reports for the MRW: *Upper Big Sioux Biotic Stressor ID report* (MPCA, 2015c), *Lower Big Sioux Biotic Stressor ID report* (MPCA, 2014a), *Rock River Stressor ID report* (MPCA, 2015d), and *Little Sioux Biotic Stressor ID report* (MPCA, 2015f).

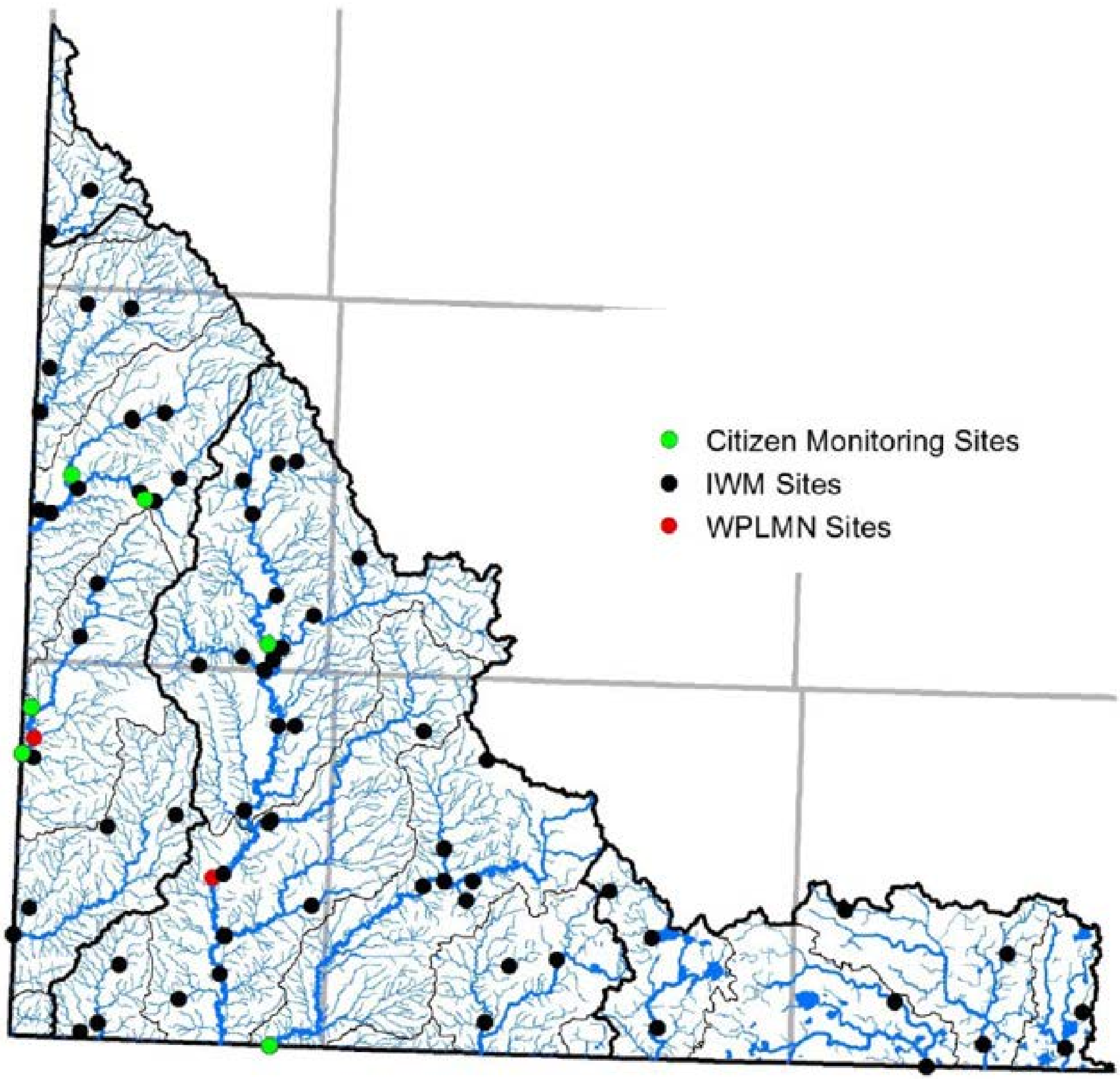
Pollutants and bio-impairments are identified in the *Monitoring and Assessment report* (MPCA, 2014b). Please reference these reports for additional details. The identified stressors were: high phosphorus, high nitrates, lack of habitat, low dissolved oxygen, high turbidity, and altered hydrology. Each of these stressors along with the identified pollutants are discussed in Section 2.2 of the MRW WRAPS document (MPCA 2018b).

5.2 MONITORING

Data from three water quality monitoring programs enable water quality assessment and create a long-term data set to track progress towards water quality goals. These programs will continue to collect and analyze data in the MRW as part of Minnesota's Water Quality Monitoring Strategy (MPCA 2011). Data needs are considered by each program and additional monitoring is implemented when deemed necessary and feasible. Combined, these programs collect data at dozens of locations around the watersheds within the MRW (**Figure 22**). The parameters collected at each monitoring site can vary. Local parameters collect additional data to supplement MPCA programs. These monitoring programs include:

- Intensive Watershed Monitoring (IWM);
- Watershed Pollutant Load Monitoring Network (WPLMN); and
- Citizen Stream and Lake Monitoring Program.

Figure 22: MRW Water Quality Monitoring Locations



Many water chemistry and aquatic life monitoring sites are within the MRW. The data collected by three (3) different water quality monitoring programs are used to assess and track area-wide conditions.
Source: MPCA, *Missouri River Basin Watersheds of Minnesota Watershed Restoration and Protection Strategies* (January 2018), Figure 5, p.10.

5.3 TRENDS IN KEY LOCATIONS

A substantial amount of change has occurred across the landscape in terms of land use, farming practices, human populations, etc. Trends observed in the Minnesota River basin – which are very similar to those in the MRW watersheds – are discussed in the *Minnesota River Basin Trends Report* (MSU, 2009a).

Statistical water quality trends were observed in two MRW streams as reported in the Water Quality Trends for Minnesota Rivers and Streams at Milestone Sites (MPCA 2014c). Both shorter-term trends (mid-1990s to about 2010) and longer-term trends (early 1960s to about 2010) were identified in Rock

River and Pipestone Creek using the Seasonal Kendall test. Longer-term trends in the Rock River showed a decrease in total suspended solids (TSS), total phosphorous (TP), ammonia (NH_3) with an increase in nitrite/nitrate (NO_2/NO_3). No shorter-term trends were identified in the Rock River, with the exception of an increase in nitrite/nitrate. Pipestone Creek's trends were similar to Rock River's trends: longer-term trends showed a decrease in TP and ammonia and an increase in nitrite/nitrate, and the shorter-term trends analysis found a decrease in TSS (**Table 2**, below).

Table 2: Shorter-term trends and longer-term trends generally indicate improving conditions in TSS, TP, and ammonia with declining conditions in nitrite/nitrate in Rock River and Pipestone Creek

Stream (trend years)	TSS	TP	NO_2/NO_3	NH_3
Rock (1995-2011)	NT	NT	+29%	NT
Rock (1962-2011)	-55%	-70%	+334%	-74%
Pipestone Creek (1995-2009)	-58%	NT	NT	NT
Pipestone Creek (1963-2009)	NT	-95%	+91%	-91%

key	
%	= Decrease
NT	= No Trend
%	= Increase
ID	= Insufficient Data

Source: MPCA, *Missouri River Basin Watersheds of Minnesota Watershed Restoration and Protection Strategies* (January 2018), Table 1, p.13.

Clarity is recorded for several lakes in the MRW. Little Spirit Lake and Lake Okabena showed improving trends while the other lakes did not have ample data to calculate a trend or no trend was observed in the data. This information is presented in Section 2.2, Phosphorus section of the MRW WRAPS document (MPCA 2018b).

5.4 POLLUTANT SOURCES

This section discusses sources of pollutants and stressors in the MRW. A source assessment for each pollutant/stressor is presented in the MRW WRAPS document, Section 2.2, and includes that for:

- Sediment;
- Altered hydrology;
- Nitrogen;
- Phosphorus;
- Fecal bacteria;
- Habitat; and
- Dissolved oxygen.

Sources of pollutants and stressors can be grouped into either point sources (NOAA 2008), which discharge directly from a discrete point, and non-point sources (MPCA 2013), which is runoff and drainage from diffuse areas. Examples of point sources are wastewater plants and industries, and examples of non-point sources are farm drainage and city runoff. Generally, point sources are regulated to ensure any discharge supports water quality standards, while non-point sources are generally not- or minimally-regulated.

The estimated contributions of point sources to the total pollutant loads delivered by all the Missouri watersheds between 2010-2014 are estimated at: 0.6% of nitrogen, 1.9% of phosphorus, and <0.1% of sediment (see MRW WRAPS document for data and calculations in Appendix 4.2). The point sources that discharge to water bodies are listed in **Table 3** and **Table 4**. Construction projects and feedlots that require National Pollutant Discharge Elimination System (NPDES; EPA, 2014) permits and other permitted facilities that are not allowed to discharge to surface waters are listed in the MRW WRAPS document, Appendix 4.2.

Table 3: NPDES Permitted Facilities in the Missouri River Watershed

Industrial Facilities	County
Worthington WTP	Nobles
Lincoln Pipestone Rural Wtr	Pipestone
Agri-Energy	Rock
Luverne WTP – Plant 1	Rock
Rock County Rural WTP	Rock

Source: MPCA, *Missouri River Basin Watersheds of Minnesota Watershed Restoration and Protection Strategies* (January 2018), Table 2, p.13.

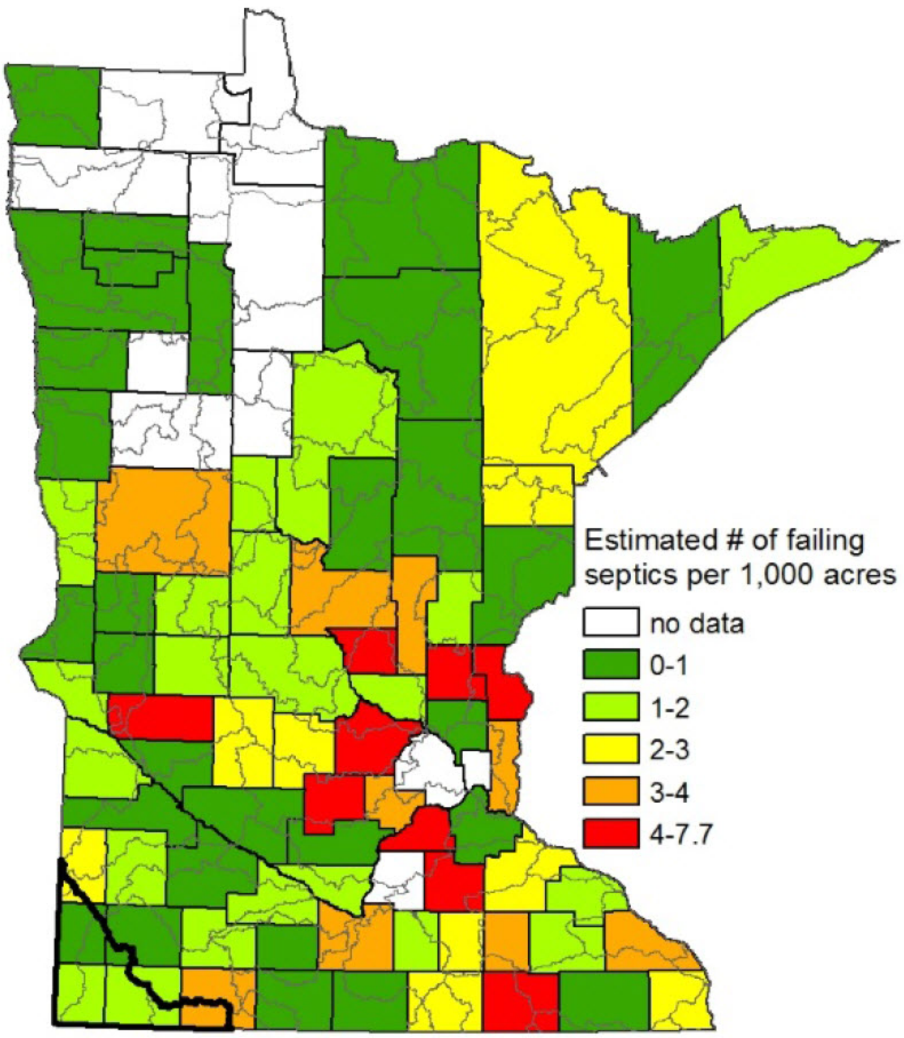
Table 4: Twenty-two municipal wastewater treatment plants (WWTPs) have NPDES permits to discharge into the Missouri River Watershed

Municipal Facilities	County
Lake Benton WWTP	Lincoln
Chandler WWTP	Murray
Adrian WWTP	Nobles
Bigelow WWTP	Nobles
Ellsworth WWTP	Nobles
Leota Sanitary District WWTP	Nobles
Lismore WWTP	Nobles
Round Lake WWTP	Nobles
Rushmore WWTP	Nobles
Wilmont WWTP	Nobles
Edgerton WWTP	Pipestone
Heartland Colonies	Pipestone
Holland WWTP	Pipestone
Pipestone WWTP	Pipestone
Woodstock WWTP	Pipestone
Beaver Creek WWTP	Rock
Hardwick WWTP	Rock
Hills WWTP	Rock
Jasper WWTP	Rock
Luverne WWTP	Rock
Magnolia WWTP	Rock
Steen WWTP	Rock

Source: MPCA, *Missouri River Basin Watersheds of Minnesota Watershed Restoration and Protection Strategies* (January 2018), Table 3, p.14.

Failing septic systems (subsurface treatment systems, SSTS) are unlikely to contribute substantial amounts of pollutants/stressors to the total annual loads in the MRW watersheds. However, the impacts of failing SSTS on water quality may be pronounced in areas with high concentrations of failing SSTS or at times of low precipitation and/or flow. Based on the estimated concentration of failing SSTS provided by counties (**Figure 23**), there are between one and four failing SSTS per 1,000 acres. SSTS are tracked but not necessarily regulated, depending on County ordinance.

Figure 23: Estimated failing subsurface treatment systems (SSTS) in Minnesota



The MRW have an estimated average of one to four failing septic systems per 1,000 acres.
Source: MPCA, *Missouri River Basin Watersheds of Minnesota Watershed Restoration and Protection Strategies* (January 2018), Figure 8, p.14.

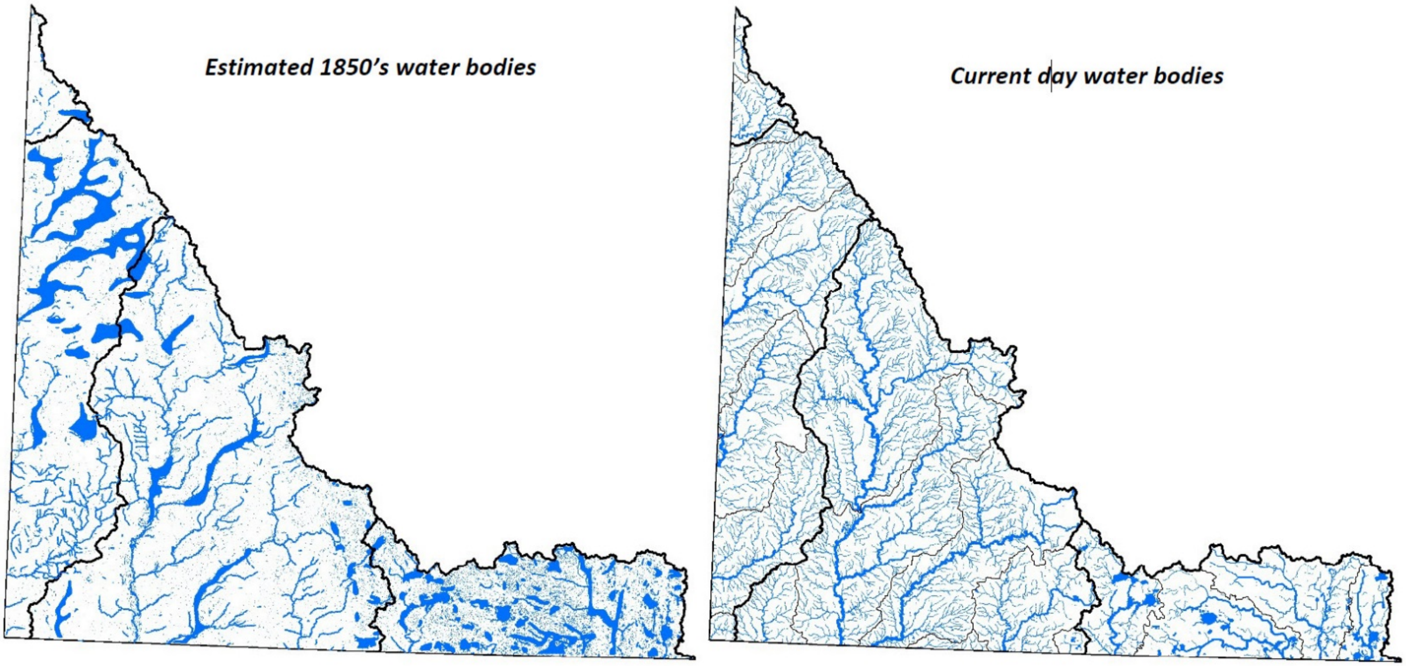
Non-point sources of pollutants/stressors are products of the ways that land is used and how well human impacts are managed/mitigated with structural and nonstructural best management practices (BMPs). Naturalized areas such as grasslands and forests tend to have lower contributions of pollutants/stressors, while highly-manipulated, not-adequately-managed/mitigated areas such as some cultivated crops, urban developments, and over-grazed pastures adjacent water bodies tend to have higher contributions of pollutants/stressors. One example of this was tested and documented by the MDA (MDA 2016), who found much larger exports of nutrients, sediment, and water runoff on a corn plot compared to a prairie plot. Manipulated land that is adequately-managed/mitigated with sufficient BMPs tends to contribute far less pollutants/stressors than not-adequately-managed/mitigated land uses. For instance, a farm that incorporates nutrient management practices, conservation tillage, grassed waterways, and buffers will contribute substantially less pollutants/stressors than if those BMPs were not used (information on BMP effectiveness is presented in the MRW WRAPS, Section 3 and Appendix 4.4).

Local county offices, NRCS, and BWSR may have BMP adoption statistics available; however, those data were not available for the MRW WRAPS report. One statistic that is available: of the 26 million acres of farm land statewide (MDA, 2015), 200,000 acres have been certified (MPCA 2017) in the Agricultural Water Quality Certification Program (MDA 2017). These farms are certified that their impacts to water quality are adequately-managed/mitigated. While these producers and others have incorporated sufficient BMPs to protect water quality, much of the cultivated crops, pastures, urban development, and residential landscape is not-adequately-managed/mitigated with best management practices (BMPs), based on local observation. When highly-manipulated land uses are not-adequately-managed/mitigated, they have the potential to contribute pollutants and stressors to water bodies in excess of the water quality standards. Because the highest land use in the MRW is cultivated crops, the management of this land use can have the largest impact on water quality.

Pollutants/stressors run off or drain from the landscape in response to precipitation. Once the area where precipitation falls cannot hold more water, the water will move, carrying pollutants/stressors with it. The pollutants/stressors can be of natural origin (like tree leaves breaking down), human-accelerated natural origin (like excessive streambank erosion from altered hydrology), or of human origin (like fertilizer applied on fields and lawns). Some areas within a landscape are particularly sensitive from a water quality perspective. For instance, a high quality, vegetative buffer adjacent a water body can help capture pollutants/stressor, stabilize the streambank, and provide habitat to sensitive aquatic species. On the contrary, the absence of a buffer – like cropping up to a stream, over-grazing the stream buffer, or developing the lake shore – can cause more pollutants/stressors to enter water bodies, accelerate erosion, and destroy sensitive habitat.

Understanding landscape conditions prior to European settlement, and between then and today, provides context for today's water quality conditions. The landscape in the MRW has been highly manipulated since European settlement. **Figure 24** compares the estimated streams, lakes, and wetlands of pre-european settlement to those of today. In 1855, portions of the Missouri watersheds, particularly the Little Sioux River watershed, were covered by prairie and speckled with prairie potholes (EPA, 2015). These potholes and the rich, healthy, prairie soils provided water storage, nutrient recycling, and superior erosion protection across the landscape.

Figure 24:Pre-European settlement water resources

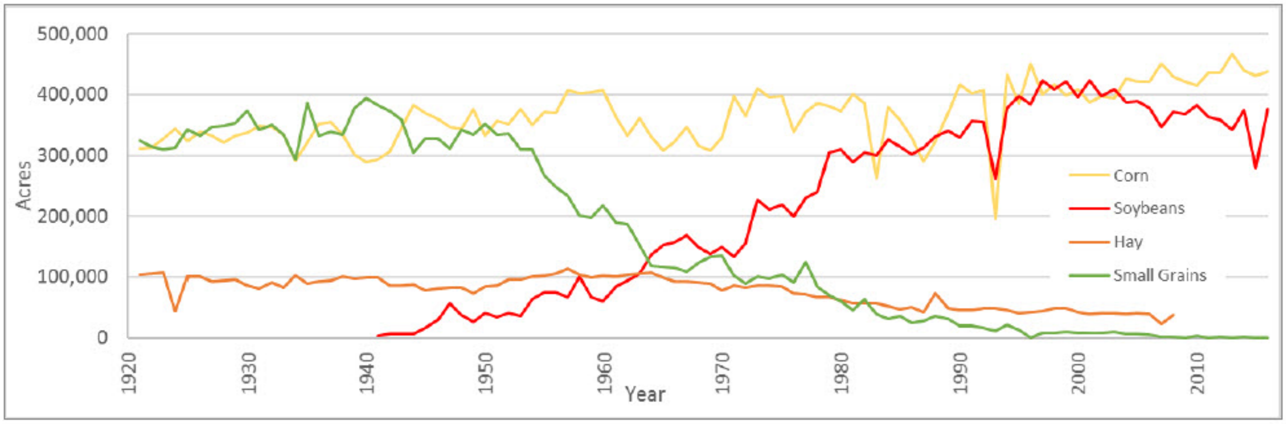


The areas covered by wetlands, lakes, and streams has changed substantially between the mid-19th century and today. The Little Sioux River watershed likely had substantial amounts of wetlands to hold, infiltrate, and evapotranspirate water. The other watersheds likely lost some water holding areas and as a result, there were fewer recognizable streams present on the landscape. The image on the left is likely underestimating many ephemeral streams, where the image on the right is illustrating all of today's ephemeral streams. This image is for illustrative purposes only. See the MRW WRAPS, Appendix 4.2 for data sources.
Source: MPCA, *Missouri River Basin Watersheds of Minnesota Watershed Restoration and Protection Strategies* (January 2018), Figure 9, p.15.

The water storage and use provided by grasslands and wetlands kept most precipitation on the landscape to be used or to recharge groundwater, which resulted in relatively fewer streams. Today, most of the grasslands have been converted to crops and cities, streams have been ditched or straightened, ditches have been added to the landscape, and prairie potholes have been drained or highly altered. The drainage networks that replaced prairies and wetlands have created a "short-circuit" in hydrologic conditions.

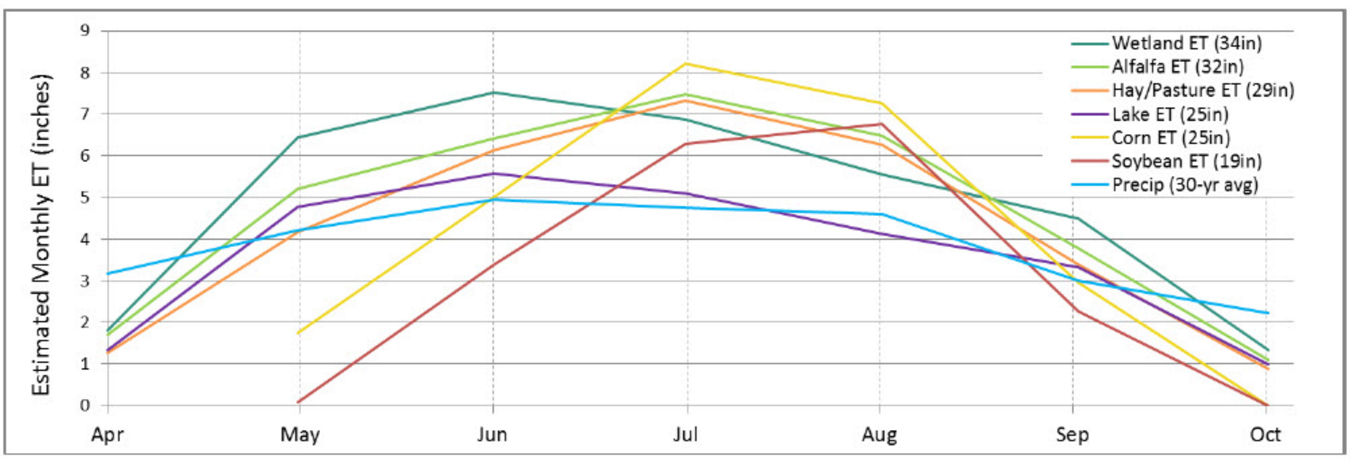
Since European settlement, the diversity of vegetation and crops on the landscape has continued to decline. Grasslands were replaced by crops and cities. Then between the mid-to late-20th century, the diverse crops – including substantial amounts of small grains and hay – were replaced by a dominance of corn and soybeans (**Figure 25**, below). The changes in land use and crops have resulted in impacts to hydrology: less evapotranspiration (ET) in spring and more ET in mid-summer (**Figure 26**), resulting in more precipitation entering rivers in spring and less entering in mid-summer.

Figure 25: Harvested acres in Rock, Pipestone, and Nobles Counties 1920-2010



The harvested acres of corn, soybeans, hays, and small grains in Rock, Pipestone, and Nobles Counties illustrate how small grains and hay were replaced through time by soybeans and corn.
Source: MPCA, *Missouri River Basin Watersheds of Minnesota Watershed Restoration and Protection Strategies* (January 2018), Figure 11, p.16.

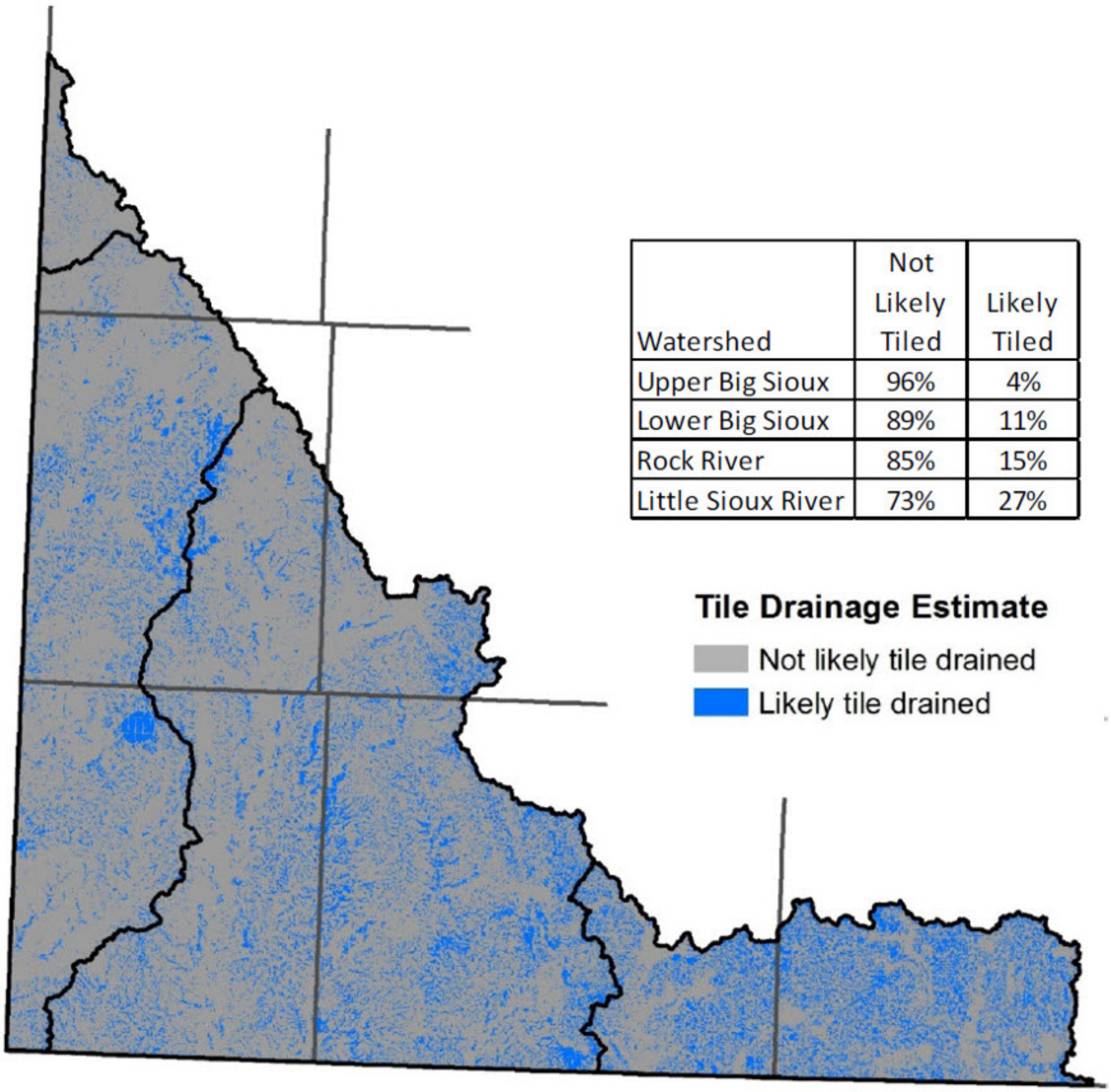
Figure 26: Evapotranspiration rates and crops grown



Since European settlement, prairies and wetlands were replaced first by diverse crops and then by corn and soybeans. The total annual ET rates (indicated in the figure legend) of these replacement crops are smaller and the timing of ET through the year has shifted. These changes affect the hydrology of the watershed. See MRW WRAPs, Appendix 4.1 for data sources and calculations.
Source: MPCA, *Missouri River Basin Watersheds of Minnesota Watershed Restoration and Protection Strategies* (January 2018), Figure 10, p.16.

Surface runoff is not the only pathway that pollutants/stressors are carried to water bodies. Subsurface drainage also carries pollutants/stressors. Subsurface tile drainage systems are typically designed to drain water from fields within a couple days of a precipitation event. With recent crop and yield changes, the application and density of subsurface drainage tile has grown. Based on Geographic information System (GIS) analysis, 17% of the MRW area is likely tile drained, with an estimated 27% of the Little Sioux River watershed tile drained (**Figure 27**).

Figure 27: Tile Drainage Estimate within the Missouri River Watershed



Watershed	Not Likely Tiled	Likely Tiled
Upper Big Sioux	96%	4%
Lower Big Sioux	89%	11%
Rock River	85%	15%
Little Sioux River	73%	27%

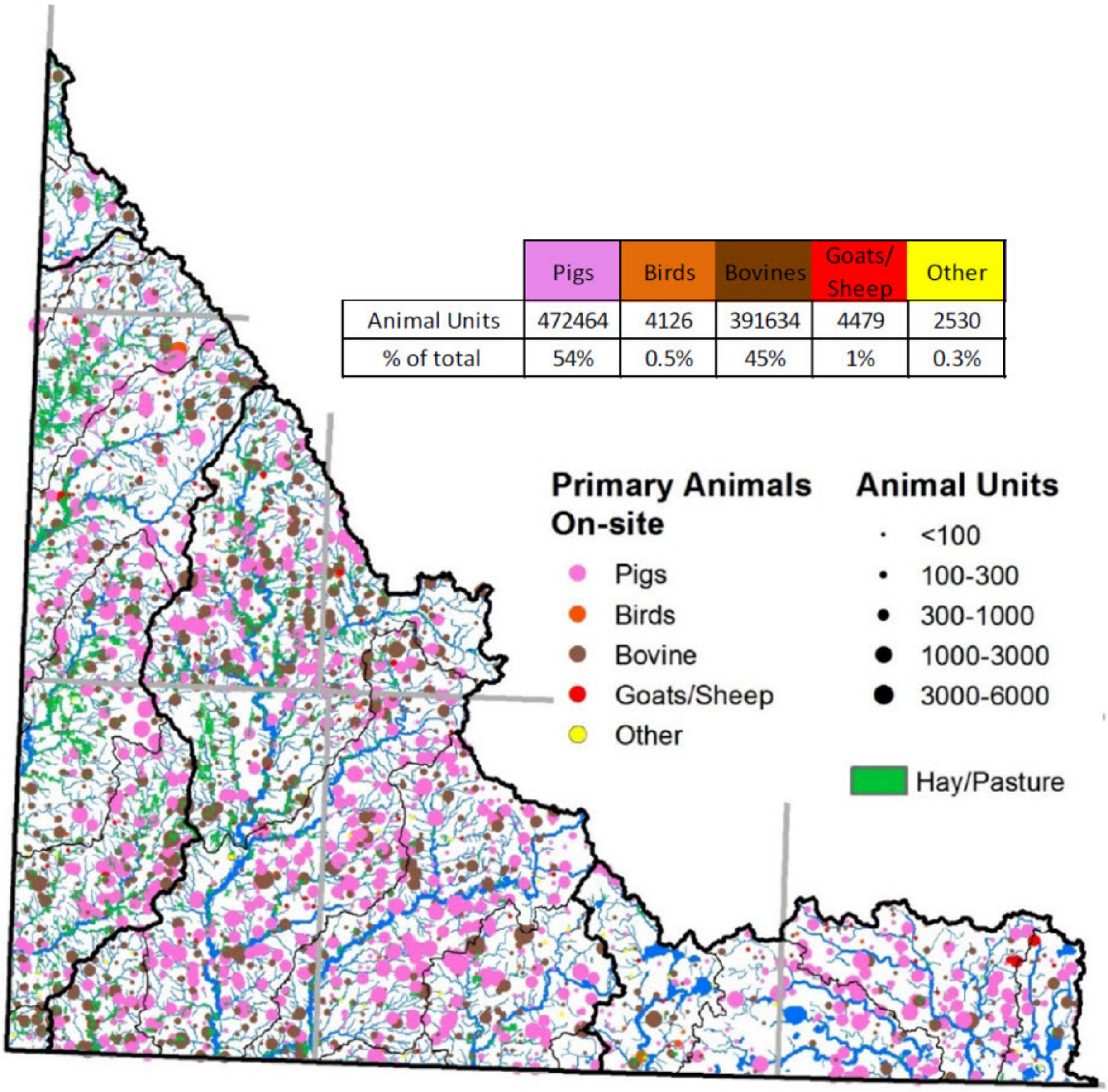
Relative to many parts of Southern Minnesota, a smaller portion of agricultural lands within the MRW are tile drained. According to a GIS analysis, 17% of the area is likely drained.
Source: MPCA, *Missouri River Basin Watersheds of Minnesota Watershed Restoration and Protection Strategies* (January 2018), Figure 12, p.17.

Because of the high number of feedlot animals and the manure that is produced and spread on fields, not-adequately-managed feedlot manure can be a large source of pollutants/stressors in the MRW. Feedlot locations and statistics are summarized and illustrated in **Figure 28**. Like other types of fertilizer application, the location, method, rate, and timing of manure application are important considerations to estimate the impact and likelihood of runoff.

Feedlot statistics are recorded by each facility and could be used for source assessment and targeting work, but this information is rarely compiled and analyzed due to staff time limitations. However, some inferences can be made based on the animal statistics. See the MRW WRAPS, Appendix 4.2 for an interpretation of feedlot statistics.

While the amount of land in pasture use compared to cultivated crop use is low, because many pastures are located directly adjacent water bodies, these land uses can disproportionately impact water bodies. Perennial vegetation, like that of pasture, typically provides an overall benefit to water quality compared to not-adequately-managed/mitigated urban and cultivated crop land uses. However, when pasture is overgrazed (indicated by too little vegetation and vegetative mat), especially adjacent a water body, these areas can be sources of pollutants/stressors. Furthermore, when cattle access streams, the delicate streambank habitat is trampled, the stream geomorphology (DNR 2017b) is negatively impacted, and streambank erosion is accelerated.

Figure 28: Feedlot locations within the Missouri River Watershed



Over 875,000 animal units are registered within the MRW. See the Animal Unit Calculator (MPCA 2016a) for conversions of animal numbers to units.
Source: MPCA, *Missouri River Basin Watersheds of Minnesota Watershed Restoration and Protection Strategies* (January 2018), Figure 13, p.18.

6 STORMWATER SYSTEMS, DRAINAGE SYSTEMS & CONTROL STRUCTURES

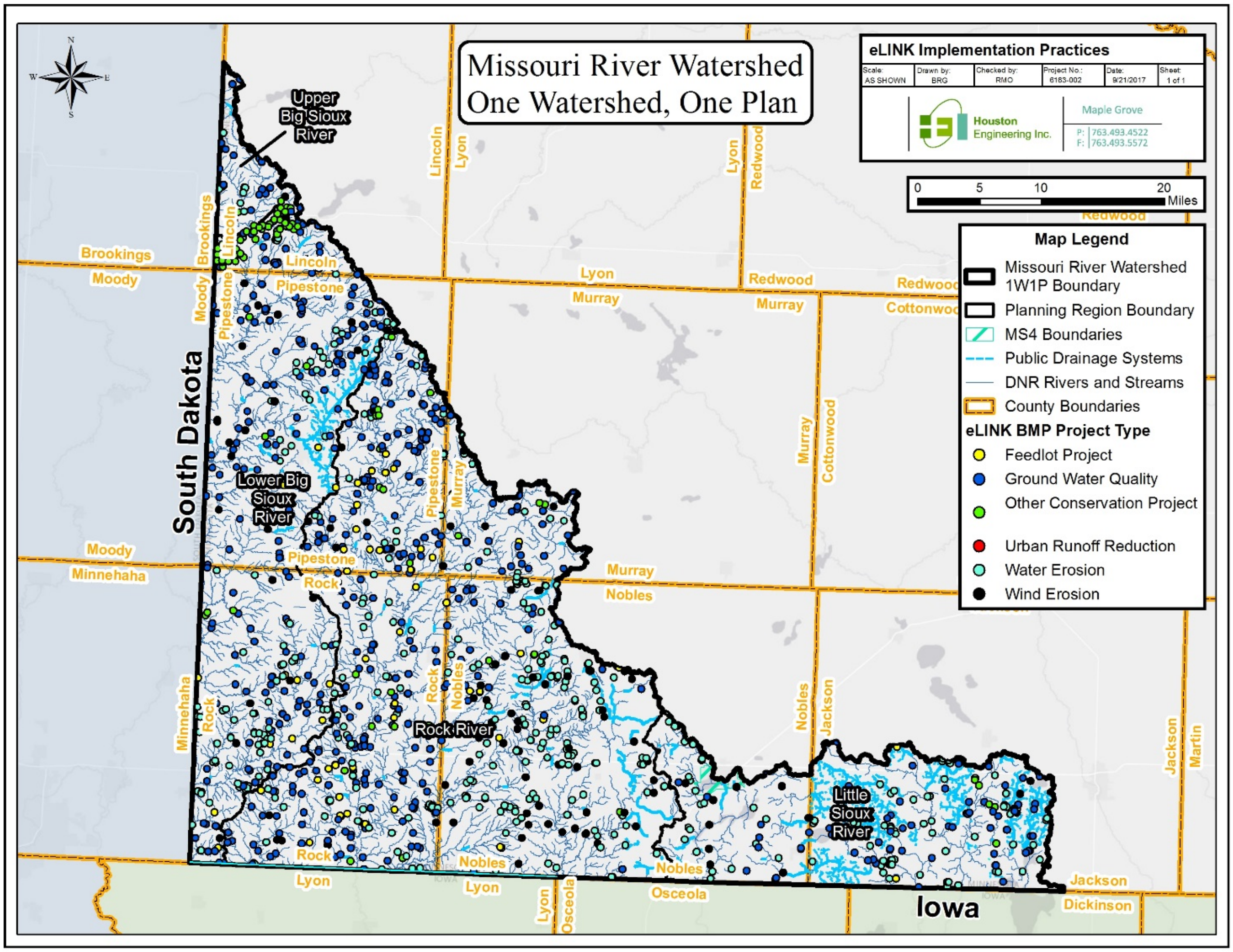
Like most areas across the Midwest, the MRW has been converted from mostly a range of tallgrass prairie and a small amount of wet prairies to a matrix of agricultural uses. Uninterrupted prairie originally covered the basin. This conversion has resulted in significant alterations in the MRW, primarily, an increase in overland flow of energy and material resources resulting from a decrease in groundwater infiltration/subsurface recharge. An increase in surface runoff has been associated with increases in the nonpoint source transport of sediment, nutrients, agricultural and residential chemicals, and feedlot runoff. (MPCA, *Missouri River Basin Monitoring and Assessment Report,* Sept 2014, p. 15)

Stormwater management and control practices and methods are wide-ranging within the watershed and it is challenging to describe or define the drainage systems present at such a large scale. For the purposes of this Land and Water Resources Inventory, stormwater systems, control structures, and drainage systems residing within the MRW are illustrated in **Figure 29** by presenting the municipal separate storm sewer system (MS4) boundaries, locations of BWSR eLINK statewide conservation efforts, and drainage ditches.

An MS4 is defined by the MPCA as a conveyance or system of conveyances which may include roads with drainage systems, municipals streets, catch basins, curbs, gutters, ditches, man-made channels, storm drains, and the like. These may be owned or operated by a public entity (e.g., city, township, county, hospitals, highway department, etc.) having jurisdiction over disposal of sewage, industrial wastes, stormwater, or other wastes, including, but not limited to, special districts under State law such as a sewer district, flood control district or drainage district. Such system(s) may be designed or used for collecting or conveying stormwater; may/may not be combined sewer; and may/may not be part of a publicly owned treatment works. Such systems are permitted through the MPCA MS4 General Permit program that is designed to reduce the amounts of sediment and pollution that enters surface and groundwater from stormwater sewer systems to the maximum extent practicable.

The MRW is predominately agricultural and has numerous public and private drainage ditches. Public drainage systems are managed by the local drainage authority on behalf of the benefitted landowners. For locations of drainage systems within the watershed, see **Figure 29**.

Figure 29: Existing eLINK water resources practices within the Missouri River Watershed



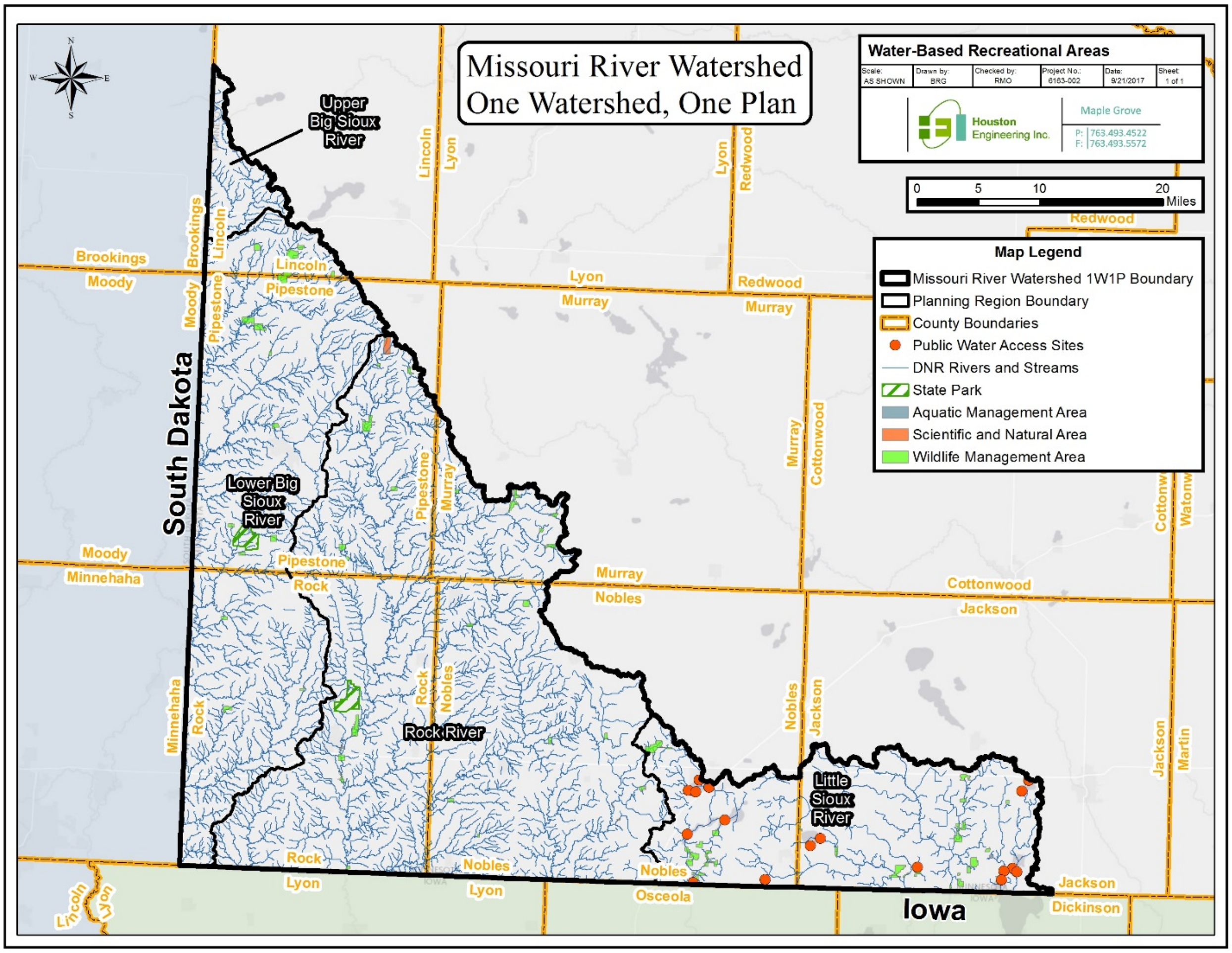
7 WATER-BASED RECREATION AREAS

At the time of drafting this Land and Water Resource Inventory for the Missouri River Watershed 1W1P, there have been no watershed-wide studies, reports, or assessments of the water based recreation in the watershed.

The MRW WRAPs document covers impairments to aquatic recreation and aquatic life. 34 streams were monitored to establish an understanding of the state of aquatic recreation within the MRW. 159 streams were not monitored. Of the 34 monitored streams, 32 were identified as impaired, 1 is supporting aquatic life and 1 is inconclusive. Also, of the 12 monitored lakes (28 unmonitored), 9 were identified as impaired with 3 inconclusive. Several lakes and stream reaches are impaired for aquatic consumption (due to mercury and PCBs). The *State-wide Mercury TMDL* (MPCA 2015b) has been published and *Fish Consumption Advice* (MDH 2013) is available from the Department of Health. A summary of these water quality conditions is provided in **Section 5** of this Land and Water Resources Inventory and detailed further in the MRW WRAPs.

The MRW offers many outdoor recreational opportunities, which include state parks, Aquatic Management Areas (AMAs), Wildlife Management Areas (WMAs), and Scientific and Natural Areas (SNAs); locations of these are presented in **Figure 30**.

Figure 30: Recreational Areas within the Missouri River Watershed



8 FISH & WILDLIFE HABITAT, RARE & ENDANGERED SPECIES

8.1 FISH & WILDLIFE HABITAT

8.1.1 TERRESTRIAL ENVIRONMENT

There currently are no readily available, watershed-wide assessments of the wildlife within the MRW.

Refer to **Section 1** of this Land and Water Resources Inventory for a general description of the MRW 1W1P planning area landscape. Refer to **Section 8.2.1** of this Land and Water Resources Inventory for the Minnesota County Biological Survey, Sites of Biodiversity Significance and Native Plant Communities.

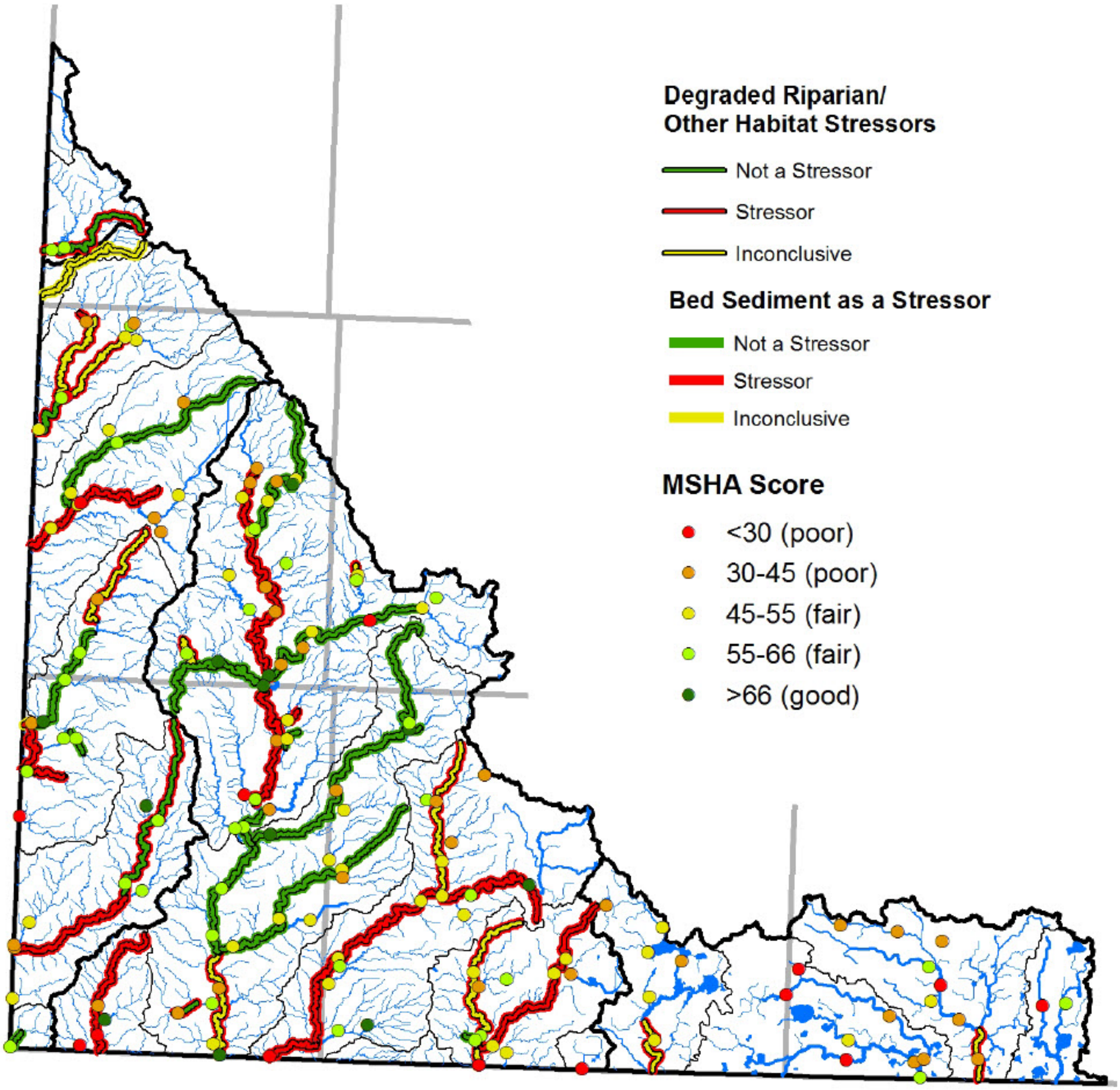
8.1.2 AQUATIC HABITAT

The MPCA has conducted biotic stressor identification reports for the Upper Big Sioux River (January 2015), Lower Big Sioux River (December 2014), Rock River (April 2015), and Little Sioux River (April 2015). These reports present a summary of key causes or “stressors” that contribute to impaired fish and aquatic macroinvertebrate communities in the MRW. These reports are located on the MPCA’s Website: https://www.MPCA.state.mn.us/water/watersheds.

Aquatic habitat was assessed for the MRW WRAPs (MPCA 2018b). Degraded habitat impacts aquatic life by reducing the amount of suitable habitat needed for all aspects of aquatic life: feeding, shelter, reproduction, etc. Of the bio-impaired stream reaches, degraded habitat was identified as a stressor in 32, ruled out in 16, and inconclusive in one. The habitat assessment results are illustrated in **Figure 31** and tabulated in **Table 5**.

The specific habitat issues identified in the MRW show a complex, interconnected set of factors that are driven by primarily a handful of stressors. Of the 32 stream reaches stressed by lack of habitat, all showed some issues with land use, riparian vegetation, channel instability, and excess sediment (see the MRW WRAPs, Table 10, p. 43). Habitat goals for the watershed are further discussed in the MRW WRAPs document, pp. 41-44.

Figure 31: Stream reaches assessed for habitat (degraded riparian/other or bed sediment)



Stream reaches assed for habitat (degraded riparian/other or bed sediment) and the assessment results are indicated by color. Red indicates a stressor (habitat is problematic in that reach), and green indicates habitat is not a stressor (habitat is not problematic in that reach).
Source: MPCA, *Missouri River Basin Watersheds of Minnesota Watershed Restoration and Protection Strategies* (January 2018), Figure 37, p.41.

Table 5: Degraded habitat assessment results

Upper Big Sioux Watershed Stream Name	Reach (AUID-3)	Habitat as a Stressor
Medary Creek	501	X

Lower Big Sioux Watershed Stream Name	Reach (AUID-3)	Habitat as a Stressor
Pipestone Creek	501	X
Flandreau Creek	502	X
Pipestone Creek	505	X
Pipestone Creek	506	X
Split Rock Creek	507	S
Split Rock Creek	509	X
Split Rock Creek	512	X
Pipestone Creek, NB	514	S
Willow Creek	515	X
Flandreau Creek	517	X
Spring Creek	518	?
Beaver Creek	521	X
Beaver Creek	522	X
Unnamed creek	531	X
Unnamed creek	538	X
Unnamed creek	549	X
Unnamed creek	553	S
Blood Run	555	S

Little Sioux River Watershed Stream Name	Reach (AUID-3)	Habitat as a Stressor
Ocheyedan River	501	X
Little Sioux River	515	X

Rock River Watershed Stream Name	Reach (AUID-3)	Habitat as a Stressor
Rock River	501	S
Rock River	504	X
Rock River	506	X
Rock River	508	S
Rock River	509	S
Little Rock Creek	511	X
Little Rock River	512	X
Little Rock River	513	X
Kanaranzi Creek, EB	514	X
Kanaranzi Creek	515	X
Kanaranzi Creek	516	X
Kanaranzi Creek	517	X
Elk Creek	519	S
Champepadan Creek	520	S
Chanarambie Creek	522	S
Poplar Creek	523	S
Mud Creek	525	X
Rock River, EB	530	X
Ash Creek	539	X
Unnamed creek	559	X
Chanarambie Creek, NB	560	S
Unnamed creek	571	X
Unnamed creek	572	S
Unnamed creek	579	S
Unnamed creek	583	S
Unnamed creek	588	X
Unnamed creek	589	S
Unnamed creek	593	X

S = not a stressor
x = stressor
? = inconclusive (need more data)

Source: MPCA, *Missouri River Basin Watersheds of Minnesota Watershed Restoration and Protection Strategies* (January 2018), Table 9, p.42.

8.2 RARE & ENDANGERED SPECIES

Minnesota's Endangered Species Statute (MS.84.0895) requires the MDNR to adopt rules designating species meeting the statutory definitions of endangered, threatened, or species of concern. Corresponding regulations that regulate the treatment of species designated as endangered and threatened is in Minnesota Administrative Rules (MN R.6212.1800 - 6212.2300). There are 13 Endangered and 11 Threatened species of plants and animals, and 43 Species of Special Concern within the MRW 1W1P Boundary that are listed in Minnesota's List of Endangered, Threatened, and Special Concern Species (MN R. 6134).

The MDNR tracks occurrences of state-listed rare species in the Natural Heritage Information System (NHIS). The NHIS also has listed an additional 4 "Watchlist" species, which have no particular legal status, but are monitored. These species of interest within the MRW 1W1P Boundary have been tabulated and provided in **Attachment 1**. A separate list of mollusks that have been found within the watershed is provided as **Attachment 2**.

Plant and animal species designated as *Endangered* or *Threatened* at the state or federal level or designated as a *species of Special Concern* are defined as:

> **"Endangered"** plants and animals are threatened with extinction throughout all or a significant portion of their ranges in Minnesota.
> **"Threatened"** plants and animals are likely to become endangered within the foreseeable future throughout all or a significant portion of their ranges in Minnesota.
> **"Special Concern"** plants and animals are extremely uncommon in Minnesota, or have unique or highly specific habitat requirements, and deserve careful monitoring. Species on the periphery of their ranges that are not listed as threatened may be included in this category along with those species that were once threatened or endangered but now have increasing or protected, stable populations.

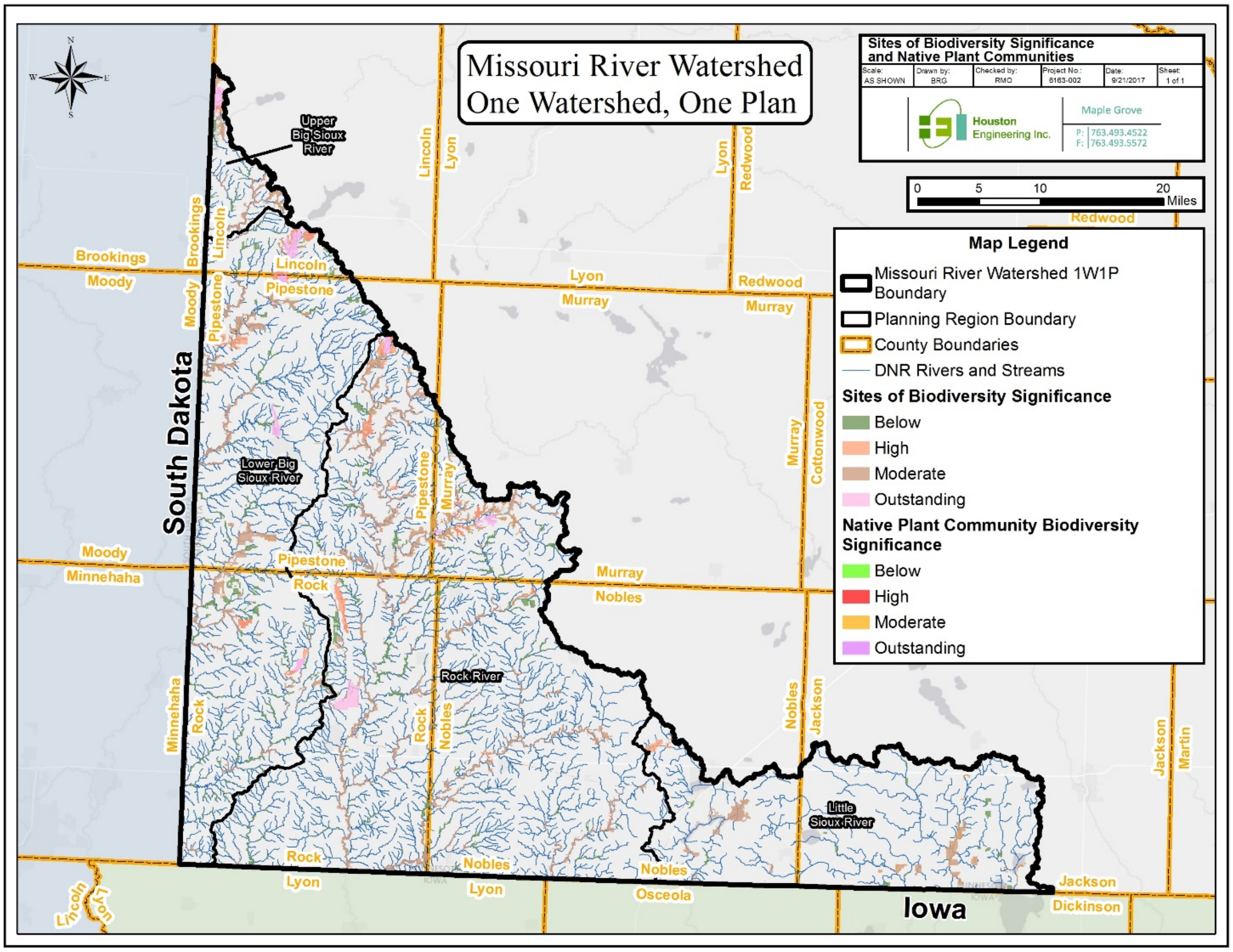
These watersheds are home to the Topeka shiner (*Notropis topeka*). The Topeka shiner is a native species minnow that was once common in headwater streams of the Midwest and western prairie (MDNR, 2004). The Topeka shiner is a federally endangered fish species. They were found with some frequency throughout the sampling in the MRW. Topeka shiner were found in the Upper Big Sioux River Watershed (1 site, 24 individuals), Lower Big Sioux River Watershed (5 sites, 23 individuals), and the Rock River Watershed (14 sites, 133 individuals). (MPCA, *Missouri River Basin Monitoring and Assessment Report*, Sept 2014, p. 1)

8.2.1 MCBS SITES OF BIODIVERSITY SIGNIFICANCE AND NATIVE PLANT COMMUNITIES

The Minnesota County Biological Survey (MCBS) is a MDNR program within the Division of Ecological and Water Resources with the goal of identifying significant natural areas and collecting and interpreting data on the distribution and ecology of rare plants, rare animals, and native plant communities. Data collected by MCBS are entered into the Natural Heritage Information System, managed by the DNR's Division of Ecological and Water Resources. As a result of this systematic survey, the relative ecological importance of natural areas and representative ecological landscapes can be assessed.

Following the initial mapping of native plant communities from aerial photos in each county, MCBS ecologists delineated sites of biodiversity significance that helped to geographically organize the data. According to the MCBS data, there are 685 sites of biodiversity significance encompassing approximately 91,510 acres within the MRW and 1,653 native plant communities encompassing approximately 17,929 acres, identified. Minnesota Sites of Biodiversity Significance and Native Plant Communities within the MRW are shown in **Figure 32**.

Figure 32: Sites of Biodiversity Significance & Native Plant Communities in the Missouri River Watershed

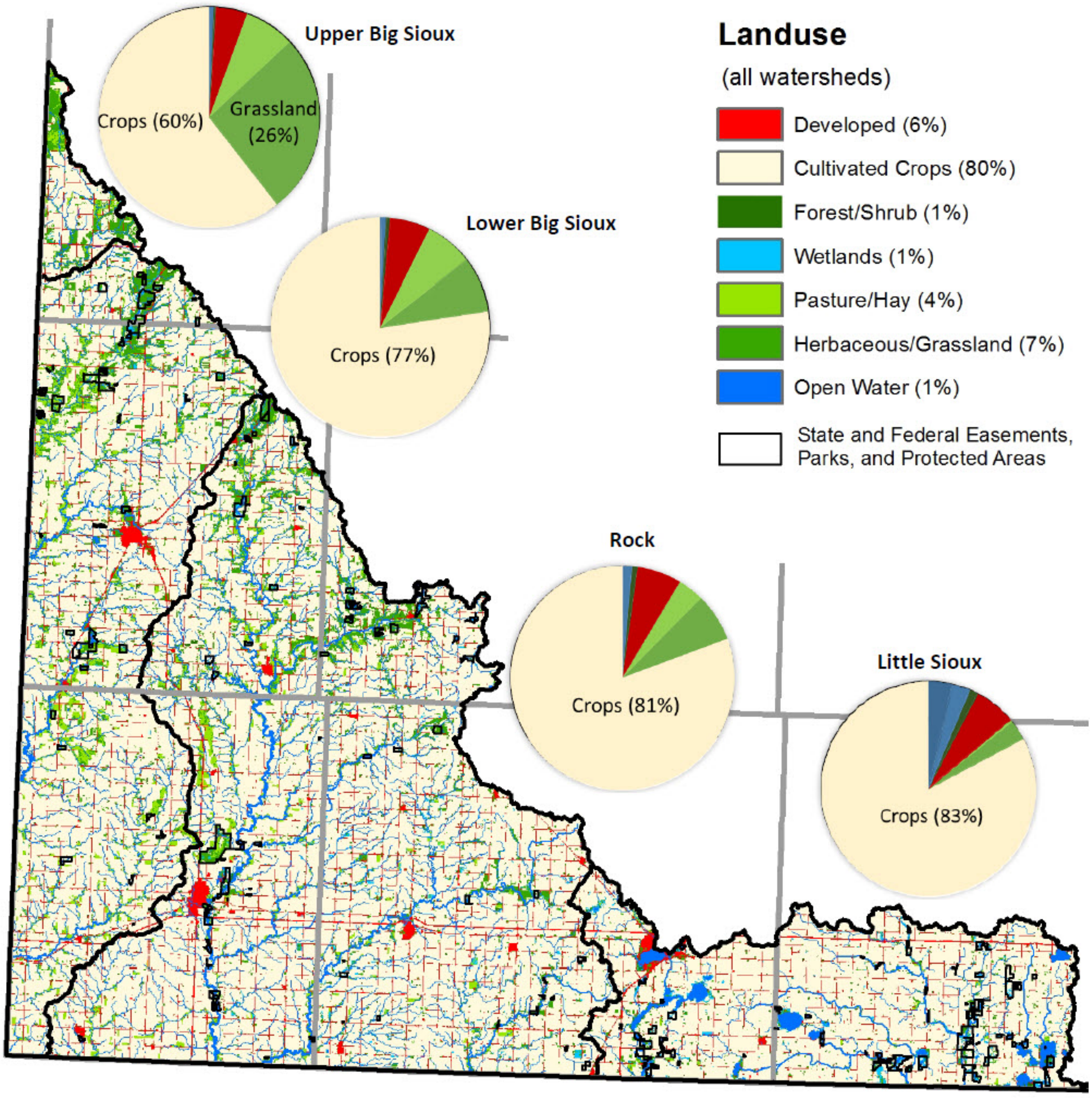


9 EXISTING LAND USES & PROPOSED DEVELOPMENT

9.1 CURRENT LAND USE

The MRW is predominately rural, with populations clustered in its largest cities of Worthington (12,764), Luverne (4,745), and Pipestone (4,317) (U.S. Census Bureau, 2010). Current land use in the MRW watersheds is similar to other regions in Southern and Western Minnesota. Land use is dominated by warm-season, annual, cultivated, row crops (**Figure 33**). Of the crops, 59% are corn, 39% are soybeans, 2% are alfalfa/hay, and <1% of crops are small grains/other. The MPCA, *Missouri River Basin Watersheds of Minnesota Watershed Restoration and Protection Strategies* (MPCA 2018b), Appendix 4.1, has additional information on crop types per watershed. Compared to other Southern Minnesota area, the MRW watersheds area has a high coverage of grassland and pastureland.

Figure 33: Land Use in the Missouri River Watershed



Land use in the MRW is dominated by cultivated crops. The land use varies within each of the four (4) major watersheds; approximate land use in each is shown in adjacent pie charts.
Source: MPCA, *Missouri River Basin Watersheds of Minnesota Watershed Restoration and Protection Strategies* (January 2018), Figure 3, p.7.

9.2 FUTURE LAND USE

Future land use planning on a watershed-wide scale has not been conducted within the MRW. It is reasonable to anticipate that the general agricultural land use trend will continue within the MRW and that this 1W1P will assist in developing a plan for establishing a sustainable approach to land (and water resources) management into the future.

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Appendix B

Memorandum of Agreement
(Planning)

MISSOURI RIVER WATERSHED
Comprehensive Watershed Management Plan

MEMORANDUM OF AGREEMENT

This agreement (Agreement) is made and entered into by and between:

The Counties of Jackson, Lincoln, Murray, Nobles, Pipestone and Rock by and through their respective County Board of Commissioners, and

The Jackson, Lincoln, Murray, Nobles, Pipestone and Rock Soil and Water Conservation Districts, by and through their respective Soil and Water Conservation District Board of Supervisors, and

The Kanaranzi-Little Rock and Okabena-Ocheda Watershed Districts, by and through their respective Board of Managers,

Collectively referred to as the "Parties."

WHEREAS, the Counties of this Agreement are political subdivisions of the State of Minnesota, with authority to carry out environmental programs and land use controls, pursuant to Minnesota Statutes Chapter 375 and as otherwise provided by law; and

WHEREAS, the Soil and Water Conservation Districts (SWCDs) of this Agreement are political subdivisions of the State of Minnesota, with statutory authority to carry out erosion control and other soil and water conservation programs, pursuant to Minnesota Statutes Chapter 103C and as otherwise provided by law; and

WHEREAS, the Watershed Districts of this Agreement are political subdivisions of the State of Minnesota, with statutory authority to carry out conservation of the natural resources of the state by land use controls, flood control, and other conservation projects for the protection of the public health and welfare and the provident use of the natural resources, pursuant to Minnesota Statutes Chapters 103B, 103D and as otherwise provided by law; and

WHEREAS, the parties to this Agreement have a common interest and statutory authority to prepare, adopt, and assure implementation of a comprehensive watershed management plan in Missouri River Watershed to conserve soil and water resources through the implementation of practices, programs, and regulatory controls that effectively control or prevent erosion, sedimentation, siltation and related pollution in order to preserve natural resources, ensure continued soil productivity, protect water quality, reduce damages caused by floods, preserve wildlife, protect the tax base, and protect public lands and waters; and

WHEREAS, with matters that relate to coordination of water management authorities pursuant to Minnesota Statutes Chapters 103B, 103C, and 103D with public drainage systems pursuant to Minnesota Statutes Chapter 103E, this Agreement does not change the rights or obligations of the public drainage system authorities.

WHEREAS, the Parties have formed this Agreement for the specific goal of developing a plan pursuant to Minnesota Statutes § 103B.801, Comprehensive Watershed Management Planning, also known as *One Watershed, One Plan*.

NOW, THEREFORE, the Parties hereto agree as follows:

1. **Purpose:** The Parties to this Agreement recognize the importance of partnerships to plan and implement protection and restoration efforts for the Missouri River Watershed. The purpose of this Agreement is to collectively develop and adopt, as local government units, a coordinated watershed management plan for implementation per the provisions of the Plan. Parties signing this agreement will be collectively referred to as Missouri River Watershed Partnership.

2. **Term:** This Agreement is effective upon signature of all Parties in consideration of the Board of Water and Soil Resources (BWSR) Operating Procedures for One Watershed, One Plan; and will remain in effect until December 31, 2019 unless canceled according to the provisions of this Agreement or earlier terminated by law.

3. **Adding Additional Parties:** A qualifying party desiring to become a member of this Agreement shall indicate its intent by adoption of a board resolution prior to March 31, 2017. The party agrees to abide by the terms and conditions of the Agreement; including but not limited to the bylaws, policies and procedures adopted by the Policy Committee.

4. **Withdrawal of Parties:** A party desiring to leave the membership of this Agreement shall indicate its intent in writing to the Policy Committee in the form of an official board resolution. Notice must be made at least 30 days in advance of leaving the Agreement.

5. **General Provisions**:

    a. **Compliance with Laws/Standards:** The Parties agree to abide by all federal, state, and local laws; statutes, ordinances, rules and regulations now in effect or hereafter adopted pertaining to this Agreement or to the facilities, programs, and staff for which the Agreement is responsible.

    b. **Indemnification:** Each party to this Agreement shall be liable for the acts of its officers, employees or agents and the results thereof to the extent authorized or limited by law and shall not be responsible for the acts of any other party, its officers, employees or agents. The provisions of the Municipal Tort Claims Act, Minnesota Statute Chapter 466 and other applicable laws govern liability of the Parties. To the full extent permitted by law, actions by the Parties, their respective officers, employees, and agents pursuant to this Agreement are intended to be and shall be construed as a "cooperative activity." It is the intent of the Parties that they shall be deemed a "single governmental unit" for the purpose of liability, as set forth in Minnesota Statutes § 471.59, subd. 1a(a). For purposes of Minnesota Statutes § 471.59, subd. 1a(a) it is the intent of each party that this Agreement does not create any liability or exposure of one party for the acts or omissions of any other party.

    c. **Records Retention and Data Practices:** The Parties agree that records created pursuant to the terms of this Agreement will be retained in a manner that meets their respective entity's records retention schedules that have been reviewed and approved by the State in accordance with Minnesota Statutes § 138.17. The Parties further agree that records prepared or maintained in furtherance of the agreement shall be subject to the Minnesota Government Data Practices Act.

At the time this agreement expires, all records will be turned over to the Nobles County for continued retention.

d. **Timeliness:** The Parties agree to perform obligations under this Agreement in a timely manner and keep each other informed about any delays that may occur.

e. **Extension:** The Parties may extend the termination date of this Agreement upon agreement by all Parties.

6. **Administration:**

   a. **Establishment of Committees for Development of the Plan.** The Parties agree to designate one representative, who must be an elected or appointed member of the governing board, to a Policy Committee for development of the watershed-based plan and may appoint of one or more technical representatives to an Advisory Committee for development of the plan in consideration of the BWSR Operating Procedures for One Watershed, One Plan.

      i. The Policy Committee will meet as needed to decide on the content of the plan, serve as a liaison to their respective boards, and act on behalf of their Board. Each representative shall have one vote.

      ii. Each governing board may choose one alternate to serve on the Policy Committee as needed in the absence of the designated member.

      iii. The Policy Committee will establish bylaws by within 90 days of execution of this document to describe the functions and operations of the committee(s).

      iv. The Advisory Committee will meet monthly or as needed to assist and provide technical support and make recommendations to the Policy Committee on the development and content of the plan. Members of the Advisory Committee may not be a current board member of any of the Parties.

   b. **Submittal of the Plan.** The Policy Committee will recommend the plan to the Parties of this agreement. The Policy Committee will be responsible for initiating a formal review process for the watershed-based plan conforming to Minnesota Statutes Chapters 103B and 103D, including public hearings. Upon completion of local review and comment, and approval of the plan for submittal by each party, the Policy Committee will submit the watershed-based plan jointly to BWSR for review and approval.

   c. **Adoption of the Plan.** The Parties agree to adopt and begin implementation of the plan within 120 days of receiving notice of state approval, and provide notice of plan adoption pursuant to Minnesota Statutes Chapters 103B and 103D.

7. **Fiscal Agent:** Nobles County will act as the fiscal agent for the purposes of this Agreement and agrees to:

a. Accept all responsibilities associated with the implementation of the BWSR grant agreement for developing a watershed-based plan.

b. Perform financial transactions as part of grant agreement and contract implementation.

c. Annually provide a full and complete audit report.

d. Provide the Policy Committee with the records necessary to describe the financial condition of the BWSR grant agreement.

e. Retain fiscal records consistent with the agent's records retention schedule until termination of the agreement (at that time, records will be turned over to Nobles County.)

8. **Grant Administration**: Okabena-Ocheda Watershed District will act as the grant administrator for the purposes of this Agreement and agrees to provide the following services:

   a. Accept all day-to-day responsibilities associated with the implementation of the BWSR grant agreement for developing a watershed-based plan, including being the primary BWSR contact for the *One Watershed, One Plan* Grant Agreement and being responsible for BWSR reporting requirements associated with the grant agreement.

   b. Provide the Policy Committee with the records necessary to describe the planning condition of the BWSR grant agreement.

9. The Nobles County agrees to provide the following services to the Parties:

   Staff will take notes of the Planning Work Group, Policy Committee and Advisory Committee meeting proceedings and distribute minutes to the committee members.

10. **Authorized Representatives:** The following persons will be the primary contacts for all matters concerning this Agreement:

Nobles County
Environmental Services Director
960 Diagonal Road, P.O. Box 187
Worthington, MN 56187
Telephone: 507-295-5322

Okabena-Ocheda Watershed District
Administrator
960 Diagonal Road, P.O. Box 114
Worthington, MN 56187
Telephone: 507-372-8228

IN TESTIMONY WHEREOF the Parties have duly executed this agreement by their duly authorized officers.
(Repeat this page for each participant)

PARTNER: ___________________________________

APPROVED:

BY: ____

Board Chair Date

BY: ____

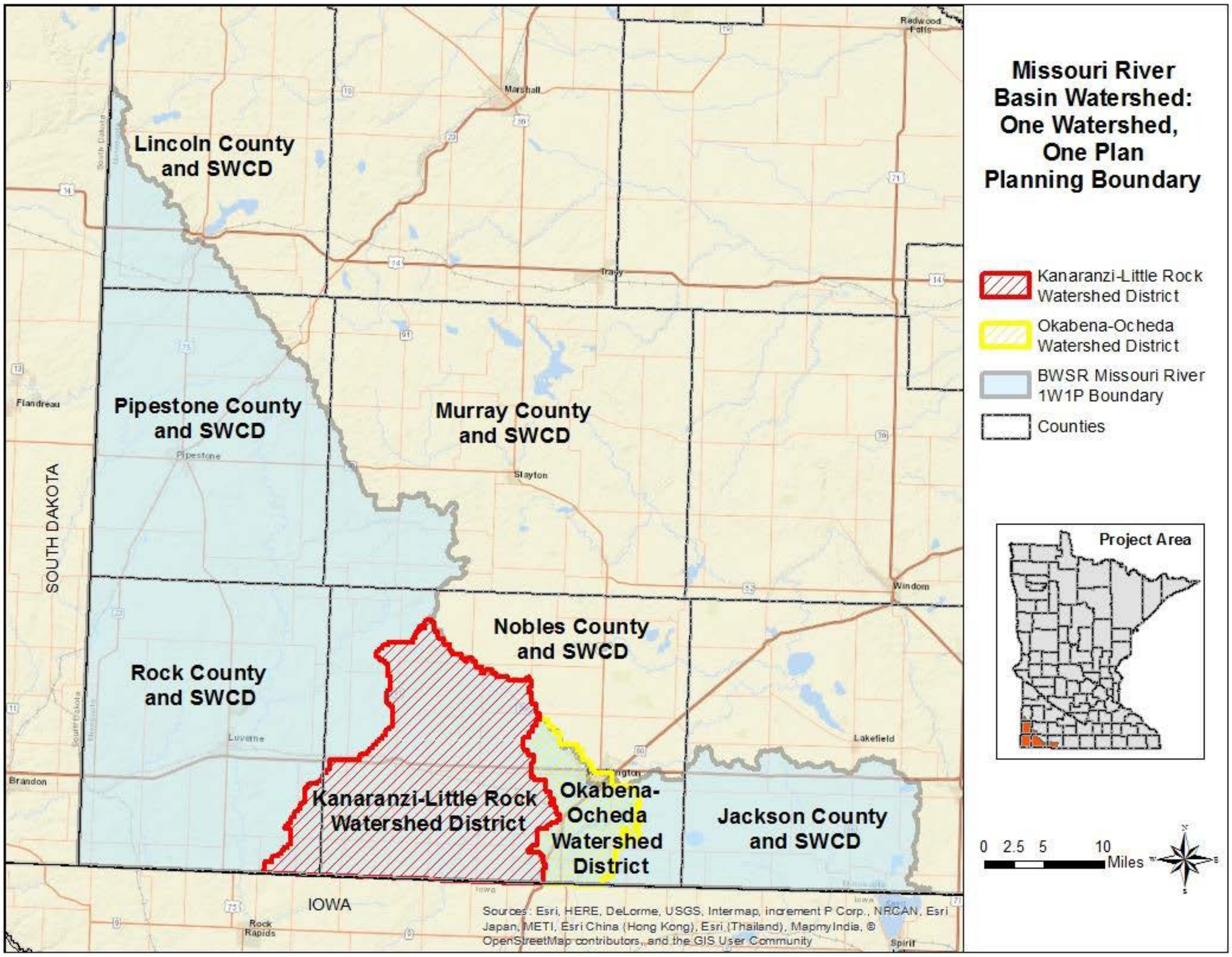
District Manager/Administrator Date

APPROVED AS TO FORM *(use if necessary)*

BY: ____

County Attorney Date

Attachment A



Appendix C

Missouri River Watershed
1W1P Participation Plan

MISSOURI RIVER WATERSHED
Comprehensive Watershed Management Plan

HoustonEngineering Inc.

August 9, 2017

Jackson County, Minnesota

ROCK COUNTY SOIL & WATER CONSERVATION DISTRICT LAND MANAGEMENT OFFICE

PIPESTONE COUNTY

NOBLES COUNTY

SWCD MURRAY SOIL AND WATER CONSERVATION DISTRICT

OKABENA OCHEDA WATERSHED DISTRICT

MURRAY COUNTY MINNESOTA

HoustonEngineering Inc.

ROCK County

LINCOLN SOIL AND WATER CONSERVATION DISTRICT SWCD Helping Bring YOU Clean Water

Kanaranzi Little Rock Watershed District

NOBLES SOIL AND WATER CONSERVATION DISTRICT

Lincoln County of Southwest Minnesota "Worth going out of the way"

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Acronyms and Abbreviations List

1W1P	One Watershed, One Plan
BWSR	Board of Water and Soil Resources
MRW	Missouri River Watershed
SWCD	Soil & Water Conservation District
WD	Watershed District

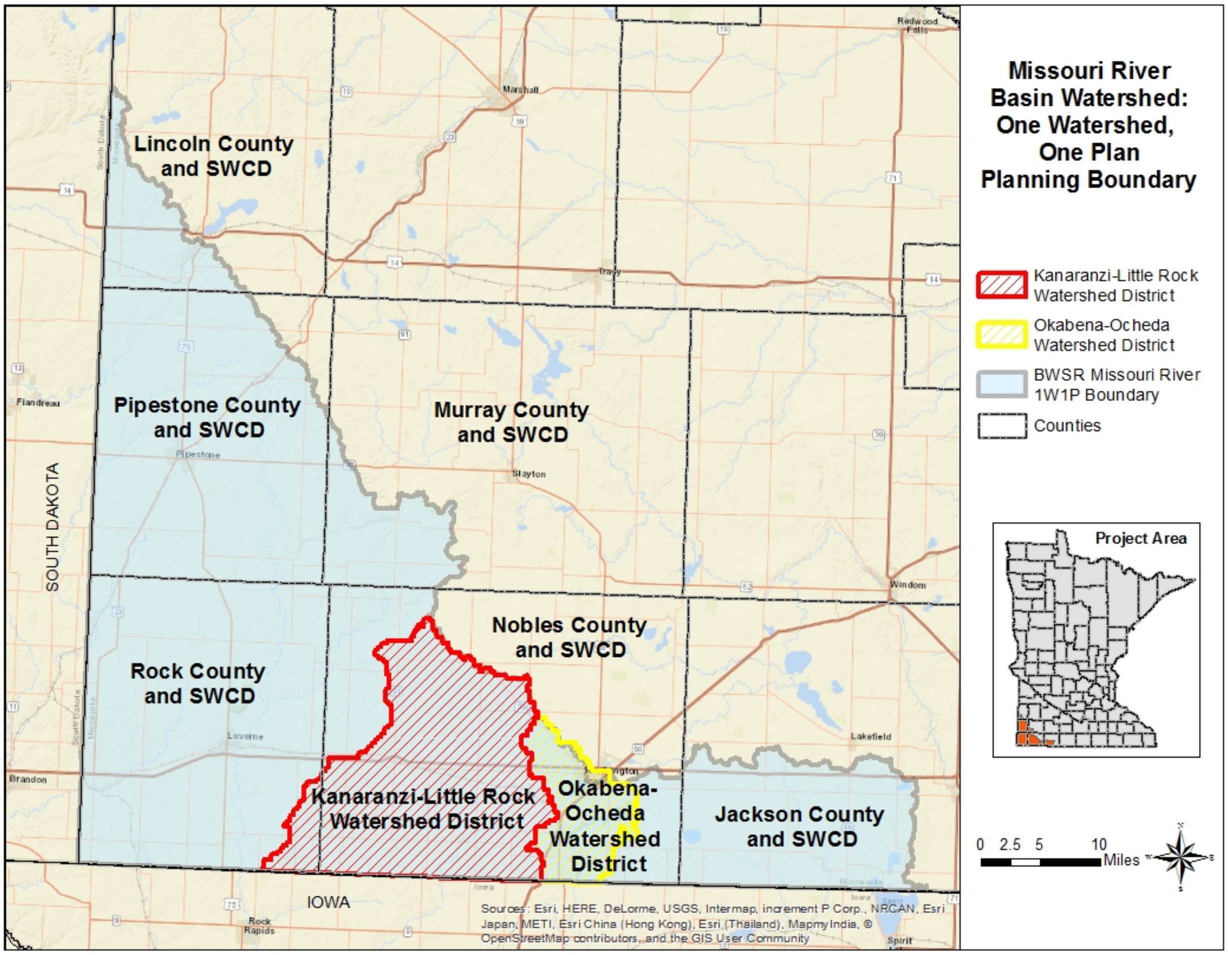
1 BACKGROUND

The Counties of Jackson, Lincoln, Murray, Nobles, Pipestone and Rock (Counties), by and through their respective County Board of Commissioners, and the Jackson, Lincoln, Murray, Nobles, Pipestone and Rock Soil and Water Conservation Districts (SWCDs), by and through their respective SWCD Board of Supervisors, and the Kanaranzi-Little Rock and Okabena-Ocheda Watershed Districts (WDs), by and through their respective Board of Managers were selected in the 2016 planning year, by the Minnesota Board of Water and Soil Resources (BWSR), to complete a One Watershed One Plan (1W1P). Collectively, the parties are called the "Missouri River Watershed Partnership" (hereafter referred to as the "MRW Partnership"). The MRW Partnership recognized the importance of partnerships to plan and implement protection and restoration efforts for the Missouri River Watershed. The Missouri River Watershed 1W1P planning area is shown in **Figure 1**.

The MRW Partnership is responsible for preparing a Comprehensive Watershed Management Plan (Plan) under the 1W1P effort. The members of the MRW Partnership share an interest in and the statutory authority to prepare, adopt, and assure implementation of a Plan for the Missouri River Watershed.

This document describes the participation process for developing the Plan.

Figure 1. Missouri River Watershed 1W1P Location.



2 AUDIENCE & ROLES

One of the Guiding Principles of 1W1P is that the process “must involve a broad range of Stakeholders to ensure an integrated approach to watershed management.” A Stakeholder is defined as a party (person or group) who holds a vested interest in the outcome of the planning process. The primary outcome resulting from the Plan will be a targeted implementation plan, focused on the implementation of specific management practices, structural best management practices, capital improvement projects, educational and outreach programs, monitoring activities, and regulatory controls. A variety of Stakeholders may be directly or indirectly affected.

Participants in the planning process are comprised of several potential target audiences or groups and collectively represent the Stakeholders. These groups are described in the following sections.

2.1 Policy Committee

The primary role of the Policy Committee is to collectively develop and adopt, as local government units, a coordinated watershed management plan pertaining to the area within the Missouri River Watershed. Bylaws have been adopted to guide the decision-making process, leadership, and direction of process for the Policy Committee. Expectations are that the Policy Committee will review and approve a draft of the plan outline, review and approve information about the priority resources, priority resource concerns and issues affecting the priority resource concerns, review and approve the targeted implementation plan, and review and approve the Plan. An additional expectation is that members of the Policy Committee will engage in constructive discussion and debate about issues addressed by the Plan and provide consensus direction on plan development matters, to the Planning Work Group. The Policy Committee will review and approve membership on the Advisory Committee. The Policy Committee has additional obligations as described by The Memorandum of Agreement executed by the MRW Partnership.

2.2 Advisory Committee

Membership on the Advisory Committee may consist of members from the Planning Work Group, other local government staff, the state's main water agencies and/or plan review agencies, the general public, trade organizations, nonprofit organizations, and special interest groups. Leaders within the local community are valued members of the Advisory Committee. Membership to the Advisory Committee is reviewed and approved by the Policy Committee.

The purpose of an Advisory Committee is to make recommendations on the Plan and the Targeted Implementation Schedule to the Policy Committee, including identification of priority resources, priority concerns, and issues affecting the priority concern. Expectations are that members of the Advisory

Committee will communicate Plan related activities to their respective organizations. Advisory Committee members are expected to communicate practical concerns during the plan development process and to assist the Policy Committee in ensuring a credible Plan development process.

Each state or federal agency or organization participating on the Advisory Committee shall designate one lead representative and one designated alternate. An agency's or organization's guidance, input, and decisions shall be communicated through the lead representative or designated alternative. The lead agency or organization representative is expected to coordinate information flow and communication within their agency or organization.

2.3 Planning Work Group

The Planning Work Group is comprised of local staff, local water planners, local watershed staff, and local SWCD staff for the purposes of logistical and day-to-day decision-making in the planning process. The Planning Work Group includes the consultant and other advisors responsible for assembling the draft and final Plan. Members of the Planning Work Group are responsible for providing information needed for the planning process, reviewing and accepting draft plan related information, and assisting in Plan development. Identifying priority resources, priority resource concerns, and issues affecting the priority resource concerns for their specific county is also the responsibility of the Planning Work Group.

2.4 General Public

Various public meetings and hearings will be completed as part of the Plan development process. The general public is expected to be an important Stakeholder group. Input from the public meetings will be used to ensure a complete list of priority resources and priority resource concerns is developed. The role of the general public is expected to include identifying issues affecting the priority resource concerns. The public will be engaged to rank concerns establishing a "public priority resource concern" rank. An additional role for the general public is expected to include review of and discussion about the targeted implementation schedule and ability to achieve the measurable goals.

3 INTENT FOR STAKEHOLDER INVOLVEMENT

The principal intent of involving stakeholders during the planning process is to build acceptance of the Plan and the recommended solutions described by the Targeted Implementation Schedule. Acceptance is critical because the MRW Partnership is focused on actively utilizing their Plan to implement projects and programs within the Missouri River Watershed. Successful implementation will depend highly on the degree to which the Stakeholders believe their concerns, issues, or expectations are addressed within the Plan.

The MRW Partnership intends for the Stakeholder involvement process to be active, genuine, and credible. To that end, the Stakeholder groups will be involved early in the planning process and will remain engaged through plan completion. Input provided by Stakeholders is intended to help ensure the comprehensiveness of the Plan and validate the implementation priorities of the MRW Partnership and Stakeholders.

4 TOOLS FOR STAKEHOLDER INVOLVEMENT

The MRW Partnership expects to use several tools to involve Stakeholders. These tools include:

- Inform the stakeholders of status and progress by posting information on a website, including document drafts as they become available.
- Convening meetings and workshops with Stakeholders at key milestones (refer to Appendix B) to discuss relevant content and obtain input.
- Use of existing "standing" committees within each county, including local water plan advisory committees. These committees tend to include broad representation.

There are many methods for conveying information and communicating messages. This Stakeholder Participation Plan will utilize a variety of tools as appropriate and beneficial for sharing progress and soliciting input. Information about the planning process can be obtained from the Missouri River Watershed 1W1P website at www.noblesswcd.org/one-watershed-one-plan.

5 CONDUCT

The conduct of members of the various Stakeholder Groups —how the committees function and affect the process—will be based on the overall intent of building acceptance of the Plan through a credible yet timely process. Where appropriate, the MRW Partnership will strive to achieve consensus on Plan related matters. However, because of the diversity of issues and range of resources, full agreement between or among all Stakeholders is not realistic or expected. Within the Policy Committee, bylaws specify voting (Article V). The ultimate responsibility for the content of the Plan rests with the Policy Committee. Participants are expected to act in a professional, constructive, and contributory manner. Members failing to act in good faith during the planning process can be removed from the Advisory Committee by consensus of the Policy Committee.

6 STAKEHOLDER LIST

6.1 Policy Committee Members

The Policy Committee Members, their affiliation, and contact information are listed in **Table 1**.

Table 1. Policy Committee Members

Name	Organization	Role	Address	City/State/Zip	Phone	e-mail
Scott McClure	Jackson	Primary	71866 375th Ave	Lakefield MN 56150	507-330-4576	scott.mcclure@co.jackson.mn.us
James Eigenberg	Jackson	Alternate	1121 4th Ave	Heron Lake MN 56137	507-793-2832	james.eigenberg@co.jackson.mn.us
Dan Riley	Jackson SWCD	Primary	33762 760 St	Round Lake MN 56167	507-945-8910	driled92@gmail.com
Dennis Daberkow	Jackson SWCD	Alternate	44331 860 St	Lakefield MN 56150	507-662-5320	
Coleen Gruis	KLR WD	Primary	316 N Bishop Ave	Rushmore MN 56168	507-360-5687	ggruis@live.com
Jerry Brake	KLR WD	Alternate	13212 Edwards Ave	Wilmont MN 56185	507-360-9430	no-email
Joe Drietz	Lincoln	Primary			507-694-1830	joedrietz@gmail.com
Cory Sik	Lincoln	Alternate			507-920-5737	
Conrad Schardin	Lincoln SWCD	Primary			507-530-2797	schardin@itctel.com
Ronald Bunjer	Lincoln SWCD	Alternate			507-530-3328	rbunjer@frontiernet.net
Gerald Magnus	Murray	Primary	1636 101 St	Slayton MN 56172	507-836-6710	gmagnus@co.murray.mn.us
Lori Gunnink	Murray	Alternate	330 Lakeview Ave	Lake Wilson MN 56151	507-879-3586	lgunnink@co.murray.mn.us
Karen Hurd	Murray SWCD	Primary	1116 50th Ave	Lake Wilson MN 56151	507-760-1255	kphtax67@gmail.com
Gary Brinks	Murray SWCD	Alternate	1577 US Hwy 59	Slayton MN 56172	507-763-3775	garybrinks@frontiernet.net
Gene Metz	Nobles	Primary	17190 180 St	Lismore MN 56155	507-920-8990	metzgene@gmail.com

Robert DeMuth Jr.	Nobles	Alternate				
Paul Langseth	Nobles SWCD	Primary	35505 280 St	Worthington MN 56187	507-360-5844	paul.langseth@gmail.com
Jim Knips	Nobles SWCD	Alternate	13510 Chaney Ave	Lismore MN 56155	507-360-9841	jdknips@gmail.com
Casey Ingenthron	O/O WD	Primary	26962 Plotts Ave	Worthington MN 56187	507-360-0770	cri.caseyi@gmail.com
Les Johnson	O/O WD	Alternate	28967 Co Hwy 35	Worthington MN 56187	507-360-6898	lucky.les@frontiernet.net
Luke Johnson	Pipestone	Primary	224 W Main St	Pipestone MN 56164	507-825-4404	mntokenman@yahoo.com
Les Nath	Pipestone	Alternate	217 10th St E	Jasper MN56144	507-220-9040	les.nath@co.pipestone.mn.us
Ken Christensen	Pipestone SWCD	Primary	994 141 St	Pipestone MN 56164	507-820-1191	kchrist1474@hotmail.com
Cal Spronk	Pipestone SWCD	Alternate	84 130 Ave	Edgerton MN 56128	507-442-5334	cspronk@frontiernet.net
Stan Williamson	Rock	Primary	165 151 St	Garretson SD 57030	507-597-6268	swill@alliancecom.net
Gary Overgaard	Rock	Alternate	1923 131 St	Magnolia MN 56158	507-283-8795	garyovergaard@co.rock.mn.us
Josh Ossefoort	Rock SWCD	Primary	1580 170 Ave	Luverne MN 56156	605-553-0312	joshossefoort@yahoo.com
Angie Raatz	Rock SWCD	Alternate	280 241 St	Jasper MN 56144	507-215-1951	angieraatz005@gmail.com

6.2 Advisory Committee Members

The Advisory Committee Members, their affiliation, and contact information are listed in **Table 2**. Note that many of the Planning Work Group Members are also on the Advisory Committee.

Table 2. Advisory Committee Members

Name	County	Affiliation	Address	City/State/Zip	Phone	E-mail
Amanda Strommer	MN Dept. of Health	MN Dept. of Health			507-476-4241	Amanda.strommer@state.mn.us
Mark Hanson	MPCA	MPCA			507-476-4259	Mark.hanson@state.mn.us
Russ Derickson	MN Dept. of Ag	MN Dept. of Ag			507-752-4652	Russ.derickson@state.mn.us
Heidi Peterson	MN Dept. of Ag	MN Dept. of Ag			651-201-6014	heidi.peterson@state.mn.us
Brian Nyborg	DNR	DNR	175 County Rd 26	Windom MN 56101	507-831-2900	Brian.Nyborg@state.mn.us
Barbara Weisman	DNR	DNR	500 Lafayette Rd	St Paul MN 55155	651-259-5147	barbara.weisman@state.mn.us
Robert Collett	DNR	DNR			507-359-6050	robert.collett@state.mn.us
Juline Holleran	DNR	DNR			651-757-2442	Juline.holleran@state.mn.us
Loren Clarke	Jackson County	NRCS Dist. Conservationist	603 S Hwy 86	Lakefield MN 56131	507-662-6682 x 3	loren.clarke@mn.usda.gov
Brian Fruchte	Lincoln County	Soybean Producers, crop insurance & seed business	1240 120 St	Verdi MN 56164	605-690-9023	brian@fruechtecrop.com
Dale Sterzinger	Lincoln County	SWCD	200 S Co Hwy 5 Ste 2	Ivanhoe MN 56142	507-694-1630 X 112	dale.sterzinger@mn.nacdnet.net
Jason Overby	LPRW	Manager LPRW	415 E Benton St	Lake Benton MN 56149	507-368-4248	lprw@itctel.com

John Busman	Murray	Corn/Soybean, Educator, Ag Business	240 2nd St	Chandler MN 56122	507-227-2301	busmanjd@gmail.com
Karen Hurd	Murray	Citizen, SWCD Supervisor	1116 50th Ave	Lake Wilson MN 56151	507-760-1255	kphtax67@gmail.com
Jared Ahlers	Nobles County	Farmer, precision ag	37599 CO Hwy 35	Worthington MN 56187	507-360-6706	jaredarepair@gmail.com
Trevor Wintz	Nobles County	Crop/Livestock Producer Bio Engineering	28177 St Hwy 264	Round Lake MN 56167	507-450-2173	
Scott Rall	O/O WD	Sportsman, Newspaper, PF Chapter President	1321 Smith Ave	Worthington MN 56187	507-360-6027	scottarall@gmail .com
Nicole Schwebach	Pipestone SWCD	Farm Bill Tech Pipestone Co & Rock River Wshd	119 2nd Ave SW Ste 13	Pipestone MN 56164	507-825-1185	nicole.schwebach@co.pipestone.mn.us
David Johnson	Pipestone SWCD	Farmer	267 221st St	Ward SD 57026	507-825-6375	no -email
Joel Adelman	Pipestone SWCD	Waste Water Supervisor City of Pipestone	119 2nd Ave SW	Pipestone MN 56164	507-825-2506	adelman@cityofpipestone.com
Laura DeBeer	Pipestone SWCD	Water Resource Tech Pipestone SWCD	119 2nd Ave SW Ste 13	Pipestone MN 56164	507-825-1185	laura.debeer@co.pipestone.mn.us
Seth Hendriks	Pipestone	Pipestone Monument	36 Resevation Ave	Pipestone MN 56164	507-825-5464 X222	seth_hendriks@nps.gov
Arlyn Gehrke	Rock	Technical	311 W Gabrielson	Luverne MN 56156	507-283-8862	arlyn.gherke@co.rock.mn.us
Brent Hoffman	Rock	Rock Co Rural Water	541 150th Ave	Luverne MN 56156	320-980-5370	brent.hoffmann@co.rock.mn.us
George Shurr	Rock	Geology Professor	1803 11th St	Ellsworth MN 56129	507-967-2457	georgeshurr@gmail.com
Jay Murphy	Rock	Central crop consultant	603 Cougar Court	Marshall MN 56258	507-828-4011	jmurphy@centrol.com
Scott Ralston	USFW	USFW	49663 Co Rd 17	Windom MN 56101	507-831-2220	Scott_Ralston@fws.gov
Adam Henning	KLR	City Adrian Public Works Supervisor	PO Box 190	Adrian MN 56110	507-483-2680	powerplant@vastbb.net

Brandon Gruis	KLR	Student, Cattle Corn Soybean	18611 290 St	Adrian MN 56110	712-348-1426	bsgruis@jacks.sdstate.edu
Brad Harberts	Nobles SWCD	NC Drainage Coordinator	PO Box 757	Worthington MN 56187	507-360-2909	bharberts@co.nobles.mn.us
Jeff Lais	Nobles SWCD	Cattle Farmer	10480 US Hwy 91	Chandler MN 56122	507-920-8988	jeffl972@yahoo.com
Shane Becker	Nobles SWCD	Citizen	77321 320 Ave,	Worthington MN 56187	507-370-3472	
Peter Bakken	Township board, Farm Bureau	Cattle Farmer, Corn Soybean	138 121st Street	Garretson, SD 57030	605-376-3640	PCBakke@gmail.com
Aaron Meyer	Minnesota Rural Water Association	Minnesota Rural Water Association				aaron.meyer@mrwa.com

6.3 Planning Work Group Members

The Planning Work Group Members, their affiliation, and contact information are listed in **Table 3**.

Table 3. Planning Work Group Members.

Name	County	Address	City/State/Zip	Phone	e-mail
Doug Goodrich	BWSR	1400 E Lyon St	Marshall MN 56258	507-537-6636	doug.goodrich@state.mn.us
Ed Lenz	BWSR	1400 E Lyon St	Marshall MN 56258	507-537-6374	Ed.lenz@state.mn.us
Jason Beckler	BWSR	1400 E Lyon St	Marshall MN 56258	507-537-6615	jason.beckler@state.mn.us
Mark Hiles	BWSR	21371 St Hwy 15	New Ulm MN 56073	507-359-6077	mark.hiles@state.mn.us
Andy Geiger	Jackson	603 S Hwy 86	Lakefield MN 56150	507-662-6682 x4	andy.geiger@co.jackson.mn.us
Chris Bauer	Jackson	603 S Hwy 86	Lakefield MN 56150	507-662-6682 x4	chris.bauer@mn.nacdent.net
John Shea	KLR WD	1567 McMillan St Ste 3	Worthington MN 56187	507-376-9150	john.shea@noblesswcd.org
Dale Sterzinger	Lincoln	200 S Co Hwy 5 STE 2	Ivanhoe MN 56142	507-694-1630 X 112	dale.sterzinger@mn.nacdnet.net
Craig Christensen	Murray	2740 22nd St	Slayton MN 56172	507-836-6697	cchristensen@co.murray.mn.us
Jean Christoffels	Murray	2500 28th St	Slayton MN 56172	507-836-1166	jchristoffels@co.murray.mn.us
Sara Soderholm	Murray	2500 28th St	Slayton MN 56172	507-836-1166	ssoderholm@co.murray.mn.us
Kathy Hendershiedt	Nobles	PO Box 187	Worthington MN 56187	507-295-5322	khenderschiedt@co.nobles.mn.us
Ross Behrends	Nobles SWCD	1567 McMillan St Ste 3	Worthington MN 56187	507-376-9150	ross.behrends@noblesswcd.org
Dan Livdahl	O/O WD	PO Box 144	Worthington MN 56187	507-372-8228	dan.livdahl@okabenaochedawd.org
Adam Ossefoort	Pipestone	119 2nd Ave SW Ste 13	Pipestone MN 56164	507-825-1185	adam.ossefoort@co.pipestone.mn.us
Kyle Krier	Pipestone	119 2nd Ave SW Ste 13	Pipestone MN 56164	507-825-1185	kyle.krier@co.pipestone.mn.us
Arlyn Gherke	Rock	311 W Gabrielson	Luverne MN 56156	507-283-8862	arlyn.gherke@co.rock.mn.us
Doug Bos	Rock	311 W Gabrielson	Luverne MN 56156	507-283-8862 x 4	doug.bos@co.rock.mn.us

7 SCHEDULE

Missouri River Watershed One Watershed, One Plan
Proposed Schedule

Meeting Number	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
Meeting Type (IP=In-person, CC=Conference Call)	IP	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD
Meeting Attendees (PWG=Planning Work Group, AC=Advisory Committee, PC=Policy Committee)	PWG, AC, PC	PWG/AC	PWG/PC	PWG/AC	PWG/PC	PWG/AC	PWG/PC	PWG/AC	PWG/PC	PWG/AC	PWG/PC	PWG/AC	PWG/PC	PWG/AC	PWG/PC	PWG/AC	PWG/PC	TBD	TBD	TBD	TBD
Year	2017							2018												2019	
Month	June	July	August	September	October	November	December	January	February	March	April	May	June	July	August	September	October	November	December	January	February
Meeting Date	5	12	9	13	11	8	13	10	14	14	11	9	13	11	8	12	10	14	12	9	13
Task 1. Selection of Plan Consultant (Completed by Local Staff and Local Planning Committees pior)																					
Task 2. Committees, Notifications, and Initial Planning Meeting																					
Task No. 2.3: Aggregate watershed information and review for commonalities, conflicts, and gaps																					
1W1P Vision (Presentation)	Present																				
Meeting Schedule	Decide																				
Participation Plan	Intro/Discuss	Decide																			
Plan Outline	Decide																				
Draft Prioritization Matrix	Introduce																				
Task 3. Draft the Plan																					
Task No. 3.1: Draft Plan - Continue to aggregate watershed information																					
Prioritization Matrix	Introduce	Discuss	Decide																		
Section 1: Introduction				Introduce	Discuss	Decide															
Land and Water Resources Inventory				Introduce	Discuss	Decide															
Task No. 3.2: Draft Plan - Analyze and Prioritize Issues																					
Prioritization Process			Intro/Discuss	Decide	Implement																
Resource Concern and Issues: Maps		Introduce	Discuss	Decide																	
Emerging Concerns				Intro/Discuss	Decide																
Section 2: Identification and Prioritization of Resources						Intro/Discuss	Decide														
Task No. 3.3: Draft Plan - Establish Measurable Goals																					
Format: Measurable Goals, Strategies, and Actions			Introduce																		
Strategies and Actions				Introduce	Discuss	Discuss	Decide														
Measurable Goals				Introduce	Discuss	Discuss	Decide														
Protection / Restoration Definitions and Mapping			Intro/Discuss	Decide																	
Section 3: Establishment of Measurable Goals								Introduce	Discuss	Decide											
Task No. 3.4: Draft Plan - Develop a targeted and measurable implementation schedule and programs																					
Additional Analysis (i.e. Nitrate Infiltration Risk Maps)							Introduce	Discuss	Decide												
Targeted Implementation Schedule								Introduce	Discuss	Discuss	Decide										
Model / Tool Implementation Approach						Discuss	Discuss	Discuss	Discuss	Decide											
Targeted Implementation Plan (from model / tool results)										Discuss	Decide										
Section 4: Targeted Implementation Schedule											Introduce	Discuss	Decide								
Implementation Programs; Capital Improvements					Introduce	Discuss	Discuss	Discuss	Discuss	Decide											
Section 5: Implementation Programs											Introduce	Discuss	Decide								
Task No. 3.6: Draft Plan - Write Plan Final review draft																					
Executive Summary												Introduce	Decide								
Drafted Final Plan														Introduce	Decide	Decide	Decide (PC)				
4. Formal Plan Review and Public Hearing																					
Task No. 4.1 (Formal review) and 4.2 (Public Hearing)																Completed by Local Staff / Planning Committees					
Task No. 4.3: Write Final Plan																				Introduce	Decide
Tasks 5 (Plan Approval by BWSR), 6 (Local Adoption), and 7 (Grant Reporting) of Workplan to be completed by Local Staff and Local Planning Committees																					

Regular Meeting Times		
	PC	9:30 AM- 12:30 PM
	PWG	1:00 - 4:00 PM
	AC	4:30 - 7:30 PM

Notes: "Introduce, Discuss, Decide" primarily relates to PWG meetings, and is intended to set planning process pace. AC and PC members will review and approve developed material as available.
Schedule is intended to document planning pace of progress and anticipated scheduled meetings. However, meeting dates and meeting committees may change to meet planning process needs.

Appendix D
Comments Received During Planning Process

MISSOURI RIVER WATERSHED
Comprehensive Watershed Management Plan

Response to Comments Received Prior to and During the 60-Day Notification and Public Hearings
Missouri River Watershed Comprehensive Watershed Management Plan
5/31/2019

KEY
Material Comments represent changes in material and content of the plan.
Editorial Comments represent spelling, grammatical, clarification, or visual issues with graphics.
Note Generally consist of a statement expressing a perspective.

Commenter	Comment #	Page / Section	Comment	Material	Editorial	Note	Plan Change Made (Yes/No)	Comment Response / Action
60-Day Notification								
BWSR	1	General	A clearer description of the conservation delivery system should be included. This should include a general discussion of the partners' roles and authorities in implementing the Plan.			x	No	Agree. We believe more information can be included in future planning efforts to better guide conservation delivery decision making on the ground. See Emerging Issue "Conservation Practice Delivery Mechanism" (Section 2.4.2.2) for more information.
	2	General	We appreciate that the group has identified a tiered implementation based on funding levels. Identifying efficiencies using known funds when compared to the total amount needed is valuable information in determining necessary funding allocations.			x	No	Comment acknowledged with thanks.
	3	General	Maps – General - Some maps show location of data points where analysis is performed or observed but don't list results or aren't really referenced in the plan, remove items that have no direct bearing on plan actions or prioritization otherwise explain better why the map subject exist – may have a better place in the resource inventory.		x		Yes	Maps revised to remove unnecessary shapefiles (e.g. MPCA biological monitoring sites).
	4	General	The baseline implementation level assumes statutory obligation and ordinance implementation levels will go unchanged. Will the local government units (LGU) self-report an audit to the partnership to ensure that this is taking place?			x	No	LGUs reporting responsibilities will be conducted per state agency requirements.
	5	General	The progress toward goal breakdown charts by planning region will be useful in building implementation plans, the planning group is to be commended for building implementation schedules specific to planning regions.			x	No	Comment acknowledged with thanks.
	6	General	While the process to prioritize issue statements yields ranked issue statements and action items for this planning effort, the concern is the ambiguity 'issue' connection to spatially prioritized areas for implementation of these actions – with this plan we have the what first, perhaps, but not necessarily the "where first" in the overall planning area. After taking into account waters that are of greatest local concern along with prioritized issues, there should be a section in the plan outlining a couple of areas on the planning area map where it would make the most sense to concentrate efforts in order to best address those issues. In doing so, this provides an area for any implementation funds to point to for focusing efforts as well as a starting point for future plan assessment and evaluation. A robust discussion and description on this subject would lend itself to other comments in this letter.	x			Yes	Subwatersheds (HUC 12) have been priortized to geographically target areas based on priority issues identified in the plan (see first page of each implementation profile). A methodology for this prioritization process has been included in Plan Appendix O.
	7	Executive Summary	Page ES-2 identifies as "14 lakes in the eastern half of the watershed; land and water resources inventory (appendix A) only lists eight in total.	x			Yes	Per MPCA Comment #13, there was a typo in the WRAPS that was cited. Executive summary changed to reflect there are 40 lakes in the planning area.
	8	Executive Summary	Page ES-2, ES-3 – perhaps expand on the definitions of the "tiered priorities" ("A" being highest and "E" being lowest priority) how will the lower priorities relate to implementation or future prioritization.		x		Yes	Revised text: "From this initial inventory, 27 issues emerged as "priority issues" (shown as either A or B Priority Tier) (Table ES-1). These issues were assigned a measurable goal and will be considered the focus for initial implementation efforts. Those issues designated as Tier C, D, and E are not anticipated to be directly addressed within this plan.
	9	Executive Summary	Table ES-2 - Good summary of targeted implementation results; will be a useful starting point for pace of progress and measuring progress toward the plan in reporting.			x	No	Comment noted with thanks.
	10	Section 2	2.2 – last paragraph – relating back to executive summary – show relation of these issues to future planning evaluation.		x		No	Change noted in Executive Summary to be consistent with 2.2
	11	Section 2	2.3.1 – Table 2-4 Priority Concerns and Issues addressing fecal coliform. Developing goals for bacteria? (Issue 1.1.2, 2.1.2) Specific Implementation?			x	No	Yes, as these are priority (Tier A or B) issues. See Measurable Goal 3.2.6 for issue 2.1.2 and Measurable Goal 3.2.2 for 1.1.2. Actions in each targeted implementation schedule relate to measurable goals (SW-Bacteria and GW - Bacteria).
	12	Section 2	2.4.2 Policy and Funding Emerging Issues. Title is confusing. Consider "Noted Impediments to Effective Water Plan Management".		x		Yes	Title revised as suggested.
	13	Section 2	2.4.2.1 – Second paragraph – an example of the use of the term "block" funding – request the word "block" be removed as the term has different connotations as currently used in state funding. This issue pops up in multiple areas through the report - suggest search and review for the word 'block'.		x		Yes	Block funding changed to "Watershed-based Funding"
	14	Section 2	2.4.2.5 – Are wind and solar activities covered by zoning authorities? This section might be rolled into land use due to ethanol/bio diesel in the previous section.		x		No	Yes. See Section 5.1.5.2 for a discussion about zoning authorities related to wind.
	15	Section 2	Figure 2-1 – since arsenic values are listed as 10 ug/L for public health risk, Arsenic symbols should break at 9.9 micrograms/L instead of 19.9.		x		Yes	Map legend changed to 0-4.9 ug/L; 5-9.9 ug/L; 10-49.9 ug/L; 50+ug/L

Commenter	Comment #	Page / Section	Comment	Material	Editorial	Note	Plan Change Made (Yes/No)	Comment Response / Action
	16	Section 2	Figure 2-3 – Streams listed as assessed are symbolled in green – a few of these aren't listed as assessed for lack of info; check to be certain they are assessed (same would go for Figure 2-11).		x		No	These streams were pulled directly from the MPCA Assessed Waters (2016) layer.
	17	Section 2	Figure 2-4 - Is this a map of areas where invasive species of carp have been documented or is this a potential threat as stated in the explanation – key should be clearer.		x		Yes	Revised explanation: Through connectivity analysis, the DNR has identified the area covered by the teal crosshatch at risk of becoming infested by the invasive Bighead Carp and Silver Carp, as many waterbodies in this area are listed as infested for the species.
	18	Section 2	Figure 2-5 – Meaning of 'Agricultural' Drainage System isn't clear – dashed lines don't come across well in the map at this scale. Recommend using 103E Public Drainage Systems.		x		Yes	From Figure 2-7: "Included in this map are known ditch locations from local counties. Also included are reaches classified as "ditch" in the DNR 24K River and Streams layer, and as "Canal / Ditch" in the NHD Flow line data layer. Agricultural drainage systems removed from this map, as it is not needed to describe issues impacting surface runoff.
	19	Section 2	Figure 2-8 – Dam location map may be dated - ground truth; calcareous fens – if they exist, not seeing them on the map (clipped?); MPCA Biological Sampling Sites shown – are the results listed somewhere or play a part in the prioritization.		x		Yes	Dam location is derived from DNR (Inventory of Dams in Minnesota). Calcareous fens locations added. Removed biological sampling sites as the information is not used elsewhere in the plan.
	20	Section 3	Measurable Goal Sheets – Really like this idea – Assuming the idea is to treat these as goal documents independent of the plan, the reference callouts to issues and implementation within these sheets are very confusing for a reader unfamiliar with the plan. Not evident how specific goals and (multiple) implementation actions are related to issues. These pages should be easy to follow and succinct.			x	No	Correct, these are intended to summarize the goal in one document. The document will function independently with someone familiar with the plan, but there is still a need to refer to Section 4 for actions that get implemented to make progress towards stated goals.
	21	Section 3	Measurable Goal Sheets – Should format consistently (Issue explanation on one side, goals on the other) tend to flip back in forth in positioning; might be best to order the explanation before the actual goals on these sheets.			x	No	Format retained as much as possible. There are some instances where ordering of text changed to accommodate information (see MG 3.2.5). Here, if format was not changed, there would not be enough page space for the goals, which would necessitate a new page that is predominately white space.
	22	Section 3	Section 3.2, page 3-3, strike "BWSRs" when referencing the Nonpoint Priority Funding Plan (multiple instances). – (Minnesota's Nonpoint Priority Funding Plan for Clean Water Fund Implementation).		x		Yes	"BWSR" removed from reference as suggested.
	23	Section 3	3.2.3 Groundwater Quality and Quantity – are "low risk nitrogen infiltration areas" related to quantity somehow? I would assume that heavy clay would be low risk but really doesn't do much for quantity. Are we saying "target retention areas on low risk of infiltration areas"? – Not quite clear. Make it clear why targeting a lowest risk area is a priority.		x		Yes	Added statement to 3.2.1: "Nitrogen infiltration risk maps were developed to identify areas of high risk (where potential recharge and nitrogen loads are high) and low risk (where nitrogen loads are low)."
	24	Section 3	3.2.4, 3.2.5, 3.2.6, 3.2.7 - "Length of stream impaired" are not measurable goals in these instances as stream length doesn't enter into it – because the WRAPS goals are based on the pollutant reduction needs per reach, its either all or nothing for the impairment on a "reach-specific" scale. Unless there will be multiple assessments per reach, might do well to make the goal # of impaired reaches or some other measurable goal.	x			Yes	Reach-specific measurable goal changed to: "Reduction in the number of streams classified as impaired by meeting a load allocation (where a TMDL has been completed)."
	25	Section 3	3.2.13, 3.2.14, 3.2.15, 3.2.16, 3.2.19, 3.2.20 – Long term goals should all state a reevaluation and assessment of resource/activity every 10 years.	x			Yes	Long-term goal revised for each to "Reevaluation and assessment of resource/activity every 10 years to consider further extension."
	26	Section 3	3.2.11 Wetlands. Will the group take credit/keep account of wetland creation or restoration completed by groups like USFWS, DNR, DU?			x	No	Yes- if local dollars are spent and to the extent of groups working cooperatively using the plan.
	27	Section 3	3.2.18 Manure Application – Outside of mapping manure application and estimated rates, this goal really doesn't seem to have goals that differ from Goal 3.2.17 (SOM Content)– could be consolidated. If we are opting to keep this goal, we will have to clarify how we target this action and what the resource outcome will result.	x			Yes	Consolidated MG 3.2.18 (Manure Application) with 3.2.17 (Rural Land Stewardship - Soil Health).
	28	Section 4	Pages 4-11 through page 4-34 – where there is a callout in the charts regarding progress toward goals there seems to be an alternation between a the term "short term goal" and progress toward "goal" (example) 4-14 and 4-20. While what is listed is factual, have to do some mental gymnastics		x		Yes	Typo error resolved to consistently refer to "short-term goal."
	29	Section 4	Table 4-7 – Should include activities that use tools available through this planning effort to explore, target, and set a schedule for possible larger scale retention projects and flood control opportunities.	x			Yes	Revised CI-7: "Repair and maintain, and implement additional flood storage practices and larger scale retention projects."
	30	Section 4	Section 4.2.1 – This is a good section; adds benefit to this plan.			x	No	Comment acknowledged with thanks.
	31	Section 4	Pgs. 4-13, 4-19, 4-25, 4-31 consider adding creation and restoration of wetlands as actions to affect ground water nitrates and ground water supplies (Goal 3.2.1 and 3.2.3).	x			Yes	Added "x" under GW- Nitrate-Nitrogen and GW-Supplies for all actions to "Create or restore wetlands."

Commenter	Comment #	Page / Section	Comment	Material	Editorial	Note	Plan Change Made (Yes/No)	Comment Response / Action
	32	Section 4	Pgs. 4-17, 4-23, 4-29 (Surface Water Quality Charts): The term "low restoration effort" would indicate that an impairment exists; there are no corresponding impairments in a few instances (-551, -583, -501, -514, -519, -502, -507). Seem to be related to TSS or TP. **ALSO – The tabular data has reaches listed as "threatened impairment risk" when they are categorized as impaired – again, seems to be TSS or TP related (-527, -523, -520, -511).		x		Yes	Text revised to clarify map interpretation (further explanation in Section3). "Streams that are nearly or barely impaired for a particular water quality parameter are summarized in the table below. Please note that a stream could be listed as "impaired" for one parameter (e.g. total suspended sediments) but merit protection for another (e.g. total phosphorus).
	33	Section 4	Pg. 4-23: Are we setting goals and measuring for E. coli, reaches -553 and -528 are a non-factor in the absence of bacteria/other measurable goals.			x	No	Yes, as these are priority (Tier A or B) issues. See Measurable Goal 3.2.6 for issue 2.1.2 and Measurable Goal 3.2.2 for 1.1.2. Actions in each targeted implementation schedule relate to measurable goals (SW-Bacteria and GW - Bacteria).
	34	Section 5	5.1.4 Should be something more to outline O/M requirements, project easements, etc. if outside funding will be considered for capital improvement projects (projects that have an effective life over 25 years) – may refer to the BWSR Grants Administration Manual for ideas on a policy for this planning group.		x		Yes	Included language "For purposes of this plan, a capital improvement is defined as a major, non-recurring expenditure for the construction, repair, retrofit, or increased utility or function of physical facilities, infrastructure, or environmental features. Capital improvements are beyond the "normal" financial means of the MRW 1W1P planning participants, and therefore require external state and federal funding. To be considered a capital improvement, project must have an anticipated cost of at least $250,000."
	35	Section 5	Table 5-2 – Though these projects may well be implied in the implementation schedule, there are no Capital Improvements Projects listed for the Kanaranzi-Little Rock WD for consideration in this table.			x	No	KLRWD is covered by the Nobles County Local Water Plan. No other CIPs are recommended for likely implementation efforts at this time.
	36	Section 5	5.1.5.1 Cite Statute as Section 103F.48. in Riparian Protection subject paragraph.		x		Yes	Statute cited as suggested.
	37	Section 5	5.1.5.3 First sentence might read "Portions of the Missouri River Watershed are within the . . . ; the way the sentence currently reads seems to indicate that the Missouri River Area is a subsection of the two watershed districts.		x		Yes	Text revised as suggested.
	38	Section 5	Table 5-3; pg. 5-18 – "Public Drainage Systems:" – these activities should be listed as statutory responsibilities; also 103E activities should be listed separately from buffer compliance specifically to 103F.48 two separate sets of rules when it comes to buffers.	x			Yes	Public drainage systems moved to statutory responsibilities; Buffer compliance listed separately.
	39	Section 5	5.3.1 – … fiscal and administrative duties will be assigned to a planning entity… the term "planning entity" should be clarified or changed to something like "member LGU" or member of original planning partnership.		x		Yes	Text revised to "member LGU" as suggested.
	40	Section 5	5.3.4.2 Biennial Evaluation. The Biennial Budget Request is not an evaluation. This section would better fit within 5.3.3 Work Planning ALSO, Replace references to BBR with Watershed Based Funding Work Plan Activities.	x			Yes	Revised text in 5.3.3.2: The Planning Work Group will collaboratively develop, review, and submit a Watershed Based Funding Work Plan Activities summary from this plan to BWSR. This summary will be submitted to and ultimately approved by the Policy Committee, prior to submittal to BWSR. The summary will be developed based on the targeted implementation schedule and any adjustments made through self-assessments
	41	Section 5	5.3.4.3 – Should mention ongoing 5 year reviews – section reads as though one review will be done and then the plan will remain in full effect thereafter. Also, plan operating procedures (Step 9.c.) lists required plan updates/revisions every 10 years as well; should be mentioned somewhere in this section.	x			Yes	Text within 5.3.4.3 revised to read "This plan has a ten-year life cycle beginning in 2019. To meet statutory requirements, this plan will be updated and/or revised every 10 years.....in 2024-25 and at every 5 year midpoint of a plan life cycle, an evaluation will be undertaken to determine if the current course of actions is sufficient to reach the goals of the plan, or if a change in the course of actions is necessary."
	42	Section 5	5.3.6 - Unless we are actually signing a Joint Power Agreement establishing a new entity, we should NOT use the language "the legal name for this new entity is…" The policy committee, if it continues in its current form, is advisory to the member LGUs to agree that the members will work together to implement. There may be additional sub-agreements and contracts that lay out how money changes hands between members and how they will share services, equipment, or staff, but those all should be specific for each implementation activity or initiative and may be limited to a subset of the partners, depending on the activity and how they are sharing any roles or financial resource to accomplish implementation. – Review the plan to be certain we aren't obligating an authority where it doesn't exist.	x			Yes	Revised text: "The parties will be entering into an agreement for purposes of implementing this plan, and will be know as the Missouri River One Watershed, One Plan (MR 1W1P) Implementation Group."
	43	Section 5	An Implementation Agreement should be developed to further identify the structure of decision making, financial and admin responsibilities.			x	No	Agreed. The PC is in the process of drafting their implementation agreement.
DNR	1	Letter	DNR staff appreciate the opportunity to contribute to the 1W1P process. Some of our contributed comments and priorities have been incorporated and others are less clear in the plan. Please allow us to reiterate some of our priority concerns. For consistency, the comments that follow are arranged per the priorities in our letter submitted in July 2017.			x	No	All state agency priorities were reviewed and considered during the prioritization process. However, as this is a local plan, some state agency priorities were not identified as local priority issues to be the focus of initial implementation efforts. For mineral and aggregate resources, please see Issue 5.2.8 (Page 2-4). For recreation, please see Issue 4.1.4 (Page 2-4). These issues were not removed from the plan, and cooperative implementation to address these issues is still encouraged.

Commenter	Comment #	Page / Section	Comment	Material	Editorial	Note	Plan Change Made (Yes/No)	Comment Response / Action
	2	Section 3	Short and Long-term goals on page 64 (3.2.10) should allow for graduated targets referencing the differences between the Little Sioux and remainder of the Missouri River watersheds. Numerous existing wetlands and lakes provide storage and retention in the Little Sioux sub-watershed compared to the rest of the Missouri River basin. The Little Sioux also has more “pothole-type” wetlands; and its topography is better suited to wetland restorations than the wetland creation scenarios that are more appropriate for the primary Missouri River Watershed.			x	No	An Altered Hydrology Analysis (Appendix J) was conducted in order to close a data gap about defining if hydrology was altered, and if so, how much, and what acre-feet storage goal would be needed to return to a "natural" hydrologic state. As shown in Appendix J, the analysis is limited by the number of long-term USGS gage data in the plan area. Without additional long-term gages or additional modeling efforts, the storage goal is presented as a representative goal for the whole plan area. This need is addressed in action DGR-13: "Define impact of altered hydrology on surface runoff and water resources within the watershed and utilize results to generate quantitative storage goals for each planning region to mitigate impacts of altered hydrology."
	3	Section 3	Measurable Goal 3.2.10 does not seem to adequately emphasize restoration of hydrologic and ecological functions. Given the watershed’s well-developed drainage-ways, both natural and artificial, storage goals cannot be met using an acre-foot goal alone. A wider variety of conservation practices are needed to achieve both water retention and ecological benefits in the watershed, including in the steeper upper tributaries, which generally support the best soils for agriculture and some of the best aquatic and terrestrial habitats.			x	No	An acre-foot storage goal is required per 1W1P Plan Content Requirements. During implementation, a wide variety of conservation practices will be pursued in order to track or measure progress towards this storage goal, including (but not limited to) large structural projects and soil health improvement (associated with a decrease in runoff volume, measured in acre-feet).
	4	Section 3	Storage as acres of “new wetland” identified in Measurable Goal 3.2.11 discusses “increasing quality wetland areas” using primarily the PTMapp results and other datasets. To achieve ecological benefits, restoring wetlands should be a higher priority than converting non-hydric soils into engineered wetlands.	x			Yes	Text changed to read: "The measurable goal for this comprehensive plan is focused on increasing quality wetland areas, focusing on restoring previously existing wetlands."
	5	Section 4	Action LSR SP-6 on page 115 should ideally separate “Create or restore wetlands” into two rows with preference given to wetland restorations for the multiple ecological and hydrological benefits.		x		No	Text revised to "Create or restore wetlands, with emphasis given to partial or complete restoration."
	6	Section 2	In Figure 2-1, the Arsenic Concentration Average in MDH Monitoring Wells (page 38), one of the graduated-triangle symbols represents a range of 5.0 to 19.9 ug/l. Since the federal drinking water standard is 10 ug/l, it is impossible to tell which wells in this group are below, versus nearly double, the standard.		x		Yes	Map legend changed to 0-4.9 ug/L; 5-9.9 ug/L; 10-49.9 ug/L; 50+ug/L
	7	Section 2	The data set for Figure 2-2 “High Volume Groundwater Users” (page 39) lists the outmoded SWUDS as the source for the Agricultural and Non-crop irrigation categories. The go-to source for current data is the Minnesota Permitting and Reporting System (MPARS), which replaced SWUDS several years ago and is updated weekly. Also, the “non-crop irrigation” category is a misnomer since the locations on Figure 2-11 appear to be for municipal water supply. Finally, in the same figure, consider a more vivid color scheme for high recharge areas, many of which are Drinking Water Source Management Areas.		x		No	There is not a publically accessible MPARS shapefile for use in this plan.
	8	Section 3	The structural or management practices detailed in Measurable Goal 3.2.1 should prioritize projects that enroll permanent easements for practices in Drinking Water Management Areas (page 53).	x			Yes	Text revised to "guide the location and quantity of management practices and structural BMPs that can be implemented to protect groundwater supplies from nitrate-nitrogen. Additional emphasis will be given to projects that enroll permanent easements for practices in Drinking Water Management Areas."
	9	Section 4	The groundwater snapshot figure (pages 95, 101, 107, and 113) displays high risk infiltration areas in dark green, which seems counterintuitive. A yellow/orange or green/yellow graduated legend would dovetail nicely with the red dots that symbolize monitoring wells above the 10 mg/l standard.		x		No	Colors remain green, as it is the only color not represented in the monitoring well protection / restoration categories. This makes the monitoring wells "pop."
	10	Section 5	Many lakes in the Little Sioux River Watershed need protection or restoration. The emphasis on addressing issues with agricultural BMPs and encouraging education and outreach is essential. Lake Bella functions as a surface water reservoir directly connected to the aquifer that supplies drinking water to the City of Worthington, therefore Table 5-2 should include targeted initiatives for managing this extremely sensitive water resource (page 146).	x			No	This was not included as a local CIP priority for implementation efforts.

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	11	Section 4	Many tributaries, streams, and rivers in the watershed are unstable and erosive, as they have become incised and wider, losing beneficial sinuosity and floodplain connectivity. Research indicates near-channel sediment accounts for 60-90% of suspended sediment and bedload contributions to sediment-impaired streams. The plan lists streambank/riverbank erosion as a Priority Tier A concern but is vague about stream/river restoration work, with few implementation strategies. PTMApp does not account for near-channel sediment sources yet. We recognize a perfect model to account for upland and near-channel sources does not exist at this time, but the largest sources of sediment loading (near-channel and bedload sources) are not being targeted in proportion to their contributing volume. This will obviously create a significant limitation to measuring or understanding sediment reduction goals.	x			No	This plan addresses unstable and erosive streams in Measurable Goal 3.2.19. The goal focuses on trampling streambanks, causing excessive erosion and widening (MPCA, 2017). This goal also includes a land use analysis map to target areas within the plan that are at highest risk for streambank trampling (Figure 3-9) which is also used to prioritized focused subwatersheds in Section 4.
	12	Section 4	Riparian stewardship is highlighted with voluntarily limiting livestock access to streams and rivers being encouraged as a perennial vegetation strategy for riparian corridors. Agricultural BMPs appear well detailed. Projects and practices to store water in the upland will provide relief and alter run-off, but there is also an opportunity with natural stream channel restorations to improve channel stability, habitat conditions, reduce sediment and nutrients, and provide multiple ecological benefits.			x	No	See response to Comment 11 above.
	13	Section 3	Page 84: Given the prevalence of pasture in the watershed (Figure 3-9), especially in the western half, consider more emphasis on establishing and maintaining healthy pastures, including rejuvenation initiatives, rotational grazing and off-site watering.			x	No	See Measurable Goal 3.2.19.
	14	Section 4	For the year five update of this plan, DNR recommends an action item related to targeting stream restoration to more specifically address the near-channel sediment contribution. Targeted and prioritized subwatershed stream restoration projects could include re-meandering channelized reaches, restoring floodplain connectivity, reconnecting oxbows, planting protective riparian vegetation and working toward protective riparian flowage easements. Significant coordination and collaboration between landowners, scientists, engineers, local government units, and agency partners is needed. It is important develop a multi-disciplinary team to set goals and objectives, prioritize where to work, complete assessments, develop design plans, and implement projects.			x	No	See response to Comment 11 above.
	15	Section 4	Stream restoration projects that overlap with the Prairie Coteau Conservation Focus Area (discussed further below) can benefit both water quality and habitat. In general, the greatest opportunities for collaboration will occur when Missouri 1W1P goals align with goals in other approved plans.			x	No	Agreed. Per DNR Advisory Committee comments during the plan drafting process, the Prairie Coteau area is highlighted specifically in Action UBSR SP-11, LBSR SP-13, RR SP-13, and LSR SP-14.
	16	Section 4	Prairie Coteau Conservation Focus Area: In parts of the plan that address fish and wildlife habitat strategies, incorporate more information about the Prairie Coteau Conservation Focus Area (PCCFA) established under the MN Wildlife Action Plan 2015-2025. This will facilitate additional targeting and prioritization of multi-benefit implementation projects. Specifically, we request including the PCCFA map below. We can provide a higher resolution image or GIS shapefile on request. The intent of the PCCFA is to reduce ecological threats, improve ecosystem function, and increase the populations of designated Species in Greatest Conservation Need and other priority wildlife. This focus area was chosen because of threats to priority resources and opportunities to continue advancing collaborative conservation through coordinated resource management in the region.	x			Yes	Changed text for Terrestrial Habitat measurable goal to: "The Prairie Coteau Conservation Focus Area (PCCFA) was established under the MN Wildlife Action Plan 2015-2025 to facilitate targeting of habitat conservation projects aimed at reducing ecological threats, improving ecosystem function, and increasing the populations of designated Species in Greatest Conservation Need and other priority wildlife (Figure 3-8). Targeting habitat conservation projects to areas identified in the Wildlife Action Plan and Prairie Plan increases the potential to realize the highest benefit from dollars invested in conservation and create multiple benefits, including cleaner water." Updated Figure 3-8 to include the PCCFA shapefiles provided by the DNR.
	17	Section 4	The Wildlife Action Network within the Prairie Coteau Conservation Focus Area (PCCFA) on the next page should also be incorporated into this plan.	x			Yes	See response to Comment 16 above.

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	18	Section 4	The PCCFA takes an integrated landscape-level approach using the MNWAP Wildlife Action Network, Minnesota Prairie Conservation Plan, and the Prairie Coteau Complex Important Bird Area as valuable decision-support tools. The associated PCCFA partnership includes the former Prairie Coteau Local Technical Team established under the Prairie Plan. The PCCFA partnership has been developing S.M.A.R.T.* objectives around connectivity, watershed conservation practices, habitat complexes, grasslands, native prairie, prairie streams, monitoring and adaptive management, and outreach and communication (*where S.M.A.R.T. = Specific, Measurable, Attainable, Results-oriented, and Time specific). Setting objectives using this approach will prioritize work and allow opportunities to monitor progress and apply adaptive management to the process over time. Although a "living document", we anticipate Version 1 of the PCCFA SMART Objectives document to be available by March 2019. The PCCFA partnership seeks to collaborate with other initiatives, including the Missouri 1W1P for an integrated, more effective approach to conservation."			x	No	The MRW 1W1P Planning Group looks forward to opportunities to partners with DNR in the future to implement conservation within the PCCFA.
	19	Section 4	On page 115, the PCCFA does not incorporate the Little Sioux Basin. Please remove PCCFA text from this watershed's implementation table.		x		Yes	PCCFA removed from LSR SP-14 as suggested.
	20	Section 3	In section 3.1.5, insert "Protect calcareous fens" and remove "Habitat loss from reduction in calcareous fens." The text to the right should read "Protect rare and natural features" and remove Protecting or improving use for aquatic life, recreation, and hunting (page 24 of 166).	x			No	As the Issues Table (Table 2-1) was vetted, approved, and used to prioritize issues during the planning process, no further changes can be made, as it would not accurately represent what the committees prioritized.
	21	Section 3	Please revise 3.1.5 to "Protect calcareous fens and rare and natural features" instead of habitat loss from reduction in calcareous fens (page 30 of 166).	x			No	See response to Comment 20 above.
	22	Section 2	In Figure 2-8 on page 45, the legend indicates calcareous fens with a green triangle, however none of the watershed's ten calcareous fens appear on the map. Let us know if you need the shapefile in order to add them.		x		Yes	Calcareous fens locations added.
	23	Section 4	Include the following or similar text within the WCA regulation language or as a separate row (page 128 of 166): Calcareous fens are protected under statute 103G.223. Any calcareous fen related activities should be coordinated with DNR (Division of Ecological and Water Resources at 651-259-5125) as a permit may be required for certain activities.	x			Yes	Added action. "Protect calcareous fens as specified under statute 103G.223."
	24	Appendix	In the Appendix, please include the status rank of each rare plant community along with its name (pages 65-66). If you do not have access to this information, contact Megan Benage at Megan.Benage@state.mn.us or 507-389-6079.	x			No	For purposes of this inventory, species of interest within the MRW 1W1P Boundary have been tabulated and provided in Attachment 1. The MRW 1W1P Planning Group will collaborate with Megan accordingly if additional information is needed for planning and implementation purposes.
	25	Appendix	In the appendix on page 155 of 331, please re-word the calcareous fen sentence to "Protection of calcareous fens from disturbances by livestock and impacts from tile, hydrologic diversion, and groundwater appropriation." The draft accidentally mentions a reduction in the amount of calcareous fens. There are ten identified calcareous fens in the basin and they support 11 rare plant species in MN. These communities are protected in statute and are covered under the Wetland Conservation Act (WCA).	x			No	See response to Comment 20 above.
	26	Section 2	The potential exists for conflict between protecting sensitive natural resources and developing mineral and aggregate resources. This includes gravel extraction near lakes, rivers, and sensitive features like calcareous fens and drinking water sources. Hard rock mining, mostly quartzite, has also been shown to host many rare plants and animal communities. In the five-year update, DNR asks that we include strategies developed between agencies and local government to avoid potential conflicts when aggregate interests intersect areas targeted for conservation practices.			x	No	See response to Comment #1 above. The Missouri 1W1P Planning Group looks forward to future opportunities to collaborate with the DNR when aggregate interests intersect areas targeted for conservation practices.
	27	Section 2	The Missouri River Watershed offers many and varied opportunities for outdoor recreation. DNR would like to further expand opportunities to promote state and local programs, such as Walk-in-Access. In addition, consider developing and exploring new outdoor recreational plans, programs and experiences for future generations to enjoy natural resources.			x	No	See response to Comment #1 above. The Missouri 1W1P Planning Group looks forward to future opportunities to collaborate with the DNR to expand recreational opportunities.
	1	General	1.On the cover page, the document needs the Clean Water Legacy logo. Clean Water Fund projects need the logo in accordance with state law.		x		Yes	Logo added to cover page.

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MPCA	2	General	2.Where possible, please use the same scale on the maps throughout the plan. Figure 3-2 through 3-7 are full-page maps, but the scale changes from map to map (e.g. 0-9 miles, 0-10 miles. 0-12 miles). MPCA also recommends checking all the map scales as the scales in Figure ES1 and Figure 1-1 are incorrect. Based on the scale shown, the Missouri basin is over 1800 miles wide.		x		Yes	Good catch. Scale size issue resolved and incorporated into all maps. Small scale size difference on other maps tailored to fit to title boxes.
	3	Section 2	3.Figures 2-2, 2-3, and 2-4, have "Draft 2016" behind Assessed Streams, Impaired Streams, Impaired Lakes, and Assessed Lakes in the legends. Please remove "Draft" as the Environmental Protection Agency has recently approved the 2016 303(d) impaired waters list.		x		Yes	"Draft" language removed from shapefile legend titles as suggested.
	4	Section 2	4.It is somewhat confusing to show "Assessed streams" (narrow green line) with "Impaired streams" (thicker red line that creates a red "outline" on the green line) in Figure 2-3. If a stream is labeled as impaired it was assessed so there is not a need to show it as assessed. Since Figure 2-2, shows "Assessed Streams", it may be better to only show the streams that were assessed and are not impaired (fully supporting) in green and impaired streams in red as this would better relate to the explanation given.		x		Yes	Stream symbology changed as suggested so impaired streams = red and assessed = green without overlap.
	5	Section 2	5.Based on the legend for Figure 2-4, it appears that Split Rock Reservoir in Pipestone County was "Assessed". However, the MRW Monitoring and Assessment Report states that no assessment data were collected.		x		No	These streams were pulled directly from the MPCA Assessed Waters (2016) layer.
	6	Section 2	6.It is hard to tell in Figure 2-4 what symbol is used or the difference between "Impaired Lakes" and "DNR Hydrography – Lakes of Phosphorus Sensitivity Significance Priority Class" which also uses "impaired lakes".		x		Yes	Removed legend item for DNR LPSS "Impaired / proposed as impaired" as that information is covered within the Impaired Lakes shapefile.
	7	Section 2	7.The narrative for Figure 2-4 states that "Other lakes within the MRW are assessed and are not impaired". The MPCA is not aware of any lakes in the MRW that have been assessed and found not impaired as all nine lakes that were assessed are on the 303(d) list, and now have completed TMDLs.		x		Yes	Language removed as suggested.
	8	Section 2	8.In the explanation of Figure 2-8, please change the word "assesses" to "assessed". MPCA may not continue to assess many of the same locations for biological health in the future.		x		Yes	Text revised to "assessed" as suggested.
	9	Section 3	9.Page 3-3, Section 3.2, states above-average quality means "Portions of a stream or river in this subcategory exhibit water quality conditions that significantly exceed numeric water quality standards for a given parameter". Please change to "Portions of a stream or river in this sub-category exhibit water quality conditions that are significantly better than numeric water quality standards for a given parameter".		x		Yes	Language changed to "significantly better" as suggested.
	10	Section 3	10.In pages 3-8 through 3-12, Measurable Goals 3.2.4-3.2.7, the word "length" is used in various statements such as "length of streams classified as impaired" and/or "Reduction in the length of impaired streams". The MPCA suggests using a different term than "length" of streams since the MPCA assesses the whole reach as either impaired or not impaired (supporting). Perhaps the word "number" would be better.		x		Yes	Reach-specific measurable goal changed to: "Reduction in the number of streams classified as impaired by meeting a load allocation (where a TMDL has been completed)."
	11	Section 3	The order of "Goals" and "Why these Issues Are Important" on pages 3-10 and 3-11 is reversed compared to the other Measurable Goals pages. MPCA recommends the order be changed to be consistent with the rest of the document.		x		No	Format retained as much as possible. There are some instances where ordering of text changed to accommodate information (see MG 3.2.5). Here, if format was not changed, there would not be enough page space for the goals, which would necessitate a new page that is predominately white space.
	12	Section 3	12.MPCA requests "bio-impaired" be changed to "impaired" on pages 3-10 through 3-12, Measurable Goals 3.2.5-3.2.7.		x		Yes	Language changed to "impaired" as suggested.
	13	Section 3	13.The 14 lakes number referenced on Page 3-14 is based on a typo in the WRAPS report. There are approximately 40 lakes (graph on page 15 of WRAPS) in the MRW. Twelve lakes in the MRW had some monitoring data with nine of them having sufficient monitoring data for assessment. All nine of the assessed lakes were determined to be impaired. As written, page 3-14 indicates all 12 lakes had assessment level data which would suggest three of the lakes were not impaired.	x			Yes	Text revised to: "There are 40 lakes in the MRW, primarily located within the eastern half of the watershed (MPCA, 2018). Twelve lakes in the MRW had some monitoring data with nine of them having sufficient monitoring data for assessment. All nine of the assessed lakes were determined to be impaired with phosphorus as a pollutant (MPCA, 2018)."
	14	Section 3	14.Page 3-14 references LPSS lakes. Are there any lakes designated as LPSS? If there are not, and there are no plans from DNR to list any, then should that be in the "goals"?		x		No	Yes, there are LPSS lakes in the MRW planning area. See Figure 2-4 for locations.

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	15	Section 3	15.Page 3-15 states “altered hydrology is a term commonly used in Minnesota to describe the changes associated with excess surface runoff”. MPCA recommends using a broader definition for altered hydrology such as “altered hydrology is a term commonly used in Minnesota to describe changes in the amount and pathways that water moves through the landscape”.		x		Yes	Text revised as suggested.
	16	Section 3	16.The last paragraph of the blue section on page 3-21 states “This measurable goal is aimed at learning the current extent and conditions of subsurface drainage within the watershed area”. Please expand on how this will be accomplished when the goal is to host one event a year to address drainage, landowner and drainage authority rights, and opportunities to improve water quality while maintaining drainage capacity.			x	No	This goal is used as one means of measuring progress. There are multiple actions associated with MG 3.2.15, found in Section 4.
	17	Section 3	17.The goal of increasing soil organic matter (SOM) by 1% stated on page 3-23 is fairly lofty. Since the metric is “percent of applicable cropland treated with management practices” maybe it would be better to just say “to increase SOM” and leave off the 1%.			x	No	A SOM change of 1% is needed in order to measure the environmental (sediment, phosphorus, runoff) benefits of management practices.
	18	Section 3	18.The Goals section on page 3-25 states “implement management practices”. This should say “implement manure management practices” as it appears the SOM goals are just copied. Please expand on the types of manure management practices to make this applicable to manure application.	x			Yes	See BWSR Comment #27 and proposed resolution.
	19	Section 3	19.In the “Why These Issues Are Important” portion on page 3-26, the MPCA 2017 reference should be MPCA 2018.		x		Yes	Reference changed to (MPCA, 2018).
	20	Section 4	20.Please insert the words “not impaired” after (threatened impairment risk) in the narrative paragraph of the Surface Water Quality portion of each figure on pages 4-11, 4-17, 4-23, and 4-29.		x		Yes	Text revised to clarify map interpretation (further explanation in Section3). "Streams that are nearly or barely impaired or a particular water quality parameter are summarized in the table below. Please note that a stream could be listed as "impaired" for one parameter (e.g. total suspended sediments) but merit protection for another (e.g. total phosphorus).
	21	Section 4	21.A turbidity impairment for reach -527 is referenced on page 4-17, but Total Suspended Solids is in the “Threatened Impairment Risk” (not impaired) category. If the reach is impaired shouldn’t it be in the “Low Restoration Effort” (impaired) category?		x		No	This map uses a statistical analysis of the TSS data and it shows that it should be in the TIR category. The method does not account for professional judgement or other WQ metrics that are used to assess a reach.
	22	Section 4	22.Similarly, a TSS impairment for reach -523 is referenced on page 4-23, but Total Suspended Solids is in the “Threatened Impairment Risk” (not impaired) category. If the reach is impaired shouldn’t it be in the “Low Restoration Effort” (impaired) category?		x		No	This map uses a statistical analysis of the TSS data and it shows that it should be in the TIR category. The method does not account for professional judgement or other WQ metrics that are used to assess a reach.
	23	Section 5	23.On page 5-21, Table 5-5, MPCA is listed in the Federal source/organization column with “Federal Clean Water Act Section 319 Grants”. This can be deleted as this is an EPA’s program and already is listed below. Also in Table 5-5 for MPCA, Clean Water Partnership (CWP), change “Financial” to “Loan”, since CWP no longer offers grants.		x		Yes	Row deleted as suggested, and changed from financial to "loan" as suggested.
	24	Appendix	24.Throughout the narrative, tables, figures, and references section of Appendix A, references to the Missouri River Basin Watersheds of Minnesota: Watershed Restoration and Protection Strategies and the MPCA Missouri River Basin Total Maximum Daily Load: Lower Big Sioux River, Little Sioux River, and Rock River Watersheds are listed as “Draft”. These reports are approved and final. Please delete the “Draft May 2017” for the WRAPS report and replace with “January 2018”, and delete the “Draft April 2018” for the TMDL report and replace with “February 2018”.		x		Yes	Materials were draft at the time they were reviewed for drafting the Land and Water Resources Inventory. Figures reviewed and updated references as suggested.
	25	Appendix	25.Figure 9 in Appendix A does not represent Little Spirit Lake in red (impaired). Replace this map with the final approved map, which can be found in the TMDL report at (https://www.pca.state.mn.us/sites/default/files/wq-iw7-44e.pdf).	x			Yes	Map revised and reference updated for this circumstance.
	26	General	26.The MRW 1W1P provides a great deal of local partner knowledge and stakeholder input on setting priority concerns, issues, measurable goals, and targeted implementation actions. It also provides the process, tools (i.e.. PTMapp), and information to utilize for prioritizing within a planning region. However, the plan stops short of explicitly identifying priority management areas (i.e.. HUC 12), priority projects, or prioritized waterbodies within the Planning Regions for implementation funding. Providing that level of detail would help focus implementation efforts in the Missouri Basin for the next ten years	x			Yes	See response to BWSR Comment #6
	1	General	•Source(s) of Figures and tables – these should be listed on the Figure or table, or cross-referenced with the Appendix.		x		No	Sources noted in maps were relevant (e.g. MPCA, 2016)

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MDA	2	Section 3	•Identifying specific targets and acres. Some goals contain specific acres while others provide a percentage reduction, and the plan does not explain/is not easily found how these numbers and percentages were arrived at.			x	No	Sources and rationale for goals (acres, % load reduction, etc.) are explained within each goal "Why These Issues Are Important" section. Example for phosphorus: "These WRAPS targets are used within this 1W1P to guide the phosphorus delivery and load reduction measurable goal."
	3	Section 3	•It is unclear how structural management practices will be chosen on goal acres to meet measurable goals. Is it assumed that all acre treatments are equal in effectiveness (Ex. Using fertilizer recommendations on row crop versus planting perennials are equally effective in reducing nitrate leaching)?			x	No	Acres treated are intended to summarize that management practices are implemented for a whole field.
	4	Section 2	Figure 2-1 – In this figure (or elsewhere) you may wish to include the (initial) township testing results to illustrate additional nitrate monitoring that has been done. https://www.mda.state.mn.us/township-testing-program. The figure notes “Vulnerable Groundwater Areas” which appears different than the map developed by MDA using the same name. https://www.mda.state.mn.us/chemicals/fertilizers/nutrient-mgmt/nitrogenplan/mitigation/wrpr/wrprpart1/vulnerableareamap. Again, it would be helpful to list data source(s) here. If there is a location in the plan where this would be beneficial, feel free to use the link provided to incorporate this vulnerable area mapping in the plan. Also, the data source for nitrate is not indicated in this map unlike for Arsenic.		x		Yes	Township testing added to Figure 2-1 as provided by MDA. Vulnerable Groundwater Areas map layer removed as data is obsolete.
	5	Section 2	Figure 2-5:& 2-7: What source was used to generate the drainage network? (This is the “public drainage network” not agricultural drainage network as labeled (which would include private field drainage)?		x		Yes	From Figure 2-7: "Included in this map are known ditch locations from local counties. Also included are reaches classified as "ditch" in the DNR 24K River and Streams layer, and as “Canal / Ditch” in the NHD Flow line data layer." Agricultural drainage systems removed from Figure 2-5, as it is not needed to describe issues impacting surface runoff.
	6	Section 2	Figure 2-12: Consider changing the color for the 0.2% chance flood as it is hard to separate it from the Riparian corridor.		x		Yes	Symbology color for riparian corridor changed as suggested.
	7	Section 3	Goal 3.2.1 – This goal aligns with the Minnesota Nitrogen Fertilizer Management Plan, and could be noted here (or referenced elsewhere as well). It is good to see that this goal includes targeted implementation of practices in the short term, and long term well monitoring to see if there is an improvement in drinking water. The goal acres are very specific; should they be rounded/combined especially for this drinking water measure, since groundwater may not follow a watershed boundary? It seems like the 2nd long term goal (“reducing the number of (wells that have high nitrates)…”) is ‘Restoration’ goal not a ‘Protection’ goal as listed. Another practice that can also help improve nitrogen efficiency and therefore reduce off-site movement on nitrate (Measurable goal 3.2.1 and 3.2.7) is precision agriculture and variable rate N (AMT). Research in MN showed Variable Rate N can reduce leaching by 17% (Dr. Mulla's group at the UMN).			x	No	For purposes of this goal, "Restoration" refers to wells that are >10 mg/L, however, "protection" wells are broken into subcategories to place emphasis on those wells near the restoration level. The Nitrogen Fertilizer Management Plan was reviewed for actions related to nutrient reduction (Table 4-1) and is included in the targeted implementation schedule "Develop and implement nutrient and/or manure management plans for agricultural producers which follow operational best management practice recommendations, summarized within the MDA Nitrogen Fertilizer Management Plan and consistent with University of Minnesota recommendations."
	8	Section 3	Goal 3.2.14 – Thanks for noting the Minnesota Agricultural Water Quality Certification Program. It is a good fit for this goal.			x	No	Comment acknowledged with thanks.
	9	Section 3	Goal 3.2.17 – Since an increase in soil organic matter is being used as the measure of soil health, a soil sampling program to directly measure organic matter would be beneficial. This may add to education and outreach and is a cost effective option and direct measurement. Implementing management practices on 6150 acres does provide a measure, however practices may or may not result in organic matter change.			x	Yes	Language added to Section 5.1: The purpose of the walkover or consultation is to evaluate how to best plan to fix a problem. Structural and Management Practices Cost-Share Program dollars can then be used to design and implement solutions to problems once identified, and evaluate progress towards goals following implementation efforts (i.e. changes to soil health).
	10	Section 3	Figure 3.7 - As noted above perhaps initial MDA Township Testing results should be shown here (or elsewhere in the document).		x		Yes	Township testing added to Figure 2-1 as provided by MDA. Vulnerable Groundwater Areas map layer removed as data is obsolete.
	11	Section 4	Appendix I and associated maps starting on Page 4-11, etc. - A change in title ‘Nitrogen Infiltration Risk” should be considered to “Nitrate Leaching Risk” or something similar to this. We appreciate that this is a tool that considers land use and hydro-geologic features, but nitrate is the N form that is a concern to groundwater.		x		No	Due to inputs used in this analysis, title must remain nitrogen. TN was used for Nitrogen Inputs under Mulla's study (Mulla et al., 2013).

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	12	Section 4	Below are some actions within the Targeted implementation tables where MDA could be included as a partner. Some of these are action items in the NFMP which outlines the formation of Local Advisory Teams (LAT) that are intended to problem solve and address nitrate in groundwater. Several implementation activities in the plan are complementary to the NFMP actions, and therefore, MDA should be included. It appears that Action number EO-10 would include what MDA identifies as LATs. Here are additional areas that are addressed in the NFMP, so MDA could be included as a partner (Action items where MDA is already shown are not included below): Page 4-33 action LRS MP-1; LRS MP-7 Page 4-41 action DGR-10; DRG-11		x		Yes	MDA added as a partner where specified, with thanks.
	13	Section 4	Page 4-37 Action Item EO-13 – "Reduced use" of ag. chemicals does not always correlate with proper management. (Ex. Under use of a pesticide may lead to pest resistance). Perhaps reword this to "proper management" or "judicious use", or "use integrated pest management" for pesticides, or similar.		x		Yes	Action text changed to "Promote judicious use of chemical management compounds (fertilizers, herbicides, pesticides, etc.) to support the function of healthy riparian corridors.
	14	Section 4	Action # DGR-1 – MDA is noted as lead. Note that MDA testing include nitrate only (with follow-up pesticide testing). It is unclear if this is intended to include the MDA Township Testing and/or Nitrate Clinics.		x		Yes	Split into 2 actions items, DGR-1: "Implement the Groundwater Protection Rule and pursue targeted township nitrate testing" Lead MDA; DGR-2: "Monitor water quality in private wells (nitrate, arsenic, manganese bacteria, etc.) by making information available to private well users about local drinking water quality and well testing. Host a well testing clinic or provide resources to well users to have their water tested"; Lead: County/SWCD
	15	Section 4	Action # DGR-8 – It appears this is a groundwater quantity goal? Additional nitrate monitoring and modeling may be a component of NFMP implementation (if this fits here or elsewhere such as page 5-9).			x	No	Yes, this is primarily focused on groundwater quantity. Outcomes will also help understanding of GW nitrate and bacteria flow / impacts to further target implementation efforts.
	16	Section 5	Page 5-13 Regulatory. If it is desired to include ag. chemicals (pesticide and fertilizer) could include: The Minnesota Department of Agriculture (MDA) is the lead agency for all aspects of pesticide and fertilizer environmental and regulatory functions as directed in the Groundwater Protection Act (Minnesota Statute 103H). These include but are not limited to the following: •Serve as lead agency for groundwater contamination from pesticide and fertilizer nonpoint source pollution •Conduct monitoring and assessment of agricultural chemicals (pesticides and nitrates) in ground and surface waters •Oversee agricultural chemical remediation sites and incident response •Regulate use, storage, handling and disposal of pesticides and fertilizer			x	No	This was not noted during the planning process as a primary statutory obligation, however, Table 5-3 is not intended to be all-inclusive. Comment noted for implementation purposes.
	17	Section 5	Page 5-22, Table 5-5: The MAWQCP could be listed here.		x		Yes	MAWQCP added to table as recommended.
	18	Appendix	Appendix A - You may wish to include Township Testing results (to date) here, and the vulnerable area map. (This may fit better elsewhere in the plan)		x		No	Township testing added to Figure 2-1 as provided by MDA. Vulnerable Groundwater Areas map layer removed as data is obsolete.
	19	Appendix	Appendix I – Nitrogen Infiltration Risk map – See comment above. Also here are a couple of comments regarding data used for to determine the "nitrogen infiltration risk: •Pg. 160: Except for soybeans, legume and alfalfa, the symbiotic contribution of N should not be credited. Corn and other cereals are not capable of symbiotic fixation of N. •Pg. 161: The denitrification potential seems to be exaggerated for the entire watershed (entire watershed is given high denitrification potential). I think using topography indices such as slope can help reclassify fields based on water ponding potential.			x	No	Comment noted for future planning purposes which consider the Nitrogen Infiltration Risk Map.

Commenter	Comment #	Page / Section	Comment	Material	Editorial	Note	Plan Change Made (Yes/No)	Comment Response / Action
	20	Appendix	Appendix K Table 1, page 3 – Here some potential additions/edits. •Nutrient Management - Include the U MN Nitrogen Fertilizer BMPs (https://www.mda.state.mn.us/pesticide-fertilizer/nitrogen-fertilizer-best-management-practices-agricultural-lands) •Soil Health/Tillage – Is there on opportunity to include a soil testing program. Should this include other practices in addition to reduced tillage be included that can also increase organic matter (perennial crops, crop rotation, etc.) •Pesticide Application – Include MDA here. (https://www.mda.state.mn.us/promoting-pesticide-bmps)			x	No	See response to Comment #9 above. Comments noted for future planning purposes which consider the Rural Land Stewardship Analysis.
	21	Appendix	Appendix N – An introduction to this appendix would be helpful to explain the graphic material.			x	No	Introductory text is provided in the body of the plan.
MDH	1	Section 2	Section 2 Figure 2-1 Issues Impacting Drinking Water (page 2-17): The monitoring well nitrate concentration data does not appear to include all the public water supply monitoring data like other similar figures in the plan. Consider altering the monitoring well arsenic concentration legend and data to include a breakdown range of 5.0-10.0 ug/L since 10 ug/L is the drinking water standard.		x		Yes	Updated shapefile to ensure all available public well supply monitoring data is present. Map legend changed to 0-4.9 ug/L; 5-9.9 ug/L; 10-49.9 ug/L; 50+ug/L
	2	Section 3	Measurable Goal 3.2.3 Groundwater-Sustain Quality and Quantity (page 3-7): The goal references the nitrogen infiltration risk maps from Appendix I but more explanation could be added to clarify why targeting low risk areas have an impact on quality and quantity. Specifically the long-term goal mentions “low risk areas in DWSMAs” and could state, “low nitrogen infiltration risk areas in DWSMAs”. Adding clarification, being clear and consistent with the wording, and referencing Appendix I may help plan readers better understand this measurable goal.		x		Yes	Added statement to 3.2.1: "Nitrogen infiltration risk maps were developed to identify areas of high risk (where potential recharge and nitrogen loads are high) and low risk (where nitrogen loads are low)."
	3	Section 4	Section 4.4 Table 4-5 (page 4-41): Action number DGR-18 is to “Identify and implement opportunities to collect data to monitor effectiveness of best management practices on nitrate levels in groundwater.” Recent conversations with local/state agency staff and public water suppliers has resulted in the recognition that this is a key need in this watershed in order to get landowners to implement practices. We would recommend considering moving this to a ‘T’ action level in the LBSR and RR watersheds.			x	No	Comment noted.
PWG: Rock County SWCD	1	Page ES-1 Paragraph 2	Wording does not sound correct “planning area is a hydrologically unique.”		x		Yes	Based on this definition, the MRW 1W1P planning area is hydrologically unique.
	2	Page 4-47 Capital Improvements Table 4-7	We have several “Critical Area Retirement” listings in section 5 But don’t specifically list Critical Area Retirement in table 4-7 Should we have practices or projects that are in Section 5 listed also in 4-7? Or maybe this is the only one that I noticed. I realize we do have the practice covered in the Management Practices in each watershed listing (MP3 in LBS, RR and MP4 in the LSR)		x		No	Added line item for Critical Area Retirement to Table 4-7 (purchasing land or permanent easements).
	3	Page 5-26 Section 5.3.2.2 Paragraph 1	Should we have MDH as part of the listings of agencies we have Vertical Coordination with since we do considerable amount with DWSMAs and Wellhead?		x		Yes	Added MDH to list of example entities listed.
	4	General	The acronym used for Water and Sediment Control Basins has usually been WASCBs, not WASCOBS even though they are pronounced as such.		x		No	Acronym remains unchanged as it is used in NRCS Practice Code 638 and PTMApp memoranda.
	5	Appendix A page 14	I do not think this section of Appendix A is correct. The Beaver Creek and Split Rock Creek are in the Lower Big Sioux River Watershed and are impaired also. I do not recognize the streams they do have listed. See section below: Lower Big Sioux River Watershed (10170203) - Impaired Streams West Fork Little Sioux River (10170203-502); Judicial Ditch 13 (Skunk Creek) (10170203-505); West Fork Little Sioux River (10170203-512); and Little Sioux River (10170203-522).		x		Yes	Stream segments and map updated to reflect the approved MPCA TMDL.

Commenter	Comment #	Page / Section	Comment	Material	Editorial	Note	Plan Change Made (Yes/No)	Comment Response / Action
	6	Appendix C page 9	Not sure if we need to add Ryan Holz to the Advisory Committee. He is the new Rock County Rural Water Manager and replaced Brent Hoffmann on the committee.		x		No	Advisory Committee roster in the Participation Plan remains unchanged as it was approved by the Policy Committee for planning purposes. Changes to the Advisory Committee roster is expected during plan implementation.
	7	Appendix G – letter from MDH	I spoke with Amanda Strommer on this but in their MRB Public Water Suppliers Table the City of Luverne Shows the Ashwood Cemetery sub-watershed and it should be the Poplar Creek. (maybe this cannot be changed because it is the letter that was submitted)		x		No	Correct- this cannot be changed as it memorializes the letter received from MDH.
	8	Appendix G	Great to see the Efficiency Curves for the water sheds for each spending level! (even though the cost and results on reducing Phosphorus is fairly discouraging)			x	No	Comment acknowledged with thanks.
PWG: BWSR (via email)	1	General	“Insignia” on each page header, etc. – “MISSOURI RIVER WATERSHED ONE WATERSHED, ONE PLAN” – might consider Missouri River Watershed Comprehensive Watershed Management Plan instead; reason being that the 1W1P is a state program and the plan itself is local. I was wondering if we should put it to the planning group to make that distinction. It also matches the title.		x		Yes	Logo changed to: Missouri River Watershed Comprehensive Watershed Management Plan
	2	Executive Summary	Executive Summary - goals - No real listing of goals in executive summary though a reference to chapter 3 and an example exist.			x	No	Correct. As there are 20 goals, arbitrarily summarizing one goal for the sake of providing a summary seemed to provide little to no value to justify the additional length.
	3	Executive Summary	Executive Summary – targeting – rewording of the plan content requirements – and summarizes result – method of targeting for this plan not clear			x	No	The best practices for implementation based on priority issues and measurable goals is shown at the field scale. Benefits of these practices is estimated.
	4	General	Page # on whole page maps throughout would be helpful		x		Yes	The PWG elected to keep the pages full PDFs (without the headers / page numbers) for maximum visibilitiy. Pages added manually to each map PDF.
	5	Section 2	Maps are clustered in Chapter 2 – not sure ease of printing trumps flow of report		x		No	Maps remain centralized at the end of the sections per feedback from the Planning Work Group during the plan development process.
	6	Section 2	Highlight section “tab” at bottom of page to correspond with the section reader is viewing		x		Yes	Section tabs updated in interactive PDF.
	7	Section 2	Section 2 – General – Separate Watershed Boundaries in maps still not discernable from overall plan area symbol – comes across as the same symbol		x		No	Planning regions are also shown in Figure 1-1 for further clarification.
	8	Section 2	In 2.4.2.1 – Strike Clean Water Accountability Act and replace with Clean Water Legacy Act		x		Yes	Revision made as suggested.
	9	Section 2	Section 2 – Maps – The term “issues impacting” is used universally but in many cases the subjects in the map are just physical representation descriptors of the resource or representation of spatial attributes of the watershed		x		No	Correct, however intent is to show that the focus of Section 2 is on issues impacting resources, not just resources (see Table 2-1).
	10	Section 2	Many map symbols are ‘clipped’ off or covered on various maps of Section 2		x		Yes	Maps reviewed for potential clipped issues (e.g. calcareous fens added to map).
	11	Section 2	Description of Groundwater Recharge Colors in Figure 2-2 list orange and green, more like brown and teal blue, may be confusing as green squares designate well numbers between 11 to 25.		x		No	Gradient for recharge colors does not include green. Symbology remains unchanged due to color limitations.
	12	Section 2	Figure 2-4 – symbols in the key renders this map nearly useless in the printed format;		x		Yes	Symbols adjusted per MPCA Comment #6
	13	Section 2	Section 3.2, page 3-3, strike “BWSRs” when referencing the Nonpoint Priority Funding Plan (multiple instances)		x		Yes	BWSR removed from reference as suggested.
	14	Section 2	Figure 2-12 – FEMA maps? Doesn’t this exist outside of Nobles County?		x		No	That is all that is available in GIS format.
	15	Section 3	3.2.1 order the goals highest priority first, long term goals appear to be listed lowest to highest priority		x		Yes	Order kept, in order to be consistent with issues as introduced in Section 2 and Goals shown in Targeted Implementation Schedules.
	16	Section 3	3.2.19 – we should target these livestock exclusions to streams where the WRAPS indicates the greatest need or ‘hot spots’ defined by the planning group.	x			No	This plan addresses unstable and erosive streams in Measurable Goal 3.2.19. The goal focuses on trampling streambanks, causing excessive erosion and widening (MPCA, 2017). This goal also includes a land use analysis map to target areas within the plan that are at highest risk for streambank trampling (Figure 3-9) which is also used to prioritized focused subwatersheds in Section 4.
	17	Section 4	Page 4-35 – “Presented below” should be “presented in the following tables”		x		Yes	Text revised as suggested.
	18	Section 4	Action ‘R-13’ on page 4-45 could read ‘Administer the MRW comprehensive watershed management plan as described in the implementation program portion of the plan’		x		Yes	"Share services" was language requested by the Planning Work Group. Text revised to read "Share services as needed to effectively administer the MRW Comprehensive Watershed Management Plan as described in the implementation program portion of the plan."
	19	Section 4	Location maps throughout section 4 – cross hatching for ‘non’ watershed areas may lead to confusion with certain maps.		x		No	Cross hatching removed during the planning process if an issue was presented.
	20	Section 5	Table 5-1 Reads: Probable list of structural and management . . . This term seems a bit uncertain –			x	No	Uncertain intentionally, as all practices require field verification and landowner willingness before they can move to implementation.

Commenter	Comment #	Page / Section	Comment	Material	Editorial	Note	Plan Change Made (Yes/No)	Comment Response / Action
	21	Section 5	Table 5-3: "Tile Drainage" row should clarify how it is different than "Public Drainage Systems" row. After clarification consider: Lincoln County – Tile Drainage – not sure this is 103E; KLR – Tile Drainage – no permit process?			x	No	These predominately related to WD rule differences, as explained in the 5.1.5.3 text.
	22	Section 5	Section 5.2.1 – Local Funding – There are a whole host of ways for local funding sources that aren't mentioned here: Levy authority through 103B.355, 103D, 103D.601 (special purpose), 103D.905 (various subd.), 103E.601, 103E.011, City Levies, etc.			x	No	Correct. Local funding sources are not explicitly mentioned here, due to the large list of sources that can be leveraged.
	23	Section 5	5.3.5: The reference to 103B.314 should say subd. 6, not subp. 6.; Why the term "general plan amendments"? (5.3.5.2) I think that this is vestigial from the removal of minor amendments. Suggest cleaning these out of the content as well		x		Yes	"General" removed and reference changed to 103B.314 subd. 6.
	24	Section 5	It would be helpful to re-arrange section 5.3.2: First criteria (through the first bulleted list in 5.3.5.1), then section 5.3.5.2, then the format discussed in the second half of 5.3.5.1. The sentence below "…this plan will…" is consistent with watershed law but not exactly consistent with the Operating Procedures (1.0)		x		Yes	Format revised as suggested.
	25	Section 5	5.3.4.3 – Should mention ongoing 5 year reviews – it reads as though one review will be done and then the plan will remain in full effect thereafter	x			Yes	Text within 5.3.4.3 revised to read "This plan has a ten-year life cycle beginning in 2019 to. To meet statutory requirements, this plan will be updated and/or revised every 10 years.....in 2024-25 and at every 5 year midpoint of a plan life cycle, an evaluation will be undertaken to determine if the current course of actions is sufficient to reach the goals of the plan, or if a change in the course of actions is necessary."
	26	Section 5	Section 5.3.5 – second paragraph, last sentence - The sentence "As such……seems to contradict the discussion of CIPs in section 5.2.	x			Yes	Sentence revised to say "As such, CIPs need only be approved by a local board to be amended to the plan if implementation of the CIP is funded by the local board, with notification to the Policy Committee. CIPs implemented with funding from the plan must follow the means and methods for funding new capital improvements as developed by members of the Policy Committee or the Planning Work Group's individual and representative Boards (Section 5.1.4)."
	27	Section 5	If we still have work to do in the planning process to figure out how we will implement CIP items using this plan, we might want more discussion beyond local approval? Suggestion: revise the "As such, CIPs need only…" sentence to say something like "CIPs need only be approved by the local board to be amended to the plan if implementation of the CIP is funded by the local board, with notification to the policy committee. CIPs implemented with funding from the plan must follow..."	x			Yes	Sentence revised to say "As such, CIPs need only be approved by a local board to be amended to the plan if implementation of the CIP is funded by the local board, with notification to the Policy Committee. CIPs implemented with funding from the plan must follow the means and methods for funding new capital improvements as developed by members of the Policy Committee or the Planning Work Group's individual and representative Boards (Section 5.1.4)."

Public Hearing

No written comments were received during and within 2 weeks following the Edgerton and Worthington public hearings. No verbal comments received during either hearing led to modification of plan content. The public hearings were recorded and those recordings are available upon request.

Working Draft Comments and Responses Prior to 60-day Notices

Commenter	Comment #	Page / Section	Comment	Material	Editorial	Note	Plan Change Made (Yes/No)	Comment Response / Action
	1	LWRI General	All references cited in the text must be listed in Section 10. This is a particular problem in about the first half of the Appendix, but is less of a problem in the second half.		x		Y	Good catch. Additions made and referenced further in responses below
	2	LWRI General	The most useful format for figures leaves off the areas outside the MRW and uses pie diagrams to compare and summarize the four constituent watersheds. Figure 33 on page 50 is an excellent example.		x		Y	With very few exceptions, this inventory utilizes and cites figures from existing reports and data. HEI made use of the best and most relevant figures found, and generated new figures only when needed to meet requirement for the LWRI. Moving forward, new figures generated by HEI will move the legend to reduce excess "white space," add HUC 8 Major Watershed (Planning Region) boundaries. New figures generated for the LWRI will be revised to include these formatting changes.
	3	LWRI General	When discussing the constituent watersheds be consistent and always list them from northwest to southeast, that is Upper Big Sioux, Lower Big Sioux, Rock, and Little Sioux.		x		Y	Change applied in LWRI and throughout plan. Restricted only in LWRI by citation of the MPCA document title: Upper Big Sioux River, Lower Big Sioux River, Little Sioux River, and Rock River Watersheds) Monitoring and Assessment Report
	4	LWRI General	The MPCA is okay for data on monitoring a variety of environmental parameters, but those reports should not be relied upon for accurate basic information on geology and hydrology. In general, reports by the MDNR, the MN Geological Survey, and the US Geological Survey need to be used and cited more extensively. Half a dozen specific suggested references are listed below.		x		Y	MN Geological Survey and other succinct sources were reviewed for inclusion in the geology section of the LWRI. Text has been revised to include these new references, yet align with results in the MPCA Monitoring and Assessment Report.
	5	LWRI	"…Inventory is largely transcribed" from three MPCA reports, but none of the three reports are listed in Section 10 References		x		Y	Good catch. Added the WRAPS draft and TMDL report to References.

Commenter	Comment #	Page / Section	Comment	Material	Editorial	Note	Plan Change Made (Yes/No)	Comment Response / Action
AC member-Emailed 9/12	6	LWRI 4	Rose (1918) is listed as (1911) in the References.		x		Y	Changed in text to Rose, 1911
	7	LWRI 5	Confused description of the Coteau and Buffalo Ridge that is even worse in Section 3.3.1. Need to more the important point that the Little Sioux is different than the other three watersheds because it has Des Moines Lobe glacial drift with lower elevations, lots of lakes, and poorly developed drainage.		x		Y	Addressed in comment 4
	8	LWRI 6	The total average precipitation is NOT 3.4 inches. That's the average for July! Figure 4 adds to the confusion because it's for July only and is not the average annual.		x		Y	Changed figure and text to summarize annual precipitation.
	9	LWRI 7	* Figure 5 format should be changed to that of Figures 2 and 3. The majority of the area shown in Figure 5 is OUTSIDE the MRW.		x		N	With very few exceptions, this inventory utilizes and cites figures from existing reports and data. HEI made use of the best and most relevant figures found, and generated new figures only when needed to meet requirement for the LWRI. Moving forward, new figures generated by HEI will move the legend to reduce excess "white space," add HUC 8 Major Watershed (Planning Region) boundaries. New figures generated for the LWRI will be revised to include these formatting changes.
	10	LWRI 8	*Floodplains in Figure 5 could be usefully summarized with pie diagrams for each of the four constituent watersheds similar to the format used in Figure 33. They could show percent of the 1% and .2% risk categories.		x		Y	With very few exceptions, this inventory utilizes and cites figures from existing reports and data. HEI made use of the best and most relevant figures found, and generated new figures only when needed to meet requirement for the LWRI. Moving forward, new figures generated by HEI will move the legend to reduce excess "white space," add HUC 8 Major Watershed (Planning Region) boundaries. New figures generated for the LWRI will be revised to include these formatting changes. Generation of pie charts may be considered in the plan itself.
	11	LWRI 9	It is confusing to discuss the Little Sioux before the Rock. Keep the geographic sequence used in the Introduction: Upper Big Sioux, Lower Big Sioux, Rock, and Little Sioux. Also, the MPCA (2017) report on TMDL is not listed in the References		x		Y	Addressed in comment 3
	12	LWRI 14	Again, follow the geographic sequence from northwest to southeast. Also, the MPCA (2008) report on TMDL in the Little Sioux is not listed in the References.		x		Y	Addressed in comment 3
	13	LWRI 16	Figure 10 would be improved by using pie diagrams for each of the four watersheds showing wetland types and historic changes.		x		N	Figures: Addressed in comment 9
	14	LWRI 18	*"Middle" Big Sioux should be "Upper" & the 8-digit code is wrong with an extra "0". * Rock and Little Sioux do not have 8-digit codes given. Be consistent. *"coarse sorted till" is wrong. Till is not sorted and most of the till in southwestern MN is clay-rich. *"shale bearing loess" is wrong. Loess is wind-blown silt and does not have pieces of shale. *This incorrect language is lifted from the MPCA (2014) Monitoring and Assessment report for the MRW, p.33. That source is not good for any geology, but it needs to be cited in the text.		x		Y	Text from Monitoring and Assessment Report. Additional in-text citations added; however, text remains from Monitoring and Assessment report, with disclaimer that this Inventory is not a scientific analysis or independent review of existing data.
	15	LWRI 20	US Fish and Wildlife Circular 39 (1971) is not listed in the References.		x		Y	Good catch. Added to references.
	16	LWRI 21	Figure 12 would be improved by adding pie diagrams that summarize public water courses and basins for each of the four watersheds. Also, watersheds outside the MRW should be removed to look like Figures 2 and 3.		x		Y	Figures: Addressed in comment 10. Map will be reformated to remove white areas.
	17	LWRI 22	Figure 13 needs to be cleaned up. Take off "B" and "5-Western Province" and all items in the Explanation except the 3 colors shown in this copied portion of the published cross section.		x		N	Figures: Addressed in comment 9. This was leveraged from the MDNR. A web link was provided in the text for further clarification.
	18	LWRI 23	MDH GRAPS maps would all be much more useful if the format of Figure 33 is used. Each of the four watersheds could be compared using pie charts.		x		N	Figures: Addressed in comment 9
	19	LWRI 30	Figure 21 could be improved using pie charts for the four watersheds.		x		N	Figures: Addressed in comment 9
	20	LWRI 33	MRW WRAPS document (Draft, May, 2017) is not listed in References.		x		Y	Will add the WRAPS draft and Monitoring and Assessment Report to Appendix.

Commenter	Comment #	Page / Section	Comment	Material	Editorial	Note	Plan Change Made (Yes/No)	Comment Response / Action
	21	LWRI 39	Figure 27 could have pie diagrams easily added.		x		N	Figures: Addressed in comment 9
	22	LWRI 41	Figure 28 is a complicated presentation of feedlots and could probably be made more understandable using the four watershed pie diagrams.		x		N	Figures: Addressed in comment 9
	23	LWRI 43	Figure 29 could also have the four pie diagrams added and the area outside the MRW removed.		x		Y	Figures: Addressed in comment 10. Map will be reformated to remove white areas.
	24	LWRI 44	Figure 30 should add pie diagram summaries and remove non-MRW areas.		x		Y	Figures: Addressed in comment 10. Map will be reformated to remove white areas.
	25	LWRI 44	Add Lehr and Gilbertson (1988) to the References.		x		Y	Changed in text citation to MPCA, 2017
	26	LWRI 45	The quartzite bedrock outcrop is NOT the ridge called Buffalo Ridge. This section is lifted from the MPCA (2014) Monitoring and Assessment report, page 15, and that's a problem. The geology language in that document is not good. Interesting use of a footnote here. Footnotes could/should be added through out this Appendix?		x		Y	Addressed in comment 4; Removed section and referred to earlier sections of the plan.
	27	LWRI 44	*Again, listing the four constituent watersheds should follow the consistent northwest to southeast sequence.		x		Y	Addressed in comment 3
	28	LWRI 44	*Figure 31 should use the four pie diagram format which could be easily done by using Table 5.		x		N	Figures: Addressed in comment 9
	29	LWRI 49	Figure 32 could have pie diagram summaries and should have the non-MRW areas removed.		x		N	Figures: Addressed in comment 10
	30	LWRI 50	Figure 33 is the BEST map format and should be used throughout the Appendix.		x		N	Figures: Addressed in comment 9
PWG Discussion 9/13	N/A	LWRI 1	Add reference that better Geologic Atlas data is coming		x		Y	Text added.
AC Discussion 9/13	N/A	LWRI 1	Add reference that future Township N testing data is coming		x		Y	Text added
PC Member	1	LWRI 25	Typo: change the word "that" to "than"		x		Y	Typo fixed
	2	LWRI 7	Remove sentence about agricultural drainage as it makes flooding a causal issue		x		Y	Sentence removed.
	3	LWRI 7	Add dates to the WRCC chart about low and high precipitation years		x		N	Years provided on the chart are in 10 year increments. Kept years in text as a range to ensure it accurately captures the low and high precipitation years.
	4	LWRI 35	Remove sentence "In the MRW, point sources have a minimal impact on the total loads of pollutants/stressors delivered to water bodies." Just present the contributions		x		Y	Sentence removed.
	5	LWRI 41	Relating to tile drainage and stream flow changes	x			Y	Removed paragraph, as it does not add to the discussion about pollutant sources in the watershed.
	6	LWRI 45	Typo: change the word "area" to "are"		x		Y	Typo fixed
	7	LWRI 47	Referenced table is 5, not table 6		x		Y	Typo fixed
PC 2/14/18	1	LWRI 25	Typo: change the word "that" to "than"		x		Y	Typo fixed
	2	LWRI 35	Typo: "longer-term"		x		Y	Typo fixed
MDH	1	N/A: Resource Concern Map Layers	We had previously sent some shapefiles to Rachel which included Pollution Sensitivity to Wells. Attached are some shapefiles for nitrate, arsenic, and well density. We have to remove the public water supply well locations from the figures we created for the initial comment letter because we can't distribute public water supply locations due to security.	x			Y	Added nitrate and arsenic data to Drinking Waters resource concern map. Added well density data to groundwater supplies map.
	2		Delete "Wellhead Protection Areas" layer as the Drinking Water Supply Management Areas layer that is listed will cover this topic. The public meeting maps had vulnerability for the Drinking Water Supply Management areas and that's a good idea to include that.		x		Y	Deleted Wellhead Protection Areas shapefile from Drinking Waters resource concern map
Policy Committee	1	2.4.2.4	Delete repetitive "the" in sentence		x		Y	Revision made to "profitability of crops produced in ~~the~~ Minnesota"
	2	1.2.2	Repetitive issue for 1.2.2			x	N	No repetitive issues listed in table- no change made

Commenter	Comment #	Page / Section	Comment	Material	Editorial	Note	Plan Change Made (Yes/No)	Comment Response / Action
Advisory Committee	1	General	Typos and editorial revisions		x		Y	Editoral revisions made.
	2	3.2.11	What is the known loss (historical evidence) of # of weltands / acres in MRW? Estimate goal of % per year restoration.			x	N	Goal of 500 acres set by PWG. Historical acreage of wetlands provided in Land and Water Resources Inventory.
	3	3.2.15	Delete "may" in statement: …drainage systems may have impacts on the natural hydrology of the landscape."		x		N	Text maintained per recommendation from Planning Work Group.
Policy Committee	1	3.2.1- GW Nitrate	Adjust text language so infants defined as 0-4 months and "substantial" risk to health is less definitive.		x		Y	Text revised to: "The U.S. Environmental Protection Agency (EPA) standard for nitrate in drinking water is 10 milligrams of nitrate (measured as nitrate-nitrogen) per liter of drinking water (mg/L). Consumption of too much nitrate be harmful to human health, especially infants (MDH, 2018)."
	2	Figure 3-1	Adjust figure so resource categories are shown first.		x		N	Figure designed to show format of measurable goals.
	2	3.2.18- Rural Land Stewardship	Revise wording related to sources of nutrient loads. Currently states that over application of manure and fertilizer is the primary source of nutrient loads.		x		Y	Text revised to: "Excessive application of applied fertilizer and manure on agricultural fields is a source of nutrient (nitrogen and phosphorus) runoff to lakes, streams, and rivers in the MRW (MPCA, 2018). "
	3	General	Typos and editorial revisions brought up during PC meeting (Luke Johnson)		x		Y	Editoral revisions made.
MPCA	1	5.1.3	To be consistent this section title should be "DATA GAPS and RESEARCH". Maybe the narrative to follow should be a section on just "Data Gaps" part and a section on "Research" that better details what each is, who's responsible, funded, etc..? Otherwise This section seems to document water quality monitoring that has occurred and may be ongoing. The monitoring may fill in some data gaps or research but this section 5.1.3 doesn't (my opinion) really seem to address the list of data gaps in Section 4, table 4-4. There are only a few actions for data gaps and research in section 4 that have monitoring or research tied to them, but yet most of this appears to imply data gaps and research on water quality monitoring? I think data gaps and research is kind a above and beyond what has been or will be done. Will the 1W1P dedicate funds to this program other than existing programs to fill data gaps?		x		Y	Retitle to "Data Gaps and Research Implementation Program"
	2		Is this different from "data gaps and research" or is there overlap? Maintaining a monitoring network is of course high value but may not be interpreted as a data gap. I suppose everything becomes a data gap if it loses funding…			x	N	Conflicts with prevoius comment. Recommendation to retitle to "Data Gaps and Research Implementation Program"
	3		What is the source of the funds and/or agency. I don't see anything on MDA's pesticide or nitrate testing program. [local groups that conduct monitoring]			x	N	For group discussion
	4		This is a confusing sentence, what does it actually mean? Since this section is Research and Monitoring Implementation it reads like 1W1P is going to provide funding to train local partners to use new Research and Monitoring tools (like sondes? secchi tubes? drones??) ["This initiative will also be used to fund implementation of actions aimed to build and maintain technical capacity to fully utilize new technology and tools for water resource management. "]		x		Y	Revise to "This initiative will also be used to fund implementation of actions aimed to build and maintain technical capacity, as summarized in the targeted implementation schedule."
	5		In-text revisions (extensive) To be shown on screen		x		Y	Revise text as provided.
	6		Please be specific. Nowhere in this whole Research and Monitoring Implementation Program are any details given about what actually is needed. You could say for example, "the program will target the 1W1P priority management areas with funding for needed flow, chemistry and biological data collection. In additions funding for training and implementation of field surveys to document likely impacts and sources of altered hydrology, habitat destruction, etc. will be provided to local partners."			x	N	This information is provided in detail within the targeted implementaiton schedule.

Commenter	Comment #	Page / Section	Comment	Material	Editorial	Note	Plan Change Made (Yes/No)	Comment Response / Action
MRWA	1	Section 4	Add action "Identify and implement opportunities to collect data to monitor effectiveness of best management practices on nitrate levels in groundwater." to data gaps and research table. Lead could either be local staff or PWS with MDH/MDA as partners.	x			Y	Action added
	2		Revise action: Implement practices which control ground water elevation, reduce water volume yield, and remove pollutants before entering ditches, streams and groundwater (e.g. drainage water management, conservation drainage, woodchip bioreactor, saturated buffers).		x		Y	Revise text as provided.
	3		Facilitate protection of natural and pervious lands through such programs as acquisition, property tax credits and easements. include high priority groundwater recharge areas.	x			Y	Discussion needed about what high priority recharge areas are.
	4		"Encourage use of conservation easement programs in marginal, erodible land, especially within DWSMAs." Why limit it to marginal and erodible lands? Many of our high priority easement sites are prime ag. I would include priority recharge areas within wellhead protection areas. Can we also add provide financial incentives?		x		Y	Revise text as provided.
	5		"Provide one-on-one consultations with landowners and producers (i.e. field walkovers) about agricultural BMPs, field productivity benefits of BMPs, and available financial incentive options for funding them." Where do we talk about alternative crops and land uses? Encourage different groundwater friendly landuses etc…Where are promoting CRP and perennials in wellhead protection areas?	x			Y	For group discussion- potentially expand action item or add new one.
	6		"Implement practices which control ground water elevation, reduce water volume yield, and remove pollutants before entering ditches and streams (e.g. drainage water management, conservation drainage, woodchip bioreactor, saturated buffers)." Bioreactors at tile outlets are needed in wellhead protection areas.		x		Y	Revise text as provided.
	7		Implement g drainage water management and conservation drainage practices to control ground water elevation, reduce water volume yield, and remove pollutants from tile discharge prior to entering surface waters and groundwaters		x		Y	Revise text as provided.
	8		"Develop new techniques to promote conservation efforts, such as administering a local certification training program or partnering with agribusiness retailers to recommend appropriate BMPs." Where are we including the certified crop advisor updates/meetings? Laura is starting them and they are very effective other parts of the state.		x		Y	Revise action to include language about CCAs
	9		Monitor precipitation and increase the number of volunteer rain gauge readers to evaluate short and long-term trends and their relationship to groundwater supplies and lake levels.		x		y	Revise text as provided.
	10		"Identify opportunities to fund sustainable forest management, prairie, wetland and other natural area preservation and restoration through grants and partnerships." Do we need a measure that talks about developing partners and funding sources to preserve and protect critical groundwater recharge areas?		x		Y	Text revised.

Commenter	Comment #	Page / Section	Comment	Material	Editorial	Note	Plan Change Made (Yes/No)	Comment Response / Action
	11		Develop a monitoring program and prioritization process to help identify priority watersheds/regions where nitrate loading to the aquifer is occurring. This process will help identify key spots where implementation activities can be implemented.		x		Y	Text revised within Section 4
	12		Create and implement a monitoring program to help track the effectiveness of ag. bmps on reducing nitrate loading to the aquifer.	x			Y	Action added
Policy Committee (4/10/2019)	1	Section 5	Include Ash Creek in the Capital Improvement Table (was recently removed as the cost was only $90K). Include an asterik that this was still included regardless of its cost as it is a high local priority project.	x			Y	Revision made as recommended.
	2	Section 2 and 3	Include page numbers on maps if possible, but keeping maps as large as possible is most important.		x		Y	Revision made as recommended.
	3	Page 3-3	Resolve grammatical error: "are" significantly better than…		x		Y	Revision made as recommended.
	4	Section 4	Revise labels in the nearly / barely maps for readability		x		Y	Revision made as recommended.
	5	Page 5-4	Resolve grammatical error: "others" instead of "other"		x		Y	Revision made as recommended.
	6	Page 5-6	Resolve sentence to read as "Plan participants have and will continue to facilitate the development and assembly of data and information.."		x		Y	Revision made as recommended.

Appendix E

BWSR One Watershed, One Plan - Plan Content Requirements v. 1.0

MISSOURI RIVER WATERSHED
Comprehensive Watershed Management Plan

One Watershed, One Plan

Plan Content Requirements

March 23, 2016

Purpose: This document outlines plan content requirements for developing comprehensive watershed management plans, as per Minnesota Statutes §103B.801, through the One Watershed, One Plan Program.

Introduction

This document contains specific content requirements for drafting a comprehensive watershed management plan through the One Watershed, One Plan program. Full operating procedures for developing the plan - including initiating the planning process through review, approval, and adoption - are contained in the *One Watershed, One Plan Operating Procedures* document.

The following Guiding Principles provided sideboards and direction in the plan content requirements outlined in this document:

- One Watershed, One Plan will result in plans with prioritized, targeted, and measurable implementation actions that meet or exceed current water plan content standards.
- One Watershed, One Plan will strive for a systematic, watershed-wide, science-based approach to watershed management, driven by the participating local governments.
- Plans developed within One Watershed, One Plan should embrace the concept of multiple benefits in the development and prioritization of implementation strategies and actions.
- One Watershed, One Plan planning and implementation efforts will recognize local commitment and contribution.
- One Watershed, One Plan is not intended to be a one-size–fits-all model.

The requirements in this document are also supported by the vision of the Local Government Water Roundtable that future watershed-based plans will have sufficient detail that local government units can, with certainty, indicate a pollutant of concern in a water body, identify the source(s) of the pollutant, and provide detailed projects that address that particular source. This vision also includes a future of limited wholesale updates to watershed-based plans; with a streamlined process to incorporate collected data, trend analysis, changes in land use, and prioritization of resource concerns into the watershed-based plan; and an emphasis on watershed management and implementation through shorter-term work plans and budgeting. This vision includes acknowledging and building off of existing plans and data (including local and state plans and data), as well as existing local government services and capacity.

Table of Contents

NOTE: Operating Procedures for establishing planning boundaries, requirements for participation and formal agreement between local governments within the boundary, and procedures for plan development are provided in a separate document.

I. Overview

The organization of this document includes background information and guidance about the requirements with the specific plan content requirements contained in a shaded box. The primary planning terms used are: priority issues, goals, and actions. These terms are defined within the sections they are used.

Plan development procedures and steps such as: initiating a plan, establishing a planning boundary, requirements for participation and formal agreements between local governments within the boundary, and procedures for formal review and approval can be found in the *One Watershed, One Plan Program Operating Procedures* document. Overall organization and format of the plan is a local decision unless otherwise specified in these requirements.

Planning partners are strongly encouraged to consider the potential for more extreme weather events and their implications for the water and land resources of the watershed in the analysis and prioritization of issues. While these events cannot be predicted with certainty as to time and occurrence, the meteorological record shows increased frequency and severity of extreme weather events, which has a direct effect on issues in local water planning.

Minnesota Statutes, Section 103B.801, subdivision 4 indicates that comprehensive local water plans should consider and discuss several issues as part of the watershed planning process. These issue areas include:

- Surface water and ground water quality protection, restoration, and improvement, including prevention of erosion and soil transport into surface waters.
- Restoration, protection, and improvement of surface water and groundwater storage and retention systems.
- Promotion of groundwater recharge.
- Flood damage reduction, especially to minimize future public expenditures needed to correct flooding problems.
- Wetland enhancement, restoration, and establishment.
- Shoreland and riparian zone management and buffers.
- Protection and enhancement of fish and wildlife habitat and water recreational facilities.

However, the local water planning process is not limited to these issues. Broad issues areas likely to be identified and discussed through the watershed planning process include:

- Soil health
- Altered hydrology
- Maintenance of core services; understanding of local capacity
- Water supply (protect, provide and conserve)
- Drinking water supply
- Drainage system management
- Wastewater management
- Drought mitigation
- Education, outreach and civic engagement
- Contaminants of emerging concern
- Emerging issues (e.g. land cover, climate change, etc.)
- Invasive species prevention and/or management

The list above is not all-inclusive. Any land and water related issue could be part of the plan. Further, issues may also include addressing administrative priorities (e.g., establishment of uniform local policies and controls in the watershed) or fiscal challenges (e.g., minimizing public capital expenditures in resolving problems in areas such as flood control or water quality protection).

Although not required, recommended steps in the planning process include developing an overarching mission or vision statement for the watershed, as well as higher-level guiding principles or purposes. The purpose of establishing a vision, mission, and/or guiding principles is to provide a sense of direction for the plan and participants in the planning process.

An underlying theme within these requirements is the intent for watershed-based plans developed through One Watershed, One Plan to be succinct, with a thorough and science-based process used in development, and an emphasis in the resulting plan on the implementation schedule and implementation programs. For example, the information found in a Land and Water Resources Inventory is extremely valuable to the planning process and ultimate implementation of the actions in the plan; however, the majority of this information can be incorporated into the final plan document by reference.

Finally, through the development of the One Watershed, One Plan program, BWSR partnered with the University of Minnesota to assess tools and models available to assist in plan development. Models and tools were assessed based on: the complexity of the tool, scale at which the tool is best used, ability of scenarios to be evaluated with the tool, ability for the tool to evaluate multiple constituents, and whether the tool has historical use or support in Minnesota. The resulting recommendations will be available on the BWSR website, and assistance with selecting and using models and tools for plan development may be available. More than one tool or model may be used in a planning effort and different tools may be used in subsequent implementation. However, the tools utilized in developing a capital improvements program must be able to demonstrate prioritized, targeted and measurable outcomes

II. Plan Content Requirements

Each watershed-based plan will contain the elements outlined in the following sections.

1. Executive Summary

Each plan will have a section entitled Executive Summary. The purpose of the executive summary is to provide a condensed and concise plain language summary of the contents of the overall plan. A well-written executive summary is beneficial for current and future elected officials, staff, citizens, and stakeholders to achieve an understanding of the plan and its intent.

Plan Content Requirement: Executive Summary

Each plan will have a section entitled Executive Summary. The purpose of the executive summary is to provide a brief look at the contents of the plan. The summary will include:

A. Purpose, mission, or vision statement if developed;
B. A general map or description of the planning boundary and smaller planning or management units if used;
C. A summary of the priority issues and goals that are addressed in the plan;
D. A summary of the implementation actions and programs;
E. A brief description of the process used to identify the measurable goals and targeted implementation actions; and
F. An outline of the responsibilities of participating local governments.

In addition to the Executive Summary, the plan may need a table of acronyms and a definitions section; however, these are not required and may be included in the appendices.

2. Identification and Prioritization of Resources and Issues

This section of the plan is intended to summarize the process that the planning partners used to reach agreement on the watershed resource issues that will be addressed within the lifespan of the plan. Prioritizing is needed because not all identified issues can be addressed in the timeframe of a ten year plan—some will be addressed before others.

The process for considering and prioritizing issues generally has two parts: agreement on priority natural resources, sometimes called geographic targeting, and agreement on priority issues impacting those resources. Examples of priority resources include high quality recreational lakes, the main stem of the primary river in the watershed, or a specific groundwater aquifer that is the primary drinking water source in the watershed. Identifying priority issues goes a step further by describing the issue(s) that impact or threaten the priority resources of the watershed, such as: "high quality recreational lakes showing a downward trend in water quality" or "sedimentation in the main stem of the priority river."

In general, the process for identifying the priority resources and issues will follow four steps:

1. Aggregate priority resources and issues from: existing local plans, studies, and reports; modeling, data collection, and assessment completed through the WRAPS and/or TMDLs; state plans or studies; feedback received from the initial notifications to the plan review authorities and stakeholders; and comments submitted by citizens at the initial planning meeting(s) held in the watershed (see *One Watershed, One Plan Operating Procedures*).
2. Apply local knowledge and information and consider the following factors to describe potential priority issues:
    - Science and data generated through modeling, data collection, and assessment such as WRAPS, TMDLs, or equivalent;

- Anticipated future impacts or land use changes that may provide an opportunity or escalate a risk if nothing occurs;
- Understanding of trends and/or tipping points for individual water resources;
- Understanding of precipitation frequency as per National Oceanic and Atmospheric Administration (NOAA) Atlas 14;
- Understanding of citizen and local landowner willingness to participate in potential changes to watershed management;
- Local values which may recognize specific water or landscape resources as a priority.

3. Consider the high-level state priorities identified in the state's Nonpoint Priority Funding Plan for Clean Water Implementation Funding. These are the priorities identified by state agencies for investing Clean Water Fund nonpoint implementation money:
   - Restore those impaired waters that are closest to meeting state water quality standards.
   - Protect those high-quality unimpaired waters at greatest risk of becoming impaired.
   - Restore and protect water resources for public use and public health, including drinking water.
4. Select priority resources and issues to be addressed in the plan, based on analysis of the sources and factors identified in Steps 1 – 3.

Plan Content Requirement: Identification and Prioritization of Resources and Issues

The plan must contain:

1. A summary of the issues and resource concerns identified from all sources for consideration in this section;
2. The steps used to consider and prioritize the identified resources and issues; and
3. A list of the agreed upon priority resources and issues for the watershed and a brief description of why the issue was selected.

Priority issues can be articulated in the plan through both a list/descriptions and map(s). The format and exact planning terminology used in the plan for presenting priority issues may vary as long as the plan covers the three requirements above and the terminology used is defined in the plan (the summary and steps are suggested to be included as appendices). The plan is not expected to address all identified issues; however, it should include a brief explanation as to why certain issues were rejected as priorities for this planning cycle.

In the event that conflicts exist in the interpretation of issues and/or selection of priority issues, consider whether the conflict can be addressed by defining both watershed-wide priorities as well as individual priorities of the participating local governments.

Plans that do not demonstrate a thorough analysis of issues, and that do not use available science and data, will not be approved. BWSR will consider the guidance and recommended tools outlined in *Section 2 Analysis and Prioritization of Issues* in assessing if analysis has been thorough.

3. Establishment of Measurable Goals

The plan must contain measurable goals, sometimes called objectives in planning, to address each of the priority issues. Measurable goals articulate what the planning partners want to achieve and allow for evaluation of progress. A useful method for assessing if a goal is measureable is to ask the question for each goal: “will we be able to measure / show / report that we have been successful in achieving this goal when we assess implementation of the plan in the future?”

The development of measurable goals and the resulting implementation actions will be an iterative process. Goals from existing local water plans and information should be summarized and discussed for potential inclusion as part of this process. WRAPS, TMDLs, and the models used for the prioritization process noted above should all be used in the setting of goals. The implementation programs and schedule for achieving the goals should be considered and goals adjusted to reflect which are achievable within the timeframe of the plan versus goals that may reflect a longer view.

Formatting, terminology, and organization in the plan to meet this requirement can vary. For example, a goal to “maintain clean drinking water for future generations” by itself is too broad to be measurable and may better serve as a guiding principle. However, a broad goal such as this could be acceptable if it is supported by a series of measurable sub-goals or objectives. The plan may contain a blend of goals common to the watershed as a whole, goals individual to a specific local government participant(s) and/or resource, and goals that persist beyond the timeframe of the plan.

Not every goal can be measurable within the timeframe of the plan; however, the aggregate of goals in the plan should together articulate an intended pace of progress. For example, if a water quality standard is unable to be met within the lifespan of the plan, the plan should contain longer-term goals with interim points at which progress can be examined and methods and models to establish the goal can be reevaluated. Ideally, these interim points would use some measure to show attainment of an interim goal.

The timeframe of goals may also need to recognize unique settings and situations across the state. As an example, The Minnesota Geological Survey notes that response time of nitrate concentrations to changes in land use practices in southeast Minnesota will likely vary in different hydrogeologic settings, and may lag behind land use changes by decades. In addition, some water quality or designated use support goals may take decades to achieve (e.g. changes in stream biota or altered base flow hydrology).

Plan Content Requirement: Establishment of Measurable Goals

Each priority issue must have associated measurable goals for addressing the issue. Some goals will be watershed-wide; however, the majority should be focused on a specific subwatershed, natural resource, or local government. Goals for prevention of future water management problems should also be considered.

Plans that do not contain sufficient measurable goals to indicate an intended pace of progress for addressing the priority issues will not be approved.

BWSR will consider Minnesota Statutes §103B.801, Subd. 4 (2), and the balance of broad versus focused goals and shorter-term versus longer-term goals and detail in the targeted implementation schedule to assess whether goals are sufficient. Additionally, the pace of progress towards achieving goals will be used in determinations of the extent or depth of future ten year plan revisions. BWSR may consider issuing findings when a plan and associated implementation is sufficient that a complete revision will not be required.

Specific Goal Requirements:

- Consistent with the Clean Water Council policy, these plans must establish water storage goals, expressed in acre-feet, and standards for water storage, retention, and infiltration.

4. Targeted Implementation Schedule

Targeting takes a closer look at the priority issues and identifies cost-effective, targeted, and measurable actions necessary to achieve the goals. These actions are included in the plan in consideration of available technical skills and capabilities, knowledge of landowner willingness, funding resources available, implementation items or projects from existing local water plans, and information and the Strategies and Actions table from the WRAPS. Actions are entered into a schedule or table that provides the details of:

- A brief description of each action;
- Location targeting where the action will occur;
- Identification of roles and who is responsible for the action;
- An estimate of cost and potential sources of funding for implementing the action;
- An estimate of when the implementation will occur within the ten year timeframe of the plan; and
- How the action will be measured.

The purposes of the implementation schedule are to: clearly indicate an intended pace of progress for achieving the goals; support development of shorter term work plans and budgets for the planning partners; and to support budget requests to the state through BWSR's Biennial Budget Request (BBR). The schedule should be supported by maps indicating the location(s) of the targeted activities.

The development of a targeted implementation schedule and associated actions is an iterative process. Additionally, BWSR recognizes that some actions may require a prior feasibility study to refine a potential implementation strategy.

The depth and specificity of targeted actions identified in the plan will vary. For example, capital improvement projects and best management practices to be implemented on public land can generally be specifically located and identified in the plan. By contrast, conservation practices proposed for private lands may be specifically identified through the use of models and tools for purposes of developing measurable goals and the targeted implementation schedule, but those locations are only generally described in the plan itself. For these private lands, the plan must overtly describe actions to work with landowners in these critical areas and tailor conservation practices.

Plan Content Requirement: Targeted Implementation Schedule

Each plan will have a targeted implementation schedule for achieving the goals with:

1. A brief description of each action;
2. Location targeting where the action will occur;
3. Identification of roles and the responsible government unit for the action;
4. An estimate of cost and potential sources of funding for implementing the action;
5. An estimate of when the implementation will occur within the ten year timeframe of the plan; and
6. How the outcomes of the action will be measured.

The schedule must clearly identify the actions the planning partners will undertake with available local funds versus the actions that will be implemented only if other sources of funds become available, and should be supported by maps indicating the location(s) of the targeted activities.

5. Implementation Programs

The implementation programs described below support the targeted implementation schedule by describing the overarching program(s) that will be used to implement actions identified in the schedule and how these programs will be coordinated between the local water management responsibilities. In addition, partners must decide what organizational structures are best suited to administer the various programs. In some cases new arrangements may be needed or desired. All programs described in this section must be included in the plan.

A. **Plan Administration and Coordination**: The plan must describe the following administration and coordination programs.

   i. **Decision-making and Staffing:** Describe how the partners will transition from a planning partnership to implementation of a watershed-based plan through descriptions of roles and responsibilities of participating local governments.

      a. **Policy Committee** (decision-making): Describe if the policy committee created to develop the plan will continue through plan implementation, or clearly outline an alternative method to provide oversight and maintain accountability throughout plan implementation.

      b. **Advisory Committee** (advising): Describe if the advisory committee(s) created for plan development will continue through plan implementation and/or describe alternative methods to ensure: a dependable forum to exchange information and knowledge about the watershed and implementation of the plan, and meet the statutory requirements for ongoing advisory committees of counties (Minnesota Statutes §103B.301-103B.3355) and watershed districts (Minnesota Statutes §103D.331-103D.337).

      The plan should also establish procedures for engaging state agencies, and describe the ongoing role and commitments of the state agencies for plan implementation.

      c. **Identification and Coordination of Shared Services** (staffing): Describe specialized and shared service areas that will be used in the watershed to implement the actions identified in the schedule and achieve greater efficiencies in service delivery. This may include shared services for program management, such as if a plan action requires forest resource management technical assistance, but the local government where the action is occurring does not have a staff forester. The watershed plan and associated formal agreements should describe how the service will be shared and/or the need met. Or the plan may include project management. For example if one county has history and experience implementing a large-scale multipurpose drainage project, another county in the watershed may want to contract for services with staff from the experienced county to implement a similar project. Shared services may also include partnership with non-governmental organizations.

   ii. **Collaboration with other Units of Government:** Describe relationships with other units of government not part of the formal agreement for plan development, including the drainage authorities within the planning boundary. For example, cities and townships are not required participants. However, recognition and inclusion of cities and townships is important and especially critical to recognize for actions involving waste water treatment plants, source water and wellhead protection for population centers, and MS4s, for example. Additionally, federal government partners are not required participants. However, federal programs and partnerships are very important resources in watershed management.

   iii. **Funding:** Describe how actions in the implementation schedule will be funded. Both the state and local governments have responsibility for funding water management. All funding methods currently available to participants remain available to the participants and/or to the organization as a whole through the participants.

a. **Local Funding:** The local government planning partners have variable methods and options for generating funds to implement watershed management and to leverage state and other funding. The funding sources and commitments of participants must be clearly outlined in the plan.

b. **State Funding:** Describe state funding needed for implementation of the plan. This can be achieved through separation in the targeted implementation schedule of locally funded projects versus projects that will proceed only with state funds.

c. **Collaborative Grants:** Describe the intended approach to coordinated submittal of state grant applications. Collaborative funding and implementation is a goal of One Watershed, One Plan.

d. **Federal Funding**: Federal sources of funds can be important to watershed management. The plan should describe what type of federal funding resources may be pursued to implement the plan.

e. **Other Funding Sources**: Other sources of funds, such as from non-governmental organizations and private landowner funding, can be important to watershed management. The plan should describe what other types of funding may be pursued to implement the plan.

iv. **Work Planning:** Describe how the targeted implementation schedule and the implementation programs will be used for work planning. For example, describe if a collaborative work plan for the watershed, individual work plans for each local government participant, or some combination of work planning will be used; and describe how the work plan will be finalized and approved.

a. **Local Work Plan Purpose:** Include a frequency, method, decision-making, and local purposes for work planning. Frequency is suggested to be annual in order to be incorporated into local budgeting and staffing decisions related to implementation of the plan. Purposes depend on the extent of collaboration intended in the implementation schedule, programs, and subsequent agreements, as well as the extent of collaborative grant-making intended.

b. **State Work Plan Purpose:** Describe a biennial commitment to collaboratively review and submit a BWSR biennial budget request (BBR) from the watershed. Future BBRs should be generated from the Targeted Implementation Schedule.

v. **Assessment and Evaluation:** Describe the frequency, method(s), purposes, decision-making, and procedures for periodic assessment and evaluation of plan implementation. Periodic understanding of accomplishments—based on the targeted implementation schedule—is needed to measure progress, drive the work plan, and provide accountability. If a Watershed Restoration and Protection Strategies report is completed within the planning area after the plan is complete, this report must be considered at the next scheduled evaluation.

a. **Annual Evaluation:** Describe an annual commitment to collaboratively review and submit to BWSR's Level I Performance Review and Assistance Program (PRAP) plans and reports for each local government in the partnership. Additionally, describe sufficient baseline local evaluation of previous years' work to support generation of the local work plan in iv.a above (if an annual local work plan is being used) and reporting requirements in v.d below.

b. **Biennial Evaluation:** If the partnership chooses a biennial work plan, a biennial evaluation must be described to evaluate the previous years' work and support the work plan. It is recommended that this baseline evaluation is tied to the requirement for measurability in the targeted implementation schedule and that a method for tracking implementation consistently across the watershed be described.

c. **Five Year Evaluation:** Include a schedule for a thorough five year assessment and potential revision to implementation schedule. The purpose of this evaluation is to determine progress and consider whether staying the course or resetting direction is necessary. It may also include revisions to models and considerations of new monitoring data. If a WRAPS has been completed or revised since the plan was originally adopted, this evaluation must include an assessment of any changes necessary due to the WRAPS. BWSR involvement in this evaluation may include Level II PRAP.

d. **Reporting:** Describe collaborative approaches to provide accountability to stakeholders and to meet annual reporting requirements of local governments, grant reporting requirements, and specific program and financial reporting requirements. Information on required annual reporting can be found on the BWSR website: www.bwsr.state.mn.us/grants/reporting/reporting.html. Consider a periodic 'state of the watershed report,' or individualized 'waterbody report cards' or other methods to provide accountability and demonstrate outcomes locally. See also the Education and Information requirements below.

vi. **Plan Amendments:** Describe procedures for considering plan amendments, who can propose amendments, what criteria will be used in considering amendments, and who makes the decision to proceed with amendments.

vii. **Organizational Structures or Formal Agreements:** List and briefly describe the organizational structures or entities that will be used to implement the plan's projects and programs. Indicate whether these are existing entities or new ones. In either case, indicate any formal agreements between local governments that are needed and whether these will be modifications of existing agreements or new agreements. For example, prior to completion of the plan, the Memorandum of Agreement (MOA) between partners for planning purposes could be revised for on-going coordination among entities responsible for plan implementation. . Consultation with Minnesota Counties Intergovernmental Trust (MCIT) and legal counsel is recommended. MCIT may recommend revising the planning agreement, establishing separate agreements or contracts for specific services or actions and/or developing a broader, watershed-wide agreement for ongoing partnership.

B. **Plan Implementation Programs**: Describe the following programs to support the targeted implementation schedule, including necessary feasibility studies.

i. **Incentive Programs:** Describe local voluntary cost share or grant programs necessary to achieve the goals, including the general purpose and scope, criteria that will be used to select projects/disperse funds, actions to work with landowners in these critical areas to tailor conservation practices, and how the program(s) will be implemented across the watershed to provide consistency and achieve goals. Incentive programs may be targeted to specific issues, e.g. grants for sealing abandoned wells, or specific areas, e.g. a watershed of priority lakes.

ii. **Capital Improvements:** Describe opportunities for watershed-wide collaboration (e.g. sharing of specialized services and/or lessons learned on these large-scale projects) on capital improvements (physical/structural improvement with an extended life) identified in the targeted implementation schedule. Consider including opportunities for improved water management associated with county and township roads and within drainage systems managed through Drainage Law.

a. **Drainage**: Describe opportunities for enabling large-scale, multi-purpose projects on a watershed basis and for engaging drainage authorities and drainage inspectors in implementation of the watershed plan. Describe local procedures for ensuring future drainage projects are not inconsistent with the goals of the plan

b. **Capital Improvement Programs (CIPs) for Watershed Districts:** CIPs are required in the plan when a watershed district is included, consistent with the requirements of Minnesota Statutes §103B and

103D. A CIP is an itemized program for at least a five-year prospective period, and any amendments to it, subject to at least biennial review, that sets forth the schedule, timing, and details of specific contemplated capital improvements by year, and, together with their estimated cost, the need for each improvement, financial sources, and the financial effect that the improvements will have on the local government unit or watershed management organization. This requirement can be incorporated into the targeted implementation schedule if the specific requirements of Minnesota statutes §103B and 103D are clearly met.

c. **Permanent Protection:** Describe opportunities for permanent land protection necessary to meet the resource needs and achieve the goals for the watershed.

iii. **Operation and Maintenance:** Include a description of who is responsible for inspection, operation and maintenance of capital projects, stormwater infrastructure, public works, facilities, and natural and artificial watercourses. Specify any new programs or revisions to existing programs needed to accomplish the goals or that may benefit from watershed-wide collaboration.

iv. **Regulation and Enforcement:** Describe existing regulations, controls, and authorities relevant to water management for the purposes of highlighting areas of duplication, gaps, and opportunities. Use this analysis to identify areas to maximize effectiveness and build efficiencies through improved coordination and consistent application of regulations, and/or to develop new regulation or enforcement in support of meeting plan goals. Consider also opportunities for efficiencies in required annual reports related to regulation, and enforcement and connections to possible data gaps. Include a description of drainage authorities and responsibilities and local implementation of the buffer law, passed in the 2015 1st Special Session. Regulatory areas to consider include, but are not limited to: shoreland, floodplain, septic, Wetland Conservation Act, Protected Waters Inventory, erosion control, municipal wastewater, Minimum Impact Design Standards (MIDS), land use, aggregate mining, feedlots, hazard mitigation, buffers, and prescription drug drop off locations.

a. **Regulation and Enforcement for Watershed Districts:** Describe the rules and associated permit programs of watershed districts in the watershed, consistent with and as necessary to meet the requirements of Minnesota statutes §103B.337-103D.345.

b. **Comprehensive or land use plans:** Describe the land use authorities within the watershed as well as potential opportunities to achieve goals through, or potential conflicts with, comprehensive land use plans.

v. **Data Collection and Monitoring:** Describe data collection and monitoring activities necessary to support the targeted implementation schedule and reasonably assess and evaluate plan progress.

a. **Inventory:** Describe additional inventories needed in the watershed to address any gaps in the land and water resources inventory support actions in the targeted implementation schedule.

b. **Monitoring:** Describe the locations, frequency, and parameters of existing water quality, quantity and other monitoring programs in the watershed. Describe if these established monitoring programs are capable of producing an accurate evaluation of the progress being made toward the goals, including improved calibration of model(s), and any new monitoring needed to improve understanding of the watershed baseline or assess particular resources. State agencies are available to assist with identification of state monitoring activities.

Include a requirement for periodic analysis of the data, a commitment to collect data consistent with state compatibility guidelines, and a commitment to submit locally collected data to the appropriate state agency for entry into public databases.

vi. **Information, Outreach, and Education Programs:** The plan must describe information, outreach, and education program(s); specifically, opportunities where there are benefits from watershed-wide collaborations and areas where focused or targeted actions will support the priority issues and goals of the plan. At a minimum, include the purpose, targeted audiences, and a description of the actions or methods. Consider development of an education plan for the overall watershed using an approach currently successfully used in Minnesota, an adaptation of the U.S. Environmental Protection Agency guidance "Getting in Step: A Guide for Conducting Watershed Outreach Campaigns" available at: www.epa.gov/owow/watershed/outreach/documents/getnstep.pdf.

6. Plan Appendix - Land and Water Resources Inventory

A land and water resource inventory is simply an account of the water resources and physical factors affecting the water resources within the watershed. In most cases, adequate data, inventories, and general analysis of land and water resources already exist; new information does not necessarily need to be generated and the majority of resource information can be incorporated by reference with a brief general description. At a minimum, the plan should acknowledge the resource information from existing local water plans and the Watershed Restoration and Protection Strategies Report (WRAPS) and NOAA Atlas 14 data. This information is important not just to understand the historic status of the watershed, but is useful in considering the future.

Going forward, wholesale updates and/or revisions to land and water resource inventories should be limited. Instead greater flexibility and a streamlined process for more frequent updates to incorporate collected data, updated trends analysis, and changes in land use typically associated with land and water resource inventories are envisioned.

<u>Plan Content Requirement: Land and Water Resources Inventory</u>

The plan must contain sufficient land and water resources information to inform the planning process and support actions in the plan. Specifically, the plan must include a brief general description of—and reference where to find—the typical and available land and water resource information. This information includes, but is not limited to:

- Topography, soils, general geology;
- Precipitation;
- Water Resources
  - Surface water resources, including streams, lakes, wetlands, public waters and public ditches;
  - Groundwater resources, including groundwater and surface water connections if known;
  - Water quality and quantity, including trends of key locations and 100-year flood levels and discharges, regulated pollutant sources and permitted wastewater discharges;
  - Stormwater systems, drainage systems and control structures;
  - Water-based recreation areas;
- Fish and wildlife habitat, rare and endangered species; and
- Existing land uses and proposed development.

Inventory information critical to supporting the priorities and actions of the plan may need to be more thoroughly described. For example, a description of results of trend analysis may need more in-depth description to support a priority issue in the plan; however, the data behind the analysis can be referenced.

If gaps in inventory information are identified through the plan development process, consider implementation action(s) to fill the gap rather than delaying the planning process to generate new data.

Appendix F

Resources Reviewed and Relied Upon During Plan Development

MISSOURI RIVER WATERSHED
Comprehensive Watershed Management Plan

RESOURCES CITED IN TEXT

Board of Water and Soil Resources (BWSR), 2016. *One Watershed, One Plan: Plan Content Requirements*. Available at: https://bwsr.state.mn.us/sites/default/files/2018-12/Plan%20Content%20for%20Program%20032316.pdf

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Appendix G
Comment Letters

MISSOURI RIVER WATERSHED
Comprehensive Watershed Management Plan

July 14, 2017

Missouri River Watershed Planning Group
C/O Dan Livdahl, Okabena-Ocheda Watershed District
PO Box 114, 960 Diagonal Road
Worthington MN, 56187

RE: Response to request for priority issues and plan expectations (One Watershed, One Plan).

Dear Mr. Livdahl,

Thank you for providing the opportunity to provide priority issues and plan expectations for the development of the Missouri River Comprehensive Watershed Management Plan (One Watershed, One Plan) under Minnesota Statutes section 103B.101, Subd. 14. We appreciate the partner's willingness to participate in development of a watershed-based plan.

The Board of Water and Soil Resources (BWSR) has the following overarching expectations for the plan:

Process

- The planning process must follow the requirements outlined in the One Watershed, One Plan – Operating Procedures document, adopted by the BWSR Board on March 23, 2016 and available on the BWSR website: www.bwsr.state.mn.us/planning/1W1P/index.html. More specifically, the planning process must:
    - Involve a broad range of stakeholders to ensure an integrated approach to watershed management.
    - Reassess the agreement established for planning purposes when finalizing the implementation schedule and programs in the plan, in consultation with the Minnesota Counties Intergovernmental Trust and/or legal counsel of the participating organizations, to ensure implementation can occur efficiently and with minimized risk. This step is critical if the plan proposes to share services and/or submit joint grant applications.

Plan Content

- The plan must meet the requirements outlined in the One Watershed, One Plan – Plan Content Requirements document, adopted by the BWSR Board on March 23, 2016 and available on the BWSR website: www.bwsr.state.mn.us/planning/1W1P/index.html. More specifically, the plan must have:
    - A thorough analysis of issues, using available science and data, in the selection of priority resource concerns.

- Sufficient measurable goals to indicate an intended pace of progress for addressing the priority issues.
- A targeted and comprehensive implementation schedule, sufficient for meeting the identified goals.
- A thorough description of the programs and activities required to administer, coordinate, and implement the actions in the schedule; including work planning (i.e. shared services, collaborative grant-making, decision making as a watershed group and not separate entities) and evaluation.

BWSR has the following specific priority issues:

<u>Pertaining to Groundwater</u>

- **Groundwater Coordination and Prioritization:** Work with BWSR staff and agency partners (MDH, DNR, MDA, and MPCA) to outline any groundwater – related priority issues for the planning area. Take into account identified Groundwater Management Areas, Drinking Water Supply Management Areas, wellhead protection areas, areas with direct connection to the water table, and other areas of groundwater concern. Address specific concerns about groundwater contamination and overuse identified and documented.
- **Groundwater References:** The Missouri River Watershed area of Minnesota has a great number of references and data available. Be sure to make use of existing groundwater data and publications. These include maps, data layers, and publications available from the Minnesota Geological Survey, MnDNR, Mn Dept. of Health, US Geological Survey, and other sources.

<u>Pertaining to Drainage Management (103E):</u>

- **Involve Drainage Authorities:** Chapter 103E stresses that drainage authorities engage starting in the early stages of the planning process. Use Section 103E.015 *CONSIDERATIONS BEFORE DRAINAGE WORK IS DONE* and other provisions of drainage law identified below to capture both the extent and the limitations of drainage authority responsibility and authority for participating in the planning and implementation of conservation practices involving public drainage systems and their associated drainage areas.
- **Multipurpose Drainage Management (MDM):** Include multipurpose drainage management in the approach for targeting best management practices (BMPs) within the drainage area of Chapter 103E drainage systems.
- **Remember PTM Concepts:** Always remember Prioritized, Targeted, and Measurable.
    - Prioritization of the watershed should include identification of Chapter 103E drainage systems and their drainage areas.
    - Measurable outcomes for erosion and sediment reduction, nutrient reduction, improved instream biology, and detention storage to assist those outcomes, should include correlation to Chapter 103E drainage systems.
- **Coordinate Implementation:** Lay out a coordinated approach for how implementation of multipurpose drainage management practices identified in the plan can be coordinated with, and/or integrated early into 103E processes and proceedings. When projecting funding needs for BMP implementation on, or within the drainage area of, public drainage systems, incorporate use of Sections 103.011, Subdivision 5. *Use of external sources of funding.*,

103E.015, Subdivision 1a. *Investigating potential use of external sources of funding and technical assistance.*, 103E.227 *IMPOUNDING, REROUTING, AND DIVERTING DRAINAGE SYSTEM WATERS.*, and 103E.701, Subdivision 6. *Wetland restoration and replacement; water quality protection and improvement.* These provisions enable public-private funding partnerships involving 103E drainage systems.

- Drainage authorities should consider the permissive authority in 103E.021 Subd. 6 to incrementally implement permanent buffer strips of perennial vegetation, and/or side inlet controls, where necessary to control erosion and sedimentation, improve water quality, or maintain the efficiency of the drainage system. Note also that a drainage authority shall order minimum 16-1/2 ft. wide strip(s) of **perennial vegetation approved by the drainage authority** for any proceeding to establish, construct, improve or do any work affecting a public drainage system under any law that appoints viewers to assess benefits and damages, pursuant to 103E.021, Subd. 1.

Pertaining to Easements

The State's Re-Invest in Minnesota (RIM) Reserve easement program, and the CREP program partnered with USDA, considers several site specific and landscape scale factors when funding applications. Though it is dependent on specific program terms, the State does consider local prioritization of areas for easement enrollment. The plan should take into account contributing areas with a higher risk of contributing to surface and subsurface water degradation such as highly erosive lands and wellhead protection areas for waters sensitive to pollution degradation that would be relieved through permanent vegetation cover.

Pertaining to Wetlands

- Wetland Management: Protection and restoration of wetlands provides benefits for water quality, flood damage reduction, habitat and wildlife. The plan should support the continued implementation of the Wetland Conservation Act and look for opportunities to improve coordination across jurisdictional boundaries. The plan should also identify high priority areas for wetland restoration and strategically target restoration projects to those areas. The Restorable Wetland Prioritization Tool is one resource that to be used to help identify areas for wetland restoration. The state is also embarking on a wetland prioritization plan that will guide wetland mitigation in the Missouri River Watershed area in the future. Wetland restoration and preservation priorities you identify in your plan may be eligible for inclusion in this statewide plan in the future.

General Comments

- The state's Nonpoint Priority Funding Plan (NPFP) outlines a criteria-based process to prioritize Clean Water Fund investments. If planning partners are intending to pursue Clean Water Fund as a future source of funding, partners are strongly encouraged to consider the high-level state priorities, keys to implementation, and criteria for evaluating proposed activities in the NPFP.

- BWSR suggests a comparative review of local ordinances and regulations across the watershed redetermination of ditches, SSTS compliance inspection requirements (property transfer, variance, etc.), level III feedlot inventories, shore land regulations, etc.) with the purpose of identifying commonalities and significant differences, and opportunities for coordination when planning implementation goals.

- The Missouri River Watershed Restoration and Protection Strategy (WRAPS) is scheduled for completion in 2017; this information should be reviewed and incorporated into your planning efforts. The draft WRAPS outlines reduction goals for excess sediment, phosphorus, nitrogen, and E. coli Bacteria as well as identifies areas for protection within the area and goals address degraded stream habitat.
- Specific resource issues that BWSR believes are relevant and important to consider in the Missouri River watershed, and should be examined, include:
  - Surface and Groundwater Quality – BWSR believes degraded water quality, both surface and groundwater, is a significant issue in the watershed. Work in the Pipestone Creek sub-watershed is showing potential improvements in the surface water quality as sediment measurements had trended better and nitrogen has been stable. The overall trend for Nitrogen in surface waters in the larger watershed area, however, has been on the increase. The surface to groundwater connections in the Missouri River area along with groundwater quantity issues make the Missouri River watershed particularly vulnerable. The group should examine listed impairments and their locations, as strategies are developed, to target areas best suited to improve surface and groundwater quality. The plan should examine the strategies/land use changes and efforts that had a favorable effect in the Pipestone Creek area, see if such activities can be attributed to landscape or anthropogenic variables, and entertain whether such strategies would be a fit for replication in the rest of the Missouri River Waters of Minnesota.
  - Accelerated Soil Erosion/Soil Health – BWSR believes that accelerated soil erosion, leading to turbidity and other water quality issues, is a significant issue in the watershed. We also would like to see the concept of soil health as a key component in addressing accelerated soil erosion on cropland and pastureland in the watershed. Improved soil health can provide a number of benefits, from increased water infiltration/reduced runoff, to nitrate scavenging, and reduced soil erosion.
  - Water Quantity/Flooding/Altered Hydrology – Surface waters of the Missouri River Watershed have experienced an increase in damaging floods. There are several causes for the increased flooding. BWSR believes the watershed plan should examine these causes, and identify specific areas within the watershed where implementation of BMPs could help contribute to the reduction of peak flows, flooding, and streambank/riparian erosion and sedimentation. Significant artificial drainage that has occurred in the watershed, primarily for more productive agricultural land and infrastructure; this should be examined for impacts to increased peak flows and flooding as well as opportunities for wetland restorations in targeted areas as one component.
- Data collection and monitoring activities necessary to support the targeted implementation schedule, reasonably assess, and evaluate plan progress are required in the process. The plan should explore any areas needing data collection and monitoring efforts to accomplish needed assessments and should be coordinated with ongoing data collection. As part of the plan,

devise methods that the planning group can follow to ensure adherence to the planned activities and reassess the plan as implementation occurs in the future.

- Planning partners are encouraged to consider the potential for more extreme weather events and their implications for the water and land resources of the watershed in the analysis and prioritization of issues. The meteorological record for the Missouri River Watershed of Minnesota shows increased frequency and severity of extreme weather events, which has a direct effect on issues in local water planning. Adjustments involving conservation and fieldwork planning activities could be explored, for instance, using an updated precipitation frequency chart such as the NOAA Atlas 14 when designing conservation projects.

We commend the partners for their participation in the planning effort. We look forward to working with you through the rest of the plan development process. If you have any questions, please feel free to contact me by phone (507) 537-6636

Sincerely,

Douglas A. Goodrich
Board Conservationist

cc: Missouri River Watershed Planning Group
Rachel Olm, Houston Engineering (via email)
Brian Nyborg, MDNR (via email)
Russell Derickson, MDA (via email)
Amanda Strommer, MDH (via email)
Mark Hanson, PCA (via email)
Ed Lenz, BWSR (via email)
Dan Livdahl, Missouri River Watershed Planning Group (via email)
Doug Bos, Missouri River Watershed Planning Group (via email)

DEPARTMENT OF NATURAL RESOURCES

Minnesota Department of Natural Resources
Southern Region
21371 State Hwy 15
New Ulm, MN 56073
507-359-6000

July 26, 2017

Dan Livdahl, District Administrator
Okabena-Ocheda Watershed District
960 Diagonal Road, PO Box 114
Worthington, MN 56187

Thank you for inviting the Minnesota Department of Natural Resources (DNR) to provide input as you and other local partners begin developing a Comprehensive Watershed Management Plan for the Missouri River Watershed.

We recognize the challenge of creating a shared vision for a healthy, well-functioning watershed. Local water management and political jurisdictions can have differing perspectives, priorities and goals. The DNR can provide technical support during the planning process.

Attached to this letter are DNR priority concerns for the Missouri River Watershed. Using sound technical science and governance strategies to sustain water resources is a top DNR priority that aligns well with the One Watershed One Plan (1W1P) effort. DNR field staff from multiple divisions helped identify specific resource issues for the watershed, focusing on common concerns of the agency. Additional information about these priorities can be provided as you progress in developing the plan.

The priority issues we have identified play a key role in watershed health by providing multiple environmental, social/economic, and recreational benefits. Addressing these priorities will improve water quality, groundwater protection and recharge, aquatic and upland habitats, and species diversity in ways that enhance the overall quality of life in the watershed.

Our lead staff person for this 1W1P project is Brian Nyborg, Area Hydrologist at the Windom Area DNR office. He can be reached by telephone at 507-831-2900 extension 224, or by email at brian.nyborg@state.mn.us. Please contact Brian if you have questions or would like more information about the attached priorities or the types of technical support we can provide. Feel free to contact me as well if you need additional support.

Sincerely,

Dennis Frederickson

Dennis Frederickson
DNR Regional Director
Southern Region

EC: Barbara Weisman, DNR EWR Clean Water Operations
Robert Collett, DNR EWR South Manager
Jim Sehl, DNR EWR South Assistant Regional Manager
Todd Kolander, DNR EWR South District Manager
Brian Nyborg, DNR Area Hydrologist
Doug Goodrich, BWSR Board Conservationist
Spencer Herbert, MDA Pesticide and Fertilizer Management
Amanda Strommer, MDH Regional Planner
Mark Hanson, MPCA Watershed Specialist

Minnesota DNR Priority Resources and Issues for the Missouri River Basin

The Department of Natural Resources (DNR) recommends the Missouri River 1W1P planning committee include the following priority concerns and opportunities, which reflect input from DNR staff in Fisheries, Wildlife, Nongame, Ecological and Water Resources, Forestry, Parks and Trails, and Lands and Minerals. These include items that can be measured, mapped, and implemented realistically within the Missouri River watershed. The DNR can provide additional data around each issue as you begin developing the watershed plan, including information to help target areas for protection and restoration.

Resource – Hydrology for the Watershed

Resource Concern – Altered Hydrology: Managing surface and subsurface drainage systems, restoring wetlands, increasing vegetative cover on the landscape, and implementing water storage projects are all ways to reduce flood damage, protect fish and wildlife habitat, maintain or improve stream stability, support summer and winter stream base flows, filter sediment and nutrients, and improve groundwater recharge.

Issues Affecting Hydrology

- **Restoring altered hydrology**: The natural hydrologic functions of streams, rivers and lakes in the Missouri River Watershed have been altered due to actions such as straightening stream channels, ditching, tilling, adding roadways with ditches, draining wetlands and adding impervious surfaces. These changes in the landscape, water conveyance and management play a large role in stream instability and water quality impairments that impact the watershed as a whole. The net increase in flows leaving the watershed results in more intensive flooding events, decreased aquatic habitat and species diversity, and an increase of nutrients and sediment loads. The watershed plan should identify targeted land use and water management strategies to reduce and mitigate these impacts.

- **Wetland restoration, groundwater infiltration and water storage projects**: The basin has experienced increases in runoff and suspended sediment, widening of stream channels, more water leaving the watershed, downstream flooding, lower summer base flows, less overall water storage and reduced groundwater recharge. This has been caused by intensive land use, loss of perennial vegetation, and surface and subsurface drainage of shallow lakes and wetlands. The Cities of Edgerton, and Luverne along the Rock River have experienced more frequent and extensive flooding as result of these changes in the watershed and also due to increased episodic rainfall events. Wetland restoration and water retention practices, specifically in the upper reaches of the sub watersheds, can help hold and meter out the water over a longer period of time. This would decrease the impact of flood events, enhance water quality, and help recharge groundwater while also reducing stream channel erosion.

Resource - Groundwater

Resource Concern - Groundwater Sustainability: Long-term planning for groundwater recharge and sustainable water supplies for drinking water, farming and industry, and natural resources requires understanding interactions between groundwater and surface water, climate, and economics. Communities and Rural Water Suppliers in the watershed are acutely aware of quality and quantity issues. Several suppliers are addressing pollutants in their drinking water supply, are actively seeking or have recently secured new sources of water from within and outside of the watershed, or have dealt with significant supply issues.

Issues Affecting Groundwater Sustainability

- **Water supply planning**: Clean drinking water is our most precious resource, but often overlooked. Increasing demand from domestic, agricultural, and industrial water users can strain water resources and municipal water supply systems. Water users should be educated on conservation measures and new technologies that can reduce overall water use. Sustainable water supplies and water conservation are items to plan for on a watershed basis. Rural water suppliers provide an invaluable service to most rural residences and several small communities in the watershed. This can create agricultural demand for water in areas without suitable local supplies. Redundancies exist within these rural water systems, but this could be an issue if the rural water supplies are limited. Agricultural use is secondary to domestic use if water supplies are limited.

- **Groundwater recharge in sensitive areas**: Groundwater resources supply 100 percent of the drinking water in the Missouri watershed and 80 percent of water used for agricultural irrigation. BMPs and sustainable land use practices should be implemented in groundwater recharge areas, especially surficial sands and gravels and outwash areas where the chance of groundwater contamination is highest.

Resource – Surface Water

Resource Concern - Surface Water Quality: Work to address water quality goals established in Watershed Restoration and Protection Strategies (WRAPS) and TMDLs in ways that prevent future surface water quality impairments and groundwater contamination, improve fish habitat in lakes and streams, and promote the watershed's resilience to climate change, invasive species, and other stressors.

Issues Affecting Surface Water Quality

- **Restoration of lakes in the Little Sioux River Watershed**: Lakes in the Little Sioux River watershed, in particular, are in need of restoration. The preliminary Missouri River WRAPS Report identifies most lakes as impaired or as having insufficient data to determine if they are swimmable. It could easily be concluded those with insufficient data are most likely impaired as well. Lakes such as Okabena, Ocheda and Bella are important groundwater recharge areas for the Worthington Well Fields. Other lakes are important recreational resources for the area include Indian, Round, Pearl, Loon and Clear Lakes.

- **Restoration of streams**: Of the streams assessed in the Missouri River Basin, only one stream reach was found to be healthy enough to fully support aquatic recreation. Current water quality conditions for both lakes and streams point to a need for significant land use changes to reverse these downward trends.

- **Restoring perennial vegetation in riparian areas:** Perennial vegetation in riparian areas and floodplains is critical. Deep rooted native plants slow the flow of water, increase water retention, reduce erosion, filter sediment and nutrients, stabilize banks, provide wildlife habitat and connect habitat corridors.

- **Agriculture and Conservation Best Management Practices (BMP's)**: Prime agricultural ground should be protected for agriculture, but the watershed would benefit from conservation BMPs. Healthy soils protected by cover crops reduce nutrients, increase residue, increase water storage within the soil profile and reduce runoff.

- **Streambank Erosion:** Streambank erosion is significant on the Kanaranzi Creek, Beaver Creek and Rock Rivers as well as their tributaries. This erosion is a result of stream bed and bank instability as well as changes in precipitation but mostly it is a symptom of the hydrologic changes within the watershed.

<u>Resource – Natural Resources</u>

Resource Concern - High Value Resources and Recreation: The Missouri River Basin retains a variety of rare and unique natural resources whose survival and health are impacted by land use and hydrologic changes. Protecting, restoring, and enhancing habitat and public recreation opportunities in and around lakes, streams, wetlands, riparian zones, and grasslands in ways that promote clean water and prevent invasive species is essential to watershed health. Connections between wildlife species, native plant communities, lakes and wetland features are many and often complex. In order to conserve these features, consider a tiered approach to preserving native communities, strategically restoring and enhancing habitat to create larger habitat networks, and promoting soil health in agricultural areas.

Issues Affecting Natural Resources

- **Protecting rare natural features:** The Missouri watershed is home to many rare species (state and federally listed: endangered, threatened, special concern, and Species of Greatest Conservation Need). Most of these need connected grasslands or prairie streams/wetland habitats to survive. Places like Hole in the Mountain, Altona Wildlife Management Area, Touch the Sky Prairie, Blue Mounds State Park, and the Chanarambie Creek valley near Chandler can play a key role in maintaining and connecting habitat. This watershed has designated Critical Habitat for federally-protected species: Dakota Skipper (Threatened), Powesheik Skipper (Endangered) and Topeka shiner (Endangered). These designations overlap with key habitats for State-listed species such as the Blanding's turtle, plains topminnow, and Blanchard's cricket frog. State and federally-listed species have special protection under Minnesota and federal law.

- **Calcareous Fens:** There are ten identified calcareous fens in the Missouri River watershed that should be protected from disturbance by livestock, impacts of tile, diversion, and groundwater appropriation. Calcareous Fens are rare and distinctive wetlands formed on peat that has a constant flow of calcium-rich groundwater. They are one of the rarest natural communities in the U.S.—occurring in only ten states and supporting eight rare plant species in Minnesota. Because they are extremely sensitive to disturbance and changes in groundwater supply and quality, these habitats have special protection in Minnesota.

- **Aggregate and mineral resources**: DNR supports planning efforts by local units of government in the development and access to natural resources for supplying aggregate and other natural construction materials for building, road maintenance, and other infrastructure that follows environmentally sound extraction and restoration practices while supporting the protection of native habitats and wildlife.

- **Existing Partnerships:** The Missouri watershed is a hot spot in terms of conservation potential. It includes a priority habitat network along the Rock River, Chanarambie Creek, Split Rock Creek, and Flandreau Creek for the Minnesota Prairie Conservation Plan, the Minnesota Wildlife Action Plan, and the Prairie Coteau Complex Important Bird Area.

- **Recreational opportunities**: Hunting, fishing, wildlife viewing, canoeing, kayaking, hiking, biking and camping are available in the watershed on a variety of public lands and waters such as the Casey Jones State Trail, Split Rock State Park, Blue Mounds State Park, and many Wildlife Management Areas. The Rock River is an underutilized recreational resource that could be enhanced by developing a State Water Trail.

DEPARTMENT OF NATURAL RESOURCES

MISSOURI RIVER WATERSHED: ONE WATERSHED ONE PLAN

REPORTS, STUDIES AND TECHNICAL INFORMATION

MNDNR Report, Study, or Data Title	Description / Relation to MRW 1W1P	Link
Missouri River Basin Hydrology, Connectivity, and Geomorphology Assessment Report, 2014	Watershed assessment completed for MPCA Stressor ID and WRAPS in 2014. Contact DNR Mankato office, Brooke Hacker or Jon Lore.	http://water-research-library.mda.state.mn.us/pages/application/filedownload.xhtml?recId=218800
Prairie Conservation Plan	Prairie Core Areas are defined as areas of 4,500 to 300,000 acres that retain features of a functioning prairie system and are at least 15% grassland, including a substantial portion that is native species.	http://www.dnr.state.mn.us/prairieplan/index.html
Minnesota Wildlife Action Plan (MN WAP) 2015-2025	Prairie Coteau is a Conservation Focus Area (CFA) for the MNWAP selected because of its vulnerability, but it is full of important biota and conservation opportunities. Contact DNR regional nongame specialist, Lisa Gelvin-Innvaer	http://www.dnr.state.mn.us/mnwap/index.html
Aquatic Invasive Species (AIS)	A high level invasive species concern is the established presence of zebra mussels in the Iowa great lakes area. For information contact Alison Gamble Regional AIS specialist (see link).	http://www.dnr.state.mn.us/invasives/ais/contacts.html
DNR Minnesota State Management Plan for Invasive Species	A plan framework to address terrestrial and aquatic invasive species issues in the state.	http://files.dnr.state.mn.us/natural_resources/invasives/state_invasive_species_plan.pdf
Calcareous Fens	Database contains points representing DNR known calcareous fens as defined in Minnesota Rules, part 8420.0935, subpart 2.	https://gisdata.mn.gov/dataset/biota-nhis-calcareous-fens
Parks and Trails Legacy Plan	25 year long range plan for parks and trails of state and regional significance. Relevant to the water access priority concern.	http://www.legacy.leg.mn/funds/parks-trails-fund/plan
DNR Hydrography – Lakes of Biological Significance	GIS layer shows lakes meeting criteria for Lakes of Biological Significance.	https://gisdata.mn.gov/sl/dataset/env-lakes-of-biological-signific

DNR Hydrography – Lakes of Phosphorus Sensitivity Significance	GIS layer to help prioritize lakes based on their sensitivity to phosphorus pollution.	https://gisdata.mn.gov/dataset/env-lakes-phosphorus-sensitivity
MN Scientific and Natural Areas Program Strategic Land Protection Plan	Multi-tiered approach for prioritizing lands to protect through designation as a Scientific & Natural Area (SNA).	http://www.dnr.state.mn.us/snap/plan.html
Rare and Natural features non-public database	Natural Heritage Information System (NHIS) database is continually updated and provides information on rare plants, animals, native plant communities, and other rare features. Contact Lisa Gelvin-Innvaer or Lisa Joyal for more information.	http://www.dnr.state.mn.us/nhnrp/nhis.html
Topeka Shiner	USFWS endangered species web page. Site contains multiple links related to conservation, recovery, and critical habitat.	https://www.fws.gov/midwest/endangered/fishes/TopekaShiner/index.html
DNR Groundwater Management Program (Draft)	Ensures that permitted groundwater appropriations do not adversely impact aquifer water quality or threaten trout streams, calcareous fens, and other groundwater-dependent biological communities.	http://files.dnr.state.mn.us/waters/gwmp/gwsp-draftplan.pdf
DNR Shallow Lakes Program Plan	The Shallow Lakes Plan is to protect and manage at least 1,800 shallow lakes in Minnesota for their ecological, recreational, and economic importance to the citizens of the state, with particular emphasis on wildlife and wildlife-based recreation.	http://www.dnr.state.mn.us/wildlife/shallowlakes/index.html
DNR Long Range Plan for the Ring-necked Pheasant in Minnesota	This vision assumes a sufficient habitat base to support an average fall population of 3 million birds.	http://files.dnr.state.mn.us/recreation/hunting/pheasant/pheasantplan_final2005.pdf
DNR Tomorrow's Habitat for the Wild and Rare	Minnesota's Comprehensive Wildlife Conservation Strategy (CWCS) is a strategic plan focusing on managing populations of species in greatest conservation need (SGCN).	http://files.dnr.state.mn.us/assistance/nrplanning/bigpicture/cwcs/chapters_appendix/tomorrows_habitat_toc.pdf
DNR Long Rage Duck Recovery Plan	This plan identifies challenges and suggests strategies that the Department of Natural Resources (DNR) and its conservation partners feel will move us in the right direction.	http://files.dnr.state.mn.us/recreation/hunting/waterfowl/duckplan_042106.pdf
DNR Watershed Health Assessment Framework	The Watershed Health Assessment Framework (WHAF) provides a comprehensive overview of the ecological health of Minnesota's watersheds.	http://www.dnr.state.mn.us/whaf/index.html

Notice of the Missouri River Watershed One Watershed, One Plan
May 23, 2017

The Missouri River Watershed Planning Group is initiating a comprehensive watershed management plan for the Missouri River Watershed (see attached map). The Missouri River Watershed Planning Group was created through a Memorandum of Agreement between the Counties of Jackson, Lincoln, Murray, Nobles, Pipestone and Rock; the Jackson, Lincoln, Murray, Nobles, Pipestone and Rock Soil and Water Conservation Districts; and the Kanaranzi-Little Rock and Okabena-Ocheda Watershed Districts; to create a watershed based plan under the Minnesota Board of Water and Soil Resources One Watershed One Plan Program.

You have been identified as a stakeholder in the planning area, which consists of all of Rock County and parts of Jackson, Lincoln, Murray, Nobles, Pipestone counties. As a stakeholder, you are invited to submit priority resource concerns and issues that you feel should be addressed in the planning process and resulting plan.

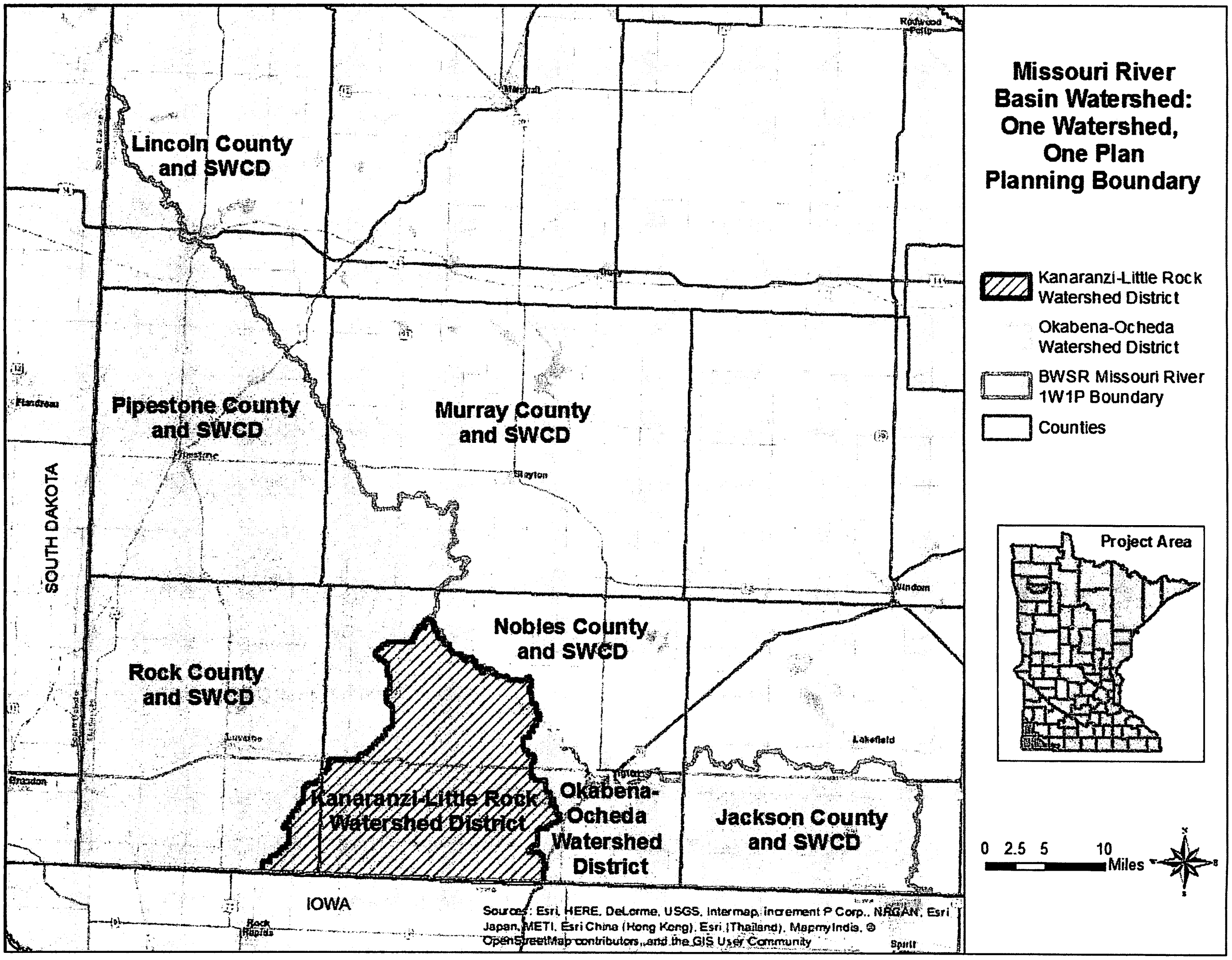
Please submit your responses to Dan Livdahl at okabenaocheda@gmail.com or Okabena-Ocheda Watershed District, P.O. Box 114, Worthington, MN 56187 by 4:30 pm, July 28, 2017.

There will be a public informational kick-off meeting scheduled following the public comment period to review watershed data, present and discuss priority resource concerns and issues identified by the stakeholders, and provide an opportunity to gain further feedback.

Attached are documents about providing input on priority resource concerns and issues and providing information on known reports, studies and technical information that should be considered during Missouri River Watershed One Watershed, One Plan process.

Feel free to contact Dan Livdahl with any questions.

Dan Livdahl
Okabena-Ocheda Watershed District
P.O. Box 114
Worthington, MN 56187
(507) 372-8228
okabenaocheda@gmail.com



Missouri River Basin Watershed: One Watershed, One Plan Planning Boundary
Kanaranzi-Little Rock Watershed District
Okabena-Ocheda Watershed District
BWSR Missouri River 1W1P Boundary
Counties
Project Area
0 2.5 5 10 Miles
Lincoln County and SWCD
Pipestone County and SWCD
Murray County and SWCD
Rock County and SWCD
Nobles County and SWCD
Kanaranzi-Little Rock Watershed District
Okabena-Ocheda Watershed District
Jackson County and SWCD
SOUTH DAKOTA
IOWA
Sources: Esri, HERE, DeLorme, USGS, Intermap, increment P Corp., NRCAN, Esri Japan, METI, Esri China (Hong Kong), Esri (Thailand), MapmyIndia, © OpenStreetMap contributors, and the GIS User Community

Good Morning Dan,

On behalf of the Minnesota Department of Agriculture, thank you for the Missouri River 1W1P notification letter. We appreciate the invitation to submit water management issues and concerns. As a first step to planning for the 1W1P, we have compiled the following information for use by the team – this information substitutes the “Known Reports, Studies and Technical Information…..” form.

Minnesota Department of Agriculture Pesticide Water Quality Monitoring

The Minnesota Department of Agriculture (MDA) has been conducting pesticide monitoring in ground water since 1985, and in surface waters since 1991. Annually, the MDA completes approximately 250 sample collection events from ground water and 800 sample collection events from rivers, streams, and lakes across the state. In general, the MDA collects water samples from agriculture and urban areas of Minnesota and analyzes water for up to approximately 140 different pesticide compounds that are widely used and/or pose the greatest risk to water resources. All groundwater monitoring is conducted by MDA staff. Surface water monitoring is conducted by MDA and local organizations. All monitoring is completed following annual work plans and standard operating procedures (SOP’s) developed by the MDA.

The purpose of the MDA’s pesticide monitoring program is to determine the presence and concentration of pesticides in Minnesota waters, and present long-term trend analysis. Trend analysis requires a long-term investments in monitoring within the MDA’s established networks. The MDA releases an annual water quality monitoring report that includes all pesticide water quality data and long term trends available at www.mda.state.mn.us/monitoirng. The MDA will continue to conduct statewide pesticide monitoring in the future and will provide additional information related to the occurrence of pesticides in Minnesota waters.

Nitrogen and Pesticide Use

The MDA surveys farmers through the National Agricultural Statistics Service (NASS). A summary of the data is attached as a PDF to this email. The most recent nitrogen use survey was for the 2014 crop year and the most recent pesticide use survey was for the 2013 crop year. For reference, the University of Minnesota fertilizer recommendations are found here:
http://www.extension.umn.edu/agriculture/nutrient-management/nutrient-lime-guidelines/fertilizer-recommendations-for-agronomic-crops-in-minnesota/index.html

The attached nitrogen use information is from the 2014 nitrogen use report, specifically the Southwestern and West Central BMP regions. Based on the information attached, the MDA would suggest that nutrient management be encouraged as a strategy to meet water quality goals. This would encouraging producers to collect soil nutrient samples, and to test their manure to identify the N & P that could be credited.

Nitrates are a priority resource concern for MDA in this region for both ground and surface water.

Minnesota Nitrogen Best Management Practices Regions

The attached pesticide use information is from the 2013 pesticide use report, specifically the Southwest (7) and South Central (8) Pesticide Management areas.

Groundwater

The MDA samples four monitoring wells semi-annually. Sampling began in 2004 with one well and the three other wells were installed and sampled beginning in 2006. Pesticide and nitrate data are available for all of the wells. In addition, semiannual water level measurements are available from the monitoring wells.

The MDA also has nitrate data from domestic wells in the watershed which were sampled once in 2016. The chemistry data is available for the wells however, due to privacy rules, the well locations can't be shared.

Monitoring of the monitoring wells in the watershed is expected to continue into the future.

Surface Water

The MDA has completed 169 pesticide and/or nutrient water quality sample collection events from 10 river or stream locations within the Missouri River Watershed from 1991-2015. The MDA also completed one pesticide water quality sample collection event from one lake (2012). There are no current pesticide water quality impairments in the watershed, however, the insecticide chlorpyrifos has been identified as a pesticide of concern. Chlorpyrifos was detected (40.8 ng/L) in Pipestone Creek in 2015 slightly below the 41 ng/L Minnesota aquatic life chronic water quality standard. There are several pending chlorpyrifos impairments in adjacent watersheds.

The MDA is actively monitoring Pipestone Creek (S000-510) and the Rock River (S005-381) and will continue to collect pesticide water quality samples at this location through at least 2020. The MDA does not have immediate plans to add additional surface water locations in 2017.

Agricultural Edge-of-Field

The MDA has one edge-of-field monitoring location within the Missouri River watershed. The monitored farm is located in Rock County northwest of Beaver Creek, MN and is part of the Discovery Farms Minnesota program. Monitoring has been conducted at this site since fall 2013.

The Discovery Farm site collects surface water year-round from a 25.5 acre watershed in a corn-soybean-alfalfa rotation with a grassed waterway. Available data includes summaries for sediment, nitrogen and phosphorus losses, surface runoff and weather/field condition data including precipitation, soil temperature, soil moisture, air temperature, relative humidity, wind speed/direction and solar radiation. It is anticipated that monitoring will continue for another three to five years. There are no immediate plans to add any additional edge-of-field monitoring sites in the Missouri River basin. For more information, please visit http://discoveryfarmsmn.org

Township Testing Program

The Missouri River Watershed does have townships which fall within MDA's Township Testing Program. The MDA has identified townships throughout the state that are vulnerable to groundwater contamination and have significant row crop production. More than 70,000 private well owners will be offered nitrate testing in over 300 townships per 2019. The sample schedule can be found on a handout downloadable here , which includes more background information. The initial sampling for Rock and Nobles County are complete and the results can be found in the links to PDFs below. The follow-up sampling will be conducted this summer and final results can be expected in 2018.

Nobles

https://www.mda.state.mn.us/protecting/cleanwaterfund/gwdwprotection/~/media/Files/protecting/cwf/nobles2016inital.pdf

Four (4) vulnerable townships were tested, 77.8% of the wells tested were over the nitrate health standard.

Rock

https://www.mda.state.mn.us/protecting/cleanwaterfund/gwdwprotection/~/media/Files/protecting/cwf/rock2016initial.pdf
Seven (7) vulnerable townships were tested, 50.9% of the wells tested were over the nitrate health standard.

Lincoln and Pipestone County have not been sampled yet, but they are scheduled to have the initial sampling in 2018. Murray and Jackson County will likely not be sampled in the township testing program.

Additional MDA Resources

Since there is a significant portion of the watershed in agricultural production, we would like to bring to your attention a couple resources, listed below, that we encourage you to reference during the planning process.

The Ag BMP Handbook (*currently in the process of updating the 2012 edition*) provides a comprehensive summary of BMPs that are practical for Minnesota: http://www.mda.state.mn.us/protecting/cleanwaterfund/research/agbmphandbook.aspx

The 2015 Nitrogen Fertilizer Management Plan (NFMP): http://www.mda.state.mn.us/nfmp

MDA has been working with Doug Bos from Rock County SWCD/Land Management office on a technical assistance project. The project allows Rock County SWCD/Land Management staff to apply their LiDAR based terrain analysis results as a planning resource for targeting BMP implementation with on-farm walk-overs. Perhaps this process could be further applied through the 1W1P process.

A couple opportunities for BMP funding or cost-share:
The Minnesota Agricultural Water Quality Certification Program (MAWQCP) is a voluntary opportunity for farmers and agricultural landowners to take the lead in implementing conservation practices that protect our water. Those who implement and maintain approved farm management practices will be certified and in turn obtain regulatory certainty for a period of ten years. This is a planning program that should be included in the IWIP because it is an opportunity for agricultural producers to evaluate nutrient and field management practices within the Missouri River Watershed to reduce losses. There are currently nineteen (19) certified producers in the Missouri River Watershed, totaling 14,247 acres. http://www.mda.state.mn.us/awqcp

The AgBMP Loan Program is a water quality program that provides low interest loans to farmers, rural landowners, and agriculture supply businesses. The purpose is to encourage agricultural Best Management Practices that prevent or reduce runoff from feedlots, farm fields and other pollution problems identified by the county in local water plans. http://www.mda.state.mn.us/agbmploans

The Nutrient Management Initiative (NMI) assists farmers and crop advisers in evaluating nutrient management practices on their own fields. This is a great opportunity for crop advisers to promote new management strategies and equipment that is available to boost yields and fertilizer efficiency for farmers, which will help reduce unnecessary losses to our water resources.
http://www.mda.state.mn.us/nmi

We look forward to being involved in the 1W1P process. Russ Derickson will be the MDA representative on the team. If you have any questions please do not hesitate to contact either Russ or myself.

Thank you for your coordination,
Heidi

Heidi Peterson, Ph.D.
Research Scientist
Clean Water Technical Assistance Unit
Minnesota Department of Agriculture
625 Robert Street North
St. Paul, MN 55155-2538
Office Phone: 651-201-6014
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DEPARTMENT OF AGRICULTURE

July 26, 2017

Dan Livdahl
Okabena-Ocheda Watershed District
P.O. Box 114
Worthington, MN 56187

Dear Mr. Livdahl:

Subject: Initial Comment Letter – *Missouri River Watershed Planning Project*

Thank you for the opportunity to submit comments regarding water management issues for consideration in the 1W1P planning process for the Missouri River Watershed Planning Area. Our agency looks forward to working closely with the local government units, stakeholders, and other agency partners on this watershed planning initiative.

The Minnesota Department of Health's (MDH) mission is to protect, maintain, and improve the health of all Minnesotans. An important aspect to protecting citizens health is the protection of drinking water sources. MDH is the agency responsible for implementing programs under the federal Safe Drinking Water Act (SDWA).

Source Water Protection (SWP) is the framework MDH uses to protect drinking water sources. The broad goal of SWP in Minnesota is to protect and prevent contamination of public and private sources of groundwater and surface water sources of drinking water using best management practices and local planning. Core MDH programs relevant to watershed planning are the State Well Code (MR 4725), Wellhead Protection (MR 4720) and surface water/intake protection planning resulting in a strong focus in groundwater management and protecting drinking water sources.

One of the three high level state priorities in Minnesota's Nonpoint Priority Funding Plan is to "Restore and protect water resources for public use and public health, including drinking water" which aligns with our agency's mission and recommendations to your planning process.

MDH Priority Concerns:

Prioritize Drinking Water Supply Management Areas (DWSMAs) in the Missouri River Watershed 1W1P and DWSMAs that are impacted by nitrate.
DWSMA boundaries establish a protection area through an extensive evaluation that determines the contribution area of a public water supply well, aquifer vulnerability and provides an opportunity to prioritize specific geographic areas for drinking water protection purposes.

Aquifer vulnerability determines the level of management required to protect a drinking water supply and provides an opportunity to target implementation practices in accordance with the level of risk different land uses pose. The attached Public Water Supply Summary Spreadsheet highlights the primary drinking water protection activities for many DWSMAs in the watershed. Prioritize protection of these important drinking water supply areas in the watershed plan.

Also, consider prioritization of protection areas that have higher nitrate levels for working with landowners on nutrient management and other sources of nitrogen. Consider streambank erosion and flash flooding which can also have an impact on public water supply wells that are near surface water features.

Prioritize Protection of Private Wells
Some residents of the Missouri River Watershed rely on a private well for the water they drink. However, no public entity is responsible for water testing or management of a private well after drilling is completed. Local governments are best equipped to assist private landowners through land use management and ordinance development, which can have the greatest impact on protecting private wells. Other suggested activities to protect private wells include: hosting well testing or screening clinics, providing water testing kits, working with landowners to better manage nutrient loss, promoting household hazardous waste collection, managing storm water runoff, managing septic systems, and providing best practices information to private well owners.

Prioritize and promote groundwater conservation & recharge.
The Missouri River Watershed has very limited groundwater resources and aquifer availability. Promote conservation practices that improve groundwater recharge and wise water use.

Prioritize Actions Identified in the Groundwater Restoration and Protection Strategies (GRAPS) report.
The MDH, along with its state agency partners, are developing a Groundwater Restoration and Protection Strategies (GRAPS) report for the Missouri River Watershed. GRAPS will provide information and strategies on groundwater and drinking water supplies to help inform the local decision making process of the 1W1P.

Prioritizing Groundwater & Drinking Water Protection in the 1W1P Planning Process

Watershed models used for prioritizing and targeting implementation scenarios in the One Watershed One Plan (1W1P), whether PTMapp, HSPF SAM or others, leverage GIS information and/or digital terrain analysis to determine the flow paths of runoff across the landscape and the pour points where concentrated flow reaches surface water features. While this is an effective approach for targeting surface water contaminates, it does not transfer to groundwater concerns because it only accounts for the movement of water on the land's surface. Unfortunately, targeting tools are not currently available to model the impact on groundwater resources. Therefore, the Minnesota Department of Health suggests using methodologies applied by the agency to prioritize and target implementation activities in the Source Water Protection program.

These methodologies for public water supply systems include:

- Identifying Drinking Water Supply Management Areas (DWSMA) located in the watershed.
- Examining the vulnerability of the aquifer to contamination risk to determine the level of management required to protect groundwater quality. For example, a highly vulnerable setting requires many different types of land uses to be managed, whereas a low vulnerability setting focuses on a few land uses due to the long recharge time and protective geologic layer.

These methodologies for private wells include:

- Evaluating the vulnerability of the upper most aquifers to determine the areas within the watershed most at risk from different land uses. Geologic atlases provide this information where available, as well as the statewide geomorphology layer, or the DNR's statewide aquifer sensitivity layer.

Attached you will find a listing of the data and information MDH can provide to help you in the planning process. Thank you for the opportunity to be involved in your watershed planning process. If you have any questions, please feel free to contact me at (507) 476-4241 or Amanda.strommer@state.mn.us.

Sincerely,

Amanda Strommer

Amanda Strommer, Principal Planner
Minnesota Department of Health, Source Water Protection Unit
1400 E. Lyon Street, Marshall, MN 56282

Attachments

CC: Yarta Clemens-Billaigbakpu, Source Water Protection Unit
Carrie Raber, Source Water Protection Unit
Chris Elvrum, Well Management Section
Doug Goodrich, BWSR Board Conservationist
Mark Hiles, BWSR Clean Water Specialist
Brian Nyborg, DNR Area Hydrologist
Mark Hanson, MPCA State Program Administrator Principal
Russ Derickson, MDA Soil Scientist

Data and information MDH can provide:

- Drinking Water Statistics – 100% of citizens and businesses get their drinking water from groundwater in the Missouri River Watershed. Water is supplied from private wells, community public water supplier, or rural water supplier. Lewis and Clark Regional Water System provides water to public water suppliers in the region to help supplement the need for water. This information can help you understand where people are obtaining their drinking water and develop implementation strategies to protect the sources of drinking water in the watershed.
- A spreadsheet of the public water supply systems in the watershed, status in wellhead protection planning, and any drinking water protection concerns or issues that have been identified in protection areas. This information can help you understand the drinking water protection issues in the watershed, prioritize areas for implementation activities, and identify potential multiple benefits for implementation activities.
- Shape files of the Drinking Water Supply Management Areas (DWSMA) in the watershed are located at http://www.health.state.mn.us/divs/eh/water/swp/maps/index.htm. This information can help you prioritize and target implementation activities that protect drinking water sources.
- A figure detailing the "Pollution Sensitivity of the Upper Most Aquifer" in the Missouri River Watershed. This information can help you understand the ease with which recharge and contaminants from the ground surface may be transmitted into the upper most aquifer on a watershed scale. Individual wellhead protection areas provide this same information on a localized scale. This is turn can be used to prioritize areas and implementation activities.
- A figure detailing "Pollution Sensitivity of Wells" in the Missouri River Watershed. This information can help you understand which wells in the watershed are most geologically sensitive based on the vulnerability of the aquifer in which the well is completed. This information allows for targeting of implementation activities to the sources of water people are drinking.
- A figure detailing "Pollution Sensitivity of Wells and Nitrate Results" in the Missouri River Watershed Underlain by Geologic Sensitivity Ratings from Wells". This information takes what we know about the sensitivity of wells to contamination and combines it with nitrate results to highlight areas of the watershed where there is known nitrate contamination of the water people are drinking. This figure can help prioritize implementation activities aimed at reducing nitrate levels in the sources of drinking water.
- A figure detailing "Pollution Sensitivity of Wells and Arsenic Results" in the Missouri River Watershed Underlain by Geologic Sensitivity Ratings from Wells. This information can help you understand which wells in the watershed contain elevated arsenic levels.

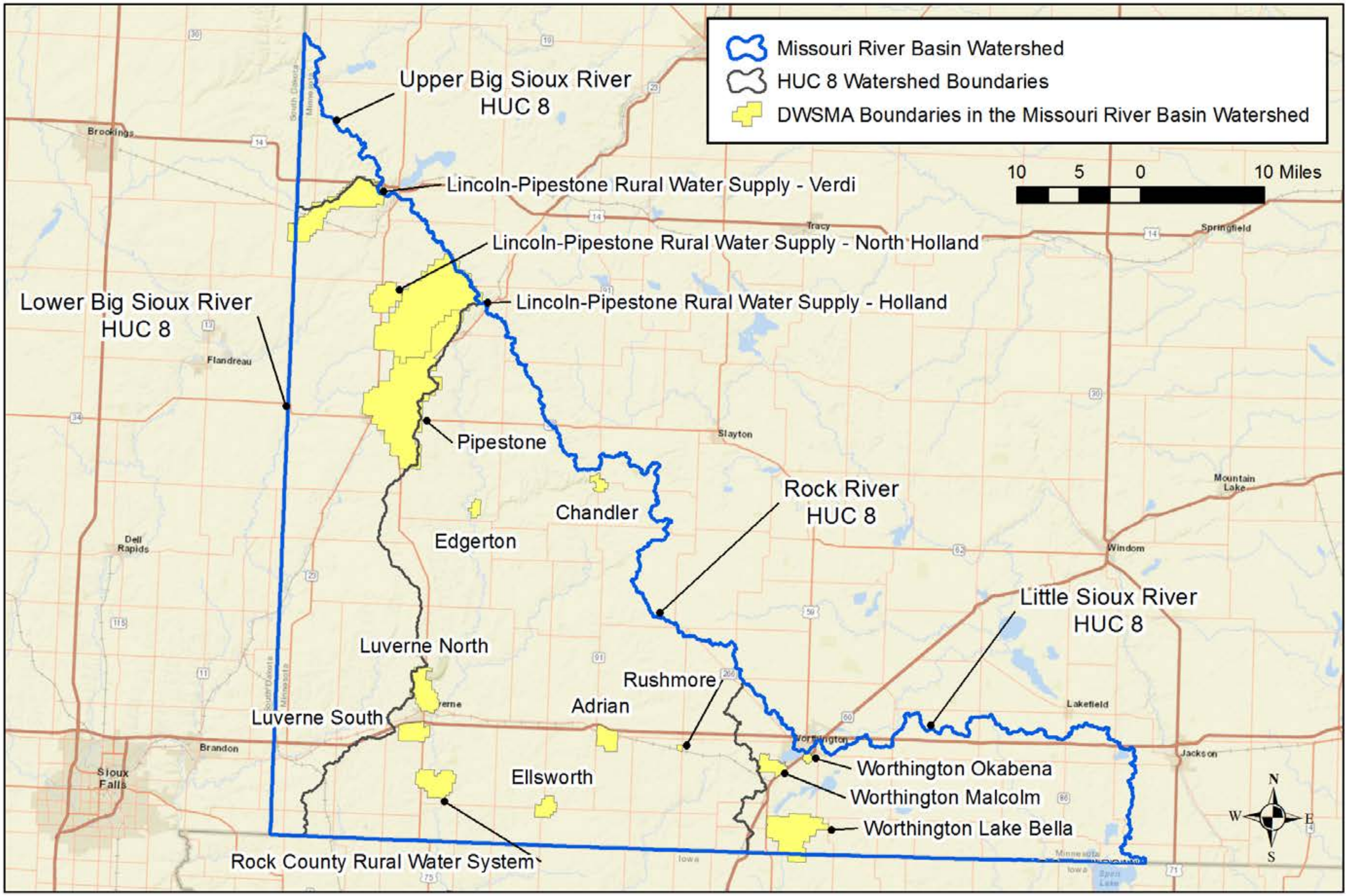
Missouri River Basin Public Water Supplies -
Drinking Water Protection Concerns for Quality (Nitrates) & Quantity

Aquifer Risk	Name	County	Watershed	Subwatershed	DWSMA Vulnerability
Very high potential contaminant risk due to connection with surface water -					
Focus on impacts from land use practices and surface water runoff					
Not currently treating for nitrates but levels in some wells exceed drinking water standard of 10 mg/L					
	Rock County Rural Water	Rock	Rock River	Ashwood Cemetary - Rock River & Ash Creek - Rock River	High with SWCA
	LPRW-Verdi	Lincoln	Lower Big Sioux	Upper Spring Creek	High with SWCA
Currently treating for nitrates due to wells exceeding drinking water standard of 10 mg/L					
	LPRW-Holland & North Holland	Pipestone	Lower Big Sioux	Lower & Upper North Branch Pipestone Creek	High with SWCA
	Ellsworth	Nobles	Rock River	Norwegian Creek	High with SWCA
	Adrian	Nobles	Rock River	City of Adrian - Kanaranzi Creek	High and low
	Edgerton	Pipestone	Rock River	City of Edgerton - Rock River	High and low
High potential contaminant risk -					
Focus on potential land use contaminant sources that may impact water quality					
	Chandler	Murray	Rock River	Headwaters Chanarambie Creek	High and low
	Pipestone	Pipestone	Lower Big Sioux	County Ditch A - Pipestone Creek	High, moderate, and low
	Luverne	Rock	Rock River	City of Luverne - Rock River & Ashwood Cemetery - Rock River	High and low
	Worthington-Lake Bella	Nobles	Little Sioux	Osterman Creek-Ocheyedan River	High with SWCA
	Worthington-Malcom	Nobles	Little Sioux	Okabena & Ocheda Lake	High with SWCA
	Worthington-Okabena	Nobles	Little Sioux	Okabena & Ocheda Lake	Moderate
Low potential contaminant risk -					
Focus on sealing of unused wells and old public water supply wells (funding available from MDH)					
	Beaver Creek	Rock	Lower Big Sioux	Middle Beaver Creek-Split Rock Creek	Anticipate to be Low
	Rushmore	Nobles	Rock River	Little Rock Creek	Low

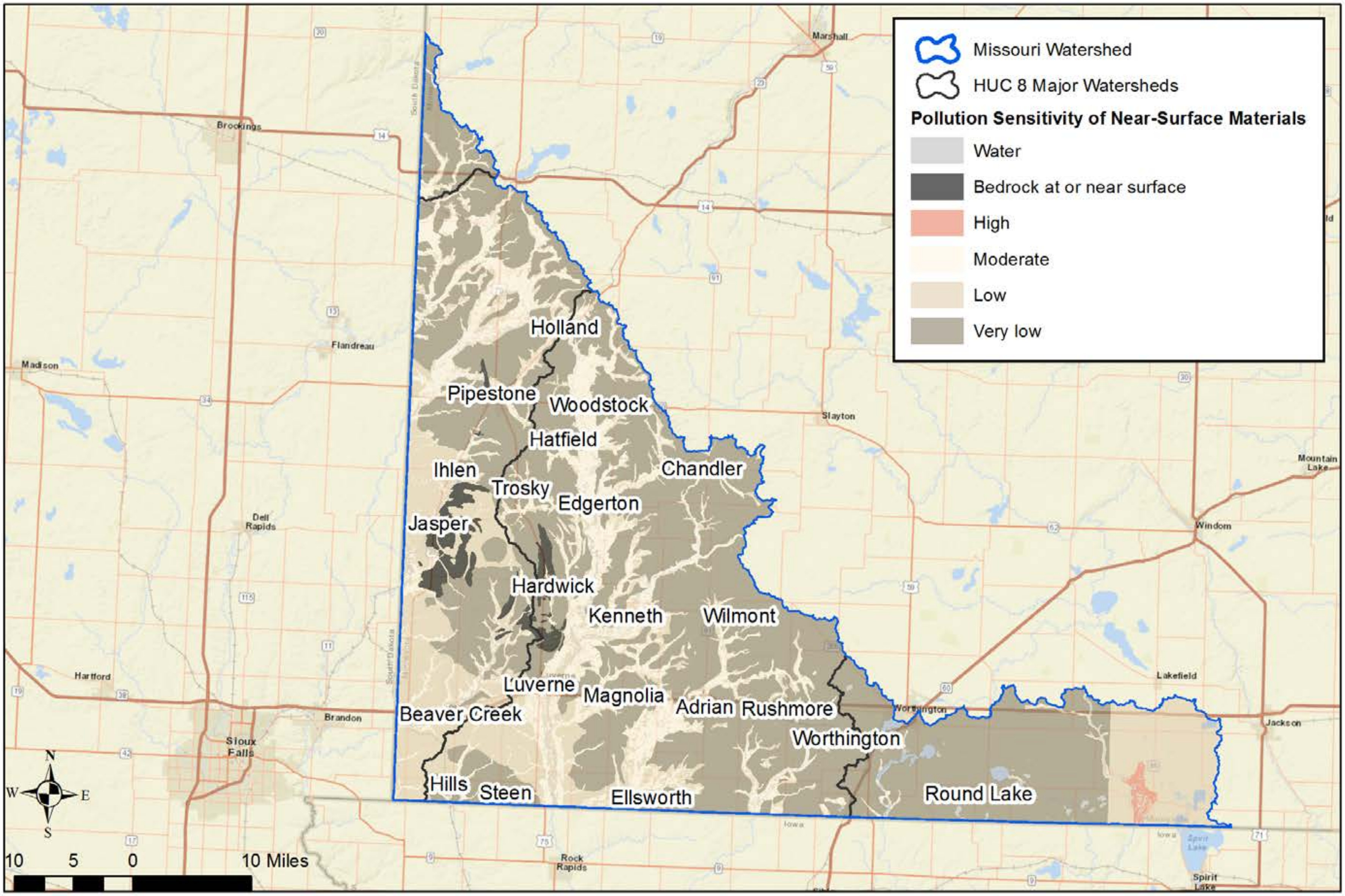
10 Communities Purchase Water from Lincoln Pipestone Rural Water
4 Communities Purchase Water from Rock County Rural Water
1 Community Purchases Water from Osceola Rural Water
1 Vulnerable Community, Non-Municipal Public Water Supplier in Flandreau Creek Subwatershed
11 Non-Community Public Water Suppliers

Acronyms:
LPRW=Lincoln Pipestone Rural Water
SWCA=Surface Water Contribution Area
DWSMA=Drinking Water Supply Management Area
WHP=Wellhead Protection Plan

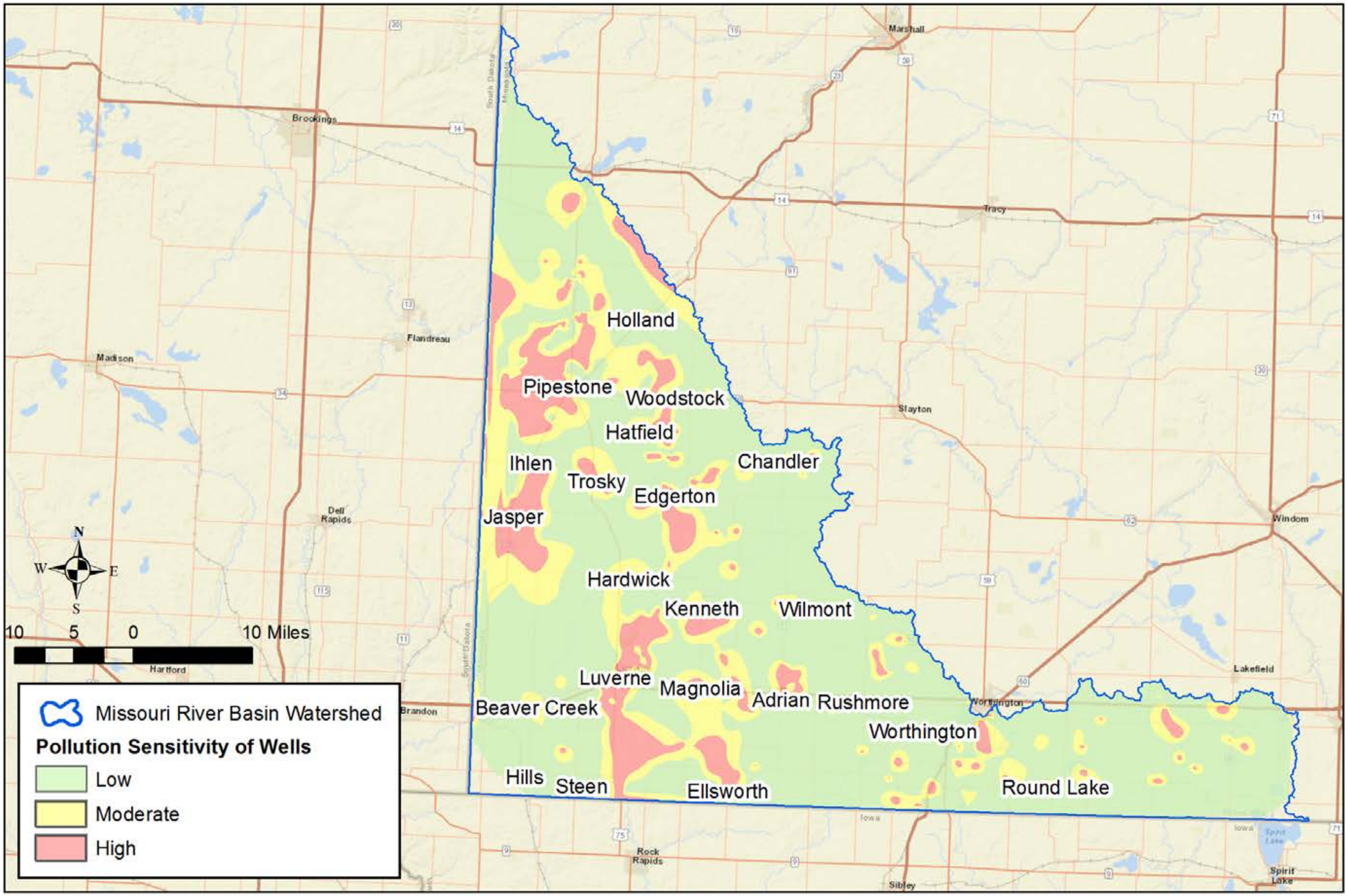
Drinking Water Supply Management Areas (DWSMAs) in the Missouri River Basin Watershed



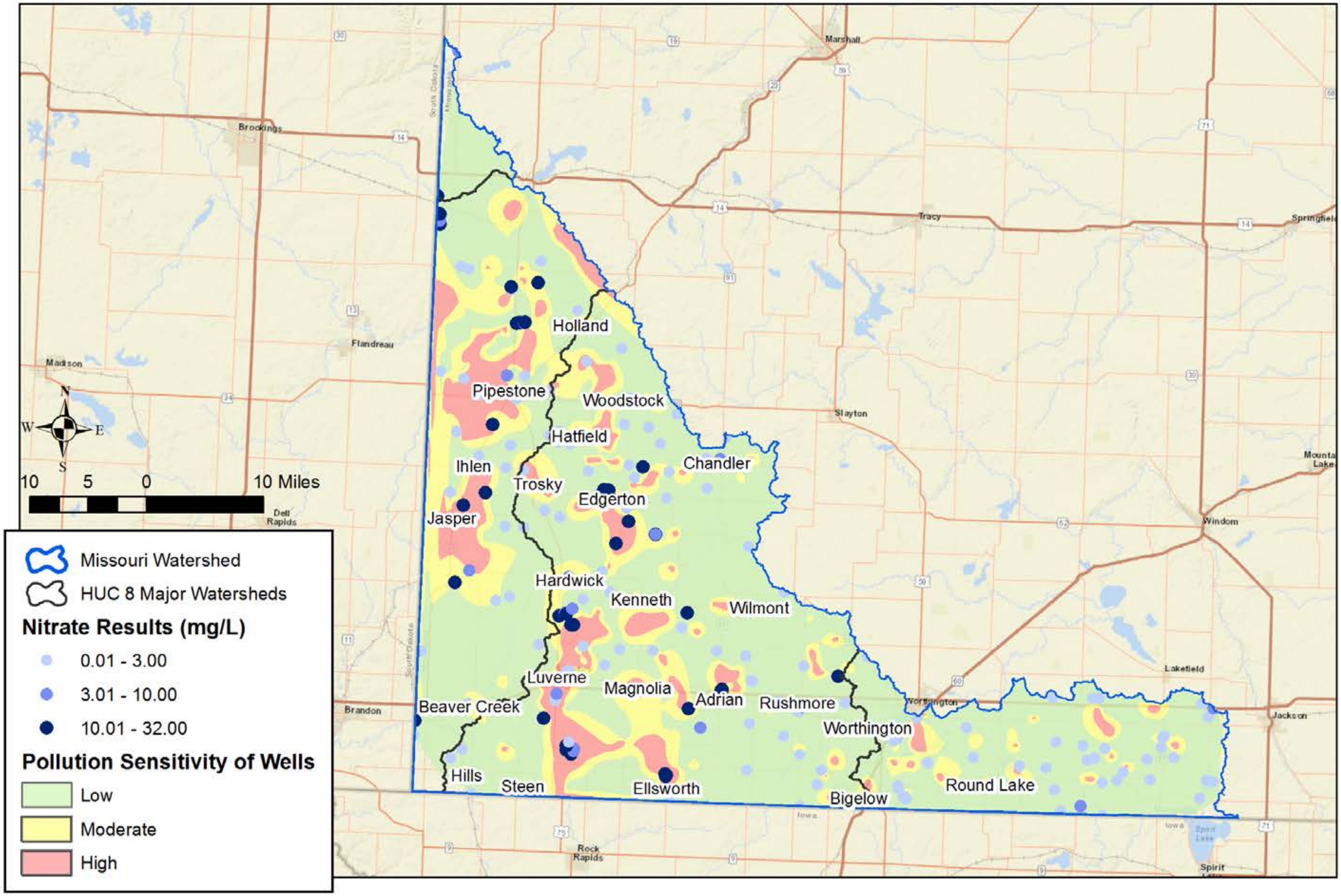
Missouri Watershed - Pollution Sensitivity of Uppermost Aquifers



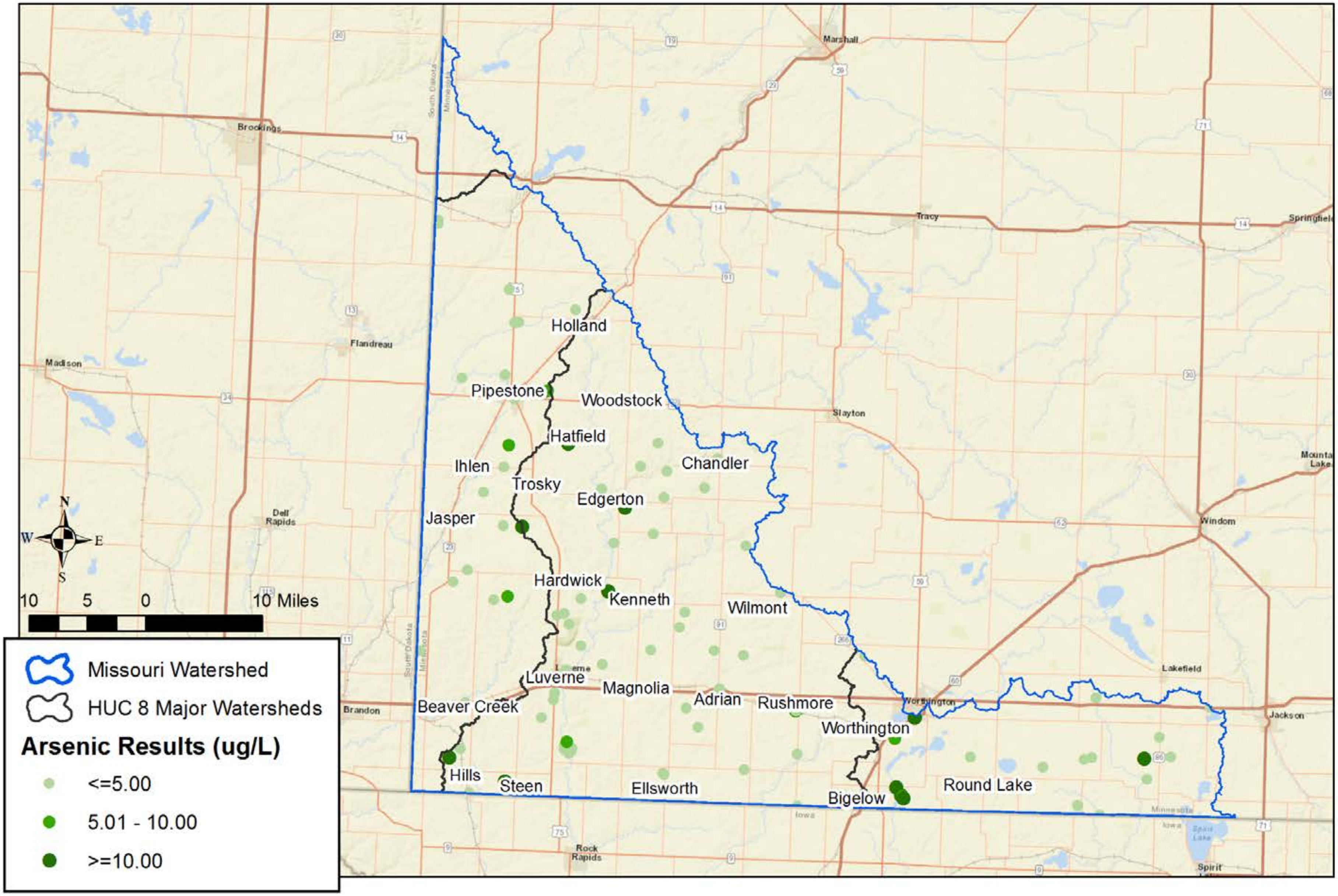
Missouri River Basin Watershed - Pollution Sensitivity of Wells



Missouri Watershed - Pollution Sensitivity of Wells and Nitrate Results



Missouri Watershed - Arsenic Results



MINNESOTA POLLUTION CONTROL AGENCY

Mankato Office | 12 Civic Center Plaza | Suite 2165 | Mankato, MN 56001-8704 | 507-389-5977

800-657-3864 | Use your preferred relay service | info.pca@state.mn.us | Equal Opportunity Employer

July 28, 2017

Mr. Dan Livdahl
Okabena-Ocheda Watershed District
P.O. Box 114
Worthington, MN 56187

RE: Missouri River Watershed One Watershed, One Plan - Priority Resource Concerns and Issues

Dear Mr. Livdahl:

The Minnesota Pollution Control Agency (MPCA) appreciates the opportunity to provide priority resource concerns and issues for consideration in the Missouri River Watershed One Watershed, One Plan (MRW1W1P). Our priority resource concerns and issues focus primarily on information available through the Watershed Approach process for the Missouri River basin that began in 2011. A list of the available reports, studies, technical information, data, and other relevant supporting documents from this process and prior watershed work is in the spreadsheet below.

Intensive watershed monitoring, stressor identification, and assessment was completed on each of the four (eight-digit hydrologic scale) watersheds for aquatic life, aquatic recreation, and fish consumption use support on several stream reaches and lakes where data was available to meet designated uses. The primary stressors to the biological community for the reaches listed for aquatic life impairments was identified: altered hydrology, poor habitat, low dissolved oxygen, high nitrates, high phosphorous, high turbidity, and fish barriers (dams). For details on the data assessment, refer to the following reports:

- Missouri River Basin Monitoring and Assessment Report
- Upper Big Sioux River Biotic Stressor ID Report
- Lower Big Sioux River Watershed Biotic Stressor ID Report
- Rock River Watershed Biotic Stressor ID Report
- Little Sioux River Watershed Biotic Stressor ID Report

Waters that do not meet their designated uses because of water quality standard violations are determined to be impaired. The MPCA is required to develop a list (303(d) List) of impaired waters that require total maximum daily loads (TMDLs) and to submit the list of impaired waters to the U.S. Environmental Protection Agency (EPA) for approval. This lead to a more comprehensive list of impairments and impaired stream reaches and lakes within the Missouri River basin. There are currently 143 impairment listings: 32 for fecal coliform or *E.coli*, 21 for turbidity (TSS), 46 for aquatic macroinvertebrate bio-assessments, 34 for fishes bio-assessments, and 9 lakes listed for nutrient (total phosphorus) eutrophication.

Missouri River basin summary of Impairments:

Impairment Type	Number of Listings	Beneficial Use
Turbidity; Total Suspended Solids	21	Aquatic Life
Nitrates	0	Drinking Water
Fecal Coliform; *E. coli*	32	Aquatic Life
Aquatic Macro-invertebrate bio-assessment	46	Aquatic Life
Fishes bio-assessment	34	Aquatic Life
Lake; Nutrient/eutrophication	9	Aquatic Recreation
Dissolved Oxygen	1	Aquatic Life

This list was used to develop the Draft Missouri River Basin TMDL and Draft Watershed Restoration and Protection Strategies (WRAPS) that provide restoration strategies for impaired waters, as well as protection strategies for non-impaired waters. Specific reduction goals for the impaired stream reaches and lakes within the Missouri River basin can be found in the following documents:

- Draft Missouri River Basin WRAPS Report
- Draft Missouri River Basin TMDL
- Pipestone Creek Fecal Coliform Bacteria & Turbidity TMDL
- Pipestone Creek Fecal Coliform & Turbidity TMDL Implementation Plan
- Rock River Watershed Fecal Coliform & Turbidity TMDL
- Rock River Fecal Coliform & Turbidity TMDL Implementation Plan
- Little Spirit Lake Turbidity & Algae TMDL
- Clean Water Partnership (CWP) Okabena-Ocheda-Bella Diagnostic/Feasibility Study and Implementation Plan (The MPCA and the Okabena Ocheda Watershed District has hard copies on file.)
- Clean Water Partnership (CWP) Verdi Wellfield Protection Area and Implementation Project (The MPCA and the Lincoln County Environmental Office have hard copies on file.)

Priority Resource Concerns and Issues in the Missouri River Basin

After scientific analysis through the intensive watershed monitoring, stressor identification, and assessment process in the Missouri River basin, impairments were found across the Missouri River basin. Based on the number of impairments that are likely influenced by the agricultural practices and development in the watershed, issues to be addressed should include: sediment, altered hydrology, nutrients, bacteria, biota, low dissolved oxygen, and lack of habitat. Addressing nonpoint source pollution would benefit from a targeted approach to best management practice (BMP) placement, identifying critical areas in watersheds that are likely more prone to be sources and pathways of contamination, and working with those landowners to restore and protect those sensitive areas. Priority resource concerns and issues that should be considered within the MRW1W1P are as follows:

- **Sediment (Total Suspended Solids)(Aquatic Life)**
  Sediment and other suspended material in water impact aquatic life by reducing visibility, which reduces feeding, clogging gills, which reduces respiration, and smothering substrate that limits reproduction. Sediment also impacts downstream waters used for navigation (larger rivers) and recreation (lakes). While the water quality standard looks at total suspended solids (TSS), most TSS is composed of sediment, and these words are used to refer to the same issue. Increases in suspended solids and turbidity, which is a measure of water clarity affected by sediment, algae, and organic matter, within aquatic systems are now considered one of the greatest causes of water quality and biological impairment in the United States (U.S. EPA, 2003). Although sediment delivery and transport are important natural processes for all stream systems, sediment imbalance (either excess sediment or lack of sediment) can result in the loss of habitat in addition to the direct harm to aquatic organisms. Future efforts and methods to control sediment from entering into the water bodies should be addressed within the MRW1W1P.

- **Altered Hydrology**
  Altered hydrology increases the amount and movement of pollutants and stressors to water bodies. Altered hydrology can also directly harm aquatic life by affecting the amount of water in the stream; both too little and too much stream flow impact aquatic life.

  Hydrology (USGS, 2014b) is the study of the amount of and way that water moves through the landscape. Altered hydrology refers to changes in hydrologic parameters including: stream flow, precipitation, drainage, impervious surfaces, wetlands, stream paths, vegetation, soil conditions, etc. Hydrology is interconnected in a landscape; when changes are made to one hydrologic parameter, there are responses in other hydrologic parameters. For instance, agricultural (ditches and subsurface) tile drainage quickly removes groundwater from the soil profile, increasing the total volume and timing of water inputs to rivers. Changes in stream flow are symptoms of this and other changes in hydrologic parameters.

  Due to the lack of a long-term stream gage data set in the Missouri River basin, altered hydrology was not analyzed in the Stressor ID reports. The Minnesota Department of Natural Resources's (DNR's) (2014b) Missouri River Basin Hydrology, Connectivity, and Geomorphology Assessment Report has identified excessive stream erosion across the Missouri watersheds, in many cases accelerated by altered hydrology. As presented in the previous section, sediment impairments are common throughout the Missouri watersheds. Therefore, because of the widespread sediment problems in the Missouri watersheds and the likeliness that altered hydrology is partially contributing to sediment problems, altered hydrology is addressed in this report. However, future iterations of the Watershed Approach should refine information about the impact of altered hydrology.

  The MPCA recognizes the importance of agricultural drainage for maintaining crop production in the Missouri River basin. Agricultural drainage can have unintended consequences on the hydrology and water quality of lakes and rivers. Public and private drainage systems provide a direct conduit for transport of pollutants such as nutrients, pesticides, and herbicides to waterbodies, degrading their recreational, aesthetic, and functional value. In addition, drainage can short-circuit the landscape's water storage potential, resulting in flashier river systems with higher peak flows. The higher flows result in bank and channel erosion, as the streams adjust to the increased energy and force. The down-cutting and widening of the channel limits stream access to the natural floodplain, reducing sediment deposition, and increasing sediment transport. Future efforts and methods to control sediment from entering into the water bodies should be addressed within the MRW1W1P.

- **Nutrients (Aquatic life/Eutrophication)**
  High levels of nutrients (phosphorus) are driving nuisance algae blooms in the impaired lakes and threatening other lakes that are on the boarder of becoming impaired. Algae blooms can deprive lakes of their oxygen as the algae die off and decay, causing fish kills. High levels of algae cause increased levels of turbidity, degrading aquatic recreation and aquatic life. Blue-green algae can be deadly to animals and humans.

  The MPCA anticipates more lakes will be listed as impaired as a result of increased monitoring during the intensive monitoring phase of the second watershed cycle (now underway). In addition, stream monitoring has documented high concentrations of total phosphorus. With the implementation of the new river eutrophication standards, the MPCA expects that some streams may be listed as impaired.

  Nutrient management plans that appropriately value the nutrient worth of manure, commercial fertilizer and previous crops and focus on the timing and intensity of the fertilizers and manure applications would help reduce the amount of phosphorus in the system. These reductions would also aid in the low dissolved oxygen problems present in some parts of the watershed. Further monitoring is recommended watershed-wide to better understand the magnitude of stress that phosphorus is causing. Future efforts and methods to control nutrients (phosphorus) from entering into the waterbodies should be addressed within the MRW1W1P.

- **Bacteria (Aquatic Recreation)**
  High levels of bacteria are widespread across the Missouri River basin. The abundance of feedlots, feedlot runoff, improper manure management, and over-grazed pastures in the watershed may correlate with this finding. High bacteria levels could also be attributed to noncompliant septic systems, which are not well quantified across the watershed. Future efforts and methods to control bacteria from entering into the waterbodies should be addressed within the MRW1W1P.

- **Biota (Aquatic Life)**
  Aquatic life use impairments within the Missouri River basin are complex. Biotic impairments are likely a result of nonpoint source pollution and localized stress linked to poor habitat condition and altered hydrology. High nitrogen levels are likely impacting fish and macroinvertebrate communities in the Missouri River basin. Increases in riparian buffer width and stabilizing stream banks would greatly help the in-stream habitat. More monitoring in cycle two will help to better understand the stress on the biological communities. Future efforts and methods to control sediment and nitrogen from entering into the waterbodies should be addressed within the MRW1W1P.

- **Low Dissolved Oxygen**
  Low dissolved oxygen (DO) impacts aquatic life primarily by limiting respiration, which contributes to stress, disease, and can cause death. Low DO in waterbodies is caused by excessive oxygen use, which is often caused by the decomposition of algae and plants, whose

growth is fueled by excess phosphorus, and/or too little re-oxygenation, which is often caused by minimal turbulence or high water temperatures. Low DO levels can be exasperated in over-widened channels because these streams move more slowly and have more direct sun warming. Future efforts and methods to control phosphorus from entering into the waterbodies should be addressed within the MRW1W1P.

- **Lack of Habitat**
  Degraded habitat impacts aquatic life by reducing the amount of suitable habitat needed for all aspects of aquatic life: feeding, shelter, reproduction, etc. The specific habitat issues identified in the Missouri watersheds show a complex, interconnected set of factors that are primarily driven by a handful of stressors. Of the 32 stream reaches stressed by lack of habitat, all showed some issues with land use, riparian vegetation, channel instability, and excess sediment. Without an adequate riparian buffer, issues such as excessive flow that causes stream instability and sediment issues are magnified because the stream lacks the strength to resist erosion. For example, cattle that trample streambanks can contribute to excessive erosion and over-widening of streams. Future efforts and methods to improve habitat conditions of waterbodies should be addressed within the MRW1W1P.

<u>Summary of Water Management Strategies in the Missouri River Basin</u>

- Focus restoration implementation actions on impaired waters listed for pollutants/stressors;
- Focus protection implementation actions on non-impaired waters;
- Identify the pollutant source(s) causing the impairment;
- Prioritize and target implementation actions to reduce the pollutant(s) causing the impairments to address impaired waters; and,
- Utilize information from the previously-mentioned reports, TMDLs, implementation plans, and selected strategies from the draft Missouri River Basin WRAPS Report in the MRW1W1P.

We trust these recommendations will help with the MRW1W1P planning efforts. If we may be of further assistance, please contact our lead contact Mark T. Hanson in the Marshall office at 507-476-4259, or myself at 507-344-5245 as needed.

Sincerely,

Wayne Cords

This document has been electronically signed.

Wayne Cords
Manager, Southeast Region
Watershed Division

WC:cz

Enclosure

cc: Ed Lenz, BWSR
Douglas Goodrich, BWSR
Brian Nyborg
Amanda Strommer, MDH
Spencer Herbert, MDA
Rebecca Flood, MPCA
Mark T. Hanson, MPCA

Report, Study, or Data Title	Description/Relation to MRW1W1P	Link
Upper Big Sioux Biotic Stressor ID Report	Identifies “stressors” for the bio-impaired reaches	Upper Big Sioux River Biotic Stressor ID Report
Lower Big Sioux Stressor ID Report	Identifies “stressors” for the bio-impaired reaches	Lower Big Sioux River Watershed Biotic Stressor ID Report
Rock River Biotic Stressor ID Report	Identifies “stressors” for the bio-impaired reaches	Rock River Watershed Biotic Stressor ID Report
Little Sioux River Stressor ID Report	Identifies “stressors” for the bio-impaired reaches	Little Sioux River Watershed Biotic Stressor ID Report
Missouri River Basin Monitoring and Assessment Report	Pollutants and bio-impairments identified in this document.	Missouri River Basin Monitoring and Assessment Report
Water Quality Trends for Minnesota Rivers/Streams	Identifies trends in Rock River and Pipestone Creek. Shorter term trends: Mid 90s - 2010 Longer term trends: 1960s - 2010	Water Quality Trends for Minnesota Rivers and Streams at Milestone Sites
Pipestone Creek Fecal Coliform & Turbidity TMDL	TMDL (MPCA 2008)	Pipestone Creek Fecal Coliform Bacteria & Turbidity TMDL
Pipestone Creek Fecal Coliform & Turbidity TMDL Implementation Plan	TMDL Implementation Plan (MPCA 2008)	Pipestone Creek Fecal Coliform & Turbidity TMDL Implementation Plan
Rock River Fecal Coliform & Turbidity TMDL	TMDL (MPCA 2008)	Rock River Watershed Fecal Coliform & Turbidity TMDL

Report, Study, or Data Title	Description/Relation to MRW1W1P	Link
Little Spirit Lake Turbidity & Algae TMDL	TMDL (Iowa DNR 2004)	Little Spirit Lake Turbidity & Algae TMDL
Draft Missouri River Basin WRAPS Report	Watershed restoration and Protection Strategies Report. Includes numerous links to a variety of reports/tools/data/etc.	Link will be provided once added to MPCA website.
Draft Missouri River Basin TMDL	Draft TMDL for Missouri River Basin	Draft Missouri River Basin TMDL
Assessment of Phosphorus Sources to Minnesota Waters	Detailed assessment for phosphorus sources to Minnesota watersheds.	Detailed Assessments of Phosphorus Sources to Minnesota Watersheds
MPCA Minnesota Nutrient Reduction Strategy Report	Addresses widespread nutrient problems.	MPCA Minnesota Nutrient Reduction Strategy Report
Surface Water Data	Data information for monitoring site stations and results.	Environmental Data Application
MPCA Upper Big Sioux River website	Variety of reports and links for the watershed.	https://www.pca.state.mn.us/water/watersheds/upper-big-sioux-river
MPCA Lower Big Sioux River website	Variety of reports and links for the watershed.	https://www.pca.state.mn.us/water/watersheds/lower-big-sioux-river
MPCA Rock River website	Variety of reports and links for the watershed.	https://www.pca.state.mn.us/water/watersheds/rock-river
MPCA Little Sioux River website	Variety of reports and links for the watershed.	https://www.pca.state.mn.us/water/watersheds/little-sioux-river

Dan,

Can you please put an x in 1.1.2 under Rock County. RCRWD has had to shut wells down and treat wells in the past due to bacteria in the groundwater. I also think that 2.1.2 and 2.1.3 should be checked for Rock County as again, our wells are impacted by the river and the wells we have had to shut down due to bacteria are the ones closest to the river which are directly impacted by the river. RCRW also tests for Nitrate N in the the surface waters of Elk Creek and the Rock River from 71st Street to the County Hwy 1 bridge and we have found in the past that Nitrate readings during the early summer periods can range from 3-35+ ppm. I don't know what the water quality standards are for surface water, but I do know that the drinking water standards are 10 ppm, and 35+ ppm is well over 3 times the legal standard I can distribute.

I believe 2.3.1 should also be checked for Rock County as currently there is not much tile line in our DWSMA, but there is some and there is a bunch located outside of our management area that discharges to surface ditches within our DWSMA. These tile lines often exceed the legal limit of 10 ppm Nitrate N and can soak into the ground as the water travels down the ditches toward the river. Some soak into the ground wholly before they ever reach the river discharge. All that elevated Nitrate water is then possibly entering the aquifer that we at RCRW are pumping our water out from.
3.1.2, I feel this one should also be checked for Rock County as with the development and installation of more and more acres with drainage tiling systems, the river and streams within Rock County seem to be even more flashy and prone to flooding and elevated stream flows with rain events. These extreme high flow events eat away at the river banks and riparian vegetation along said stream banks. This erosion causes excess turbidity and will degrade the associated aquatic vegetation, invertebrates and fishes that may utilize these streams.

5.3.6 I feel should also be checked for Rock County, even though it doesn't occur in my DWSMA, I see most streams within the county are full of cattle from Late May through August into September. These cattle create a massive disturbance and downstream turbidity and bacteria issues.

If you have any questions or concerns, Please feel free to contact me.

Regards,

Brent Hoffmann
Brent.hoffmann@co.rock.mn.us

ROCK COUNTY RURAL WATER
541 150th Ave. LUVERNE, MN 56156-9563
PHONE 507-283-8886
FAX 507-283-8309

July 21, 2017

Dan Livdahl
Okabena-Ocheda Watershed District
P.O. Box 114
Worthington, MN 56187

Dear Mr. Livdahl:

Subject: Initial Comment Letter – *Missouri River Watershed Planning Project*

Thank you for the opportunity to submit priority issues for consideration in the Missouri River Watershed One Watershed One Plan. The Rock County Rural Water District (RCRWD) has adopted a Wellhead Protection Area (WPA) that resides within a Drinking Water Supply Management Area (DWSMA).

The DWSMA boundary is the political boundary outside of the WPA contribution area for the public water supply wells. Protection efforts within this area can help to further RCRWD's efforts in drinking water protection. As a public water supplier we have been dealing with high nitrate levels. Our daily Nitrate readings at the RCRWD plant have increased significantly over the last few years due to several factors. These factors are mainly a lack of best management practices for Nitrogen application to intensive row cropping and extreme weather events . Streambank erosion and flash flooding can also have an impact on public water supply wells such as ours that are located very near the Rock River. By having very shallow and highly vulnerable wells, we are very susceptible to events that occur above ground and can leach through the soil profile and into the aquifer beneath. The plan should also seek to promote groundwater conservation and recharge given water quantity concerns in the region.

Please feel free to contact me at (507) 283-8886 or email me at brent.hoffmann@co.rock.mn.us if you have any further questions or concerns.

Sincerely,

Brent Hoffmann – Manager
Rock County Rural Water District

Lincoln Pipestone Rural Water

415 East Benton St., Box 188
Lake Benton, Minnesota 56149-0188
(507)368-4248
FAX: (507)368-4573
Email: lprw@itctel.com

Quality Water on Tap

December 19, 2018

Dan Livdahl
Okabena-Ocheda Watershed District
P.O. Box 114
Worthington, MN 56187

Dear Mr. Livdahl:

Subject: Initial Comment Letter – *Missouri River Watershed Planning Project*

Thank you for the opportunity to submit priority issues for consideration in the Missouri River Watershed One Watershed One Plan. Lincoln-Pipestone Rural Water System (LPRW) has adopted Wellhead Protection Plans that identifies Drinking Water Supply Management Area's (DWSMA) at each of its public water supply sources. Currently, LPRW is undergoing a plan revision, as required by Minnesota Department of Health, and will be assimilating all source water supply areas into a single plan document.

For each of our water sources, the DWSMA boundary is the contribution area of the public water supply wells and protection efforts within this area can help to further our efforts in drinking water protection. The emphasis of the Wellhead Protection Plan is on preventing problems before they occur, supporting public health protection, and protecting the resources that have been invested in the public water supply system.

LPRW provides treatment at three of its four groundwater sources. Incidentally, LPRW's Holland and North Holland water sources incorporate Reverse Osmosis (RO) treatment to remove high level nitrates from raw water to meet the state and federal guidelines set forth for safe drinking water. LPRW will be losing the ability to treat for nitrates by 2018, and likely source capacity, due to discharge issues stemming from the treatment process. Finding solutions to these issues comes with a steep price tag; inevitably resulting in higher costs to our customer base. As a public water supplier, groundwater quality and quantity are very important issues that we would like to see considered during development of the Missouri River Watershed One Watershed One Plan.

If you have any questions, please feel free to contact me at (507) 368-4248 or email at lprw@itctel.com.

Sincerely,

Jason Overby, Manager
Lincoln-Pipestone Rural Water System

City of Pipestone

City Office Building
119 2nd Ave S.W.
Pipestone, MN 56164
(507) 825-3324
(VOICE & TDD)
Fax (507) 825-5353

Peacepipes, Pioneers, and Progress

July 26, 2017

Dan Livdahl
Okabena-Ocheda Watershed District
P.O. Box 114
Worthington, MN 56187

Dear Mr. Livdahl:

Subject: Initial Comment Letter-*Missouri River Watershed Planning Projects*

Thank you for the opportunity to submit priority issues for consideration in the Missouri River Watershed One Watershed One Plan. The City of Pipestone has adopted a Wellhead Protection Plan that identifies the Drinking Water Supply Management Area (DWSMA).

The DWSMA boundary is contribution area of the public water supply wells and protection efforts within this area can help to further our efforts in drinking water protection. The emphasis of the Wellhead Protection Plan is on preventing problems before they occur, supporting public health protection, and protecting the resources that have been invested in the public water supply system.

As a public water supplier, groundwater quality and quantity are important issues that we would like to see considered during development of the Missouri River Watershed One Watershed One Plan.

If you have any questions, please feel free to contact me at (507) 825-2506 or email.

Sincerely,

Joel Adelman
Water/Wastewater Supervisor

CITY OF RUSHMORE
136 N THOMPSON AVE
PO BOX 227
RUSHMORE, MN 56168
507-478-4338
rushmore@iw.net

July 24, 2017

Dan Livdahl
Okabena-Ocheda Watershed District
P.O. Box 114
Worthington, MN 56187

Dear Mr. Livdahl:

Subject: Initial Comment Letter – *Missouri River Watershed Planning Project*

Thank you for the opportunity to submit priority issues for consideration in the Missouri River Watershed One Watershed One Plan. The City of Rushmore has adopted a Wellhead Protection Plan that identifies the Drinking Water Supply Management Area (DWSMA). The City of Rushmore in concerned about approximately 30 unused residential wells within our DWSMA. These wells have not been properly sealed. We would like to prevent contamination of underground aquifers by offering a cost share program to encourage residents to seal their abandoned wells.

Another concern for a small city like Rushmore are the unfunded mandates that continue to come from Minnesota agencies. While we may agree with the ecological reason for the new changes made by agencies such as MPCA and MDH, these changes often cause a burden to small city residents. Complying as mandated is a concern if grants or matching funds are not easily available to upgrade our water and wastewater equipment to the new standards.

As a public water supplier, groundwater quality and quantity are important issues that we would like to see considered during development of the Missouri River Watershed One Watershed One Plan. If you have any questions, please feel free to contact me.

Sincerely,

Coleen Gruis City Clerk/Treasurer

Worthington PUBLIC UTILITIES

318 Ninth Street
P. O. Box 458
Worthington, MN 56187-0458
Phone 507-372-8680
Fax 507-372-8688
www.worthingtonutilities.com

July 25, 2017

Dan Livdahl
Okabena-Ocheda Watershed District
P.O. Box 114
Worthington, MN 56187

Dear Mr. Livdahl:

Subject: Initial Comment Letter – *Missouri River Watershed Planning Project*

Thank you for the opportunity to submit priority issues for consideration in the Missouri River Watershed One Watershed One Plan. Worthington Public Utilities has adopted a Wellhead Protection Plan that identifies the Drinking Water Supply Management Area (DWSMA).

The DWSMA boundary is the contribution area of the public water supply wells and protection efforts within this area can help to further our efforts in drinking water protection. The emphasis of the Wellhead Protection Plan is on preventing problems before they occur, supporting public health protection, and protecting the resources that have been invested in the public water supply system.

As a public water supplier, groundwater quality and quantity are important issues that we would like to see considered during development of the Missouri River Watershed One Watershed One Plan.

If you have any questions, please feel free to contact me at (507) 372-8680 or email – eroos@worthingtonutilities.com.

Sincerely,

Eric Roos

Eric Roos
Worthington Public Utilities
Water Superintendent
318 Ninth Street, P.O. Box 458
Worthington, Minnesota 56187-0458
Phone (507) 372-8696
Fax (507) 372-8688
mailto:eroos@worthingtonutilities.com

Appendix H
Technical Issues Table

MISSOURI RIVER WATERSHED
Comprehensive Watershed Management Plan

Missouri River Watershed, One Watershed One Plan
APPROVED Issues Table

Resource Category	Resource Concern		Issue Affecting a Resource Concern
	Name	Description	Issue
1. Groundwater: Water which is held underground within the pores of rocks and soils and which reaches the ground surface			
	1.1 Drinking Water	Groundwater is the primary source of drinking water in Southwestern Minnesota. The vulnerability of the drinking water supply to contamination is driven largely by how quickly and easily water can be transported from the surface to the aquifer, and conditions within the primary aquifer recharge areas. Many aquifers in the Missouri River Watershed are shallow, and therefore more vulnerable to contamination.	1.1.1: Water Quality: Increasing levels of nitrates, which if excessive can result in implications to human health and treatment costs for community, municipal, and individual wells
			1.1.2: Water Quality: Elevated levels of E. coli, fecal coliform bacteria, and total coliform bacteria levels in groundwater used for drinking water, which can have implications to human health
			1.1.3: Water Quality: Elevated levels of dissolved minerals (sulfate, iron, manganese) in quartzite deposits of groundwater used for drinking water, which are found objectionable for human consumption
			1.1.4: Water Quality: Elevated levels of arsenic in groundwater, and the implications to human health
			1.1.5: Water Quality: Presence of pathways for water supply contamination on the landscape, including abandoned gravel pits and wells
			1.1.6: Water Quality: Land use changes for specific areas on the landscape where surface water moves into the aquifer (i.e., Wellhead Protection Area, vulnerable DWSMA boundary), which can affect how the water can be beneficially used
			1.1.7: Water Quantity: Sustainable quantities of groundwater supplies for drinking water use with suitable water quality.
	1.2 Supplies for Non-Potable Use (Quantity)	Groundwater supplies within the plan area are regionally important, and are heavily utilized for commercial/agricultural use.	1.2.1: Water Quantity: Diminished rate of aquifer recharge from land use changes in primary recharge areas, including lack of vegetative cover and altered hydrology, and its impact on groundwater supplies
			1.2.2: Water Quantity: Insufficient knowledge of groundwater resource supplies and/or condition, and its interaction with surface water features
2. Surface Waters: Water resulting from excess precipitation leaving the landscape and collecting in streams, rivers, creeks, wetlands, lakes and ponds			
	2.1 Streams and Rivers	Numerous streams and rivers are found within the Missouri River Watershed. The water quality within some of these currently supports the beneficial uses. Beneficial uses of rivers and streams in the watershed include swimming, fishing, support of aquatic life, drinking and irrigation. However the majority of monitored stream and river reaches in the Missouri River Watershed do not meet their beneficial uses. Streams and rivers which meet these beneficial uses need water quality maintained at or no less than the current level (protected). Others need to have the water quality improved (i.e., restored).	2.1.1: Water Quality: Elevated concentrations of total phosphorus and suspended solids and sediment approaching (protection) or exceeding (restoration) water quality standards for aquatic life
			2.1.2: Water Quality: Elevated concentrations of bacteria approaching (protection) or exceeding (restoration) water quality standards for aquatic recreation
			2.1.3: Water Quality: Elevated concentrations of nitrate-nitrogen approaching (protection) or exceeding (restoration) water quality standards for potable uses and for aquatic life
			2.1.4: Water Quality: Reduced concentrations of dissolved oxygen approaching (protection) or below (restoration) tolerable levels that can affect the diversity of quality of aquatic life
			2.1.5: Increased spread of aquatic invasive species in streams and rivers, and its implications on environmental, economic, or human health endpoints
			2.1.6: Modifications within the drainage area (e.g., reduction in soil organic matter content creating high erosion areas) contributing wind and overland runoff to streams and rivers, which increases the delivery of sediment and nutrients, increasing the risk of exceeding minimum standards and requirements
			2.1.7: Water Quality: Streambank and riverbank erosion, which can be caused by (or exacerbated by) changes in surface and subsurface hydrology and/or precipitation intensity, leading to impacts on water quality, the amount of aquatic habitat, and drinking water supplies.
	2.2 Lakes	There are 14 lakes in the Missouri River Watershed, all located within the eastern half of the watershed. Of these lakes, several need more monitoring data to make a scientifically-conclusive finding about their water quality and whether they are impaired. None of the monitored lakes currently support aquatic recreational beneficial uses, and need to have the water quality improved (i.e., restored).	2.2.1: Water Quality: Elevated nutrient (total phosphorus) enrichment in lakes approaching (protection) or exceeding (restoration) water quality standards causing increasing the frequency of algal blooms, lowering dissolved oxygen levels for aquatic life, reducing opportunities for recreation, and causing drinking water concerns
			2.2.2: Increased spread of aquatic invasive species in lakes, and its implications on environmental, economic, or human health endpoints
			2.2.3: Lake levels controlled by water control structures which no longer replicate the natural range of hydrologic conditions, and the adverse impact on aquatic life, recreation, and local economy
	2.3 Surface Runoff	An excess of surface runoff in a watershed may lead to flooding. Flooding is the inundation of land, homes, buildings and roads. Flooding causes infrastructure damage, economic loss and has adverse societal consequences in the community. Flooding can also have ecological benefits by maintaining a hydrologic connection between the river and the adjacent (riparian) lands.	2.3.1: Water Quantity: Changes in drainage management systems and its impact on the hydrograph, impacting the timing and magnitude of runoff delivery
			2.3.2: Changes in the landscape including loss of vegetative cover and amount of field residue, which can cause an increase in the volume of runoff, peak discharges, and water levels, and causing problems within the conveyance system, including natural streams
			2.3.3: Water Quantity: Loss of natural water storage on the landscape, including natural depressional areas, wetlands, loss of vegetative cover and soil organic matter, which can cause an increase in the volume of runoff, peak discharges, and water levels, causing flooding and flood damages to agricultural land, transportation systems, and building and structures
	2.4 Wetlands	Wetlands are frequently saturated lands with multiple potential benefits. Wetland loss and modification is an ongoing concern and focus of several state and federal agencies, and non-profit organizations.	2.4.1: Water Quantity: Drainage and filling of wetlands (including seeps, fens, bogs, ephemeral wetlands) resulting in increased discharge and runoff, and decreased water storage capacity, nutrient filtering capacity, groundwater recharge, and wildlife habitat.
	2.5 Agricultural Drainage Systems	Agricultural drainage is intended to remove standing or excess water from land which does not drain naturally. These systems use surface ditches and permeable subsurface pipes to direct water off the land. These are important infrastructure features within the Missouri River Watershed for maintaining agricultural production.	2.5.1 Degradation of vegetative areas adjacent to agricultural drainage systems associated with increased drainage management and development, and its impact on bank erosion and delivery of pollutants associated with overland runoff
			2.5.2 Neglected maintenance of existing ditch systems, and its impact on ditch functioning
3. Fish and Wildlife Habitat: Natural features and characteristics of the landscape which support aquatic life and terrestrial wildlife.			
	3.1 Aquatic Habitat for Fish, Macroinvertebrates and Aquatic Life	The pools, riffles, runs and bank overhangs within streams, creeks and rivers, the pooled areas of wetland, and the underwater areas of lakes and backwater areas comprise the livable space for aquatic life. A number of the waterways on the state's Impaired list are listed for impairments to fish, macroinvertebrates, and aquatic life. Frequently, these impairments are a result of degraded aquatic habitat. Protection of aquatic habitat is important for threatened or endangered species, such as the Topeka shiner.	3.1.1: Degradation of aquatic and riparian habitat associated with the physical damage to the banks and beds of creeks, streams and rivers from higher and faster flows
			3.1.2: Degradation of aquatic vegetation and riparian habitat associated with increased drainage management and development
			3.1.3 Channel succession leading to pool filling, and its impact on habitat and aquatic diversity
			3.1.4: Physical presence of water control structures and its impacts on aquatic and riparian habitat segmentation
			3.1.5: Reduction in the amount of calcareous fens from disturbances by livestock and impacts from tile, hydrologic diversion, and groundwater appropriation; There as 10 identified in the MRW and they support 8 rare plant species in MN
	3.2 Terrestrial Habitat for Wildlife	Habitat provides food, shelter, terrestrial ecological corridors, and breeding territory for animals. Many locations within the Missouri River Watershed provide habitat for unique and rare plant (i.e. Western prairie fringed orchid) and animal species (i.e. Blanding Turtle, Dakota Skipper). Because of their uniqueness, there is a general desire to preserve and protect these locations.	3.2.1: Increased habitat fragmentation and loss of habitat providing food, shelter, terrestrial ecological corridors, and breeding territory for both protected (e.g. endangered, threatened, special concern, and Species of Greatest Conservation Need) and unprotected species
			3.2.2: Presence of noxious weeds threatening the quality of native plant communities
4. Local Knowledge Base and Technical Capacity: The collective understanding of water related matters within the community and the ability to respond to and resolve water related issues			
	4.1 Public Knowledge of and Behavior Relative to Water Issues	The behavioral changes needed to understand the relationship between daily decisions and the affect on water requires knowledge, beginning at an early age and continuing through adulthood. The necessary behavioral changes are most effective when based upon positive relationships and experiences. These positive relationships are often driven by education and outreach efforts that inform and engage urban, rural, and shoreland residents, landowners, and farmers to better understand context.	4.1.1 Lack of watershed-wide sound and credible education and outreach program about water management focused on the next generation (youth and grade school aged children) for building future water awareness
			4.1.2 Lack of watershed-wide sound and credible education and outreach program intended for general public audiences for gaining an understanding of natural resources and water related issues (i.e. drinking water protection, maintenance of SSTSs, proper disposal of hazardous chemicals, water conservation, low impact development, BMPs, properly sealing wells, and solid waste disposal), and changing behaviors adverse to wise water management
			4.1.3 Lack of watershed-wide sound and credible education and outreach program for gaining a better understanding of water issues (i.e. nutrient management, agricultural BMPs, wellhead protection), the adverse and beneficial consequences of decisions as they relate to water management and necessary behavioral changes, for local units of government staff, local offices, and elected public officials
			4.1.4 Frequency of use and public access to recreational resources along waterbodies and other nature resources which allow for wildlife viewing, canoeing, kayaking, hiking, biking, camping, hunting, and fishing.
	4.2 Landowner, Producer and Lake Shore Owner Engagement in Water Management	How private lands are managed affects water resources. Some programs focused on implementing practices to improve water quality and reduce the rate and volume of runoff, go unused for a variety of reasons. Understanding, engaging, and communicating with landowners, agricultural producers and those controlling the land resource is needed to facilitate effective water resources management with the plan area. Increased implementation of practices may result from increased capacity and understanding.	4.2.1 Lack of and quality of watershed-wide education and outreach programs to communicate information about incentive and cost-share programs and their benefits to landowners
			4.2.2 Lack of and quality of watershed-wide education and outreach programs to communicate information about management practices and structural best management practices, and their relation to agricultural profitability, value in recharging groundwater, reducing runoff volumes and benefits to streambank/ shoreline stability
	4.3 Technology, Tools, Funding, and Existing Capabilities	New tools and technology are frequently being developed for use in water resources management. In order to take advantage of these tools, there is often a need to build and maintain the technical capacity to utilize them. There is also a need to provide effective and efficient plan administration and implementation through coordination of roles and consistent funding.	4.3.1 Maintenance of sufficient technical capacity to use emerging technologies and tools at the local level
			4.3.2 Lack of clarity about the coordination of roles and responsibilities among local, state and federal agencies for the delivery of programs and pooling of resources focused on managing water issues at the watershed level
			4.3.3 Lack of understanding, agreement and consensus about the hydrologic impacts of pattern tile drainage within rural landscapes and the fiscal benefits provided to producers, creating a barrier to constructive solutions to water management
			4.3.4 Piecemeal approach and lack of long term and consistent funding for water management programs at the local level
			4.3.5 Lack of consistent and effective watershed-wide approach to a regulatory program, including ordinances and rules

Missouri River Watershed, One Watershed One Plan
APPROVED Issues Table

Resource Category	Resource Concern		Issue Affecting a Resource Concern
	Name	Description	Issue
			4.3.6 The identification and examination of vulnerabilites to aquifers within a Drinking Water Supply Management Area (DWSMA) as part of a Wellhead Protection Plan, and the needed state and federal agency support for local government units to enforce regulations and provide cost share or other incentives to landowners and users to ensure protection of drinking water features
			4.3.7 The need for improved tools and data that link surface hydrology and Best Management Practice Implementation to groundwater hydrology (quantity/quality).
5. Local Development and Land Stewardship: The management of urban and rural land use through sustainable development			
	5.1 Urban Land Stewardship	There are 25 towns or cities within the Missouri River Watershed. Many of these communities are experiencing strong residential or commercial developmental pressures. Increased urban development increases the amount of impervious surface, which can impact surface and groundwater resources.	5.1.1 Increases in the amount of impervious surface with insufficient runoff retention and the rate, volume and duration of stormwater runoff associated with increases in soil erosion and nutrient loading
			5.1.2 Increased construction activities from increased development, and its impact on water and soil
			5.1.3 Compliance with, and downstream water quality consequences from permitted wastewater treatment facilities to waterways
			5.1.4 Use of fertilizers and pesticides in urban landscapes and their affect on surface water quality
			5.1.5 Disposal of solid waste, household hazardous waste, and prescription and non-prescription drugs in urban landscapes and their affect on surface water quality
	5.2 Rural Land Stewardship	Land stewardship is a cornerstone of ensuring a prosperous rural economy in the Missouri River Watershed. Factors which typify rural land stewardship include using agricultural management practices which maintain soil health, the judicious use of fertilizers and pesticides in agricultural operations especially in sensitive environmental settings, and utilizing smart methods to dispose of animal and human wastes. Practices implemented to improve water resources should complement and be consistent with maintaining and enhancing agricultural productivity.	5.2.1 Decreased soil health and its impact on agricultural productivity and water holding capacity
			5.2.2 Increased sheet, rill, and wind erosion, and its impact on agricultural productivity, surface water quality, and deposits in drainage systems
			5.2.3 Increased developmental pressures between expanding rural residences, agricultural, and feedlot operations
			5.2.4 Increased demand for irrigation, and its impact on groundwater and surface water supplies
			5.2.5 Application and disposal of pesticides to promote productivity, and its potential to impact groundwater and surface water resources
			5.2.6 The efficient and safe application and disposal of manure from animal operations and its impact on surface and ground water quality
			5.2.7 Adequacy and efficiency of using individual sewage treatment systems (ISTSs) for wastewater treatment for private residences and small communities
			5.2.8 Methods and processes for extracting and processing aggregate and other natural construction materials and the means for rehabilitation of the landscape for continued sustained use
	5.3 Riparian Stewardship	Lake shorelands are lands within 1,000 feet of a lake. Stream riparian corridors are the land areas adjacent to a creek, stream, river or similar water body characterized by perennial vegetation and relatively frequent flooding. For lake shorelands and stream riparian corridors, perennial vegetation preferably consists of native plant species. Lake shorelands and riparian corridors serve important functions including filtering runoff, habitat and travel corridors for fish and wildlife, and aesthetic enjoyment. Both lake shoreland and riparian corridors are sometimes subject to regulatory controls (e.g., shoreland ordinance; floodplain requirements).	5.3.1: Increased development along lakes causing loss of native and perennial shoreland plants for pollutant filtering, capturing precipitation, increasing bank stability, and habitat connectivity
			5.3.2: Presence of meandering prairie streams which undercut stream banks, causing instability and erosion
			5.3.3: Presence of water control structures acting as barriers to fish movement and a reduction in longitudinal connectivity and reduction in ecosystem services
			5.3.4 Improperly sized road crossings for current bankfull channel and its impact on geomorphic stability and routing of sediment downstream
			5.3.5: Insufficient stream channel volume, causing streams to leave their banks during flood events
			5.3.6 Livestock accessibility to streams and its impacts on geomorphology and streambank erosion
			5.3.7: Presence, width and quality of vegetated areas adjacent to streams and rivers within urban and rural landscapes for filtering surface runoff, providing shading and maintaining surface water temperatures, habitat connectivity, and increasing bank stability

Appendix I

Methodology:
Nitrogren Infiltration Risk Maps

MISSOURI RIVER WATERSHED
Comprehensive Watershed Management Plan

Nitrogen Infiltration Risk Map

Purpose and Method for Plan Appendix

A risk-based map, showing the relative risk of areas on the landscape with regard to the amount of nitrogen potentially reaching groundwater, is needed as an implementation aide and to guide the placement of structural conservation practices. Currently available geo-spatial products (e.g., pollution sensitivity of near surface materials (http://www.dnr.state.mn.us/waters/programs/gw_section/mapping/platesum/mha_ps-ns.html) are solely based upon hydrologic consideration; (e.g., potential groundwater recharge rates or thickness of the surficial material and estimated travel time to a depth of 10-feet). These products fail to consider land use, and specifically the nitrogen input pathways on the landscape. This analysis includes specific consideration of the total estimated nitrogen (mass) input based on land use and the potential for denitrification as water infiltrating from the surface travels through surficial materials. Improvement to the risk map is possible with the investment of additional resources to reflect the fate and transport of nitrate-nitrogen. A limitation of the analysis is it fails to estimate the fate and transport of nitrate-nitrogen and uses total nitrogen (TN) as a surrogate. This analysis also does not compute a magnitude of nitrogen reaching groundwater, but instead assigns a relative risk factor (high, moderate, low). This was chosen due to the uncertainty in the fate and transport of TN.

The method used to develop the risk map and assess the susceptibility of groundwater to nitrogen is based upon three factors; 1) the potential groundwater recharge magnitude; 2) the estimated annual TN input (in a mass balance term) based on a 4-year crop rotation or, in the absence of a defined rotation, the land cover type and; 3) the soil denitrification potential as water carrying nitrogen (assumed to be in part nitrate-nitrogen) moves through the soil horizon. **Table 1** shows the sources of the geo-spatial information used in developing the risk map.

Generating the risk map requires a two-step process. The first step is applying **Equation 1** to the geo-spatial data layers:

EQ 1

(Estimated Total N Input * Potential Annual Groundwater Recharge Rate) –
[% Potential Denitrification * (Estimated Total N Input * Potential Annual Groundwater Recharge Rate)]

The estimated TN Input (4-year mean; pounds/year) is based on the cropland nitrogen balance data of Mulla et al. (2013) and represents the TN input mass applied to a 4-year crop rotation. **Table 2** shows typical TN values for single crop types (see **Table 2**). A value of 124.9 lb-N/acre/year was used for other land use types. The potential annual groundwater recharge rate (inches/year) is based on a 1-km scale water balance model completed by the United States Geological Survey (2015). The first term, although dimensionally meaningless, is intended to represent the potential mass of nitrogen reaching groundwater carried by water.

Table 1. Data type, source and spatial resolution of the data used to develop the Nitrogen Infiltration Risk Map. Any necessary data pre-processing for use in this analysis is also shown.

Data Type	Data Source	Spatial Resolution	Additional Information and Data Pre-processing Needs
Groundwater Recharge	US Geological Survey (USGS)	1 kilometer	• Data represents mean annual potential recharge rates (inches/year) for years 1996-2010 • For 'No data' cells along the project boundary (data gaps which existed in the original Minnesota Department of Natural Resources (MNDNR) dataset), recharge rates in these cells were estimated based on the mean of adjacent cells • For 'No data' cells not along the project boundary – no analysis occurred as these were flagged as 'No data' in the original dataset
Land Use and Agricultural Crop Rotations	MN Soybean and Research Promotion Council	Common Land Area Unit	• Crop rotations available for years 2011-2014 • For data where the mid-summer primary crop was not determined (labeled as 'background' in dataset), crop type was backfilled with previous (or most recent years for 2011) crop type
Soil Hydrologic Group	USDA Natural Resource Conservation Service (NRCS) Gridded Soil Survey Geographic Database (gSSURGO)	10 meter	• Cells without data typically overlay water and were not analyzed

Table 2. Estimated Total Nitrogen Inputs (lb – N/acre/year) (derived from Mulla et al., 2013).

Crop Type	Planted Seeds (Elemental N)	Atmospheric Deposition (inorganic N)	Symbiotic Nitrogen Fixation (elemental N)	Nonsymbiotic Fixation (elemental N)	Mineralization	Inorganic Fertilizer (non-manure)	Sum of Total Nitrogen Inputs (lb-N/acre/year)
Potatoes	23.40	8.40	50.00	2.00	64.50	195.00	343.30
Corn	0.30	8.40	50.00	2.00	64.50	140.00	265.20
Spring Wheat	3.46	8.40	50.00	2.00	64.50	107.00	235.36
Sugar Beets		8.40	50.00	2.00	64.50	83.00	207.90
Barley	1.49	8.40	50.00	2.00	64.50	66.00	192.39
Oats	2.80	8.40	50.00	2.00	64.50	48.00	175.70
Alfalfa		8.40	50.40	2.00	64.50	10.00	135.30
Other Hay		8.40	50.00	2.00	64.50	10.00	134.90
Soybean	4.00	8.40	50.00	2.00	64.50	3.00	131.90
Grass / Legume		8.40	43.50	2.00	64.50		118.40

The second term in the equation represents the potential for denitrification within the surficial materials as water travels vertically from the land surface to the surficial aquifer. The % potential denitrification term is applied as a function of hydrologic soil group, which can be used as a surrogate for the depth to the surficial aquifer and the travel time. No land was assumed to be tiled. Thus, dual soil classes A/D, B/D, and C/D, were treated as if they were undrained (and therefore A, B, and C-type soils, respectively). The % of inorganic nitrogen denitrified by hydrologic soil group is shown in **Table 3**.

Table 3. Percent potential denitrification (used in Equation 1) as a function of hydrologic soil group.

Hydrologic Soil Group(s)	Mulla et al. (2013) Soil Characterization	% of Inorganic N Denitrified (non-tile)
A	Excessive to well drained (sandy, loam, muck)	3
B	Somewhat poorly drained (loam)	20
C	Poorly drained	30
D	Very poorly drained	30

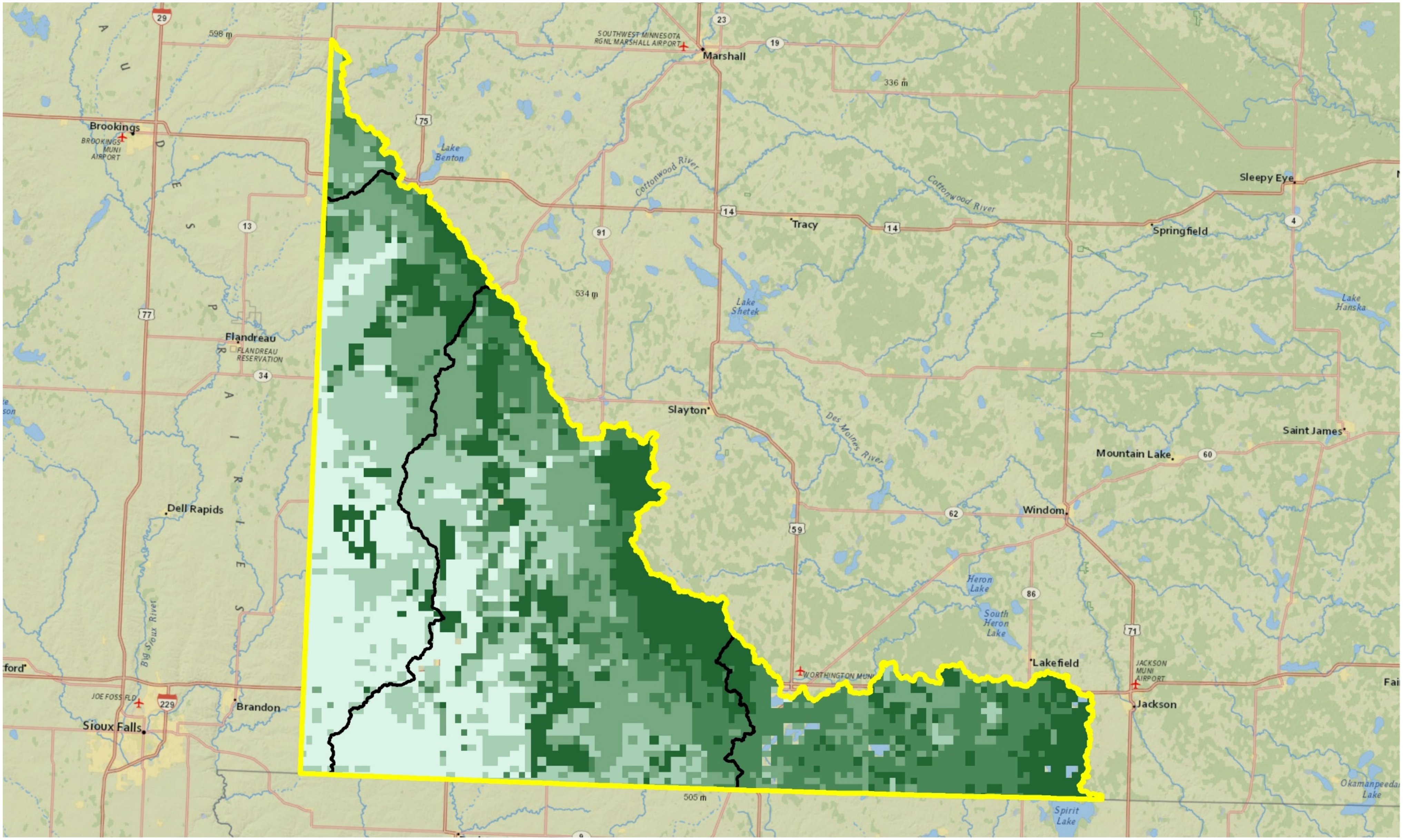
The second step in the process is placing the values computed using **Equation 1**, into a relative risk category as shown in **Table 4**. The relative risk categories were binned into quantiles using the values computed using Equation 1.

Table 4. Assignment of Relative Risk Category based on Equation 1

Relative Risk Category	Percentile Range for value estimated in Equation 1
High Risk	> 80%
Moderately High Risk	60% to < 80%
Moderate Risk	40% to < 60%
Moderately Low Risk	20% to < 40%
Low Risk	< 20%

Product Results and Use

Figures 1, 2 and **3** show the specific input values used in **Equation 1** for the plan area. **Figure 4** shows the final Nitrogen Infiltration Risk Map. Data shown in **Figure 4** can be used to screen the applicability of specific structural conservation practices and to help guide implementation. For example, infiltration practices can be targeted to those areas with low risk to encourage groundwater recharge, and their use minimized in areas with high risk.



Potential Annual Groundwater Recharge

- Low
- Moderately Low
- Moderate
- Moderately High
- High

- Plan Boundary
- HUC-8 Planning Boundaries

0 5 10 20 Miles

N W E S

Figure 1. Missouri River One Watershed One Plan Potential Annual Groundwater Recharge					
Scale: AS SHOWN	Drawn by: KSG	Checked by:	Project No.: 6163-002	Date: 11/22/2017	Sheet:

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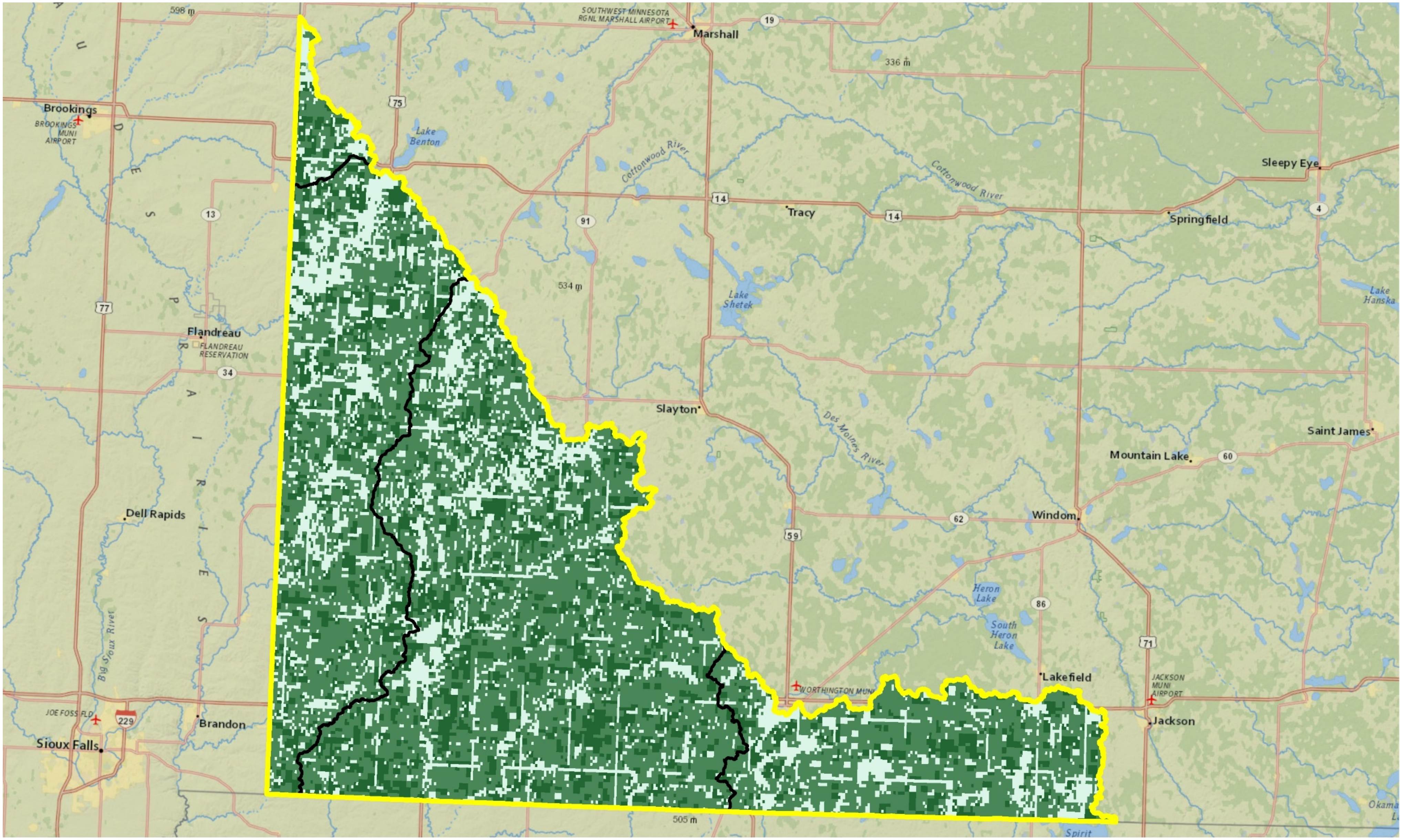

Estimated Total Nitrogen Input

- Low
- Moderately Low
- Moderate
- Moderately High
- High

- Plan Boundary
- HUC-8 Planning Regions

0 5 10 20 Miles

N E S W

Figure 2. Missouri River One Watershed One Plan Estimated Total Nitrogen Input					
Scale: AS SHOWN	Drawn by: KSG	Checked by:	Project No.: 6163-002	Date: 11/22/2017	Sheet:

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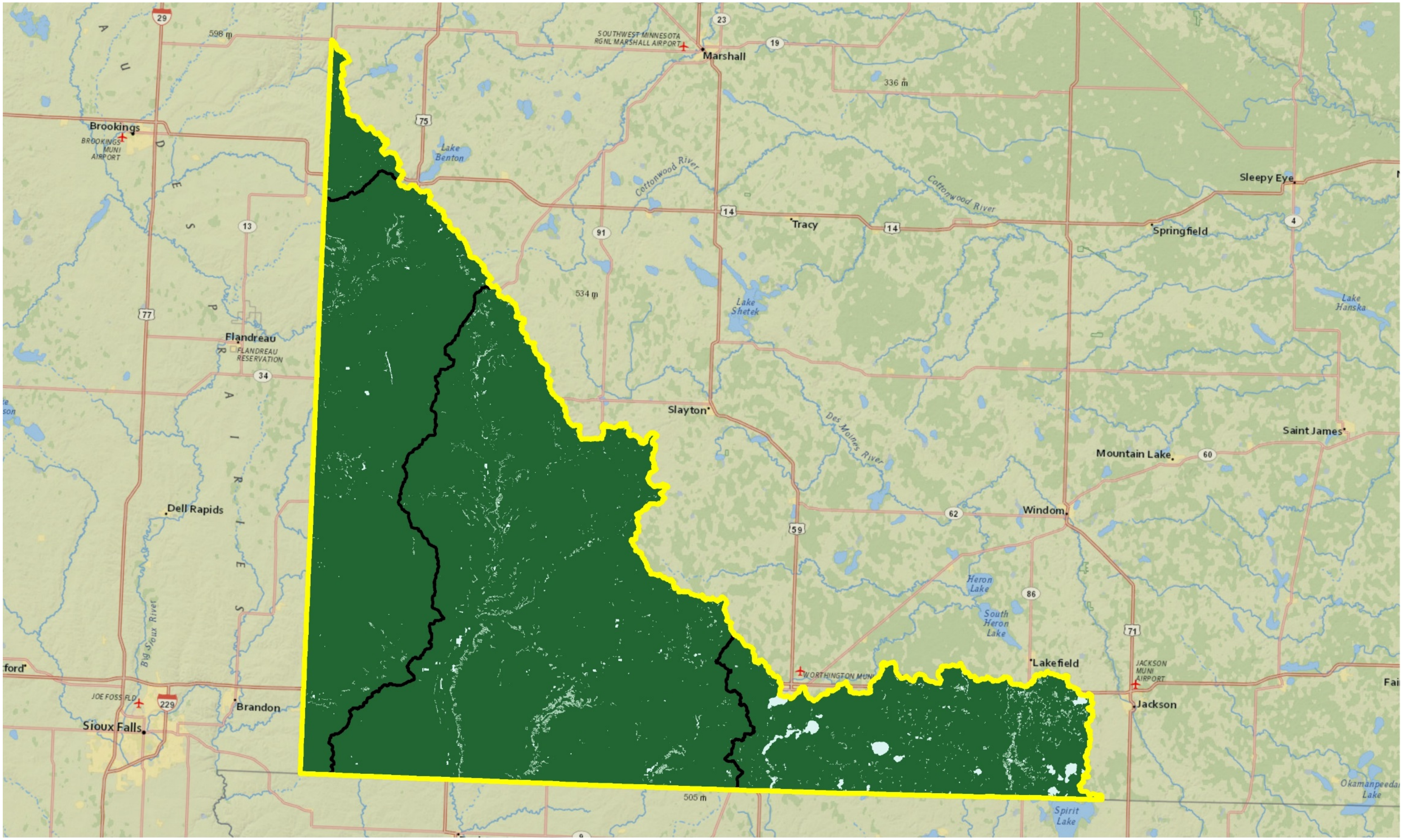

Potential Denitrification

- Low
- Moderately Low
- Moderate
- Moderately High
- High

- Plan Boundary
- HUC-8 Planning Regions

0 5 10 20 Miles

N E S W

Figure 3. Missouri River One Watershed One Plan Potential Denitrification					
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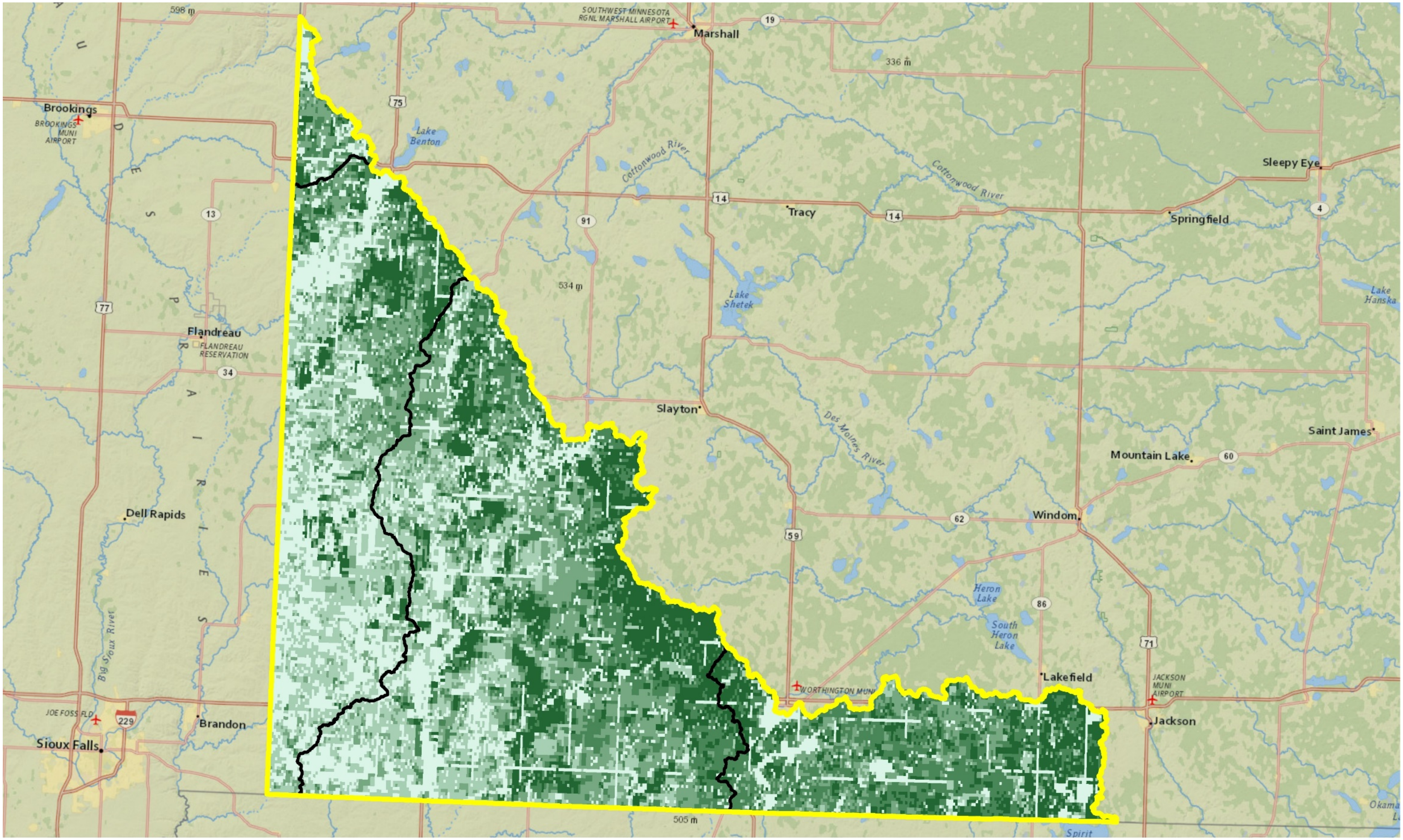

Nitrogen Infiltration Risk

- Low
- Moderately Low
- Moderate
- Moderately High
- High

- Plan Boundary
- HUC-8 Planning Regions

0 5 10 20 Miles

N S W E

Figure 4. Missouri River One Watershed One Plan
Nitrogen Infilltration Risk Map

Scale:	Drawn by:	Checked by:	Project No.:	Date:	Sheet:
AS SHOWN	KSG		6163-002	11/22/2017	

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Smith, E.A., and Westenbroek, S.M., 2015, Potential groundwater recharge for the State of Minnesota using the Soil-Water-Balance model, 1996–2010: U.S. Geological Survey Scientific Investigations Report 2015–5038, 85 p., http://dx.doi.org/10.3133/sir20155038.

Appendix J
Methodology:
Altered Hydrology Analysis

MISSOURI RIVER WATERSHED
Comprehensive Watershed Management Plan

Technical Memorandum

To: Missouri River Watershed 1W1P Planning Work Group

From: Timothy Erickson PE

Houston Engineering, Inc.

Subject: Missouri River Basin Altered Hydrology Analysis

Date: December 18, 2017

Project: 6163-002

1.0 INTRODUCTION

1.1 NEED TO ASSESS ALTERED HYDROLOGY

One of the stressors commonly referenced as a reason for aquatic life impairments is "altered hydrology." Altered hydrology is commonly thought to be characterized by increases in peak discharge and runoff volume for a range of precipitation events, as compared to some historic or benchmark condition. Numerous studies have suggested that this hydrologic alteration is a result of some combination of climatic variation, land use/land cover changes, or other landscape scale changes. Aquatic habitat loss, increased streambank erosion and bank failure, and increased sediment levels are some of the suggested consequences of altered hydrology. Individually and collectively these are believed to lead to the impairment of aquatic life, exhibited by lower ecological diversity.

Although a general sense of the characteristics of altered hydrology exists, a substantive challenge remains. A challenge associated with addressing altered hydrology is the lack of a common definition, including agreement on a set of science-based metrics to establish the desired (i.e., benchmark) condition, and assess whether altered hydrology has indeed occurred. **Figure 1** provides an example of hydrologic data which could be used to illustrate altered hydrology. **Figure 1** shows a flow duration curve for a streamflow gage in the Sand Hill River Watershed, within northwestern Minnesota. Two 30-year time periods are shown on the graph; i.e., 1980 – 2010 (solid line) and 1945 - 1975 (dashed line). The graph represents the likelihood of exceeding a specific daily mean discharge. The graph indicates an increase in the daily mean

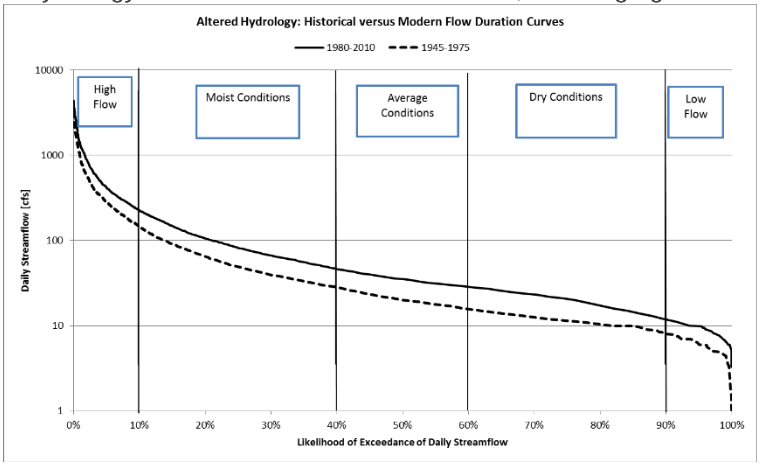

Figure 1. Flow duration curve for the Sand Hill River at Climax, Minnesota. The solid black line shows an increase in daily mean discharge for the 1980 – 2010 period, compared to the early 1945 – 1975 period.

discharge through most of the flow range, because for the same likelihood of exceedance the daily mean discharge is greater for the more recent time periods. This suggests "altered hydrology" meaning that flow conditions in the watershed differ between the two time periods. The example illustrates one possible metric which could be used to describe altered hydrology.

Agreement on a set of science-based metrics to assess the extent of hydrologic alteration and the desired (i.e., benchmark) condition is needed in order to quantitatively assess changes in the hydrology of a watershed. A definition is needed to rigorously assess whether hydrology has indeed changed through time, establish goals for altered hydrology, and assess and evaluate various means, methods and projects to mitigate the adverse effects of altered hydrology.

Considerable research and technical information relative to describing altered hydrology has been completed. The recently release draft report titled "Technical Report: Protection Aquatic Life from Hydrologic Alternatives" (Novak et al., 2015) is one example. The report presents metrics which can be used to describe altered hydrology. However, causal information about how the change in hydrology results in the alteration or loss of ecological function is lacking within the report.

For the hydrology of a watershed to be altered there must be some deviation from a preferred or desired hydrologic condition; i.e., a "benchmark" condition. The benchmark for altered hydrology could be the "natural hydrologic regime" or some other condition. The natural hydrologic regime (Poff et al 1997; Arthington et al 2006; Bunn and Arthington 2002 ; Sparks 1995) is the characteristic pattern of water quantity, timing and variability in a natural water body. A river's hydrologic or flow regime consists of environmental flow components (Mathews and Richter, 2007; The Nature Conservancy, 2009), each of which can be described in terms of the magnitude, frequency, duration, timing and rate of change in discharge. The integrity of an aquatic system presumably depends on the natural dynamic character of these flow components to thereby driving ecological processes.

Defining altered hydrology and the benchmark condition, identifying the metrics to describe altered hydrology and translating the information into goals to mitigate the adverse consequences is technically challenging. The approach used to evaluate whether a watershed exhibits altered hydrology is presented within this document. A definition of altered hydrology is presented. Specific quantitative metrics to assess the extent of hydrologic change and the desired (i.e., benchmark) condition are also presented. No effort is made to describe the causal relationship between hydrology and the ecological, geomorphological or water quality effects. Rather, the assumption is made that the desired condition is achieved by obtaining the benchmark condition. These results are intended to be a beginning point in addressing the topic of altered hydrology in a more rigorous manner, which no doubt will evolve through time.

2.0 METHODS

2.1 A BRIEF HISTORY OF CHANGING HYDROLOGY

Streamflow in Minnesota (Novotny & Stefan, 2007) and across the contiguous United States (Lins and Slack 1999, McCabe and Wolock, 2002) have been changing during the past century, with flows in the period starting from the 1970s to the beginning of the 21st Century tending to be higher than during the early to mid-1900s (Ryberg et al. 2014). Numerous studies have been conducted to quantify magnitude of impact and pinpoint relative importance of potential causes of these changes, but scientific consensus has currently not been achieved. The science is not at a point where specific causes can be attributed to altered hydrology with any significant certainty and public discussion about specific causes usually leads to barriers to implementation. In general, the leading candidate causes of altered hydrology can be categorized into to two primary groups: climatic changes and changes in the landscape. Examples of climatic changes include changes in annual precipitation volumes, in surface air temperature, timing of the spring snowmelt, annual distribution of precipitation, and rainfall characteristics (timing, duration, and intensity). Examples of changes in the landscape include changes in land use/land cover, increased imperviousness (urbanization), tile drainage, wetland removal/restoration, groundwater pumpage, flow retention and regulation, and increased storage (both in-channel and upland storage). A summary of the current scientific debate about the changing hydrology is provide in Appendix F.

Although it is important to water resource management to understand the mechanics behind the changes in hydrology, the focus of this analysis is developing a definition for altered hydrology, a method for assessing whether it has occurred within a watershed, and establishing a goal for addressing altered hydrology.

2.2 ALTERED HYDROLOGY DEFINED

Altered hydrology is defined as a *discernable* change in specific metrics derived from stream discharge, occurring through an entire annual hydrologic cycle, which exceed the measurement error, compared to a benchmark condition. For this framework, *discernable* has been used as a proxy for statistical comparisons. The metrics are typically some type of hydrologic statistic derived from the annual discharge record across a long period of time, usually a minimum of 20-years (Gan et al. 1991). The amount of baseflow, the hydrograph shape, peak discharge, and runoff volume for a range of precipitation event magnitudes, intensities, and durations are specific components of or derived from the annual hydrograph.

2.3 ESTABLISHING BENCHMARK CONDITION

A reference or “benchmark” condition is needed to complete an assessment of whether hydrology is altered. A minimum of a 20-year time-periods reasonably ensures stable estimates of streamflow predictably (Gan et al. 1991; Olden & Poff 2003), sufficient duration to capture climate variability and the interdecadal oscillation typically found in climate (McCabe et al. 2004, Novonty and Stefan 2007), and is the standard timespan used for establishing “normal” climate statistics in the United States. Where the extent data allows it, the analysis is performed for two 35-year time periods; i.e., a benchmark period called “historic” and an “altered” state or called “modern”). The benchmark period used to establish benchmark conditions represents the period before shifts in hydrology are commonly thought to have begun within Minnesota as a result of land use/land cover changes, or increases in the depth, intensity, and duration of precipitation.

To illustrate an example of a change in streamflow and the validity in the breakpoint period, cumulative streamflow (using annual depth values) is plotted across time (**Figure 2**) for the USGS gage at Crow River at Rockford, MN (USGS ID: 05280000). Cumulative streamflow was used instead of straight annual streamflow because (1) it linearizes streamflow relationship where the slope of a trendline would be the average annual streamflow, (2) no assumptions about multi-year dependencies (e.g. changes in storage) or autocorrelation is necessary, and (3) changes in slope can be easily visualized, showing an altered state of hydrology.

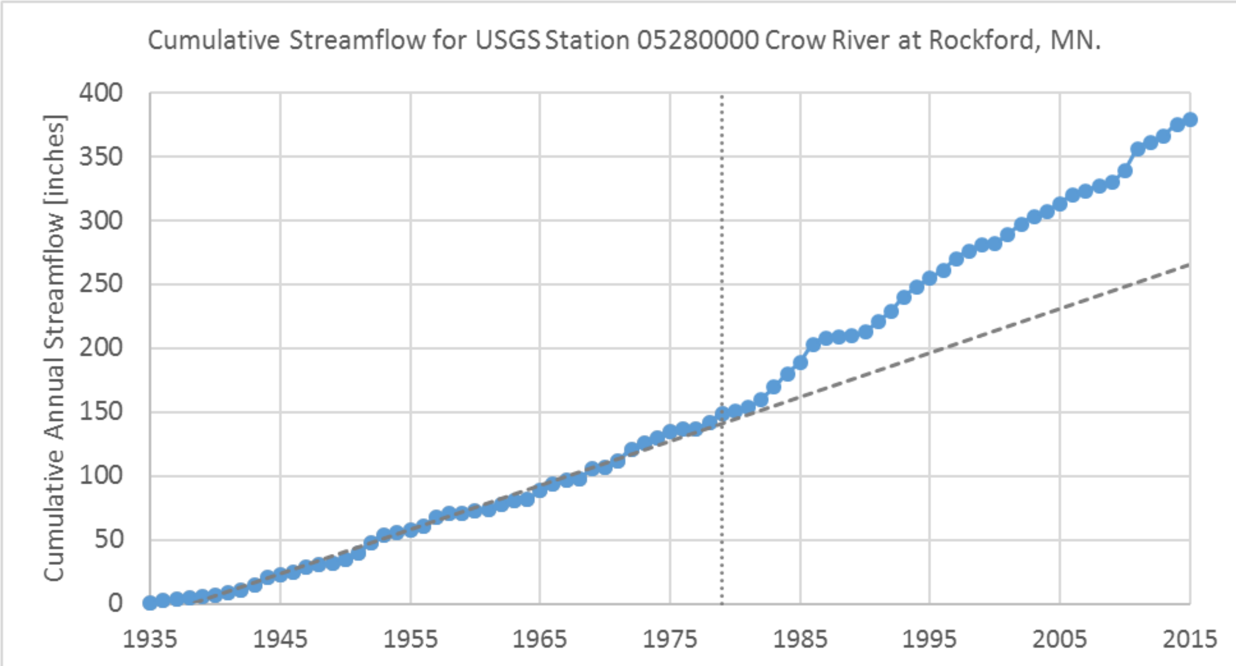

Figure 2. Cumulative streamflow for the Crow River at Rockford, MN (USGS Station 05280000).

Results from analysis shown in the example (**Figure 2**) determine the break point and define the benchmark and modern conditions.

2.4 METRICS USED TO ASSESS ALTERED HYDROLOGY

Many potential metrics can be used to describe a measurable change in the annual hydrograph. For example, the indicators of hydrologic alteration software developed by the Nature Conservancy (https://www.conservationgateway.org/ConservationPractices/Freshwater/EnvironmentalFlows/MethodsandTools/IndicatorsofHydrologicAlteration/Pages/indicators-hydrologic-alt.aspx) uses 67 different statistics derived from mean daily discharge to describe altered hydrology. Ideally, each indicator or metric could be causally linked to an ecological or geomorphological consequence, although this is technically challenging. Use of such a large number of indictors can be problematic as many of the metrics can be correlated and are therefore interdependent or lack ecological or geomorphological meaning.

The structure and therefore function of ecological systems are often “driven” by “non-normal” events; e.g., low flows associated with drought, higher flows which inundate the floodplain. Metrics used to complete this analysis were preferentially selected to reflect the variability in specific characteristics of the annual hydrograph, and include peak discharges, runoff volumes and hydrograph shape. Each metric was specifically selected to represent a flow condition believed to be of ecological or geomorphological importance, in the absence of causal information. **Table 1** shows the specific metrics used to complete the analysis. The use of these metrics is intended to identify: 1) whether the hydrology within a watershed is indeed altered: and 2) which resources may be at risk because of the alteration.

Table 1. Metrics used to define and assess whether hydrology is "altered" for a specific watershed.

Relevance	Hydrograph Feature	Frequency of Occurrence	Duration	Metric	Ecological or Geomorphic Endpoint
Condition of Aquatic Habitat	Baseflow	10-year	30 day	The minimum change between time periods is the accuracy of measuring streamflow discharge and estimating daily mean discharge. A discharge measurement accurate within 10% of the true value is considered excellent by the United States Geological Survey (USGS). Some additional error is induced through the conversion of these data to discharge. Therefore, a minimum change of 15% is needed between "historic" and "modern" period for this metric to classified as "altered."	Discharge needed to maintain winter flow for fish and aquatic life.
		Annual	30-day median (November)		
Aquatic Organism Life Cycle	Shape	Mean	Monthly average of daily means	Use the "historic" period of record to define "normal variability." Develop a histograms of daily mean discharges for each month within the period of record for the "historic" and "modern" time periods. Compare the histograms of the monthly average of daily means using an appropriate statistical test. Assume the histograms are from the same statistical population and text for significance at an appropriate significance level.	Shape of the annual hydrograph and timing of discharges associated with ecological cues.
	Timing	Julian day of minimum	1-day		
		Julian day of maximum			
Riparian Floodplain (Lateral) Connectivity	Peak discharge	10-year	24-hour and 10-day	The minimum change between time periods is the accuracy of measuring streamflow discharge and estimating daily mean discharge. A discharge measurement accurate within 10% of the true value is considered excellent by the United States Geological Survey (USGS). Some additional error is induced through the conversion of these data to discharge. Therefore, a minimum change of 15% is needed between "historic" period and "modern" period for this metric to classified as "altered."	Represents the frequency and duration of flooding of the riparian area and the lateral connectivity between the stream and the riparian area. Functions include energy flow, deposition of sediment, channel formation and surface water – groundwater interactions
		50-year			
		100-year			
	Volume	10-year	Total runoff volume for those days with a daily mean discharge exceeding the 24-hour discharge		
		50-year			
		100-year			

Relevance	Hydrograph Feature	Frequency of Occurrence	Duration	Metric	Ecological or Geomorphic Endpoint
Geomorphic Stability and Capacity to Transport Sediment	Peak Discharge	1.5 year	24 - hour	The minimum change between time periods is the accuracy of measuring streamflow discharge and estimating daily mean discharge. A discharge measurement accurate within 10% of the true value is considered excellent by the United States Geological Survey (USGS). Some additional error is induced through the conversion of these data to discharge. Therefore, a minimum change of 15% is needed between “historic” period and “modern” period for this metric to classified as “altered.”	Channel forming discharge. An increase is interpreted as an increased risk of stream channel susceptibility to erosion.
	Volume	1.5 year	Cumulative daily volume exceeding channel forming discharge		
		Average daily	30-year flow duration curve		

2.5 DETERMINATION OF ALTERED HYDROLOGY

A simple weight of evidence approach is used to decide whether the hydrology of a watershed is "altered" between two time periods. A "+" is assigned to each metric if it has a discernable increase from the benchmark as defined by the metric, between the historic and modern time periods. A "-" is assigned to each metric if it has a discernable decrease from the benchmark as defined by the metric, between the historic and modern time periods. An "o" is assigned to each metric if it lacks a discernable increase or decrease from the benchmark as defined by the metric, between the historic and modern time periods. If the number of "+" values exceeds the number of "-" values, an increase in the watershed response to precipitation is implied and the hydrology is considered altered between the two time periods. If the number of "-" values exceeds the number of "+" values, the a decrease in the watershed response to precipitation is implied and the hydrology is considered altered between the two time periods. The hydrologic response of the watershed is considered "altered" if the percentage of + and – signs exceeds 50% in any group of metrics.

2.6 ESTABLISHING ALTERED HYDROLOGY GOALS

There are two types of goals; i.e., a qualitative and a quantitative goal. The qualitative goal is to return the hydrology to the benchmark condition. The qualitative goal is evaluated using a weight of evidence approach. The goal is simply to achieve the conditions for the historic period as defined by the metrics with **Table 1**. It is presumed the historic period is "better" from an ecological and geomorphological perspective.

The second type of goal is a quantitative storage goal. Several of the metrics within **Table 1** can be used to establish storage goals, which may be accomplished by a variety of types of projects. These project types include not only traditional storage, but increasing the organic matter content of soils. These goals are the change in volume between the historic and modern time periods. The volume needs to be described by the effective volume, which is the amount of storage required on the landscape.

2.7 METHODS FOR EVALUATING ALTERED HYDROLOGY MITIGATION STRATEGIES

Several methods can be used to develop strategies to mitigate the effects of altered hydrology. These methods include the use of continuous simulation hydrology models (like the Hydrologic Simulation Program Fortran) and the event-based hydrology approaches (like those within the Prioritize, Target and Measure Application).

3.0 ALTERED HYDOLOGY IN THE MISSOURI RIVER BASIN

The following are summaries of results from the altered hydrology analysis conducted on long-term gaging stations in steams that drain the Missouri River Basin's watersheds in Minnesota. There were no long-term gaging stations in the Minnesota portion of the Missouri Basin, therefore, the nearest, downstream, long-term gaging stations were used to conduct this analysis to provide coverage of Minnesota's portion of the Missouri River Basin.

3.1 LITTLE SIOUX RIVER

3.1.1 Little Sioux River at Linn Grove, IA (USGS# 06605850)

The closest long-term gaging site in the Little Sioux River to the Minnesota portion of the drainage area is the USGS site at Linn Grove, IA (USGS# 06605850). The total drainage area for this site is 1,548 square miles, according to the USGS. The Minnesota portion of the drainage area includes approximately 321 square miles of the upper reaches. The data record starts in October 1972 and runs to the present (2017). The site only includes average daily streamflow records (i.e. no peak flow measurements). **Figure 3** shows the cumulative streamflow (in inches per year) for the gaging site. Cumulative streamflow is used to determine a breakpoint between the benchmark condition and the altered condition (see **Section 2.3**).

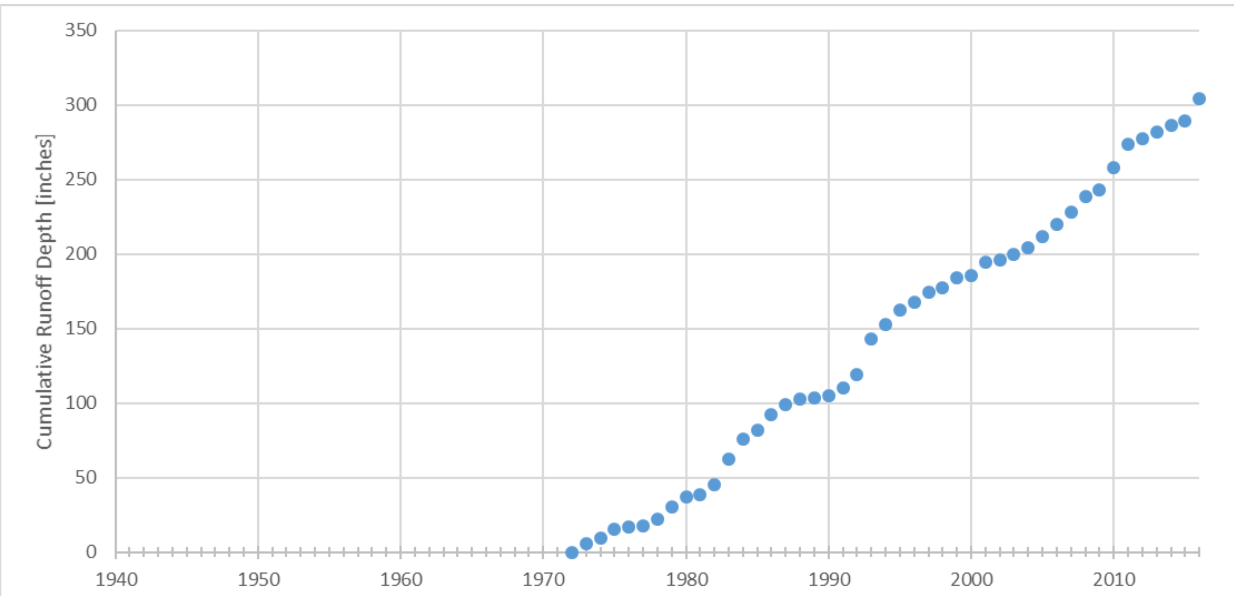

Figure 3. Cumulative streamflow for Little Sioux River at Linn Grove, IA (USGS# 06605850)

According to the cumulative streamflow analysis, a breakpoint exists around 1981-1982. Therefore, the benchmark ("historic") conditions will include data from 1971-1981 and the altered ("modern") will include data form 1982-2015. Since the data starts in 1972 and only 9 complete years of data are available of the benchmark condition period, an additional site (USGS# 06606600) further downstream was included to test the validity of the analysis (see **Section 3.1.2**).

A summary of the results from the altered hydrology analysis is provided in **Table 2.** A more detailed description of the results is provided in **Appendix A**. A summary of the storage goals based on the altered hydrology analysis are provided in **Section 4**.

Table 2: Altered Hydrology Summary for Little Sioux River at Linn Grove, IA. (USGS# 06605850).

Group	Metric	% Difference	Altered Hydrology Metric	Evidence of Altered Hydrology for Group
Aquatic Habitat	10-year, Annual Minimum 30-day Mean Daily Discharge	364.4%	+	Yes, Increasing
	10-year, Annual Minimum 7-day Mean Daily Discharge	374.4%	+	
	Median November (Winter Base) Flow	22.5%	+	
Aquatic Organism Life Cycle	Magnitude of Monthly Runoff Volumes	-16.3%-to-159%	o	No, Limited change
	Distribution of Monthly Runoff Volumes	-51.4%-to-50.2%	o	
	Timing of Annual Peak Discharge	-8.93%	o	
	Timing of Annual Minimum Discharge	23.61%	+	
Riparian Floodplain (Lateral) Connectivity	10-year Peak Discharge Rate	54.35%	+	Yes, Increasing
	50-year Peak Discharge Rate	31.13%	+	
	100-year Peak Discharge Rate	21.73%	+	
	Average Cumulative Volume above the Historic 10-year Peak Discharge	916.22%	+	
	Average Cumulative Volume above the Historic 50-year Peak Discharge	NA	o	
	Average Cumulative Volume above the Historic 100-year Peak Discharge	NA	o	
Geomorphic Stability and Capacity to Transport Sediment	1.5-year Peak Discharge Rate	71.20%	+	Yes, Increasing
	2-year Peak Discharge Rate	72.57%	+	
	Average Cumulative Volume above the Historic 1.5-year Peak Discharge	139.64%	+	
	Average Cumulative Volume above the Historic 2-year Peak Discharge	223.09%	+	
	Duration above the Historic 1.5-year Peak Discharge	60.93%	+	
	Duration above the Historic 2-year Peak Discharge	145.07%	+	
	Flow Duration Curve	63.1%-to-418%	+	

3.1.2 Little Sioux River at Correctionville, IA (USGS# 06606600).

Since there was only 9 useable years of data for the benchmark condition at the Linn Grove, IA site, the next long-term gaging site was analyzed to see if the results were valid. The next closest long-term gaging site in the Little Sioux River to the Minnesota portion of the drainage area is the USGS site at Correctionville, IA (USGS# 06606600). The total drainage area for this site is 2,500 square miles, according to the USGS. The Minnesota portion of the drainage area includes approximately 321 square miles of the upper reaches. The data record starts in 1918 and runs to the present (2017). The site only includes average daily streamflow records (i.e. no peak flow measurements). **Figure 4** shows the cumulative streamflow (in inches per year) for the gaging site. Cumulative streamflow is used to determine a breakpoint between the benchmark condition and the altered condition (see **Section 2.3**).

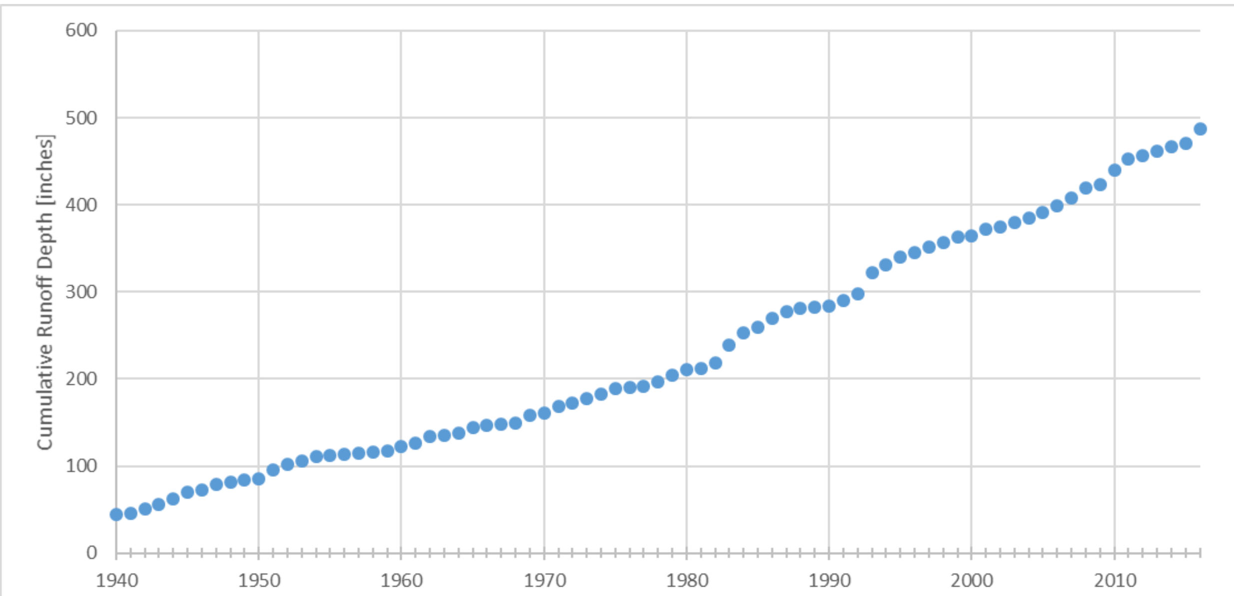

Figure 4. Cumulative streamflow for Little Sioux River at Correctionville, IA (USGS# 06606600)

According to the cumulative streamflow analysis, a breakpoint exists around 1981-1982. Therefore, for the analysis, the benchmark ("historic") conditions will include data from 1948-1981 and the altered ("modern") will include data form 1982-2015 and each period having 34 years of data to compare.

A summary of the results from the altered hydrology analysis is provided in **Table 3.** A more detailed description of the results is provided in **Appendix B**. A summary of the storage goals based on the altered hydrology analysis are provided in **Section 4**.

Table 3: Altered Hydrology Summary for Little Sioux River at Correctionville, IA (USGS# 06606600).

Group	Metric	% Difference	Altered Hydrology Metric	Evidence of Altered Hydrology for Group
Aquatic Habitat	10-year, Annual Minimum 30-day Mean Daily Discharge	267.2%	+	Yes, Increasing
	10-year, Annual Minimum 7-day Mean Daily Discharge	254.2%	+	
	Median November (Winter Base) Flow	96.8%	+	
Aquatic Organism Life Cycle	Magnitude of Monthly Runoff Volumes	36.5%-to-175%	+	Yes, Increasing
	Distribution of Monthly Runoff Volumes	-29.3%-to-42.5%	o	
	Timing of Annual Peak Discharge	21.51%	+	
	Timing of Annual Minimum Discharge	17.70%	+	
Riparian Floodplain (Lateral) Connectivity	10-year Peak Discharge Rate	-2.43%	o	No, Limited change
	50-year Peak Discharge Rate	-6.05%	o	
	100-year Peak Discharge Rate	-6.28%	o	
	Average Cumulative Volume above the Historic 10-year Peak Discharge	-43.12%	-	
	Average Cumulative Volume above the Historic 50-year Peak Discharge	NA	o	
	Average Cumulative Volume above the Historic 100-year Peak Discharge	NA	o	
Geomorphic Stability and Capacity to Transport Sediment	1.5-year Peak Discharge Rate	27.37%	+	Yes, Increasing
	2-year Peak Discharge Rate	16.12%	+	
	Average Cumulative Volume above the Historic 1.5-year Peak Discharge	85.04%	+	
	Average Cumulative Volume above the Historic 2-year Peak Discharge	80.27%	+	
	Duration above the Historic 1.5-year Peak Discharge	130.18%	+	
	Duration above the Historic 2-year Peak Discharge	104.75%	+	
	Flow Duration Curve	0.0%-to-330%	o	

3.2 SPLIT ROCK CREEK

3.2.1 Split Rock Cr at Corson, SD (USGS# 06482610).

The closest long-term gaging site in the Split Rock Creek to the Minnesota portion of the drainage area is the USGS site at Corson, SD (USGS# 06482610). The total drainage area for this site is 482 square miles, according to the USGS. The Minnesota portion of the drainage area includes approximately 279 square miles of the upper reaches. The data record starts in 1965 and runs to the present (2017). The site only includes average daily streamflow records (i.e. no peak flow measurements). **Figure 5** shows the cumulative streamflow (in inches per year) for the gaging site. Cumulative streamflow is used to determine a breakpoint between the benchmark condition and the altered condition (see **Section 2.3**).

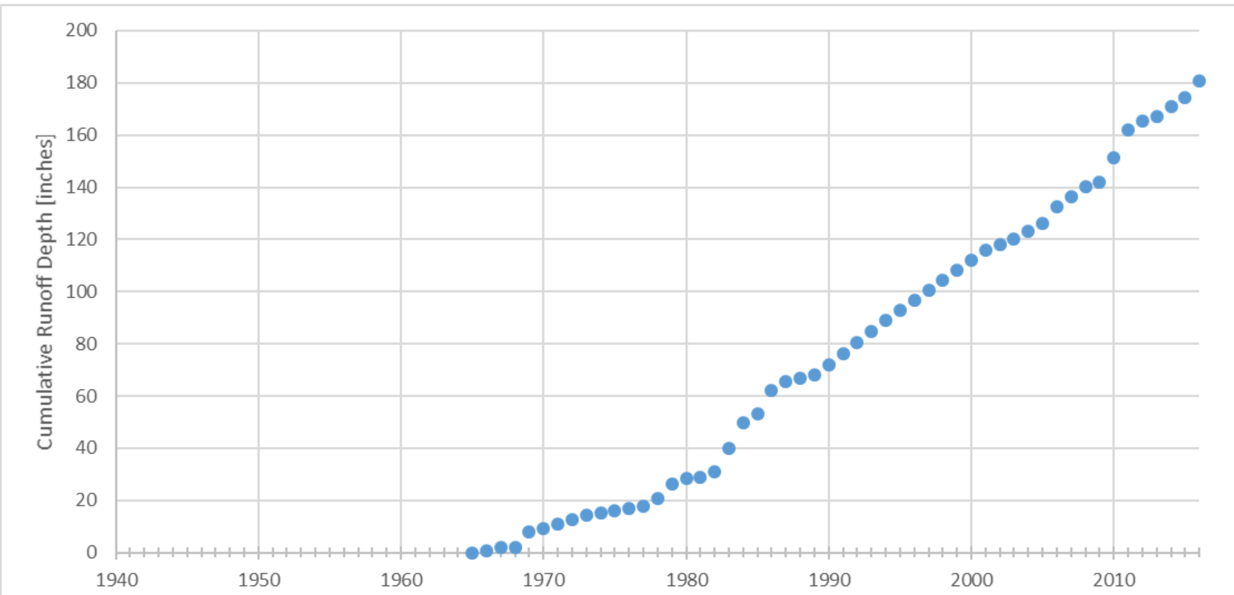

Figure 5. Cumulative streamflow for Split Rock Creek at Corson, SD (USGS# 06482610)

According to the cumulative streamflow analysis, a breakpoint exists around 1981-1982. Therefore, the benchmark ("historic") conditions will include data from 1966-1981 and the altered ("modern") will include data form 1982-2015. No data was available between 1990 and 2001. Therefore, the data shown in **Figure 5** for that period was interpolated using a ten-year running average. The altered hydrology metrics and statistics are not impacted by this hole in the data record, as years with more than 5 days of missing data are ignored in most of the computations. The benchmark period included 16 years of data and the altered condition included 22 years of data. It was determined that the limited data was sufficient to develop a storage goal.

A summary of the results from the altered hydrology analysis is provided in **Table 4.** A more detailed description of the results is provided in **Appendix C**. A summary of the storage goals based on the altered hydrology analysis are provided in **Section 4**.

Table 4: Altered Hydrology Summary for Split Rock Creek at Corson, SD. (USGS# 06482610).

Group	Metric	% Difference	Altered Hydrology Metric	Evidence of Altered Hydrology for Group
Aquatic Habitat	10-year, Annual Minimum 30-day Mean Daily Discharge	74.6%	+	Yes, Increasing
	10-year, Annual Minimum 7-day Mean Daily Discharge	1407.8%	+	
	Median November (Winter Base) Flow	238.3%	+	
Aquatic Organism Life Cycle	Magnitude of Monthly Runoff Volumes	34.3%-to-981%	+	Yes, Increasing
	Distribution of Monthly Runoff Volumes	-45.9%-to-335%	o	
	Timing of Annual Peak Discharge	19.42%	+	
	Timing of Annual Minimum Discharge	10.42%	+	
Riparian Floodplain (Lateral) Connectivity	10-year Peak Discharge Rate	48.74%	+	Maybe, Decreasing
	50-year Peak Discharge Rate	-22.62%	-	
	100-year Peak Discharge Rate	-43.64%	-	
	Average Cumulative Volume above the Historic 10-year Peak Discharge	-68.82%	-	
	Average Cumulative Volume above the Historic 50-year Peak Discharge	NA	NA	
	Average Cumulative Volume above the Historic 100-year Peak Discharge	NA	NA	
Geomorphic Stability and Capacity to Transport Sediment	1.5-year Peak Discharge Rate	92.92%	+	Yes, Increasing
	2-year Peak Discharge Rate	108.30%	+	
	Average Cumulative Volume above the Historic 1.5-year Peak Discharge	42.63%	+	
	Average Cumulative Volume above the Historic 2-year Peak Discharge	57.29%	+	
	Duration above the Historic 1.5-year Peak Discharge	125.69%	+	
	Duration above the Historic 2-year Peak Discharge	168.90%	+	
	Flow Duration Curve	4.9%-to-1614%	o	

3.3 ROCK RIVER

3.3.1 Rock River near Rock Valley, IA (USGS# 06483500).

The closest long-term gaging site in the Rock River to the Minnesota portion of the drainage area is the USGS site at Rock Valley, IA (USGS# 06483500). The total drainage area for this site is 1,592 square miles, according to the USGS. The Minnesota portion of the drainage area includes approximately 909 square miles of the upper reaches. The data record starts in 1948 and runs to the present (2017). The site only includes average daily streamflow records (i.e. no peak flow measurements). **Figure 6** shows the cumulative streamflow (in inches per year) for the gaging site. Cumulative streamflow is used to determine a breakpoint between the benchmark condition and the altered condition (see **Section 2.3**).

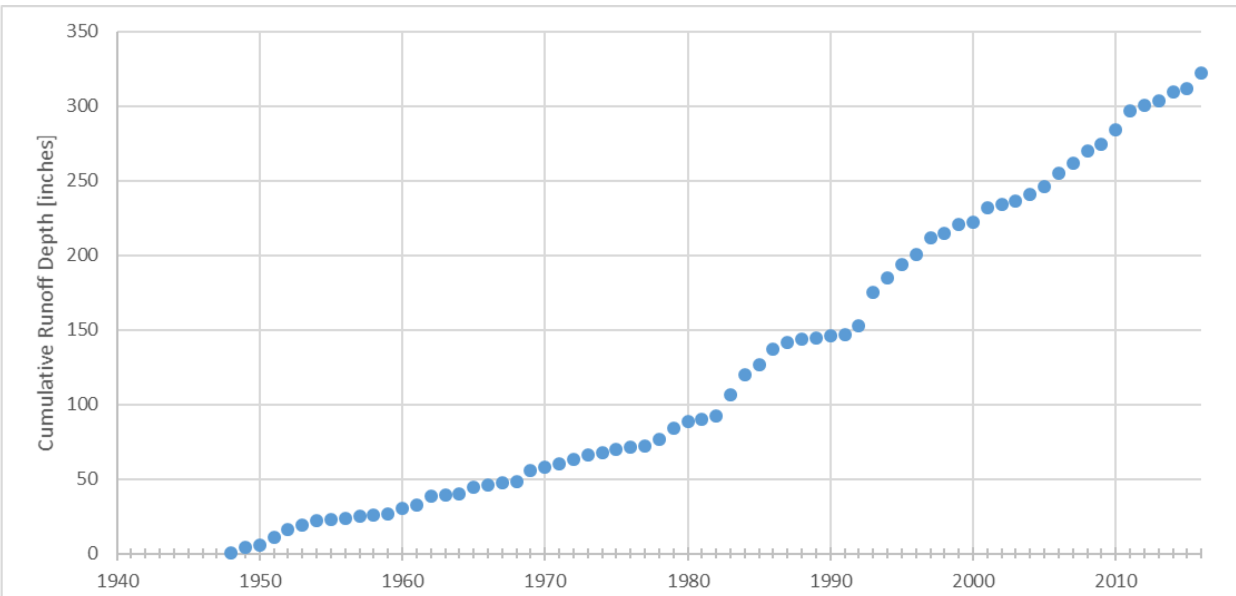

Figure 6. Cumulative streamflow for Rock River near Rock Valley, IA (USGS# 06483500).

According to the cumulative streamflow analysis, a breakpoint exists around 1981-1982. Therefore, the benchmark ("historic") conditions will include data from 1948-1981 and the altered ("modern") will include data form 1982-2015 and each period having 34 years of data to compare.

A summary of the results from the altered hydrology analysis is provided in **Table 5.** A more detailed description of the results is provided in **Appendix D**. A summary of the storage goals based on the altered hydrology analysis are provided in **Section 4**.

Table 5: Altered Hydrology Summary for Rock River near Rock Valley, IA (USGS# 06483500.

Group	Metric	% Difference	Altered Hydrology Metric	Evidence of Altered Hydrology for Group
Aquatic Habitat	10-year, Annual Minimum 30-day Mean Daily Discharge	1995.9%	+	Yes, Increasing
	10-year, Annual Minimum 7-day Mean Daily Discharge	8274.8%	+	
	Median November (Winter Base) Flow	283.3%	+	
Aquatic Organism Life Cycle	Magnitude of Monthly Runoff Volumes	43.5%-to-396.5%	+	Yes, Increasing
	Distribution of Monthly Runoff Volumes	-40.6%-to-105.5%	o	
	Timing of Annual Peak Discharge	22.97%	+	
	Timing of Annual Minimum Discharge	36.19%	+	
Riparian Floodplain (Lateral) Connectivity	10-year Peak Discharge Rate	5.19%	o	Yes, Increasing
	50-year Peak Discharge Rate	24.32%	+	
	100-year Peak Discharge Rate	36.51%	+	
	Average Cumulative Volume above the Historic 10-year Peak Discharge	8.70%	o	
	Average Cumulative Volume above the Historic 50-year Peak Discharge	2112%	+	
	Average Cumulative Volume above the Historic 100-year Peak Discharge	NA	NA	
Geomorphic Stability and Capacity to Transport Sediment	1.5-year Peak Discharge Rate	32.47%	+	Yes, Increasing
	2-year Peak Discharge Rate	14.77%	+	
	Average Cumulative Volume above the Historic 1.5-year Peak Discharge	88.25%	+	
	Average Cumulative Volume above the Historic 2-year Peak Discharge	95.78%	+	
	Duration above the Historic 1.5-year Peak Discharge	124.65%	+	
	Duration above the Historic 2-year Peak Discharge	173.77%	+	
	Flow Duration Curve	17.1%-to-1000%	+	

3.4 BIG SIOUX RIVER

3.4.1 Big Sioux River at Akron, IA (USGS# 06485500).

The closest long-term gaging site in the Big Sioux River to the Minnesota portion of the drainage area is the USGS site at Arkon, IA (USGS# 06485500). The total drainage area for this site is 7,879 square miles, according to the USGS. The Minnesota portion of the drainage area includes approximately 552 square miles of the upper reaches and includes areas covered by the Split Rock Creek gage and Rock River gages. This site was included to verify those results and include additional areas of Beaver Creek, Flandreau Creek, and Medary Creek that are not covered by other gages. The data record starts in 1928 and runs to the present (2017). The site only includes average daily streamflow records (i.e. no peak flow measurements). **Figure 7** shows the cumulative streamflow (in inches per year) for the gaging site. Cumulative streamflow is used to determine a breakpoint between the benchmark condition and the altered condition (see **Section 2.3**).

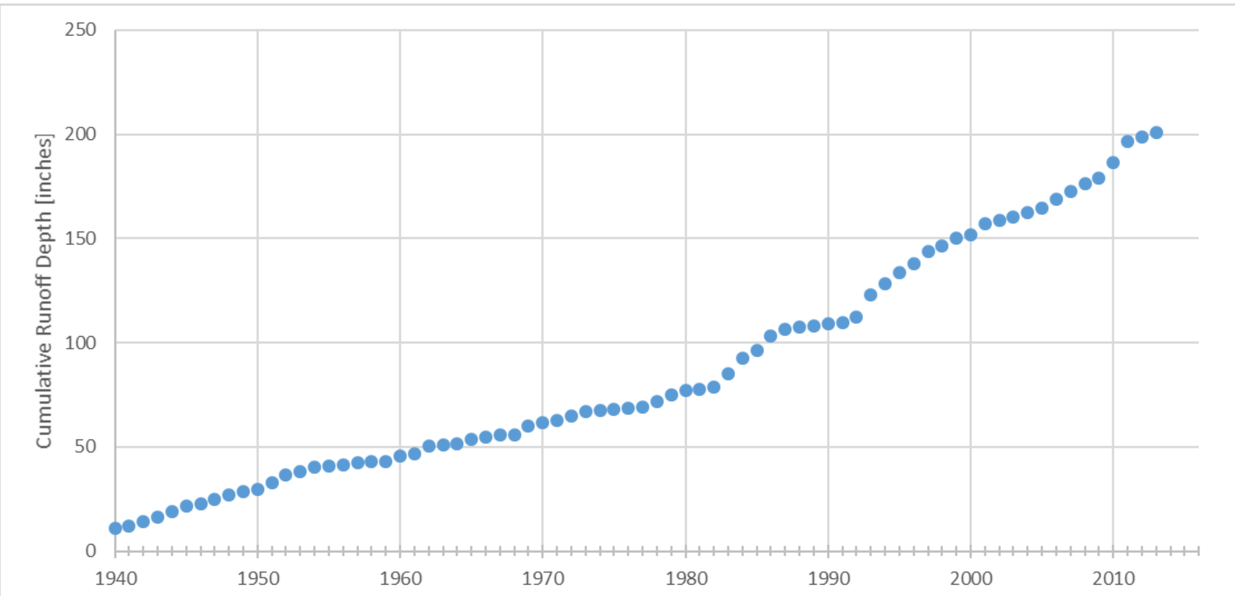

Figure 7. Cumulative streamflow for Big Sioux River at Akron, IA (USGS# 06485500).

According to the cumulative streamflow analysis, a breakpoint exists around 1981-1982. Therefore, the benchmark (“historic”) conditions will include data from 1948-1981 and the altered (“modern”) will include data form 1982-2015 and each period having 34 years of data to compare.

A summary of the results from the altered hydrology analysis is provided in **Table 6.** A more detailed description of the results is provided in **Appendix E**. A summary of the storage goals based on the altered hydrology analysis are provided in **Section 4**.

Table 6: Altered Hydrology Summary for Big Sioux River at Akron, IA (USGS# 06485500).

Group	Metric	% Difference	Altered Hydrology Metric	Evidence of Altered Hydrology for Group
Aquatic Habitat	10-year, Annual Minimum 30-day Mean Daily Discharge	328.4%	+	Yes, Increasing
	10-year, Annual Minimum 7-day Mean Daily Discharge	329.5%	+	
	Median November (Winter Base) Flow	303.8%	+	
Aquatic Organism Life Cycle	Magnitude of Monthly Runoff Volumes	50.6%-to-354%	+	Yes, Increasing
	Distribution of Monthly Runoff Volumes	-38.7%-to-84.8%	o	
	Timing of Annual Peak Discharge	19.57%	+	
	Timing of Annual Minimum Discharge	74.27%	+	
Riparian Floodplain (Lateral) Connectivity	10-year Peak Discharge Rate	18.79%	o	Maybe, Increasing
	50-year Peak Discharge Rate	13.28%	+	
	100-year Peak Discharge Rate	12.90%	+	
	Average Cumulative Volume above the Historic 10-year Peak Discharge	-56.31%	o	
	Average Cumulative Volume above the Historic 50-year Peak Discharge	2655%	+	
	Average Cumulative Volume above the Historic 100-year Peak Discharge	NA	NA	
Geomorphic Stability and Capacity to Transport Sediment	1.5-year Peak Discharge Rate	61.85%	+	Yes, Increasing
	2-year Peak Discharge Rate	45.77%	+	
	Average Cumulative Volume above the Historic 1.5-year Peak Discharge	132.72%	+	
	Average Cumulative Volume above the Historic 2-year Peak Discharge	103.69%	+	
	Duration above the Historic 1.5-year Peak Discharge	187.87%	+	
	Duration above the Historic 2-year Peak Discharge	221.80%	+	
	Flow Duration Curve	-4.6%-to-528%	+	

4.0 STORAGE GOALS

Goals for addressing the change in hydrology were estimated using three methods. Each method is based on different assumptions and altered the metrics for a specific “altered hydrology” group (see **Table 6** as an example). The first method is focused on the aquatic habitat and geomorphic and ability to transport sediment metric group and uses the change in the cumulative volume for mean daily discharges, exceeding the 1.5-year return period event. The cumulative total volume when the daily average discharge exceeds the 1.5-year peak discharge includes all flows above the 1.5-year peak, i.e. can include storms with much larger return periods. This method is based on the changes in the observed data and since it includes all flows above the 1.5-year flow relies on the two periods to have a similar distribution of flows. The second method is based on the changes in hydrology across the entire annual hydrograph, and integrates the differences in return period discharges between the modern and historic period and finding a probability-weighted representative change in flow rate. A volume is found by assuming a flow period equal to the change in flow period for the 1.5-year flow (i.e. the change in the number of days above the 1.5-year flow). This method assumes a constant flow over a representative duration to estimate the storage goal. Since a hydrograph typically changes over time, this method may over-estimate the storage goal. The third method is also based on addressing the effects through the entire flow range and is a revision to Method 2. Method 3 considers incorporates the observed change in the timing of the peak discharge for each return period event. This method uses the probability-weighted representative change in flow rate and multiples the flow rates by the change in the number of days exceeding the return period flow for each return period

This analysis presents a preliminary framework for defining altered hydrology, applying a method to determine whether altered hydrology has occurred, and establishing a goal for relating to proposed projects. The storage goals are provided in **Table** 7 for each of the 3 methods and an average, representative storage goal. For planning purposes, we recommend a preliminary goal equal to the representative goals, across the watershed, realizing that the altered hydrology goals should ideally be established at the 12-digit HUC scale. The actual amount of mitigation needed may exceeds the estimated range, as the methods used to achieve the goal are not expected to be 100% effective in removing volume from peak of the hydrograph. The means to achieve the estimated mitigation goal may include the use of structural practices and management practices and should be specifically evaluated through completion of a hydrologic study or the use of appropriate tools and models.

Table 7: Storage goals for rivers in the Missouri Basin.

Stream	USGS ID	Storage Targets			
		Method 1	Method 2	Method 3	Representative Method
Little Sioux River	06605850	1.18 in.	1.58 in.	1.14 in.	1.30 in.
	06606600	0.62 in.	0.37 in.	0.29 in.	0.43 in.
Split Rock Creek	06482610	0.35 in.	1.18 in.	0.63 in.	0.72 in.
Rock River	06483500	0.72 in.	0.44 in.	0.26 in.	0.47 in.
Big Sioux River	06485500	0.63 in.	0.88 in.	0.48 in.	0.66 in.

Details on calculations of the storage goals can be found in the Appendices.

The goals provided in **Table 7** are by watershed. In the Little Sioux River, it is recommended the site at Correctionville, IA (USGS# 06606600) be used since it has a full period of data and provides results similar to the other watersheds. The Linn Grove, IA site has limited data and results from the analysis tended to be much higher than the other watersheds. If local knowledge of Minnesota portion of the Little Sioux River is consistent with the results at the Linn Grove, IA site, the results for that site should be considered. For an overall storage goal for the Missouri River Basin in Minnesota, it is recommended the results from the Split Rock River, Little Sioux River at Correctionville, IA, and Rock River be used to develop a storage goal. These three watersheds represent a majority of land area in the Minnesota portion of Missouri River Basin and will provide the most representative results. A representative storage goal for Minnesota’s portion of the Missouri River Basin is **0.54 inches** of water across the basin.

It is our opinion that the Minnesota portion of the Big Sioux River at Arkon, IA is too small compared to the others that it can be ignored when computing a representative storage goal. Including it in the establishment of a representative storage goal would have minimal impact (0.57 inches compared to 0.54 inches).

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APPENDIX A: METRICS OF ALTERED HYDROLOGY FOR LITTLE SIOUX RIVER AT LINN GROVE, IA (USGS# 06605850).

The following is the summary statistics used to determine the altered hydrology metrics in detail and develop the storage goals. A summary of these statistic is shown in **Table 2** in **Section 3.1.1**.

A.1 CONDITION OF AQUATIC HABITAT

The condition of aquatic habitat includes a group of metrics that primarily reflect the flow characteristics of the annual hydrograph, needed to maintain adequate habitat for fish and aquatic life. The 7-day low flow, the 30-day low flow, and the median November mean daily discharge are metrics used to represent changes in the availability of flow for aquatic habitat.

A.1.1 Annual minimum 30-day mean daily discharge

The annual minimum 30-day mean daily discharge is the minimum of the 30-day moving mean daily discharge within a year (an annual minimum series). **Figure A.1** shows the annual minimum 30-day mean daily discharge for select return periods (1.01-year, 1.5-year, 2-year, 5-year, 10-year, 25-year, 50-year, and 100-year). **Table A.1** summarizes the data shown in **Figure A.1**.

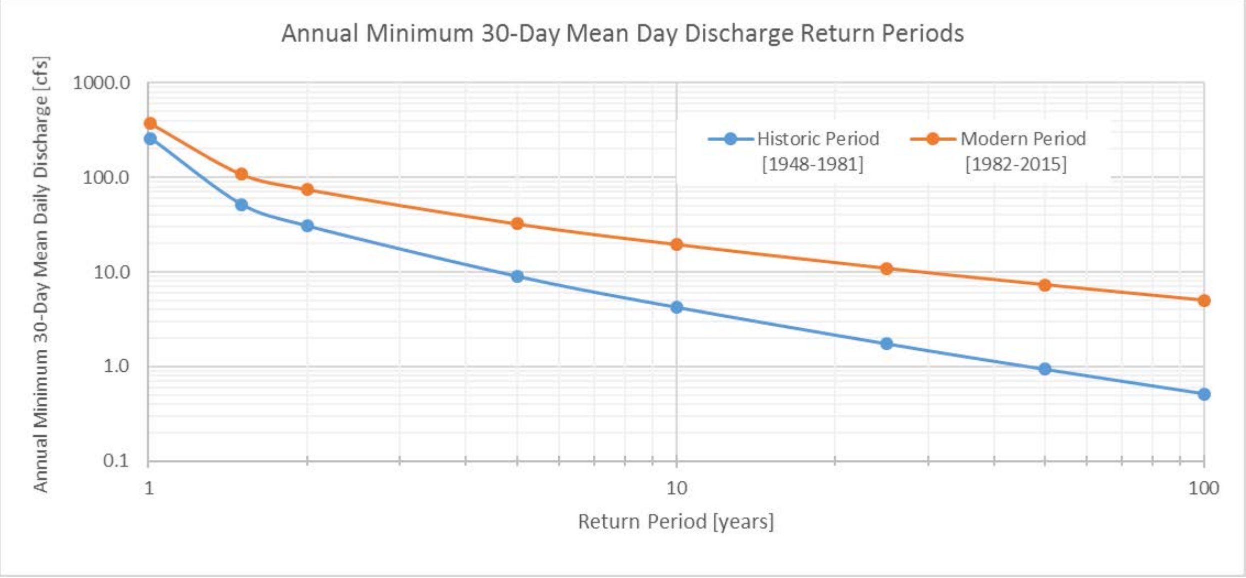

Figure A.1. Historical (1973-1981) versus modern (1982-2015) annual minimum 30-day mean daily discharge versus return period for Little Sioux River at Linn Grove, IA.

Table A.1: Summary of annual minimum 30-day mean daily discharge by return periods for the Little Sioux River at Linn Grove, IA.

Return Period	Historic Period [1948-1981]	Modern Period [1982-2015]	% Diff.	Altered Hydrology Criterion
1.01	258.0	373.9	44.9%	+
1.5	51.7	108.6	110.0%	+
2	30.5	74.7	144.8%	+
5	8.9	32.3	260.8%	+
10	4.2	19.6	364.4%	+
25	1.7	11.0	532.2%	+
50	0.9	7.3	689.0%	+
100	0.5	5.0	878.0%	+

+ symbol indicates metric exhibits altered hydrology and an increase for the modern period compared to the historic period
o symbol indicates fails to exhibit altered hydrology for the modern period compared to the historic period
- symbol indicates metric exhibits altered hydrology and a decrease for the modern period compared to the historic period

A.1.2 Annual Minimum 7-Day Mean Daily Discharge

Like the annual minimum 30-day mean daily discharge, the annual minimum 7-day mean daily discharge is the minimum of the 7-day moving average flow in the year. **Figure A.2** shows the annual minimum 7-day mean daily discharges for select return periods (1.01-year, 1.5-year, 2-year, 5-year, 10-year, 25-year, 50-year, and 100-year). **Table A.2** summarizes the data shown in **Figure A.2**.

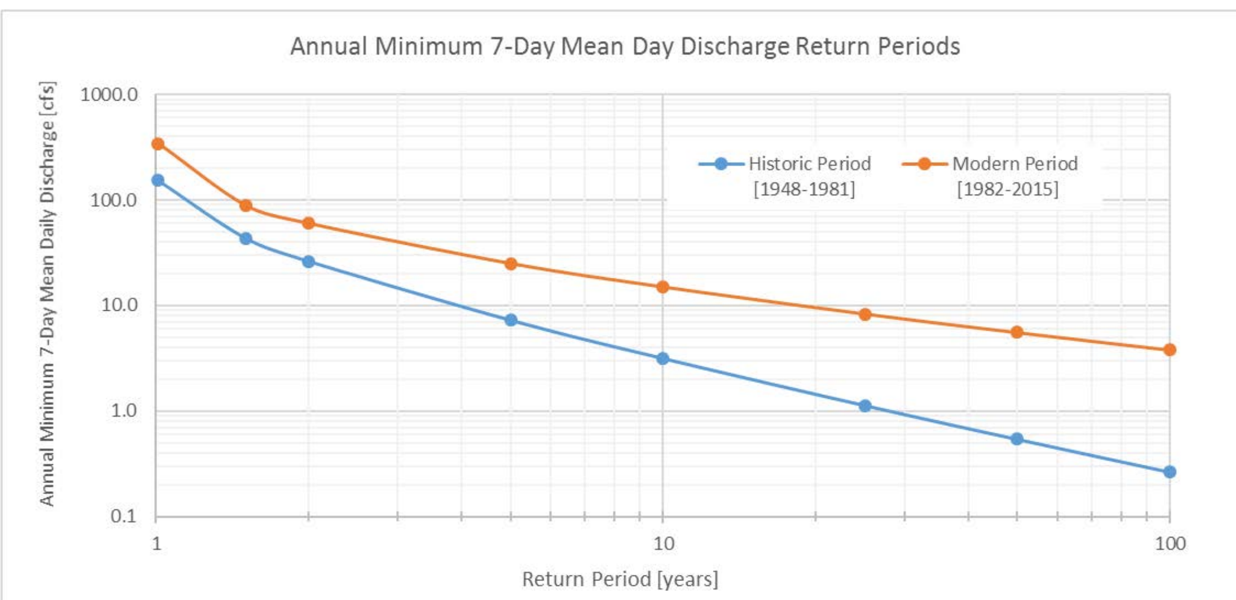

Figure A.2. Historical (1973-1981) versus modern (1982-2015) annual minimum 7-day mean daily discharge return periods for Little Sioux River at Linn Grove, IA.

Table A.2: Summary of annual minimum 7-day mean daily discharge return periods for the Little Sioux River at Linn Grove, IA.

Return Period	Historic Period [1948-1981]	Modern Period [1982-2015]	% Diff.	Altered Hydrology Criterion
1.0101	152.8	342.5	124.2%	+
1.5	43.7	89.0	103.8%	+
2	26.3	60.0	127.9%	+
5	7.3	25.1	243.0%	+
10	3.2	15.0	374.4%	+
25	1.1	8.3	633.5%	+
50	0.5	5.5	923.0%	+
100	0.3	3.8	1329.7%	+

+ symbol indicates metric exhibits altered hydrology and an increase for the modern period compared to the historic period
o symbol indicates fails to exhibit altered hydrology for the modern period compared to the historic period
- symbol indicates metric exhibits altered hydrology and a decrease for the modern period compared to the historic period

A.1.3 November Median Daily Discharge

The median daily mean discharge for November is another indicator of baseflow. This metric is intended to represent baseflow condition during the winter months. **Table A.3** provides the median November flow for each period.

Table A.3: Historical (1940-1975) and modern (1980-2015) median November flow for the Little Sioux River at Linn Grove, IA.

Return Period	Historic Period [1948-1981]	Modern Period [1982-2015]	% Diff.	Altered Hydrology Criterion
Period median November flow [cfs]	188.5	231.0	22.5%	+

+ symbol indicates metric exhibits altered hydrology and an increase for the modern period compared to the historic period
o symbol indicates fails to exhibit altered hydrology for the modern period compared to the historic period
- symbol indicates metric exhibits altered hydrology and a decrease for the modern period compared to the historic period

A.2 AQUATIC ORGANISM LIFE CYCLE

The shape of the annual hydrograph and timing of discharges are associated with ecological cues. Metrics related to the aquatic organism life cycle include the shape of the annual hydrographs, timing of the annual minimum flow, and timing of the annual peak flow.

A.2.1 Annual Distribution of Discharges

The annual distribution of runoff is shown two ways: as average monthly runoff volume in acre-feet per month (**Figure A.3**) and as a percentage of average annual runoff volume (**Figure A.4**). **Table A.4** summarized the data used to generate **Figures A.3** and **A.4**.

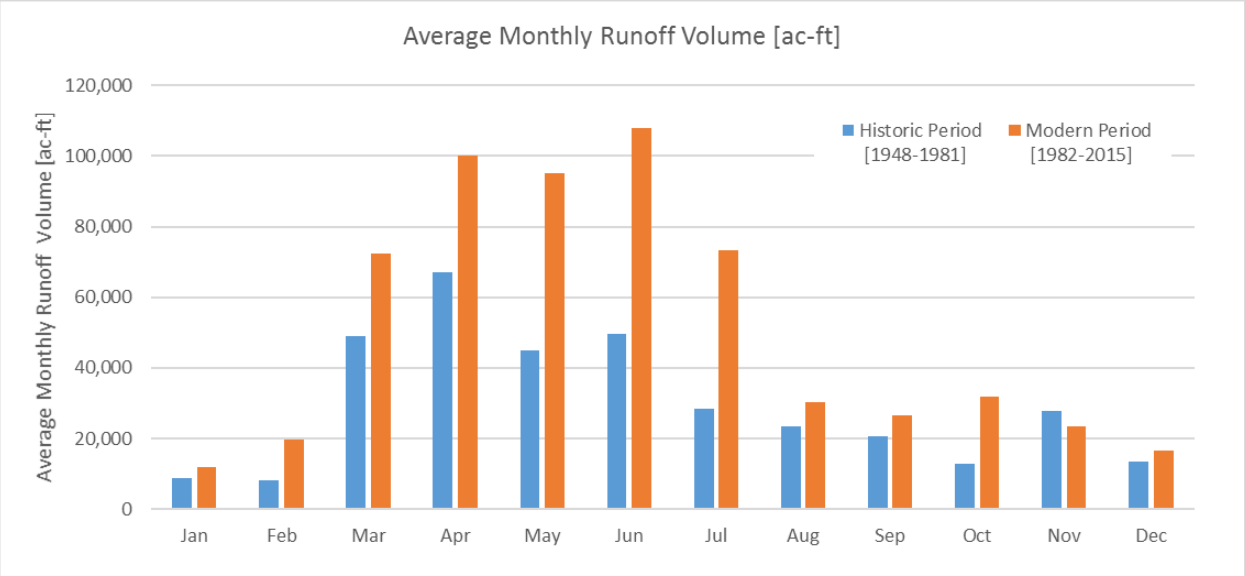

Figure A.3. Average monthly runoff volume [ac-ft] in the Little Sioux River at Linn Grove, IA.

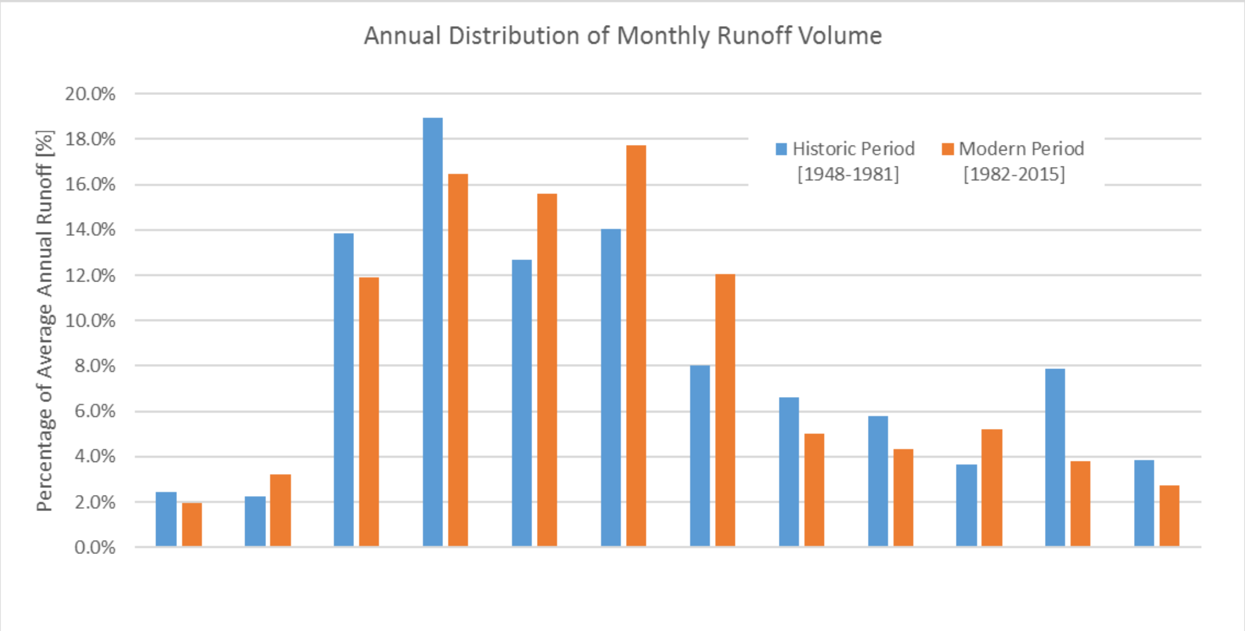

Figure A.4. Annual distribution of average monthly runoff volume as a percentage of annual total volume in the Little Sioux River at Linn Grove, IA.

Table A.4. Average monthly runoff volume and annual distribution of monthly runoff volumes in Little Sioux River at Linn Grove, IA.

Month	Average Monthly Volumes [ac-ft]				Distribution of Annual Volume			
	Historic Period [1948-1981]	Modern Period [1982-2015]	% diff.	AH	Historic Period [1948-1981]	Modern Period [1982-2015]	% diff.	AH
Jan	8,629	11,855	37.4%	+	2.4%	1.9%	-20.2%	-
Feb	7,988	19,642	145.9%	+	2.3%	3.2%	42.9%	+
Mar	48,958	72,303	47.7%	+	13.8%	11.9%	-14.2%	-
Apr	67,023	100,133	49.4%	+	19.0%	16.5%	-13.2%	-
May	44,883	95,013	111.7%	+	12.7%	15.6%	23.0%	+
Jun	49,725	107,794	116.8%	+	14.1%	17.7%	26.0%	+
Jul	28,398	73,425	158.6%	+	8.0%	12.1%	50.2%	+
Aug	23,310	30,399	30.4%	+	6.6%	5.0%	-24.2%	-
Sep	20,464	26,486	29.4%	+	5.8%	4.4%	-24.8%	-
Oct	12,897	31,696	145.8%	+	3.6%	5.2%	42.8%	+
Nov	27,791	23,265	-16.3%	-	7.9%	3.8%	-51.4%	-
Dec	13,579	16,628	22.5%	+	3.8%	2.7%	-28.8%	-

+ symbol indicates metric exhibits altered hydrology and an increase for the modern period compared to the historic period
o symbol indicates fails to exhibit altered hydrology for the modern period compared to the historic period
- symbol indicates metric exhibits altered hydrology and a decrease for the modern period compared to the historic period
AH means altered hydrology criterion

A.2.2 Timing of Annual Maximum and Minimum Flows

The timing of the annual maximum daily discharge and annual minimum daily discharge are important metrics of the annual distribution of flows. The timing of the annual maximum typical occurs during the spring flood and the timing of the annual minimum usually occurs during the winter months. **Table A.5** provides statistics on the Julian day of the annual maximum flow and **Table A.6** provides the Julian day for the annual minimum flow. The statistics include the average, the median, and the standard deviation of the Julian days when the maximum or minimum flow occur.

Table A.5. Julian Day of annual maximum in the Little Sioux River at Linn Grove, IA.

Statistic	Historic Period [1948-1981]	Modern Period [1982-2015]	% diff.	AH
Average	6-Jun	23-May	-8.93%	o
Median	29-Apr	1-Jun	27.73%	+
Standard Deviation	101 days	49 days	-52.03%	-

[1]Based on 365-day year.
+ symbol indicates metric exhibits altered hydrology and an increase for the modern period compared to the historic period
o symbol indicates fails to exhibit altered hydrology for the modern period compared to the historic period
- symbol indicates metric exhibits altered hydrology and a decrease for the modern period compared to the historic period
AH means altered hydrology criterion

Table A.6. Julian Day of annual minimum flow in the Little Sioux River at Linn Grove, IA.

Statistic	Historic Period [1948-1981]	Modern Period [1982-2015]	% diff.	AH
Average	2-Jun	8-Jul	23.61%	+
Median	10-Aug	10-Sep	14.19%	+
Standard Deviation	114 days	118 days	3.59%	o

[1]Based on 365-day year.
+ symbol indicates metric exhibits altered hydrology and an increase for the modern period compared to the historic period
o symbol indicates fails to exhibit altered hydrology for the modern period compared to the historic period
- symbol indicates metric exhibits altered hydrology and a decrease for the modern period compared to the historic period
AH means altered hydrology criterion

A.3 RIPARIAN FLOODPLAIN (LATERAL) CONNECTIVITY (PEAK FLOWS)

The riparian floodplain connectivity metrics represent the frequency and duration of flooding of the riparian area and the lateral connectivity between the stream and the riparian area. Functions include energy flow, deposition of sediment, channel formation and surface water – groundwater interactions. The riparian floodplain connectivity metrics include the discharge rates for the 10-year, the 25-year, the 50-year, and the 100-year peak discharges. The annual peak discharge rates for select return periods (1.01-year, 1.5-year, 2-year, 5-year, 10-year, 25-year, 50-year, 100-year, and 200-year) are shown in **Figure A.5**.

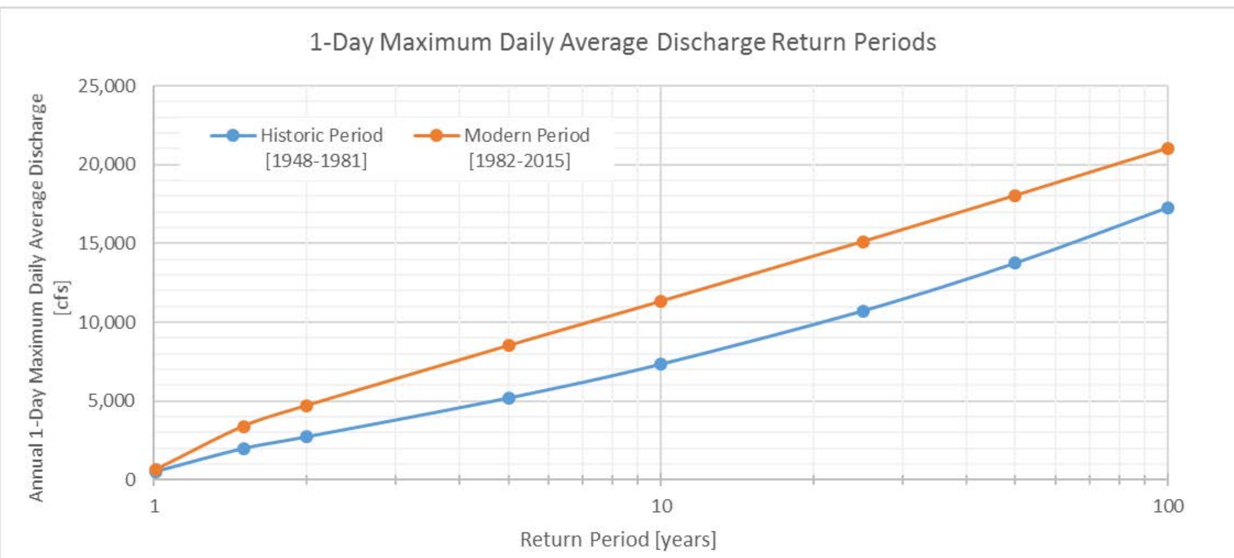

Figure A.5. Historical (1973-1981) versus modern (1982-2015) peak discharge return periods for Little Sioux River at Linn Grove, IA.

In addition, the number of years with discharges exceeding the historic peak discharge within a period, the average number of days above the historic peak discharge rates, and the average cumulative volume of discharge above the historic peak discharges are provide (**Table A.7**).

Table A.7. Riparian floodplain connectivity metrics for the Little Sioux River at Linn Grove, IA.

Flow Metric	Historic Period [1948-1981]	Modern Period [1982-2015]	% Diff.[1]	Altered Hydrology
5-Year Peak Discharge, Q(5) [cfs]	5,191	8,515	64.0%	+
Number of years with Discharge (Q) > Q_H (5)	2	13	550.0%	+
Average number of days per year Q > Q_H (5)	8	16	97.1%	+
Average annual cumulative volume > Q_H (5) [ac-ft]	19,002	69,469	265.6%	+
10-Year Peak Discharge, Q(10) [cfs]	7,342	11,332	54.3%	+
Number of years with Discharge (Q) > Q_H (10)	1	10	900.0%	+
Average number of days per year Q > Q_H (10)	2	8	290.0%	+
Average annual cumulative volume > Q_H (10) [ac-ft]	3,363	34,177	916.2%	+
25-Year Peak Discharge, Q(25) [cfs]	10,722	15,116	41.0%	+
Number of years with Discharge (Q) > Q_H (25)	0	5	NA	o
Average number of days per year Q > Q_H (25)	0	4	NA	o
Average annual cumulative volume > Q_H (25) [ac-ft]	0	12,409	NA	o
50-Year Peak Discharge, Q(50) [cfs]	13,761	18,044	31.1%	+
Number of years with Discharge (Q) > Q_H (50)	0	1	NA	o
Average number of days per year Q > Q_H (50)	0	3	NA	o
Average annual cumulative volume > Q_H (50) [ac-ft]	0	4,003	NA	o
100-Year Peak Discharge, Q(100) [cfs]	17,280	21,034	21.7%	+
Number of years with Discharge (Q) > Q_H (100)	0	0	NA	o
Average number of days per year Q > Q_H (100)	0	0	NA	o
Average annual cumulative volume > Q_H (100) [ac-ft]	0	0	NA	o

[1]No events occurred above return period discharge.
+ symbol indicates metric exhibits altered hydrology and an increase for the modern period compared to the historic period
o symbol indicates fails to exhibit altered hydrology for the modern period compared to the historic period
- symbol indicates metric exhibits altered hydrology and a decrease for the modern period compared to the historic period

A.4 GEOMORPHIC STABILITY AND CAPACITY TO TRANSPORT SEDIMENT

The geomorphic stability and capacity to transport sediment metrics are related to the channel forming discharge. An increase in these metrics would be interpreted as an increase in the risk of the stream channel susceptibility to erosion. These metrics include changes to the flow duration curves, the 1.5-year peak flow, the 2-year peak flow. The 1.5-year to 2-year peak flows are generally consider the range of channel forming flow. In addition, the number of years within a period exceeding the historic peak flows, the average number of days above the historic peak flow rates, and the average volume of flow above the historic peak flows are provided (**Table A.8**). **Figure A.6** is the flow duration curves for the historic and modern periods and **Table A.8** provides a summary of flows for select percent exceedances. Both show that discharges across the flow spectrum have increased substantially, with the exception of the very high flows.

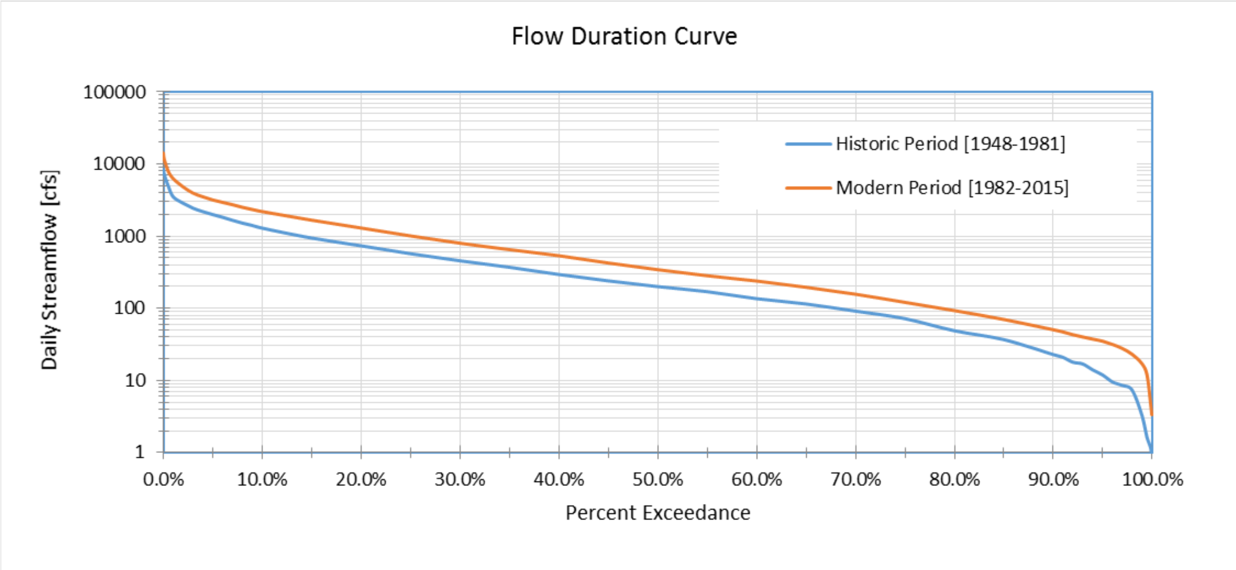

Figure A.6. Historical (1973-1981) versus modern (1982-2015) flow duration for Little Sioux River at Linn Grove, IA.

Table A.8. Select summary of the flow duration curves for the Little Sioux River at Linn Grove, IA.

Percent Exceedance	Historic Period [1948-1981]	Modern Period [1982-2015]	% Diff.	Altered Hydrology
0.10%	7,149	11,658	63.1%	+
1.0%	3,486	6,293	80.5%	+
10.0%	1,285	2,200	71.2%	+
25.0%	570	1,010	77.2%	+
50.0%	200	344	72.0%	+
75.0%	91	157	71.6%	+
90.0%	23	50	119.4%	+
99.0%	3	17	417.5%	+
99.9%	1	4	281.0%	+

+ symbol indicates metric exhibits altered hydrology and an increase for the modern period compared to the historic period
o symbol indicates fails to exhibit altered hydrology for the modern period compared to the historic period
- symbol indicates metric exhibits altered hydrology and a decrease for the modern period compared to the historic period

Table A.9 provides the 1.5-year and 2-year annual peak flows and flow statistics, including peak discharge, number of years with flow rates above the historic return period flow, average number of days per year above the historic return period flow, and average volume above the historic return period flow.

Table A.9. Geomorphic stability and capacity to transport sediment metrics for the Little Sioux River at Linn Grove, IA.

Flow Metric	Historic Period [1948-1981]	Modern Period [1982-2015]	% Diff.	Altered Hydrology
1.5-Year Peak Discharge, Q(1.5) [cfs]	1,991	3,408	71.2%	+
Number of years with Discharge (Q) > Q_H (1.5)	5	28	460.0%	+
Average number of days per year Q > Q_H (1.5)	33	52	60.9%	+
Average annual cumulative volume > Q_H (1.5) [ac-ft]	69,778	167,219	139.6%	+
2-Year Peak Discharge, Q(2) [cfs]	2,733	4,717	72.6%	+
Number of years with Discharge (Q) > Q_H (2)	5	25	400.0%	+
Average number of days per year Q > Q_H (2)	14	35	145.1%	+
Average annual cumulative volume > Q_H (2) [ac-ft]	37,407	120,858	223.1%	+

+ symbol indicates metric exhibits altered hydrology and an increase for the modern period compared to the historic period
o symbol indicates fails to exhibit altered hydrology for the modern period compared to the historic period
- symbol indicates metric exhibits altered hydrology and a decrease for the modern period compared to the historic period

A.5 SETTING GOALS

A summary of the storage goals is provided in **Table 7** in **Section 4.** The following are the methods used to develop those goals. Goals for addressing the change in hydrology were estimated using three methods. Each method is based on different assumptions and altered the metrics for a specific "altered hydrology" group (see Table 6). The first method is focused on the aquatic habitat and geomorphic and ability to transport sediment metric group and uses the change in the cumulative volume for mean daily discharges, exceeding the 1.5-year return period event. The cumulative total volume when the daily average discharge exceeds the 1.5-year peak discharge includes all flows above the 1.5-year peak, i.e. can include storms with much larger return periods. The change in average annual cumulative volume above the 1.5-year peak flow (see **Table A.9**) This method is based on the changes in the observed data and since it includes all flows above the 1.5-year flow relies on the two periods to have a similar distribution of flows.

The second method is based on the changes in hydrology across the entire annual hydrograph, and integrates the differences in return period discharges between the modern and historic period (see **Table A.10**) and finding a probability-weighted representative change in flow rate. A volume is then found by assuming a flow period equal to the change in flow period for the 1.5-year flow (i.e. the change in the number of days above the 1.5-year flow; see **Table A.9**).

Table A.10. Estimated goal for the drainage area of the Little Sioux River at Linn Grove, IA. using method 2.

Return Period	Historic Period Discharges (cfs)	Modern Period Discharges (cfs)	Difference (cfs)	Probability of Occurrence	Difference*Probability (cfs)
1.5	1,991	3,408	1417	0.67	945.0
2	2,733	4,717	1984	0.50	991.8
5	5,191	8,515	3324	0.20	664.8
10	7,342	11,332	3990	0.10	399.0
25	10,722	15,116	4394	0.04	175.7
50	13,761	18,044	4283	0.02	85.7
100	17,280	21,034	3754	0.01	37.5
				Sum (cfs):	3,300
				Sum (ac-ft/day):	6,546
		Number of days:	20	Total Volume Goal:	130,038 AF (1.58 in.)

The third method is also based on addressing the effects through the entire flow range and is a revision to Method 2. Method 3 considers incorporates the observed change in the timing of the peak discharge for each return period event. This method uses the probability-weighted representative change in flow rate and multiples the flow rates by the change in the number of days exceeding the return period flow for each return period (see **Table A.11**).

Table A.11. Estimated goal for the drainage area of the Little Sioux River at Linn Grove, IA. using method 3.

Return Period	Change in Flow (Q_m-Q_h) [cfs]	Probability of Occurrence	Probability Weighted Flow [AF/day]	Change in number of days above flow (days)	Storage Volume
1.5	1,417	0.67	1,874.8	20	37,242
2	1,984	0.50	1,967.8	21	40,536
5	3,324	0.20	1,319.0	8	10,247
10	3,990	0.10	791.6	6	4,592
25	4,394	0.04	348.7	4	1,325
50	4,283	0.02	170.0	3	510
100	3,754	0.01	74.5	0	0
				Total Volume Goal:	94,452 AF (1.14 in.)

APPENDIX B: METRICS OF ALTERED HYDROLOGY FOR LITTLE SIOUX RIVER AT CORRECTIONVILLE, IA (USGS# 06606600).

The following is the summary statistics used to determine the altered hydrology metrics in detail and develop the storage goals. A summary of these statistic is shown in **Table 3** in **Section 3.1.2**.

B.1 CONDITION OF AQUATIC HABITAT

The condition of aquatic habitat includes a group of metrics that primarily reflect the flow characteristics of the annual hydrograph, needed to maintain adequate habitat for fish and aquatic life. The 7-day low flow, the 30-day low flow, and the median November mean daily discharge are metrics used to represent changes in the availability of flow for aquatic habitat.

B.1.1 Annual minimum 30-day mean daily discharge

The annual minimum 30-day mean daily discharge is the minimum of the 30-day moving mean daily discharge within a year (an annual minimum series). **Figure B.1** shows the annual minimum 30-day mean daily discharge for select return periods (1.01-year, 1.5-year, 2-year, 5-year, 10-year, 25-year, 50-year, and 100-year). **Table B.1** summarizes the data shown in **Figure B.1**.

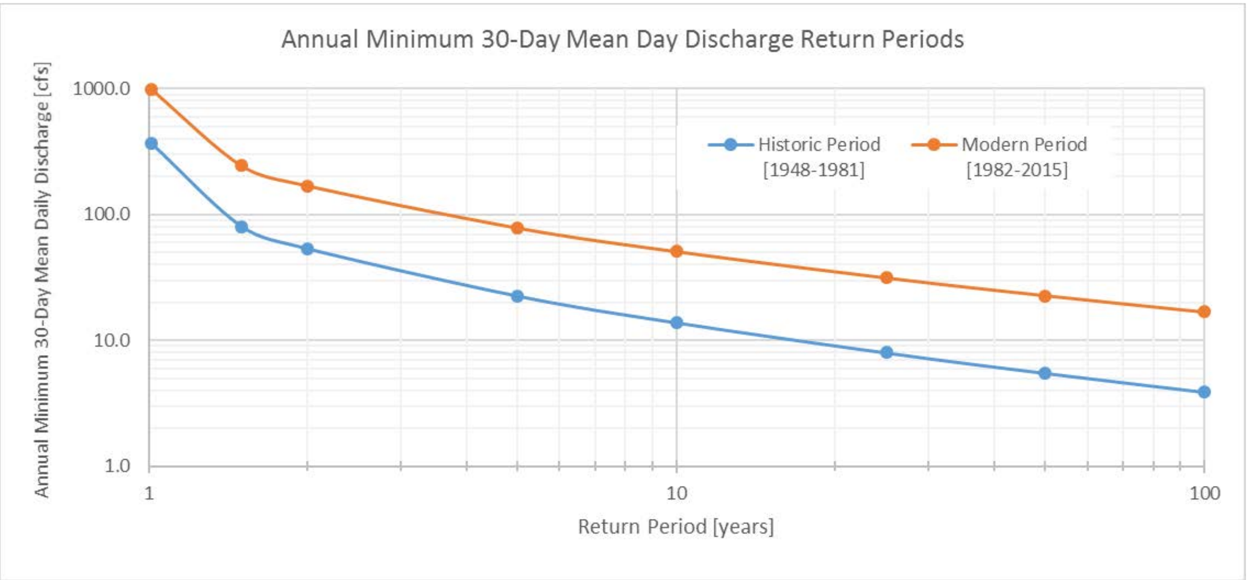

Figure B.1. Historical (1948-1981) versus modern (1982-2015) annual minimum 30-day mean daily discharge versus return period for Little Sioux River at Correctionville, IA.

Table B.1: Summary of annual minimum 30-day mean daily discharge by return periods for the Little Sioux River at Correctionville, IA.

Return Period	Historic Period [1948-1981]	Modern Period [1982-2015]	% Diff.	Altered Hydrology Criterion
1.01	369.5	996.9	169.8%	+
1.5	80.5	244.0	203.1%	+
2	53.6	169.0	215.5%	+
5	22.6	78.2	246.6%	+
10	13.8	50.8	267.2%	+
25	8.0	31.3	293.2%	+
50	5.5	22.7	312.5%	+
100	3.9	16.8	331.8%	+

+ symbol indicates metric exhibits altered hydrology and an increase for the modern period compared to the historic period
o symbol indicates fails to exhibit altered hydrology for the modern period compared to the historic period
- symbol indicates metric exhibits altered hydrology and a decrease for the modern period compared to the historic period

B.1.2 *Annual Minimum 7-Day Mean Daily Discharge*

Like the annual minimum 30-day mean daily discharge, the annual minimum 7-day mean daily discharge is the minimum of the 7-day moving average flow in the year. **Figure B.2** shows the annual minimum 7-day mean daily discharges for select return periods (1.01-year, 1.5-year, 2-year, 5-year, 10-year, 25-year, 50-year, and 100-year). **Table B.2** summarizes the data shown in **Figure B.2**.

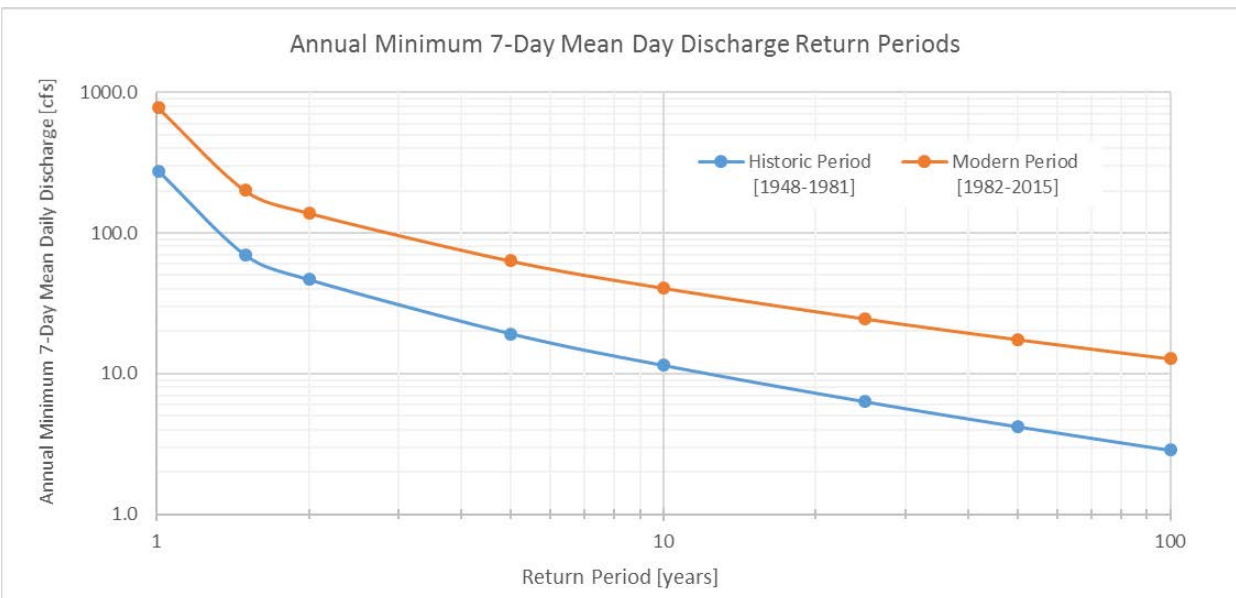

Figure B.2. Historical (1948-1981) versus modern (1982-2015) annual minimum 7-day mean daily discharge return periods for Little Sioux River at Correctionville, IA.

Table B.2: Summary of annual minimum 7-day mean daily discharge return periods for the Little Sioux River at Correctionville, IA.

Return Period	Historic Period [1948-1981]	Modern Period [1982-2015]	% Diff.	Altered Hydrology Criterion
1.0101	275.6	777.8	182.3%	+
1.5	69.5	200.1	188.0%	+
2	46.5	138.6	197.8%	+
5	19.2	63.3	229.4%	+
10	11.5	40.6	254.2%	+
25	6.3	24.5	288.7%	+
50	4.2	17.5	316.4%	+
100	2.9	12.7	345.8%	+

+ symbol indicates metric exhibits altered hydrology and an increase for the modern period compared to the historic period
o symbol indicates fails to exhibit altered hydrology for the modern period compared to the historic period
- symbol indicates metric exhibits altered hydrology and a decrease for the modern period compared to the historic period

B.1.3 November Median Daily Discharge

The median daily mean discharge for November is another indicator of baseflow. This metric is intended to represent baseflow condition during the winter months. **Table B.3** provides the median November flow for each period.

Table B.3: Historical (1940-1975) and modern (1980-2015) median November flow for the Little Sioux River at Correctionville, IA.

Return Period	Historic Period [1948-1981]	Modern Period [1982-2015]	% Diff.	Altered Hydrology Criterion
Period median November flow [cfs]	205.5	404.5	96.8%	+

+ symbol indicates metric exhibits altered hydrology and an increase for the modern period compared to the historic period
o symbol indicates fails to exhibit altered hydrology for the modern period compared to the historic period
- symbol indicates metric exhibits altered hydrology and a decrease for the modern period compared to the historic period

B.2 AQUATIC ORGANISM LIFE CYCLE

The shape of the annual hydrograph and timing of discharges are associated with ecological cues. Metrics related to the aquatic organism life cycle include the shape of the annual hydrographs, timing of the annual minimum flow, and timing of the annual peak flow.

B.2.1 *Annual Distribution of Discharges*

The annual distribution of runoff is shown two ways: as average monthly runoff volume in acre-feet per month (**Figure B.3**) and as a percentage of average annual runoff volume (**Figure B.4**). **Table B.4** summarized the data used to generate **Figures B.3** and **B.4**.

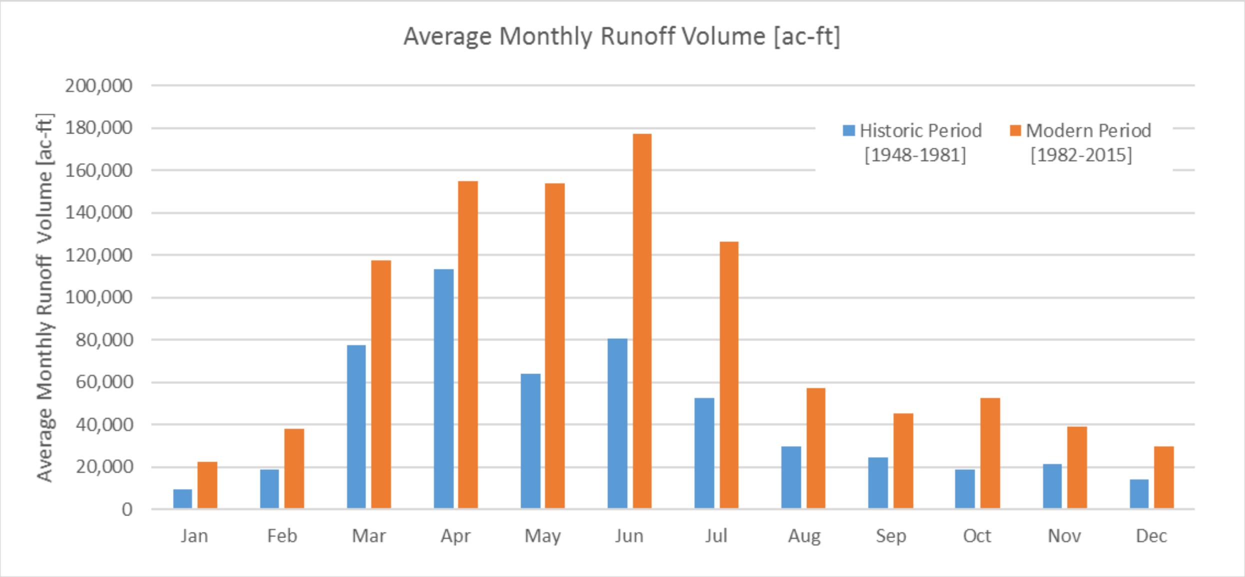

Figure B.3. Average monthly runoff volume [ac-ft] in the Little Sioux River at Correctionville, IA.

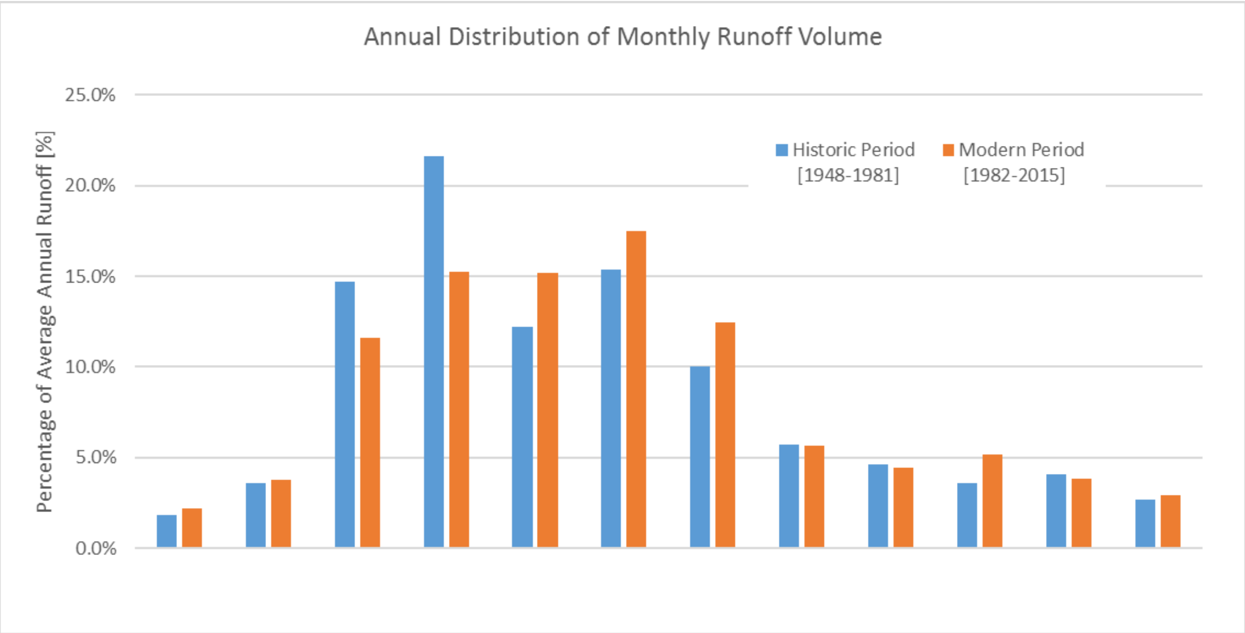

Figure B.4. Annual distribution of average monthly runoff volume as a percentage of annual total volume in the Little Sioux River at Correctionville, IA.

Table B.4. Average monthly runoff volume and annual distribution of monthly runoff volumes in Little Sioux River at Correctionville, IA.

Month	Average Monthly Volumes [ac-ft]				Distribution of Annual Volume			
	Historic Period [1948-1981]	Modern Period [1982-2015]	% diff.	AH	Historic Period [1948-1981]	Modern Period [1982-2015]	% diff.	AH
Jan	9,525	22,583	137.1%	+	1.8%	2.2%	22.8%	+
Feb	18,910	38,034	101.1%	+	3.6%	3.8%	4.2%	o
Mar	77,260	117,661	52.3%	+	14.7%	11.6%	-21.1%	-
Apr	113,397	154,747	36.5%	+	21.6%	15.3%	-29.3%	-
May	64,030	153,673	140.0%	+	12.2%	15.2%	24.3%	+
Jun	80,633	177,204	119.8%	+	15.4%	17.5%	13.9%	+
Jul	52,616	126,189	139.8%	+	10.0%	12.4%	24.3%	+
Aug	29,919	57,365	91.7%	+	5.7%	5.7%	-0.7%	o
Sep	24,259	45,073	85.8%	+	4.6%	4.4%	-3.7%	o
Oct	19,007	52,291	175.1%	+	3.6%	5.2%	42.5%	+
Nov	21,556	39,190	81.8%	+	4.1%	3.9%	-5.8%	o
Dec	14,144	29,835	110.9%	+	2.7%	2.9%	9.3%	o

+ symbol indicates metric exhibits altered hydrology and an increase for the modern period compared to the historic period
o symbol indicates fails to exhibit altered hydrology for the modern period compared to the historic period
- symbol indicates metric exhibits altered hydrology and a decrease for the modern period compared to the historic period
AH means altered hydrology criterion

B.2.2 Timing of Annual Maximum and Minimum Flows

The timing of the annual maximum daily discharge and annual minimum daily discharge are important metrics of the annual distribution of flows. The timing of the annual maximum typical occurs during the spring flood and the timing of the annual minimum usually occurs during the winter months. **Table B.5** provides statistics on the Julian day of the annual maximum flow and **Table B.6** provides the Julian day for the annual minimum flow. The statistics include the average, the median, and the standard deviation of the Julian days when the maximum or minimum flow occur.

Table B.5. Julian Day of annual maximum in the Little Sioux River at Correctionville, IA.

Statistic	Historic Period [1948-1981]	Modern Period [1982-2015]	% diff.	AH
Average	30-Apr	26-May	21.51%	+
Median	7-Apr	6-Jun	62.37%	+
Standard Deviation	60 days	50 days	-16.63%	-

[1]Based on 365-day year.
+ symbol indicates metric exhibits altered hydrology and an increase for the modern period compared to the historic period
o symbol indicates fails to exhibit altered hydrology for the modern period compared to the historic period
- symbol indicates metric exhibits altered hydrology and a decrease for the modern period compared to the historic period
AH means altered hydrology criterion

Table B.6. Julian Day of annual minimum flow in the Little Sioux River at Correctionville, IA.

Statistic	Historic Period [1948-1981]	Modern Period [1982-2015]	% diff.	AH
Average	22-Jun	23-Jul	17.70%	+
Median	2-Sep	16-Sep	5.92%	o
Standard Deviation	136 days	125 days	-8.65%	o

[1]Based on 365-day year.
+ symbol indicates metric exhibits altered hydrology and an increase for the modern period compared to the historic period
o symbol indicates fails to exhibit altered hydrology for the modern period compared to the historic period
- symbol indicates metric exhibits altered hydrology and a decrease for the modern period compared to the historic period
AH means altered hydrology criterion

B.3 RIPARIAN FLOODPLAIN (LATERAL) CONNECTIVITY (PEAK FLOWS)

The riparian floodplain connectivity metrics represent the frequency and duration of flooding of the riparian area and the lateral connectivity between the stream and the riparian area. Functions include energy flow, deposition of sediment, channel formation and surface water – groundwater interactions. The riparian floodplain connectivity metrics include the discharge rates for the 10-year, the 25-year, the 50-year, and the 100-year peak discharges. The annual peak discharge rates for select return periods (1.01-year, 1.5-year, 2-year, 5-year, 10-year, 25-year, 50-year, 100-year, and 200-year) are shown in **Figure B.5**.

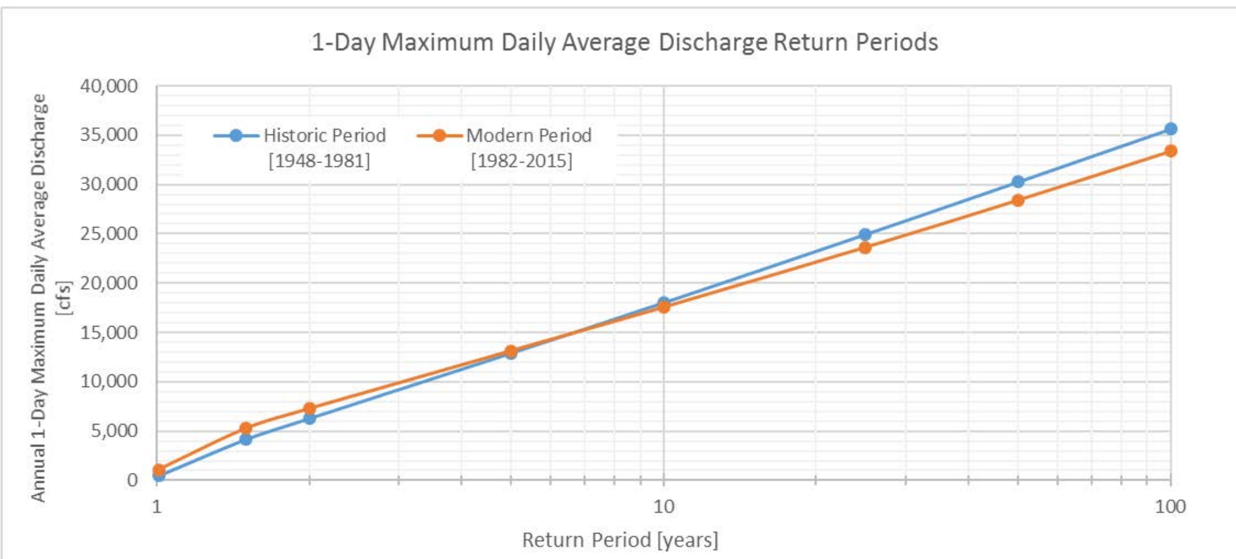

Figure B.5. Historical (1948-1981) versus modern (1982-2015) peak discharge return periods for Little Sioux River at Correctionville, IA.

In addition, the number of years with discharges exceeding the historic peak discharge within a period, the average number of days above the historic peak discharge rates, and the average cumulative volume of discharge above the historic peak discharges are provide (**Table B.7**).

Table B.7. Riparian floodplain connectivity metrics for the Little Sioux River at Correctionville, IA.

Flow Metric	Historic Period [1948-1981]	Modern Period [1982-2015]	% Diff.[1]	Altered Hydrology
5-Year Peak Discharge, Q(5) [cfs]	12,904	13,148	1.9%	o
Number of years with Discharge (Q) > Q_H (5)	9	8	-11.1%	-
Average number of days per year Q > Q_H (5)	3	7	133.3%	+
Average annual cumulative volume > Q_H (5) [ac-ft]	27,592	41,701	51.1%	+
10-Year Peak Discharge, Q(10) [cfs]	18,018	17,580	-2.4%	o
Number of years with Discharge (Q) > Q_H (10)	3	5	66.7%	+
Average number of days per year Q > Q_H (10)	3	2	-33.3%	-
Average annual cumulative volume > Q_H (10) [ac-ft]	20,588	11,711	-43.1%	-
25-Year Peak Discharge, Q(25) [cfs]	24,932	23,641	-5.2%	o
Number of years with Discharge (Q) > Q_H (25)	1	0	NA	o
Average number of days per year Q > Q_H (25)	1	0	NA	o
Average annual cumulative volume > Q_H (25) [ac-ft]	5,888	0	NA	o
50-Year Peak Discharge, Q(50) [cfs]	30,247	28,417	-6.1%	o
Number of years with Discharge (Q) > Q_H (50)	0	0	NA	o
Average number of days per year Q > Q_H (50)	0	0	NA	o
Average annual cumulative volume > Q_H (50) [ac-ft]	0	0	NA	o
100-Year Peak Discharge, Q(100) [cfs]	35,607	33,370	-6.3%	o
Number of years with Discharge (Q) > Q_H (100)	0	0	NA	o
Average number of days per year Q > Q_H (100)	0	0	NA	o
Average annual cumulative volume > Q_H (100) [ac-ft]	0	0	NA	o

[1]No events occurred above return period discharge.

+ symbol indicates metric exhibits altered hydrology and an increase for the modern period compared to the historic period

o symbol indicates fails to exhibit altered hydrology for the modern period compared to the historic period

- symbol indicates metric exhibits altered hydrology and a decrease for the modern period compared to the historic period

B.4 GEOMORPHIC STABILITY AND CAPACITY TO TRANSPORT SEDIMENT

The geomorphic stability and capacity to transport sediment metrics are related to the channel forming discharge. An increase in these metrics would be interpreted as an increase in the risk of the stream channel susceptibility to erosion. These metrics include changes to the flow duration curves, the 1.5-year peak flow, the 2-year peak flow. The 1.5-year to 2-year peak flows are generally consider the range of channel forming flow. In addition, the number of years within a period exceeding the historic peak flows, the average number of days above the historic peak flow rates, and the average volume of flow above the historic peak flows are provide (**Table B.8**). **Figure B.6** is the flow duration curves for the historic and modern periods and **Table B.8** provides a summary of flows for select percent exceedances. Both show that discharges across the flow spectrum have increased substantially, with the exception of the very high flows.

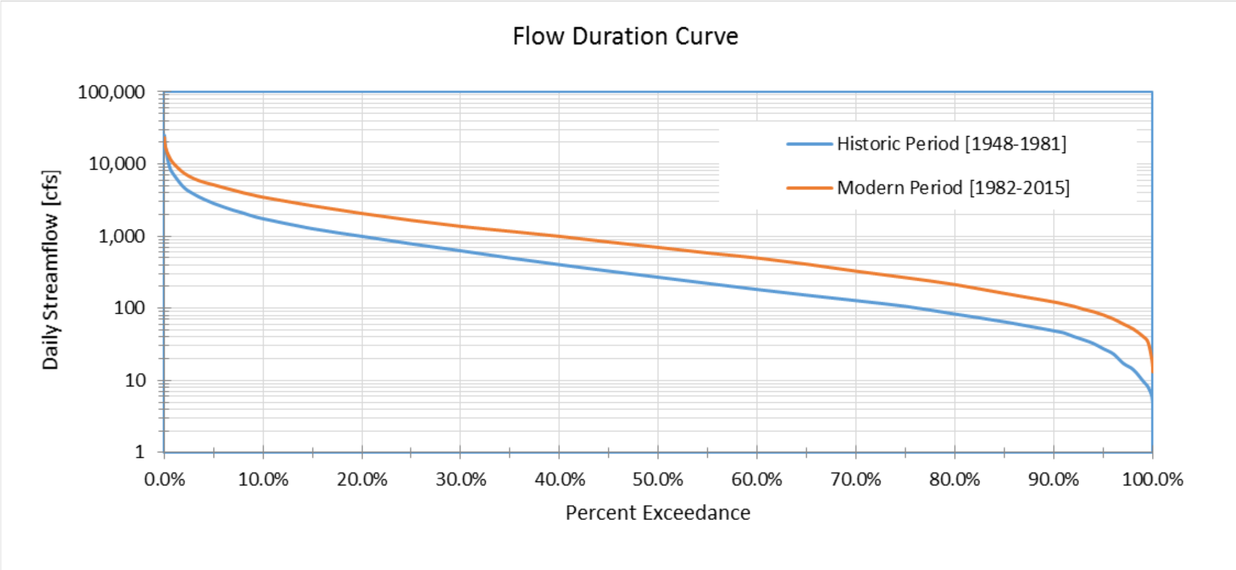

Figure B.6. Historical (1948-1981) versus modern (1982-2015) flow duration for Little Sioux River at Correctionville, IA.

Table B.8. Select summary of the flow duration curves for the Little Sioux River at Correctionville, IA.

Percent Exceedance	Historic Period [1948-1981]	Modern Period [1982-2015]	% Diff.	Altered Hydrology
0.10%	17,416	17,417	0.0%	o
1.0%	6,866	9,928	44.6%	+
10.0%	1,720	3,470	101.7%	+
25.0%	772	1,660	115.0%	+
50.0%	266	700	163.2%	+
75.0%	126	328	160.3%	+
90.0%	48	123	156.3%	+
99.0%	10	41	323.9%	+
99.9%	6	19	222.0%	+

+ symbol indicates metric exhibits altered hydrology and an increase for the modern period compared to the historic period
o symbol indicates fails to exhibit altered hydrology for the modern period compared to the historic period
- symbol indicates metric exhibits altered hydrology and a decrease for the modern period compared to the historic period

Table B.9 provides the 1.5-year and 2-year annual peak flows and flow statistics, including peak discharge, number of years with flow rates above the historic return period flow, average number of days per year above the historic return period flow, and average volume above the historic return period flow.

Table B.9. Geomorphic stability and capacity to transport sediment metrics for the Little Sioux River at Correctionville, IA.

Flow Metric	Historic Period [1948-1981]	Modern Period [1982-2015]	% Diff.	Altered Hydrology
1.5-Year Peak Discharge, Q(1.5) [cfs]	4,149	5,285	27.4%	+
Number of years with Discharge (Q) > Q_H (1.5)	21	28	33.3%	+
Average number of days per year Q > Q_H (1.5)	14	33	130.2%	+
Average annual cumulative volume > Q_H (1.5) [ac-ft]	97,596	180,590	85.0%	+
2-Year Peak Discharge, Q(2) [cfs]	6,272	7,282	16.1%	+
Number of years with Discharge (Q) > Q_H (2)	16	19	18.8%	+
Average number of days per year Q > Q_H (2)	10	20	104.7%	+
Average annual cumulative volume > Q_H (2) [ac-ft]	71,547	128,976	80.3%	+

+ symbol indicates metric exhibits altered hydrology and an increase for the modern period compared to the historic period
o symbol indicates fails to exhibit altered hydrology for the modern period compared to the historic period
- symbol indicates metric exhibits altered hydrology and a decrease for the modern period compared to the historic period

B.5 SETTING GOALS

A summary of the storage goals is provided in **Table 7** in **Section 4.** The following are the methods used to develop those goals. Goals for addressing the change in hydrology were estimated using three methods. Each method is based on different assumptions and altered the metrics for a specific "altered hydrology" group (see Table 6). The first method is focused on the aquatic habitat and geomorphic and ability to transport sediment metric group and uses the change in the cumulative volume for mean daily discharges, exceeding the 1.5-year return period event. The cumulative total volume when the daily average discharge exceeds the 1.5-year peak discharge includes all flows above the 1.5-year peak, i.e. can include storms with much larger return periods. The change in average annual cumulative volume above the 1.5-year peak flow (see **Table B.9**) This method is based on the changes in the observed data and since it includes all flows above the 1.5-year flow relies on the two periods to have a similar distribution of flows.

The second method is based on the changes in hydrology across the entire annual hydrograph, and integrates the differences in return period discharges between the modern and historic period (see **Table B.10**) and finding a probability-weighted representative change in flow rate. A volume is then found by assuming a flow period equal to the change in flow period for the 1.5-year flow (i.e. the change in the number of days above the 1.5-year flow; see **Table B.9**).

Table B.10. Estimated goal for the drainage area of the Little Sioux River at Correctionville, IA using method 2.

Return Period	Historic Period Discharges (cfs)	Modern Period Discharges (cfs)	Difference (cfs)	Probability of Occurrence	Difference*Probability (cfs)
1.5	4,149	5,285	1136	0.67	757.2
2	6,272	7,282	1011	0.50	505.4
5	12,904	13,148	245	0.20	48.9
10	18,018	17,580	-437	0.10	0.0
25	24,932	23,641	-1291	0.04	0.0
50	30,247	28,417	-1830	0.02	0.0
100	35,607	33,370	-2237	0.01	0.0
				Sum (cfs):	1,312
				Sum (ac-ft/day):	2,602
		Number of days:	20	Total Volume Goal:	49,037 AF (0.37 in.)

The third method is also based on addressing the effects through the entire flow range and is a revision to Method 2. Method 3 considers incorporates the observed change in the timing of the peak discharge for each return period event. This method uses the probability-weighted representative change in flow rate and multiples the flow rates by the change in the number of days exceeding the return period flow for each return period (see **Table B.11**).

Table B.11. Estimated goal for the drainage area of the Little Sioux River at Correctionville, IA using method 3.

Return Period	Change in Flow (Q_m-Q_h) [cfs]	Probability of Occurrence	Probability Weighted Flow [AF/day]	Change in number of days above flow (days)	Storage Volume
1.5	1,136	0.67	1,502.2	19	28,309
2	1,011	0.50	1,002.8	10	10,044
5	245	0.20	97.1	4	388
10	-437	0.10	0.0	0	0
25	-1,291	0.04	0.0	0	0
50	-1,830	0.02	0.0	0	0
100	-2,237	0.01	0.0	0	0
				Total Volume Goal:	38,742 AF (0.29 in.)

APPENDIX C: METRICS OF ALTERED HYDROLOGY FOR SPLIT ROCK CREEK AT CORSON, SD (USGS# 06482610).

The following is the summary statistics used to determine the altered hydrology metrics in detail and develop the storage goals. A summary of these statistics is shown in **Table 4** in **Section 3.2.1**.

C.1 CONDITION OF AQUATIC HABITAT

The condition of aquatic habitat includes a group of metrics that primarily reflect the flow characteristics of the annual hydrograph, needed to maintain adequate habitat for fish and aquatic life. The 7-day low flow, the 30-day low flow, and the median November mean daily discharge are metrics used to represent changes in the availability of flow for aquatic habitat.

C.1.1 Annual minimum 30-day mean daily discharge

The annual minimum 30-day mean daily discharge is the minimum of the 30-day moving mean daily discharge within a year (an annual minimum series). **Figure C.1** shows the annual minimum 30-day mean daily discharge for select return periods (1.01-year, 1.5-year, 2-year, 5-year, 10-year, 25-year, 50-year, and 100-year). **Table C.1** summarizes the data shown in **Figure C.1**.

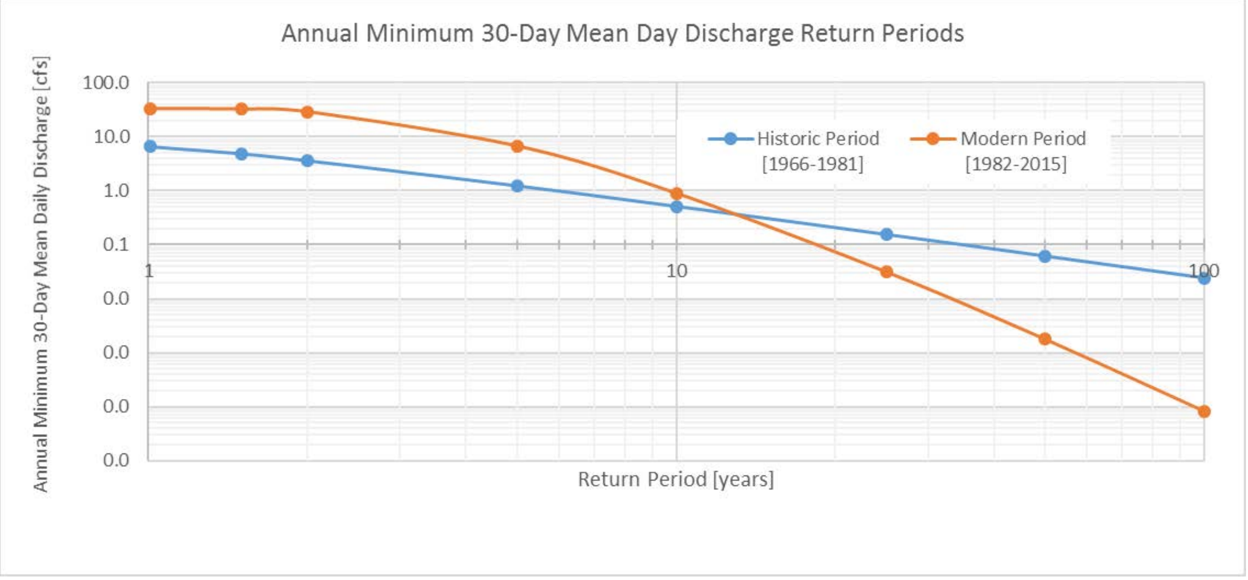

Figure C.1. Historical (1966-1981) versus modern (1982-2015) annual minimum 30-day mean daily discharge versus return period for Split Rock Creek at Corson, SD.

Table C.1: Summary of annual minimum 30-day mean daily discharge by return periods for the Split Rock Creek at Corson, SD.

Return Period	Historic Period [1948-1981]	Modern Period [1982-2015]	% Diff.	Altered Hydrology Criterion
1.01	6.5	33.1	406.3%	+
1.5	4.9	32.5	568.9%	+
2	3.6	28.9	700.0%	+
5	1.2	6.7	442.4%	+
10	0.5	0.9	74.6%	+
25	0.2	0.03	-79.9%	-
50	0.1	0.002	-97.1%	-
100	0.024	0.0001	-99.7%	-

+ symbol indicates metric exhibits altered hydrology and an increase for the modern period compared to the historic period
o symbol indicates fails to exhibit altered hydrology for the modern period compared to the historic period
- symbol indicates metric exhibits altered hydrology and a decrease for the modern period compared to the historic period

C.1.2 Annual Minimum 7-Day Mean Daily Discharge

Like the annual minimum 30-day mean daily discharge, the annual minimum 7-day mean daily discharge is the minimum of the 7-day moving average flow in the year. **Figure C.2** shows the annual minimum 7-day mean daily discharges for select return periods (1.01-year, 1.5-year, 2-year, 5-year, 10-year, 25-year, 50-year, and 100-year). **Table C.2** summarizes the data shown in **Figure C.2**.

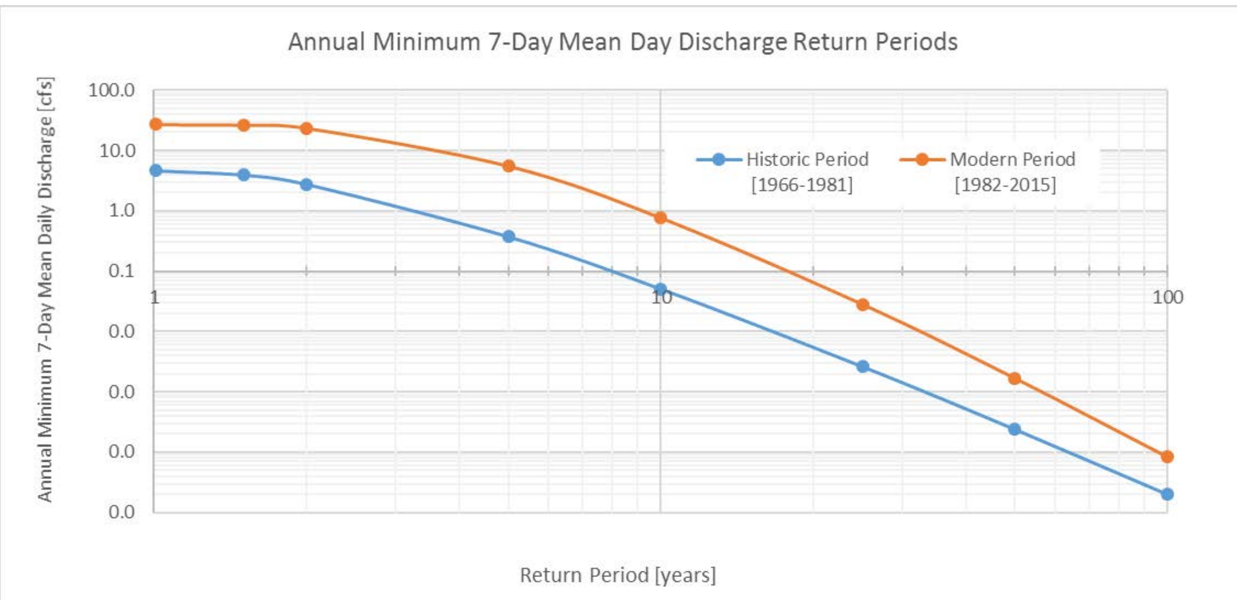

Figure C.2. Historical (1966-1981) versus modern (1982-2015) annual minimum 7-day mean daily discharge return periods for Split Rock Creek at Corson, SD.

Table C.2: Summary of annual minimum 7-day mean daily discharge return periods for the Split Rock Creek at Corson, SD.

Return Period	Historic Period [1948-1981]	Modern Period [1982-2015]	% Diff.	Altered Hydrology Criterion
1.0101	4.6	26.9	481.3%	+
1.5	3.9	26.4	571.4%	+
2	2.8	23.5	753.1%	+
5	0.4	5.5	1380.8%	+
10	0.1	0.8	1407.8%	+
25	0.003	0.028	978.3%	+
50	0.00024	0.002	604.3%	+
100	0.00002	0.0001	317.2%	+

+ symbol indicates metric exhibits altered hydrology and an increase for the modern period compared to the historic period
o symbol indicates fails to exhibit altered hydrology for the modern period compared to the historic period
- symbol indicates metric exhibits altered hydrology and a decrease for the modern period compared to the historic period

C.1.3 November Median Daily Discharge

The median daily mean discharge for November is another indicator of baseflow. This metric is intended to represent baseflow condition during the winter months. **Table C.3** provides the median November flow for each period.

Table C.3: Historical (1966-1981) and modern (1982-2015) median November flow for the Split Rock Creek at Corson, SD.

Return Period	Historic Period [1948-1981]	Modern Period [1982-2015]	% Diff.	Altered Hydrology Criterion
Period median November flow [cfs]	15.0	50.8	238.3%	+

+ symbol indicates metric exhibits altered hydrology and an increase for the modern period compared to the historic period
o symbol indicates fails to exhibit altered hydrology for the modern period compared to the historic period
- symbol indicates metric exhibits altered hydrology and a decrease for the modern period compared to the historic period

C.2 AQUATIC ORGANISM LIFE CYCLE

The shape of the annual hydrograph and timing of discharges are associated with ecological cues. Metrics related to the aquatic organism life cycle include the shape of the annual hydrographs, timing of the annual minimum flow, and timing of the annual peak flow.

C.2.1 Annual Distribution of Discharges

The annual distribution of runoff is shown two ways: as average monthly runoff volume in acre-feet per month (**Figure C.3**) and as a percentage of average annual runoff volume (**Figure C.4**). **Table C.4** summarized the data used to generate **Figures C.3** and **C.4**.

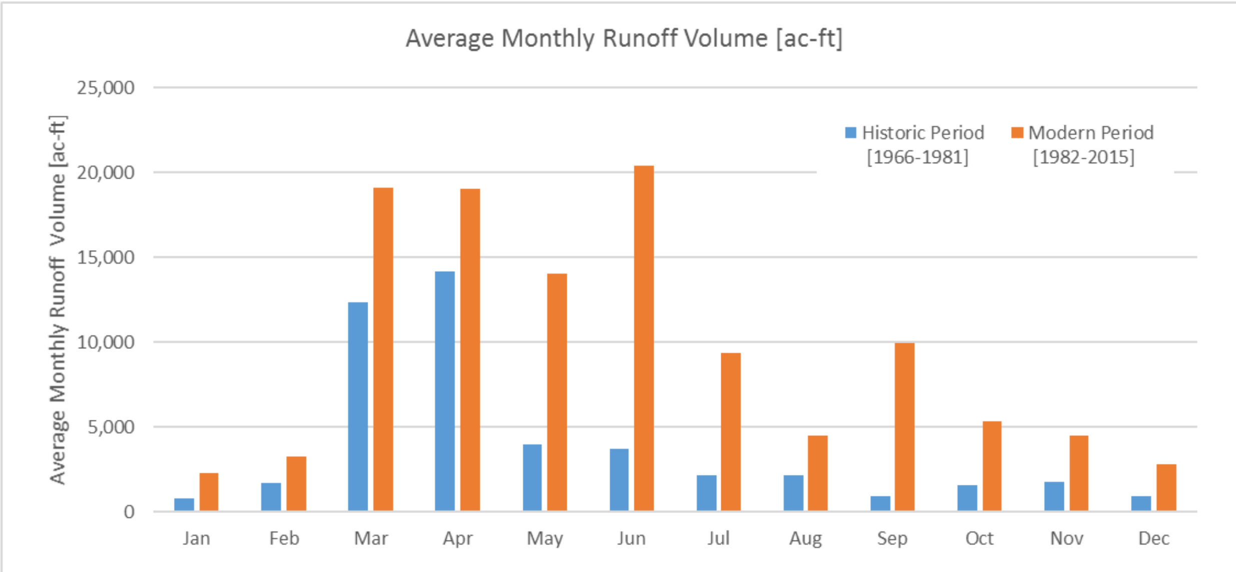

Figure C.3. Average monthly runoff volume [ac-ft] in the Split Rock Creek at Corson, SD.

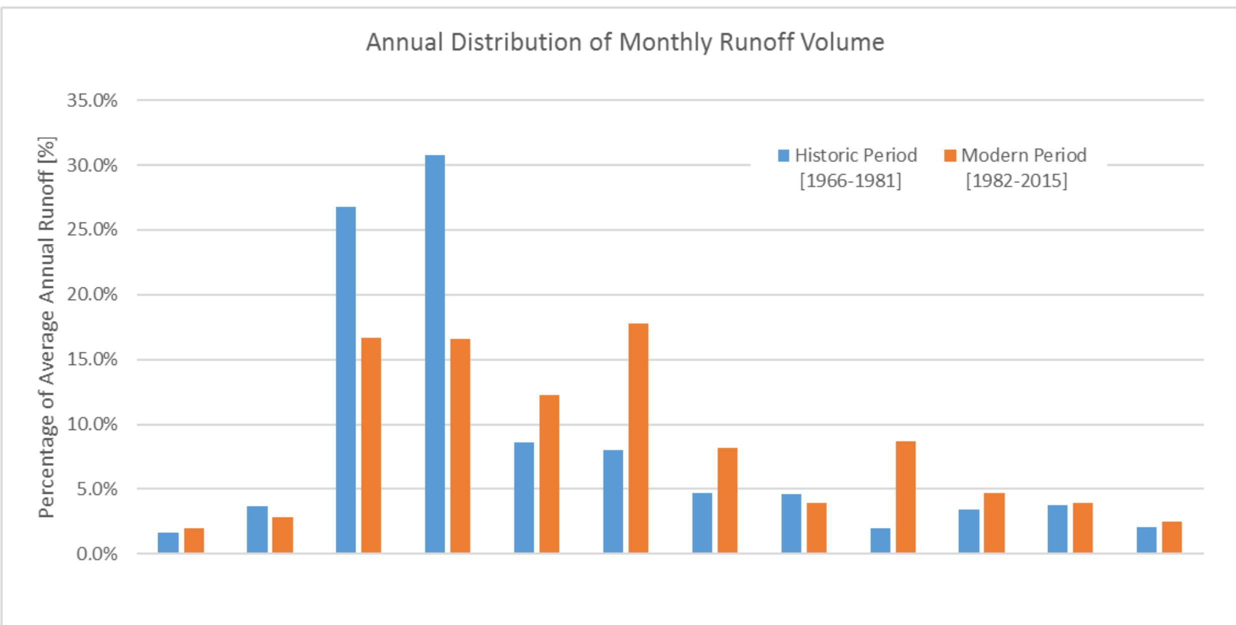

Figure C.4. Annual distribution of average monthly runoff volume as a percentage of annual total volume in the Split Rock Creek at Corson, SD.

Table C.4. Average monthly runoff volume and annual distribution of monthly runoff volumes in Split Rock Creek at Corson, SD.

Month	Average Monthly Volumes [ac-ft]	Distribution of Annual Volume

	Historic Period [1948-1981]	Modern Period [1982-2015]	% diff.	AH	Historic Period [1948-1981]	Modern Period [1982-2015]	% diff.	AH
Jan	766	2,271	196.4%	+	1.7%	2.0%	19.3%	+
Feb	1,689	3,283	94.3%	+	3.7%	2.9%	-21.8%	-
Mar	12,343	19,134	55.0%	+	26.8%	16.7%	-37.6%	-
Apr	14,174	19,041	34.3%	+	30.7%	16.6%	-45.9%	-
May	3,954	14,008	254.3%	+	8.6%	12.2%	42.6%	+
Jun	3,684	20,413	454.1%	+	8.0%	17.8%	123.0%	+
Jul	2,181	9,386	330.3%	+	4.7%	8.2%	73.2%	+
Aug	2,143	4,474	108.8%	+	4.6%	3.9%	-16.0%	-
Sep	922	9,963	980.7%	+	2.0%	8.7%	334.9%	+
Oct	1,572	5,349	240.2%	+	3.4%	4.7%	36.9%	+
Nov	1,752	4,484	156.0%	+	3.8%	3.9%	3.0%	o
Dec	942	2,812	198.4%	+	2.0%	2.5%	20.1%	+

+ symbol indicates metric exhibits altered hydrology and an increase for the modern period compared to the historic period
o symbol indicates fails to exhibit altered hydrology for the modern period compared to the historic period
- symbol indicates metric exhibits altered hydrology and a decrease for the modern period compared to the historic period
AH means altered hydrology criterion

C.2.2 Timing of Annual Maximum and Minimum Flows

The timing of the annual maximum daily discharge and annual minimum daily discharge are important metrics of the annual distribution of flows. The timing of the annual maximum typical occurs during the spring flood and the timing of the annual minimum usually occurs during the winter months. **Table C.5** provides statistics on the Julian day of the annual maximum flow and **Table C.6** provides the Julian day for the annual minimum flow. The statistics include the average, the median, and the standard deviation of the Julian days when the maximum or minimum flow occur.

Table C.5. Julian Day of annual maximum in the Split Rock Creek at Corson, SD.

Statistic	Historic Period [1948-1981]	Modern Period [1982-2015]	% diff.	AH
Average	2-May	25-May	19.42%	+
Median	27-Mar	19-May	61.27%	+
Standard Deviation	79 days	73 days	-7.46%	o

[1]Based on 365-day year.
+ symbol indicates metric exhibits altered hydrology and an increase for the modern period compared to the historic period
o symbol indicates fails to exhibit altered hydrology for the modern period compared to the historic period
- symbol indicates metric exhibits altered hydrology and a decrease for the modern period compared to the historic period
AH means altered hydrology criterion

Table C.6. Julian Day of annual minimum flow in the Split Rock Creek at Corson, SD.

Statistic	Historic Period [1948-1981]	Modern Period [1982-2015]	% diff.	AH
Average	122	146	19.42%	+
Median	87	140	61.27%	+
Standard Deviation	79	73	-7.46%	o

[1]Based on 365-day year.
+ symbol indicates metric exhibits altered hydrology and an increase for the modern period compared to the historic period
o symbol indicates fails to exhibit altered hydrology for the modern period compared to the historic period
- symbol indicates metric exhibits altered hydrology and a decrease for the modern period compared to the historic period
AH means altered hydrology criterion

C.3 RIPARIAN FLOODPLAIN (LATERAL) CONNECTIVITY (PEAK FLOWS)

The riparian floodplain connectivity metrics represent the frequency and duration of flooding of the riparian area and the lateral connectivity between the stream and the riparian area. Functions include energy flow, deposition of sediment, channel formation and surface water – groundwater interactions. The riparian floodplain connectivity metrics include the discharge rates for the 10-year, the 25-year, the 50-year, and the 100-year peak discharges. The annual peak discharge rates for select return periods (1.01-year, 1.5-year, 2-year, 5-year, 10-year, 25-year, 50-year, 100-year, and 200-year) are shown in **Figure C.5**.

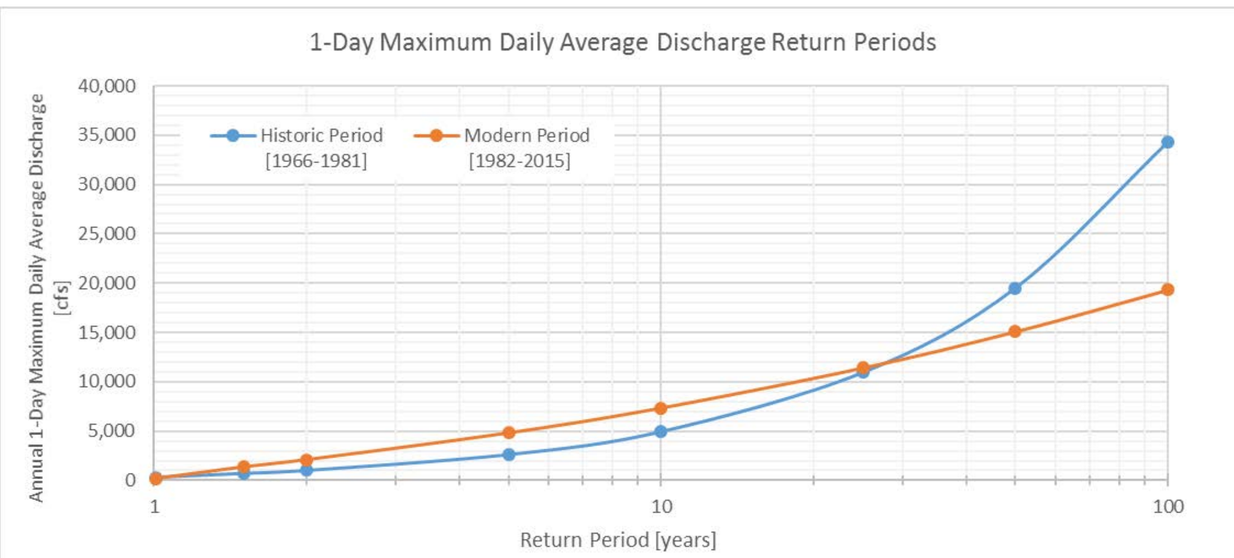

Figure C.5. Historical (1966-1981) versus modern (1982-2015) peak discharge return periods for Split Rock Creek at Corson, SD.

In addition, the number of years with discharges exceeding the historic peak discharge within a period, the average number of days above the historic peak discharge rates, and the average cumulative volume of discharge above the historic peak discharges are provide (**Table C.7**).

Table C.7. Riparian floodplain connectivity metrics for the Split Rock Creek at Corson, SD.

Flow Metric	Historic Period [1948-1981]	Modern Period [1982-2015]	% Diff.[1]	Altered Hydrology
5-Year Peak Discharge, Q(5) [cfs]	2,606	4,814	84.7%	+
Number of years with Discharge (Q) > Q_H (5)	3	9	200.0%	+
Average number of days per year Q > Q_H (5)	4	4	-2.6%	o
Average annual cumulative volume > Q_H (5) [ac-ft]	29,680	14,909	-49.8%	-
10-Year Peak Discharge, Q(10) [cfs]	4,937	7,344	48.7%	+
Number of years with Discharge (Q) > Q_H (10)	2	5	150.0%	+
Average number of days per year Q > Q_H (10)	3	2	-28.0%	-
Average annual cumulative volume > Q_H (10) [ac-ft]	25,710	8,015	-68.8%	-
25-Year Peak Discharge, Q(25) [cfs]	10,938	11,414	4.3%	o
Number of years with Discharge (Q) > Q_H (25)	1	1	0.0%	o
Average number of days per year Q > Q_H (25)	2	1	-50.0%	-
Average annual cumulative volume > Q_H (25) [ac-ft]	12,740	1,510	-88.1%	-
50-Year Peak Discharge, Q(50) [cfs]	19,512	15,098	-22.6%	-
Number of years with Discharge (Q) > Q_H (50)	0	0	NA	o
Average number of days per year Q > Q_H (50)	0	0	NA	o
Average annual cumulative volume > Q_H (50) [ac-ft]	0	0	NA	o
100-Year Peak Discharge, Q(100) [cfs]	34,335	19,352	-43.6%	-
Number of years with Discharge (Q) > Q_H (100)	0	0	NA	o
Average number of days per year Q > Q_H (100)	0	0	NA	o
Average annual cumulative volume > Q_H (100) [ac-ft]	0	0	NA	o

[1]No events occurred above return period discharge.
+ symbol indicates metric exhibits altered hydrology and an increase for the modern period compared to the historic period
o symbol indicates fails to exhibit altered hydrology for the modern period compared to the historic period
- symbol indicates metric exhibits altered hydrology and a decrease for the modern period compared to the historic period

C.4 GEOMORPHIC STABILITY AND CAPACITY TO TRANSPORT SEDIMENT

The geomorphic stability and capacity to transport sediment metrics are related to the channel forming discharge. An increase in these metrics would be interpreted as an increase in the risk of the stream channel susceptibility to erosion. These metrics include changes to the flow duration curves, the 1.5-year peak flow, the 2-year peak flow. The 1.5-year to 2-year peak flows are generally consider the range of channel forming flow. In addition, the number of years within a period exceeding the historic peak flows, the average number of days above the historic peak flow rates, and the average volume of flow above the historic peak flows are provide (**Table C.8**). **Figure C.6** is the flow duration curves for the historic and modern periods and **Table C.8** provides a summary of flows for select percent exceedances. Both show that discharges across the flow spectrum have increased substantially, with the exception of the very high flows.

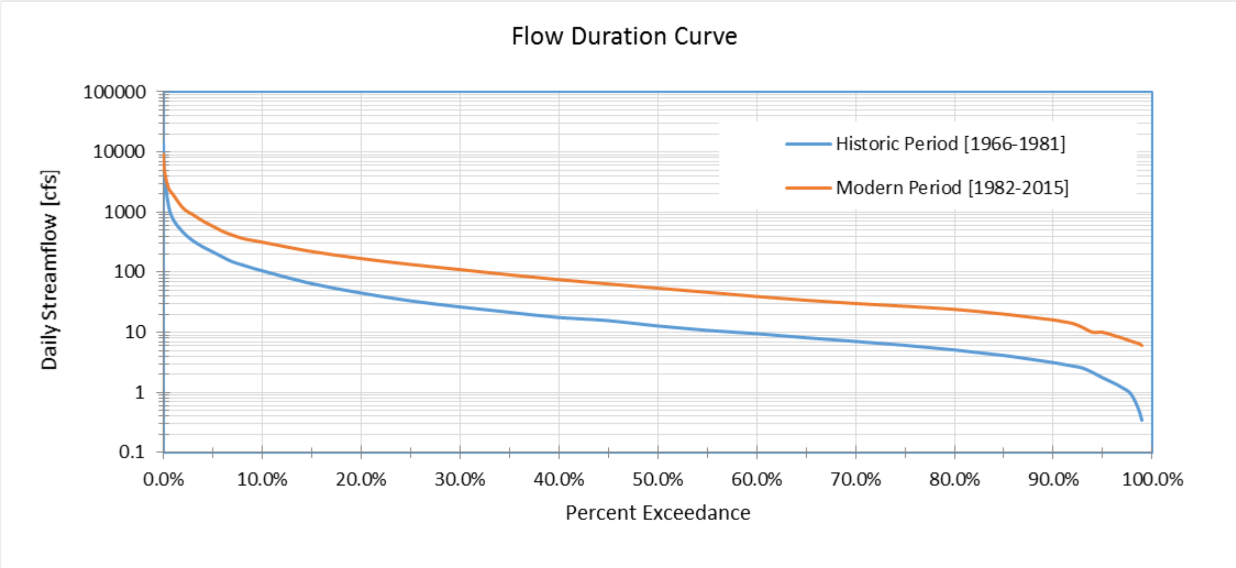

Figure C.6. Historical (1966-1981) versus modern (1982-2015) flow duration for Split Rock Creek at Corson, SD.

Table C.8. Select summary of the flow duration curves for the Split Rock Creek at Corson, SD.

Percent Exceedance	Historic Period [1948-1981]	Modern Period [1982-2015]	% Diff.	Altered Hydrology
0.10%	4,800	5,036	4.9%	o
1.0%	769	1,937	151.8%	+
10.0%	108	315	191.4%	+
25.0%	34	134	294.1%	+
50.0%	13	54	315.4%	+
75.0%	7	30	316.7%	+
90.0%	3	16	400.0%	+
99.0%	0.4	6	1614.3%	+
99.9%	0.0	0.0		

+ symbol indicates metric exhibits altered hydrology and an increase for the modern period compared to the historic period
o symbol indicates fails to exhibit altered hydrology for the modern period compared to the historic period
- symbol indicates metric exhibits altered hydrology and a decrease for the modern period compared to the historic period

Table C.9 provides the 1.5-year and 2-year annual peak flows and flow statistics, including peak discharge, number of years with flow rates above the historic return period flow, average number of days per year above the historic return period flow, and average volume above the historic return period flow.

Table C.9. Geomorphic stability and capacity to transport sediment metrics for the Split Rock Creek at Corson, SD.

Flow Metric	Historic Period [1948-1981]	Modern Period [1982-2015]	% Diff.	Altered Hydrology
1.5-Year Peak Discharge, Q(1.5) [cfs]	701	1,351	92.9%	+
Number of years with Discharge (Q) > Q_H (1.5)	9	20	122.2%	+
Average number of days per year Q > Q_H (1.5)	7	16	125.7%	+
Average annual cumulative volume > Q_H (1.5) [ac-ft]	20,918	29,836	42.6%	+
2-Year Peak Discharge, Q(2) [cfs]	1,006	2,095	108.3%	+
Number of years with Discharge (Q) > Q_H (2)	9	16	77.8%	+
Average number of days per year Q > Q_H (2)	5	12	168.9%	+
Average annual cumulative volume > Q_H (2) [ac-ft]	17,501	27,527	57.3%	+

+ symbol indicates metric exhibits altered hydrology and an increase for the modern period compared to the historic period
o symbol indicates fails to exhibit altered hydrology for the modern period compared to the historic period
- symbol indicates metric exhibits altered hydrology and a decrease for the modern period compared to the historic period

C.5 SETTING GOALS

A summary of the storage goals is provided in **Table 7** in **Section 4.** The following are the methods used to develop those goals. Goals for addressing the change in hydrology were estimated using three methods. Each method is based on different assumptions and altered the metrics for a specific "altered hydrology" group (see Table 6). The first method is focused on the aquatic habitat and geomorphic and ability to transport sediment metric group and uses the change in the cumulative volume for mean daily discharges, exceeding the 1.5-year return period event. The cumulative total volume when the daily average discharge exceeds the 1.5-year peak discharge includes all flows above the 1.5-year peak, i.e. can include storms with much larger return periods. The change in average annual cumulative volume above the 1.5-year peak flow (see **Table C.9**) This method is based on the changes in the observed data and since it includes all flows above the 1.5-year flow relies on the two periods to have a similar distribution of flows.

The second method is based on the changes in hydrology across the entire annual hydrograph, and integrates the differences in return period discharges between the modern and historic period (see **Table C.10**) and finding a probability-weighted representative change in flow rate. A volume is then found by assuming a flow period equal to the change in flow period for the 1.5-year flow (i.e. the change in the number of days above the 1.5-year flow; see **Table C.9**).

Table C.10. Estimated goal for the drainage area of the Split Rock Creek at Corson, SD using method 2.

Return Period	Historic Period Discharges (cfs)	Modern Period Discharges (cfs)	Difference (cfs)	Probability of Occurrence	Difference*Probability (cfs)
1.5	701	1,351	651	0.67	433.9
2	1,006	2,095	1089	0.50	544.5
5	2,606	4,814	2208	0.20	441.6
10	4,937	7,344	2407	0.10	240.7
25	10,938	11,414	476	0.04	19.0
50	19,512	15,098	-4414	0.02	0.0
100	34,335	19,352	-14984	0.01	0.0
				Sum (cfs):	1,680
				Sum (ac-ft/day):	3,333
		Number of days:	20	Total Volume Goal:	30,252 AF (1.18 in.)

The third method is also based on addressing the effects through the entire flow range and is a revision to Method 2. Method 3 considers incorporates the observed change in the timing of the peak discharge for each return period event. This method uses the probability-weighted representative change in flow rate and multiples the flow rates by the change in the number of days exceeding the return period flow for each return period (see **Table C.11**).

Table C.11. Estimated goal for the drainage area of the Split Rock Creek at Corson, SD using method 3.

Return Period	Change in Flow (Q_m-Q_h) [cfs]	Probability of Occurrence	Probability Weighted Flow [AF/day]	Change in number of days above flow (days)	Storage Volume
1.5	651	0.67	860.9	9	7,815
2	1,089	0.50	1,080.3	8	8,313
5	2,208	0.20	876.1	0	0
10	2,407	0.10	477.5	0	0
25	476	0.04	37.7	0	0
50	-4,414	0.02	0.0	0	0
100	-14,984	0.01	0.0	0	0
				Total Volume Goal:	16,128 AF (0.63 in.)

APPENDIX D: METRICS OF ALTERED HYDROLOGY FOR ROCK RIVER NEAR ROCK VALLEY, IA (USGS# 06483500).

The following is the summary statistics used to determine the altered hydrology metrics in detail and develop the storage goals. A summary of these statistic is shown in **Table 5** in **Section 3.3.1**.

D.1 CONDITION OF AQUATIC HABITAT

The condition of aquatic habitat includes a group of metrics that primarily reflect the flow characteristics of the annual hydrograph, needed to maintain adequate habitat for fish and aquatic life. The 7-day low flow, the 30-day low flow, and the median November mean daily discharge are metrics used to represent changes in the availability of flow for aquatic habitat.

D.1.1 Annual minimum 30-day mean daily discharge

The annual minimum 30-day mean daily discharge is the minimum of the 30-day moving mean daily discharge within a year (an annual minimum series). **Figure D.1** shows the annual minimum 30-day mean daily discharge for select return periods (1.01-year, 1.5-year, 2-year, 5-year, 10-year, 25-year, 50-year, and 100-year). **Table D.1** summarizes the data shown in **Figure D.1**.

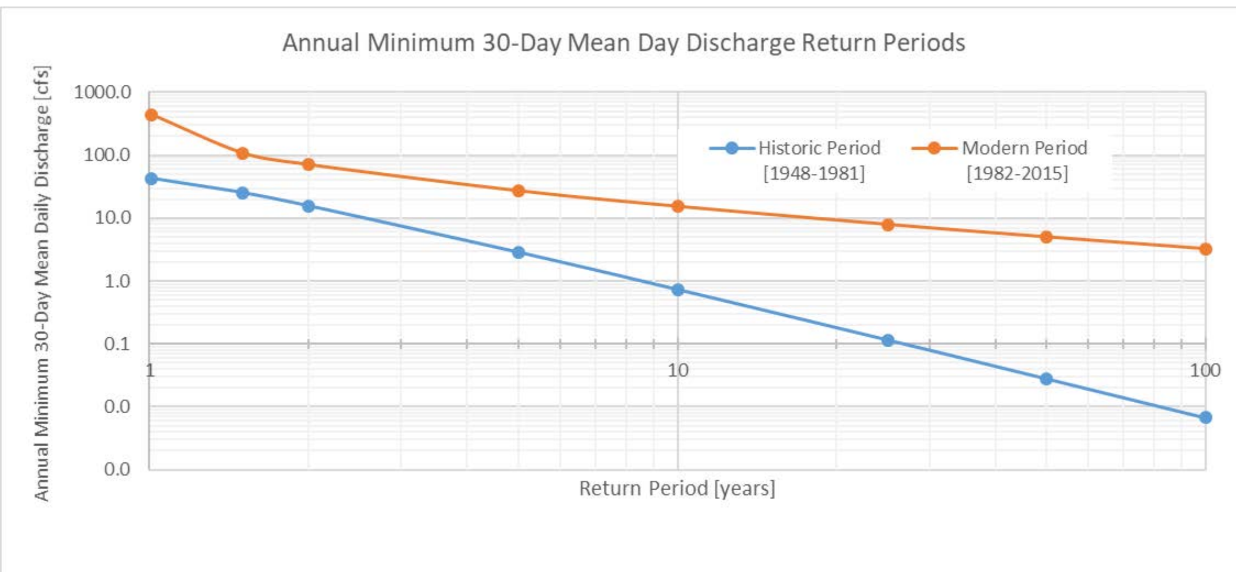

Figure D.1. Historical (1948-1981) versus modern (1982-2015) annual minimum 30-day mean daily discharge versus return period for Rock River near Rock Valley, IA.

Table D.1: Summary of annual minimum 30-day mean daily discharge by return periods for the Rock River near Rock Valley, IA.

Return Period	Historic Period [1948-1981]	Modern Period [1982-2015]	% Diff.	Altered Hydrology Criterion
1.01	42.6	442.9	939.7%	+
1.5	25.3	108.3	328.6%	+
2	15.6	70.7	353.2%	+
5	2.9	27.1	851.0%	+
10	0.7	15.3	1995.9%	+
25	0.1	7.9	6741.0%	+
50	0.0	5.0	17756.7%	+
100	0.0	3.2	48317.2%	+

+ symbol indicates metric exhibits altered hydrology and an increase for the modern period compared to the historic period
o symbol indicates fails to exhibit altered hydrology for the modern period compared to the historic period
- symbol indicates metric exhibits altered hydrology and a decrease for the modern period compared to the historic period

D.1.2 Annual Minimum 7-Day Mean Daily Discharge

Like the annual minimum 30-day mean daily discharge, the annual minimum 7-day mean daily discharge is the minimum of the 7-day moving average flow in the year. **Figure D.2** shows the annual minimum 7-day mean daily discharges for select return periods (1.01-year, 1.5-year, 2-year, 5-year, 10-year, 25-year, 50-year, and 100-year). **Table D.2** summarizes the data shown in **Figure D.2**.

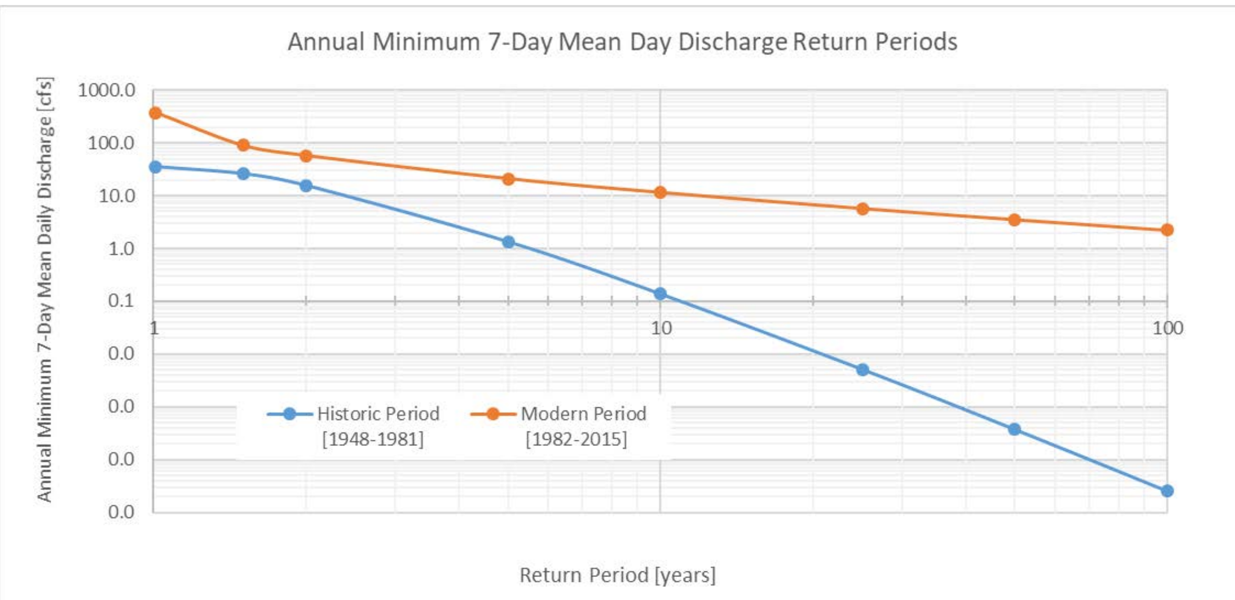

Figure D.2. Historical (1948-1981) versus modern (1982-2015) annual minimum 7-day mean daily discharge return periods for Rock River near Rock Valley, IA.

Table D.2: Summary of annual minimum 7-day mean daily discharge return periods for the Rock River near Rock Valley, IA.

Return Period	Historic Period [1948-1981]	Modern Period [1982-2015]	% Diff.	Altered Hydrology Criterion
1.0101	35.6	370.9	941.9%	+
1.5	26.1	89.3	241.3%	+
2	15.6	57.4	267.4%	+
5	1.3	21.1	1467.2%	+
10	0.1	11.6	8274.8%	+
25	0.0	5.7	110965.7%	+
50	0.0	3.5	932670.4%	+
100	0.0	2.2	8662066.0%	+

+ symbol indicates metric exhibits altered hydrology and an increase for the modern period compared to the historic period
o symbol indicates fails to exhibit altered hydrology for the modern period compared to the historic period
- symbol indicates metric exhibits altered hydrology and a decrease for the modern period compared to the historic period

D.1.3 November Median Daily Discharge

The median daily mean discharge for November is another indicator of baseflow. This metric is intended to represent baseflow condition during the winter months. **Table D.3** provides the median November flow for each period.

Table D.3: Historical (1940-1975) and modern (1980-2015) median November flow for the Rock River near Rock Valley, IA.

Return Period	Historic Period [1948-1981]	Modern Period [1982-2015]	% Diff.	Altered Hydrology Criterion
Period median November flow [cfs]	60.0	230.0	283.3%	+

+ symbol indicates metric exhibits altered hydrology and an increase for the modern period compared to the historic period
o symbol indicates fails to exhibit altered hydrology for the modern period compared to the historic period
- symbol indicates metric exhibits altered hydrology and a decrease for the modern period compared to the historic period

D.2 AQUATIC ORGANISM LIFE CYCLE

The shape of the annual hydrograph and timing of discharges are associated with ecological cues. Metrics related to the aquatic organism life cycle include the shape of the annual hydrographs, timing of the annual minimum flow, and timing of the annual peak flow.

D.2.1 Annual Distribution of Discharges

The annual distribution of runoff is shown two ways: as average monthly runoff volume in acre-feet per month (**Figure D.3**) and as a percentage of average annual runoff volume (**Figure D.4**). **Table D.4** summarized the data used to generate **Figures D.3** and **D.4**.

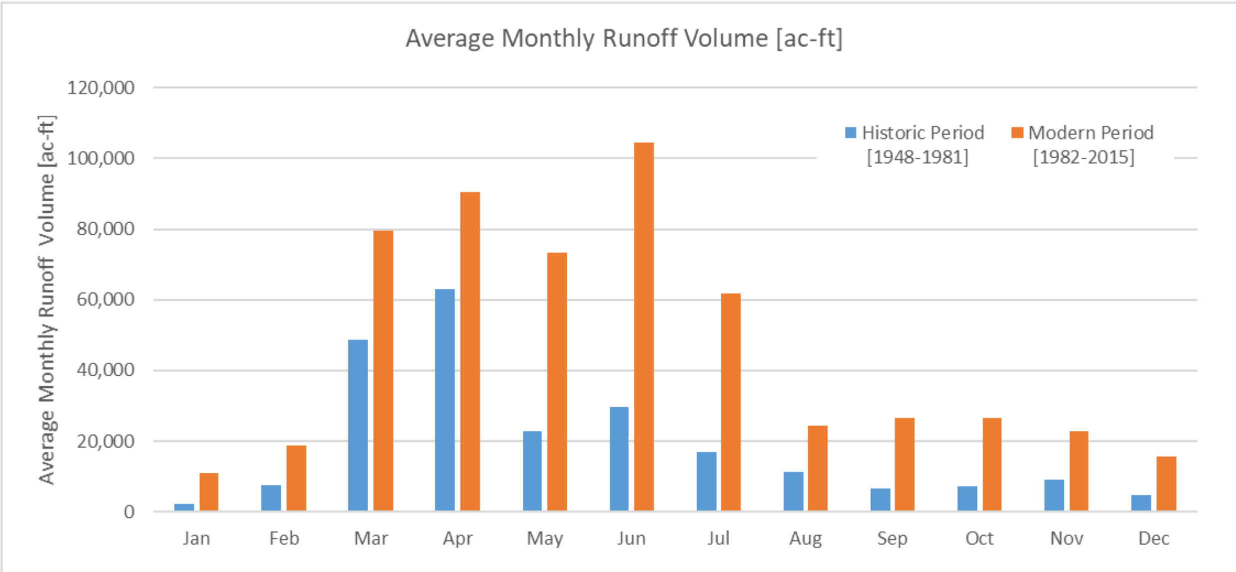

Figure D.3. Average monthly runoff volume [ac-ft] in the Rock River near Rock Valley, IA.

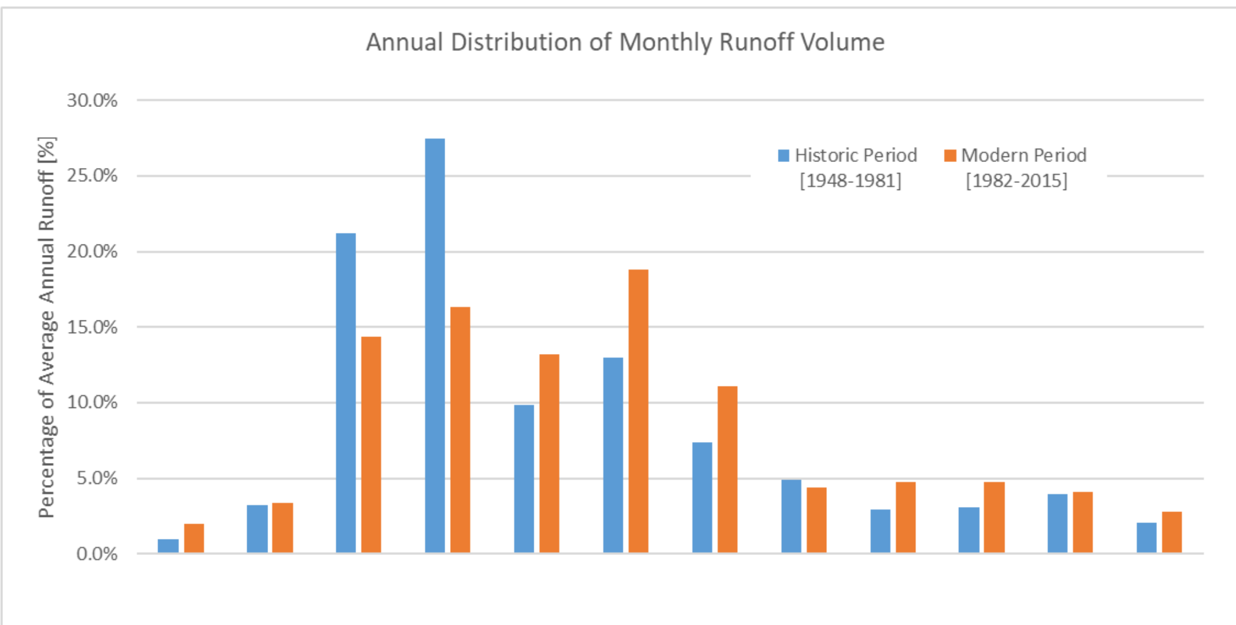

Figure D.4. Annual distribution of average monthly runoff volume as a percentage of annual total volume in the Rock River near Rock Valley, IA.

Table D.4. Average monthly runoff volume and annual distribution of monthly runoff volumes in Rock River near Rock Valley, IA.

Month	Average Monthly Volumes [ac-ft]	Distribution of Annual Volume

	Historic Period [1948-1981]	Modern Period [1982-2015]	% diff.	AH	Historic Period [1948-1981]	Modern Period [1982-2015]	% diff.	AH
Jan	2,228	11,064	396.5%	+	1.0%	2.0%	105.5%	+
Feb	7,469	18,808	151.8%	+	3.3%	3.4%	4.2%	o
Mar	48,712	79,693	63.6%	+	21.2%	14.4%	-32.3%	-
Apr	63,099	90,568	43.5%	+	27.5%	16.3%	-40.6%	-
May	22,691	73,281	223.0%	+	9.9%	13.2%	33.6%	+
Jun	29,792	104,454	250.6%	+	13.0%	18.8%	45.1%	+
Jul	16,878	61,667	265.4%	+	7.3%	11.1%	51.2%	+
Aug	11,195	24,216	116.3%	+	4.9%	4.4%	-10.5%	-
Sep	6,673	26,399	295.6%	+	2.9%	4.8%	63.7%	+
Oct	7,106	26,489	272.8%	+	3.1%	4.8%	54.2%	+
Nov	9,156	22,792	148.9%	+	4.0%	4.1%	3.0%	o
Dec	4,699	15,664	233.4%	+	2.0%	2.8%	37.9%	+

+ symbol indicates metric exhibits altered hydrology and an increase for the modern period compared to the historic period
o symbol indicates fails to exhibit altered hydrology for the modern period compared to the historic period
- symbol indicates metric exhibits altered hydrology and a decrease for the modern period compared to the historic period
AH means altered hydrology criterion

D.2.2 Timing of Annual Maximum and Minimum Flows

The timing of the annual maximum daily discharge and annual minimum daily discharge are important metrics of the annual distribution of flows. The timing of the annual maximum typical occurs during the spring flood and the timing of the annual minimum usually occurs during the winter months. **Table D.5** provides statistics on the Julian day of the annual maximum flow and **Table D.6** provides the Julian day for the annual minimum flow. The statistics include the average, the median, and the standard deviation of the Julian days when the maximum or minimum flow occur.

Table D.5. Julian Day of annual maximum in the Rock River near Rock Valley, IA.

Statistic	Historic Period [1948-1981]	Modern Period [1982-2015]	% diff.	AH
Average	23-Apr	19-May	22.97%	+
Median	1-Apr	29-May	64.29%	+
Standard Deviation	66 days	61 days	-7.47%	o

[1]Based on 365-day year.
+ symbol indicates metric exhibits altered hydrology and an increase for the modern period compared to the historic period
o symbol indicates fails to exhibit altered hydrology for the modern period compared to the historic period
- symbol indicates metric exhibits altered hydrology and a decrease for the modern period compared to the historic period
AH means altered hydrology criterion

Table D.6. Julian Day of annual minimum flow in the Rock River near Rock Valley, IA.

Statistic	Historic Period [1948-1981]	Modern Period [1982-2015]	% diff.	AH
Average	1-May	14-Jun	36.19%	+
Median	10-Feb	16-Aug	457.32%	+
Standard Deviation	128 days	128 days	-0.27%	o

[1]Based on 365-day year.
+ symbol indicates metric exhibits altered hydrology and an increase for the modern period compared to the historic period
o symbol indicates fails to exhibit altered hydrology for the modern period compared to the historic period
- symbol indicates metric exhibits altered hydrology and a decrease for the modern period compared to the historic period
AH means altered hydrology criterion

D.3 RIPARIAN FLOODPLAIN (LATERAL) CONNECTIVITY (PEAK FLOWS)

The riparian floodplain connectivity metrics represent the frequency and duration of flooding of the riparian area and the lateral connectivity between the stream and the riparian area. Functions include energy flow, deposition of sediment, channel formation and surface water – groundwater interactions. The riparian floodplain connectivity metrics include the discharge rates for the 10-year, the 25-year, the 50-year, and the 100-year peak discharges. The annual peak discharge rates for select return periods (1.01-year, 1.5-year, 2-year, 5-year, 10-year, 25-year, 50-year, 100-year, and 200-year) are shown in **Figure D.5**.

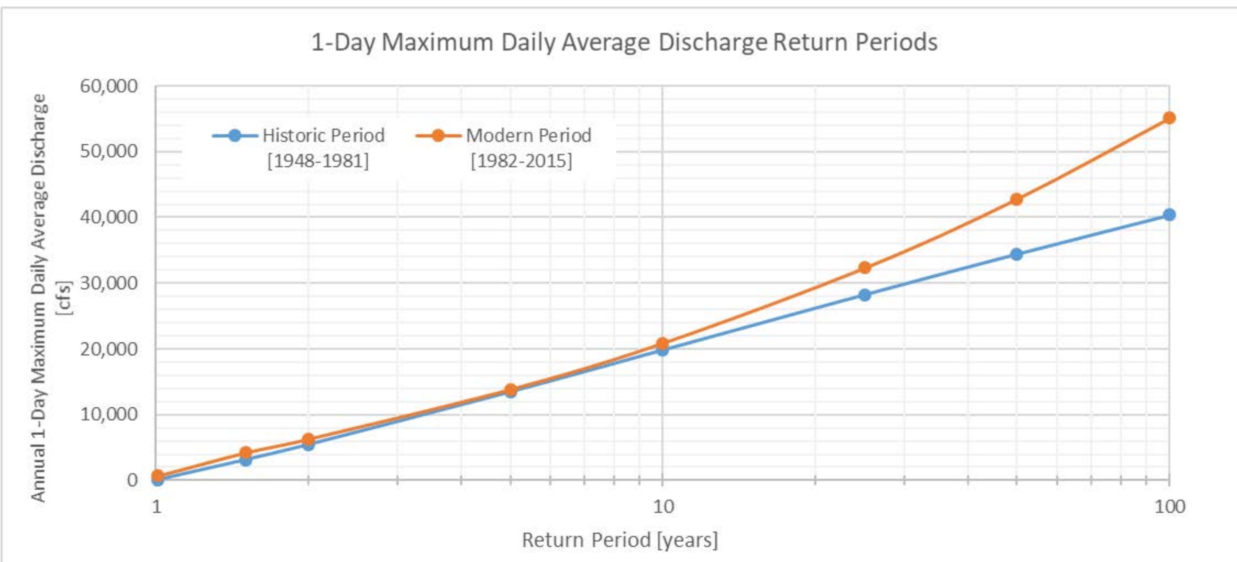

Figure D.5. Historical (1948-1981) versus modern (1982-2015) peak discharge return periods for Rock River near Rock Valley, IA.

In addition, the number of years with discharges exceeding the historic peak discharge within a period, the average number of days above the historic peak discharge rates, and the average cumulative volume of discharge above the historic peak discharges are provide (**Table D.7**).

Table D.7. Riparian floodplain connectivity metrics for the Rock River near Rock Valley, IA.

Flow Metric	Historic Period [1948-1981]	Modern Period [1982-2015]	% Diff.[1]	Altered Hydrology
5-Year Peak Discharge, Q(5) [cfs]	13,490	13,848	2.7%	o
Number of years with Discharge (Q) > Q_H (5)	7	9	28.6%	+
Average number of days per year Q > Q_H (5)	2	3	23.5%	+
Average annual cumulative volume > Q_H (5) [ac-ft]	26,143	31,727	21.4%	+
10-Year Peak Discharge, Q(10) [cfs]	19,850	20,881	5.2%	o
Number of years with Discharge (Q) > Q_H (10)	2	3	50.0%	+
Average number of days per year Q > Q_H (10)	3	2	-20.0%	-
Average annual cumulative volume > Q_H (10) [ac-ft]	35,157	38,215	8.7%	o
25-Year Peak Discharge, Q(25) [cfs]	28,250	32,308	14.4%	+
Number of years with Discharge (Q) > Q_H (25)	1	1	0.0%	o
Average number of days per year Q > Q_H (25)	2	2	0.0%	o
Average annual cumulative volume > Q_H (25) [ac-ft]	19,637	67,240	242.4%	+
50-Year Peak Discharge, Q(50) [cfs]	34,426	42,798	24.3%	+
Number of years with Discharge (Q) > Q_H (50)	1	1	0.0%	o
Average number of days per year Q > Q_H (50)	1	2	100.0%	+
Average annual cumulative volume > Q_H (50) [ac-ft]	1,932	42,741	2111.9%	+
100-Year Peak Discharge, Q(100) [cfs]	40,353	55,084	36.5%	+
Number of years with Discharge (Q) > Q_H (100)	0	1	NA	o
Average number of days per year Q > Q_H (100)	0	1	NA	o
Average annual cumulative volume > Q_H (100) [ac-ft]	0	23,102	NA	o

[1]No events occurred above return period discharge.
+ symbol indicates metric exhibits altered hydrology and an increase for the modern period compared to the historic period
o symbol indicates fails to exhibit altered hydrology for the modern period compared to the historic period
- symbol indicates metric exhibits altered hydrology and a decrease for the modern period compared to the historic period

D.4 GEOMORPHIC STABILITY AND CAPACITY TO TRANSPORT SEDIMENT

The geomorphic stability and capacity to transport sediment metrics are related to the channel forming discharge. An increase in these metrics would be interpreted as an increase in the risk of the stream channel susceptibility to erosion. These metrics include changes to the flow duration curves, the 1.5-year peak flow, the 2-year peak flow. The 1.5-year to 2-year peak flows are generally consider the range of channel forming flow. In addition, the number of years within a period exceeding the historic peak flows, the average number of days above the historic peak flow rates, and the average volume of flow above the historic peak flows are provide (**Table D.8**). **Figure D.6** is the flow duration curves for the historic and modern periods and **Table D.8** provides a summary of flows for select percent exceedances. Both show that discharges across the flow spectrum have increased substantially, with the exception of the very high flows.

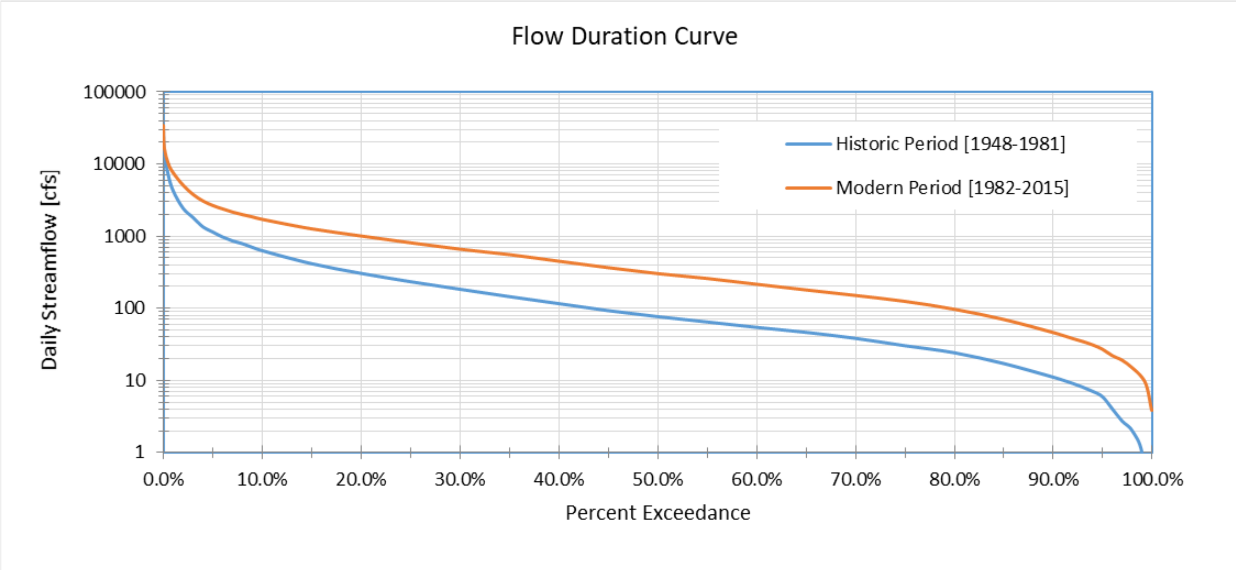

Figure D.6. Historical (1948-1981) versus modern (1982-2015) flow duration for Rock River near Rock Valley, IA.

Table D.8. Select summary of the flow duration curves for the Rock River near Rock Valley, IA.

Percent Exceedance	Historic Period [1948-1981]	Modern Period [1982-2015]	% Diff.	Altered Hydrology
0.10%	14,495	16,966	17.1%	+
1.0%	4,214	7,613	80.6%	+
10.0%	624	1,720	175.8%	+
25.0%	232	814	250.8%	+
50.0%	76	304	300.0%	+
75.0%	38	151	297.4%	+
90.0%	11	46	320.0%	+
99.0%	1	11	1000.0%	+
99.9%	0	4	NA	+

+ symbol indicates metric exhibits altered hydrology and an increase for the modern period compared to the historic period
o symbol indicates fails to exhibit altered hydrology for the modern period compared to the historic period
- symbol indicates metric exhibits altered hydrology and a decrease for the modern period compared to the historic period

Table D.9 provides the 1.5-year and 2-year annual peak flows and flow statistics, including peak discharge, number of years with flow rates above the historic return period flow, average number of days per year above the historic return period flow, and average volume above the historic return period flow.

Table D.9. Geomorphic stability and capacity to transport sediment metrics for the Rock River near Rock Valley, IA.

Flow Metric	Historic Period [1948-1981]	Modern Period [1982-2015]	% Diff.	Altered Hydrology
1.5-Year Peak Discharge, Q(1.5) [cfs]	3,164	4,191	32.5%	+
Number of years with Discharge (Q) > Q_H (1.5)	20	25	25.0%	+
Average number of days per year Q > Q_H (1.5)	9	19	124.7%	+
Average annual cumulative volume > Q_H (1.5) [ac-ft]	69,648	131,112	88.2%	+
2-Year Peak Discharge, Q(2) [cfs]	5,480	6,289	14.8%	+
Number of years with Discharge (Q) > Q_H (2)	17	18	5.9%	o
Average number of days per year Q > Q_H (2)	5	13	173.8%	+
Average annual cumulative volume > Q_H (2) [ac-ft]	50,264	98,408	95.8%	+

+ symbol indicates metric exhibits altered hydrology and an increase for the modern period compared to the historic period
o symbol indicates fails to exhibit altered hydrology for the modern period compared to the historic period
- symbol indicates metric exhibits altered hydrology and a decrease for the modern period compared to the historic period

D.5 SETTING GOALS

A summary of the storage goals is provided in **Table 7** in **Section 4.** The following are the methods used to develop those goals. Goals for addressing the change in hydrology were estimated using three methods. Each method is based on different assumptions and altered the metrics for a specific “altered hydrology” group (see Table 6). The first method is focused on the aquatic habitat and geomorphic and ability to transport sediment metric group and uses the change in the cumulative volume for mean daily discharges, exceeding the 1.5-year return period event. The cumulative total volume when the daily average discharge exceeds the 1.5-year peak discharge includes all flows above the 1.5-year peak, i.e. can include storms with much larger return periods. The change in average annual cumulative volume above the 1.5-year peak flow (see **Table D.9**) This method is based on the changes in the observed data and since it includes all flows above the 1.5-year flow relies on the two periods to have a similar distribution of flows.

The second method is based on the changes in hydrology across the entire annual hydrograph, and integrates the differences in return period discharges between the modern and historic period (see **Table D.10**) and finding a probability-weighted representative change in flow rate. A volume is then found by assuming a flow period equal to the change in flow period for the 1.5-year flow (i.e. the change in the number of days above the 1.5-year flow; see **Table D.9**).

Table D.10. Estimated goal for the drainage area of the Rock River near Rock Valley, IA using method 2.

Return Period	Historic Period Discharges (cfs)	Modern Period Discharges (cfs)	Difference (cfs)	Probability of Occurrence	Difference*Probability (cfs)
1.5	3,164	4,191	1027	0.67	684.8
2	5,480	6,289	810	0.50	404.8
5	13,490	13,848	358	0.20	71.6
10	19,850	20,881	1031	0.10	103.1
25	28,250	32,308	4058	0.04	162.3
50	34,426	42,798	8372	0.02	167.4
100	40,353	55,084	14731	0.01	147.3
				Sum (cfs):	1,741
				Sum (ac-ft/day):	3,455
		Number of days:	11	Total Volume Goal:	37,036 AF (0.44 in.)

The third method is also based on addressing the effects through the entire flow range and is a revision to Method 2. Method 3 considers incorporates the observed change in the timing of the peak discharge for each return period event. This method uses the probability-weighted representative change in flow rate and multiples the flow rates by the change in the number of days exceeding the return period flow for each return period (see **Table D.11**).

Table D.11. Estimated goal for the drainage area of the Rock River near Rock Valley, IA using method 3.

Return Period	Change in Flow (Q_m-Q_h) [cfs]	Probability of Occurrence	Probability Weighted Flow [AF/day]	Change in number of days above flow (days)	Storage Volume
1.5	1,027	0.67	1,358.7	11	14,565
2	810	0.50	803.1	8	6,485
5	358	0.20	142.0	1	81
10	1,031	0.10	204.5	0	0
25	4,058	0.04	322.0	0	0
50	8,372	0.02	332.2	1	332
100	14,731	0.01	292.3	1	292
				Total Volume Goal:	21,756 AF (0.26 in.)

APPENDIX E: METRICS OF ALTERED HYDROLOGY FOR BIG SIOUX RIVER AT AKRON, IA (USGS# 06485500).

The following is the summary statistics used to determine the altered hydrology metrics in detail and develop the storage goals. A summary of these statistic is shown in **Table 6** in **Section 3.4.1**.

E.1 CONDITION OF AQUATIC HABITAT

The condition of aquatic habitat includes a group of metrics that primarily reflect the flow characteristics of the annual hydrograph, needed to maintain adequate habitat for fish and aquatic life. The 7-day low flow, the 30-day low flow, and the median November mean daily discharge are metrics used to represent changes in the availability of flow for aquatic habitat.

E.1.1 Annual minimum 30-day mean daily discharge

The annual minimum 30-day mean daily discharge is the minimum of the 30-day moving mean daily discharge within a year (an annual minimum series). **Figure E.1** shows the annual minimum 30-day mean daily discharge for select return periods (1.01-year, 1.5-year, 2-year, 5-year, 10-year, 25-year, 50-year, and 100-year). **Table E.1** summarizes the data shown in **Figure E.1**.

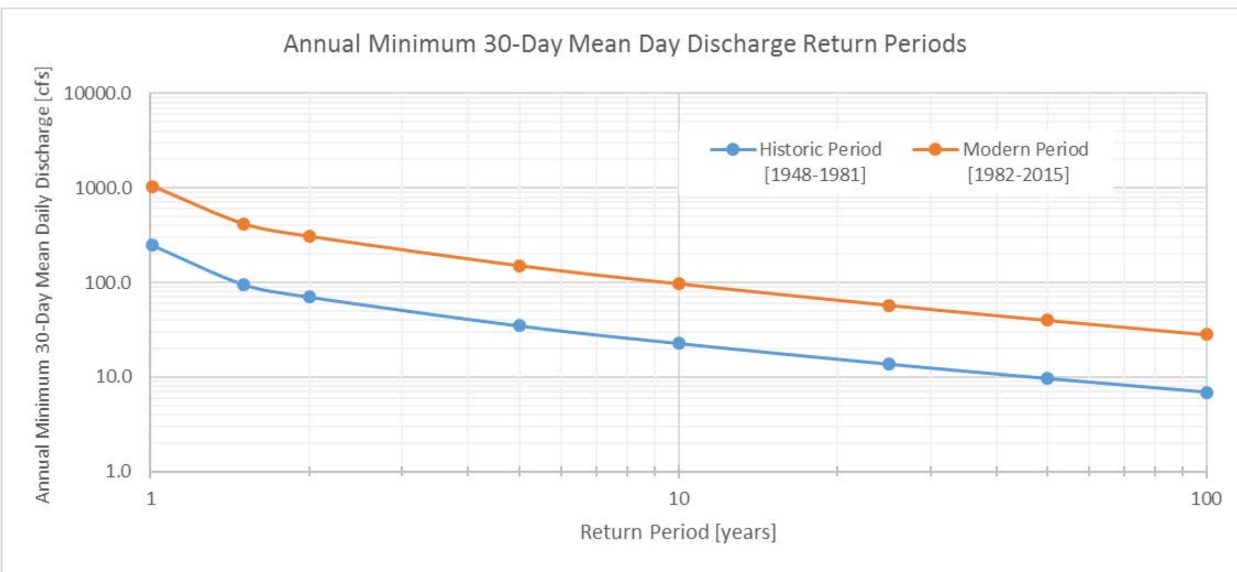

Figure E.1. Historical (1940-1975) versus modern (1980-2015) annual minimum 30-day mean daily discharge versus return period for Big Sioux River at Akron, IA.

Table E.1: Summary of annual minimum 30-day mean daily discharge by return periods for the Big Sioux River at Akron, IA.

Return Period	Historic Period [1948-1981]	Modern Period [1982-2015]	% Diff.	Altered Hydrology Criterion
1.01	247.3	1040.1	320.5%	+
1.5	95.3	417.7	338.3%	+
2	70.2	308.0	338.7%	+
5	34.7	150.8	333.9%	+
10	22.7	97.1	328.4%	+
25	13.7	57.6	320.1%	+
50	9.7	39.9	313.4%	+
100	6.9	28.1	306.6%	+

+ symbol indicates metric exhibits altered hydrology and an increase for the modern period compared to the historic period
o symbol indicates fails to exhibit altered hydrology for the modern period compared to the historic period
- symbol indicates metric exhibits altered hydrology and a decrease for the modern period compared to the historic period

E.1.2 Annual Minimum 7-Day Mean Daily Discharge

Like the annual minimum 30-day mean daily discharge, the annual minimum 7-day mean daily discharge is the minimum of the 7-day moving average flow in the year. **Figure E.2** shows the annual minimum 7-day mean daily discharges for select return periods (1.01-year, 1.5-year, 2-year, 5-year, 10-year, 25-year, 50-year, and 100-year). **Table E.2** summarizes the data shown in **Figure E.2**.

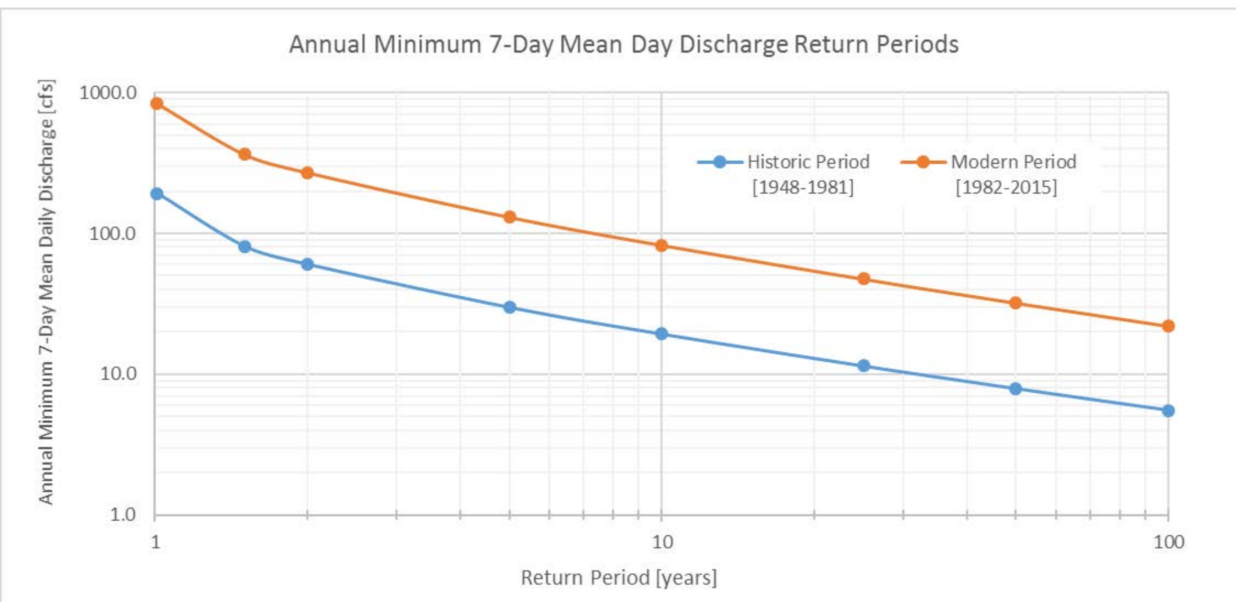

Figure E.2. Historical (1940-1975) versus modern (1980-2015) annual minimum 7-day mean daily discharge return periods for Big Sioux River at Akron, IA.

Table E.2: Summary of annual minimum 7-day mean daily discharge return periods for the Big Sioux River at Akron, IA.

Return Period	Historic Period [1948-1981]	Modern Period [1982-2015]	% Diff.	Altered Hydrology Criterion
1.0101	192.8	837.2	334.3%	+
1.5	81.2	365.7	350.3%	+
2	60.3	270.9	349.0%	+
5	29.8	130.9	338.9%	+
10	19.2	82.6	329.5%	+
25	11.4	47.5	316.2%	+
50	7.9	32.0	306.0%	+
100	5.5	21.9	295.8%	+

+ symbol indicates metric exhibits altered hydrology and an increase for the modern period compared to the historic period
o symbol indicates fails to exhibit altered hydrology for the modern period compared to the historic period
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E.1.3 November Median Daily Discharge

The median daily mean discharge for November is another indicator of baseflow. This metric is intended to represent baseflow condition during the winter months. **Table E.3** provides the median November flow for each perioE.

Table E.3: Historical (1940-1975) and modern (1980-2015) median November flow for the Big Sioux River at Akron, IA.

Return Period	Historic Period [1948-1981]	Modern Period [1982-2015]	% Diff.	Altered Hydrology Criterion
Period median November flow [cfs]	198.0	799.5	303.8%	+

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o symbol indicates fails to exhibit altered hydrology for the modern period compared to the historic period
- symbol indicates metric exhibits altered hydrology and a decrease for the modern period compared to the historic period

E.2 AQUATIC ORGANISM LIFE CYCLE

The shape of the annual hydrograph and timing of discharges are associated with ecological cues. Metrics related to the aquatic organism life cycle include the shape of the annual hydrographs, timing of the annual minimum flow, and timing of the annual peak flow.

E.2.1 Annual Distribution of Discharges

The annual distribution of runoff is shown two ways: as average monthly runoff volume in acre-feet per month (**Figure E.3**) and as a percentage of average annual runoff volume (**Figure E.4**). **Table E.4** summarized the data used to generate **Figures E.3** and **E.4**.

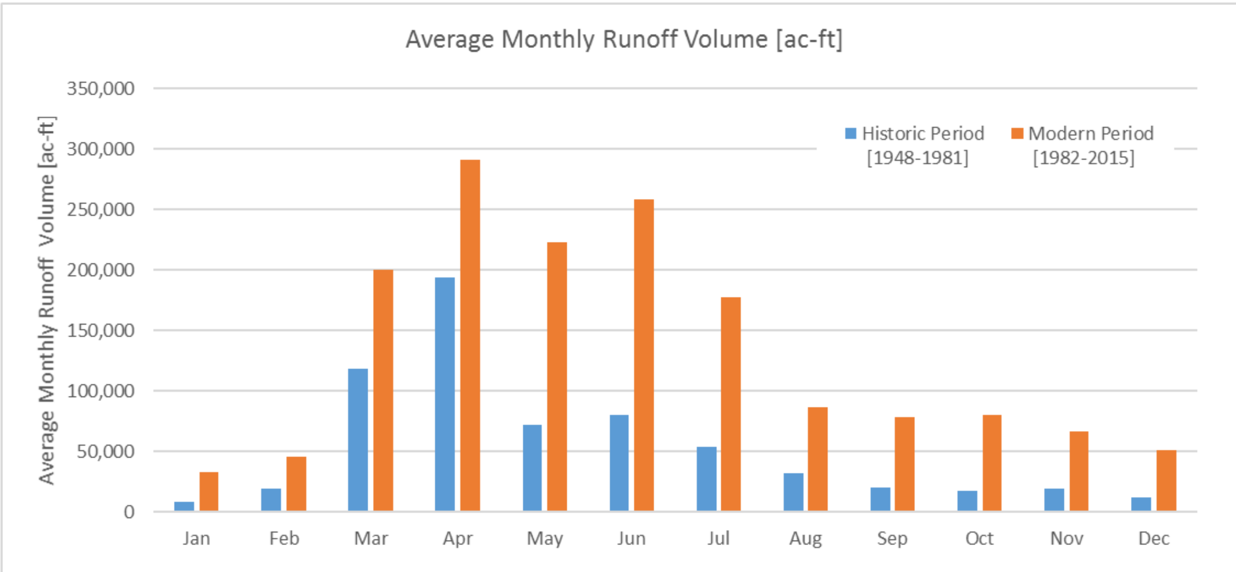

Figure E.3. Average monthly runoff volume [ac-ft] in the Big Sioux River at Akron, IA.

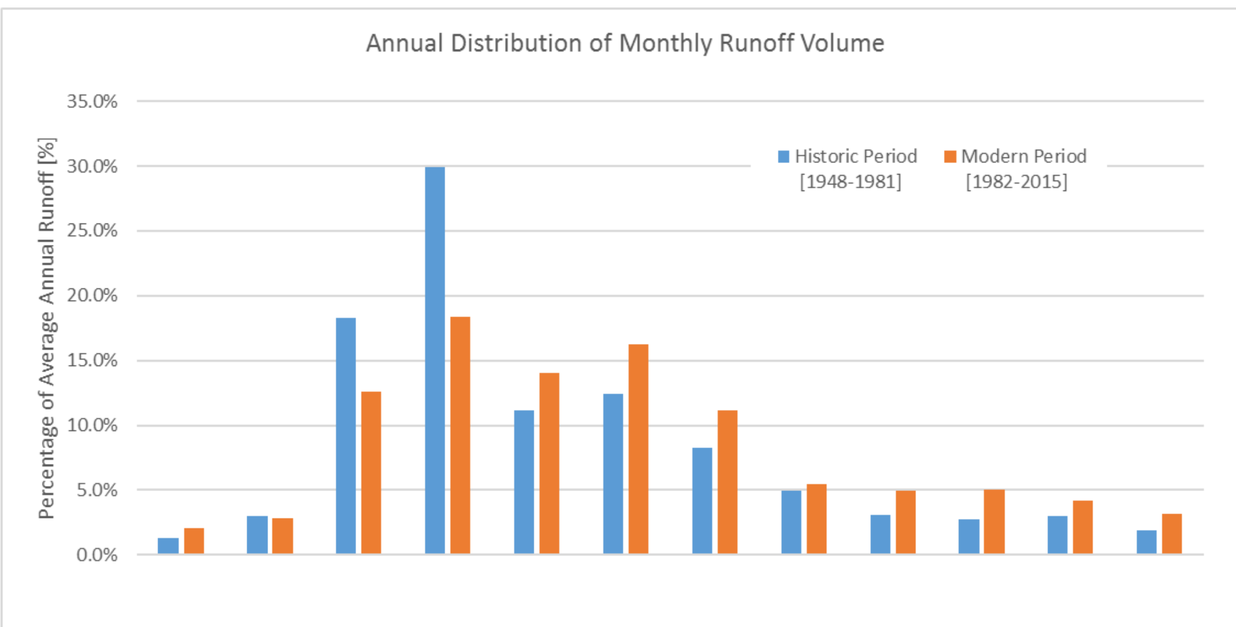

Figure E.4. Annual distribution of average monthly runoff volume as a percentage of annual total volume in the Big Sioux River at Akron, IA.

Table E.4. Average monthly runoff volume and annual distribution of monthly runoff volumes in Big Sioux River at Akron, IA.

Month	Average Monthly Volumes [ac-ft]	Distribution of Annual Volume

	Historic Period [1948-1981]	Modern Period [1982-2015]	% diff.	AH	Historic Period [1948-1981]	Modern Period [1982-2015]	% diff.	AH
Jan	8,216	32,855	299.9%	+	1.3%	2.1%	62.9%	+
Feb	19,445	45,504	134.0%	+	3.0%	2.9%	-4.7%	o
Mar	118,473	199,879	68.7%	+	18.3%	12.6%	-31.3%	-
Apr	193,592	291,454	50.6%	+	29.9%	18.3%	-38.7%	-
May	72,118	222,750	208.9%	+	11.1%	14.0%	25.8%	+
Jun	80,433	258,104	220.9%	+	12.4%	16.2%	30.7%	+
Jul	53,440	177,335	231.8%	+	8.3%	11.2%	35.1%	+
Aug	31,868	86,367	171.0%	+	4.9%	5.4%	10.4%	+
Sep	20,210	78,206	287.0%	+	3.1%	4.9%	57.6%	+
Oct	17,647	80,059	353.7%	+	2.7%	5.0%	84.8%	+
Nov	19,621	66,509	239.0%	+	3.0%	4.2%	38.0%	+
Dec	12,336	50,617	310.3%	+	1.9%	3.2%	67.1%	+

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AH means altered hydrology criterion

E.2.2 Timing of Annual Maximum and Minimum Flows

The timing of the annual maximum daily discharge and annual minimum daily discharge are important metrics of the annual distribution of flows. The timing of the annual maximum typical occurs during the spring flood and the timing of the annual minimum usually occurs during the winter months. **Table E.5** provides statistics on the Julian day of the annual maximum flow and **Table E.6** provides the Julian day for the annual minimum flow. The statistics include the average, the median, and the standard deviation of the Julian days when the maximum or minimum flow occur.

Table E.5. Julian Day of annual maximum in the Big Sioux River at Akron, IA.

Statistic	Historic Period [1948-1981]	Modern Period [1982-2015]	% diff.	AH
Average	26-Apr	19-May	19.57%	+
Median	5-Apr	25-May	51.83%	+
Standard Deviation	57 days	52 days	-8.05%	o

[1]Based on 365-day year.
+ symbol indicates metric exhibits altered hydrology and an increase for the modern period compared to the historic period
o symbol indicates fails to exhibit altered hydrology for the modern period compared to the historic period
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AH means altered hydrology criterion

Table E.6. Julian Day of annual minimum flow in the Big Sioux River at Akron, IA.

Statistic	Historic Period [1948-1981]	Modern Period [1982-2015]	% diff.	AH
Average	26-Mar	29-May	74.27%	+
Median	2-Feb	27-Feb	75.76%	+
Standard Deviation	103 days	127 days	22.54%	+

[1]Based on 365-day year.
+ symbol indicates metric exhibits altered hydrology and an increase for the modern period compared to the historic period
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- symbol indicates metric exhibits altered hydrology and a decrease for the modern period compared to the historic period
AH means altered hydrology criterion

E.3 RIPARIAN FLOODPLAIN (LATERAL) CONNECTIVITY (PEAK FLOWS)

The riparian floodplain connectivity metrics represent the frequency and duration of flooding of the riparian area and the lateral connectivity between the stream and the riparian area. Functions include energy flow, deposition of sediment, channel formation and surface water – groundwater interactions. The riparian floodplain connectivity metrics include the discharge rates for the 10-year, the 25-year, the 50-year, and the 100-year peak discharges. The annual peak discharge rates for select return periods (1.01-year, 1.5-year, 2-year, 5-year, 10-year, 25-year, 50-year, 100-year, and 200-year) are shown in **Figure E.5**.

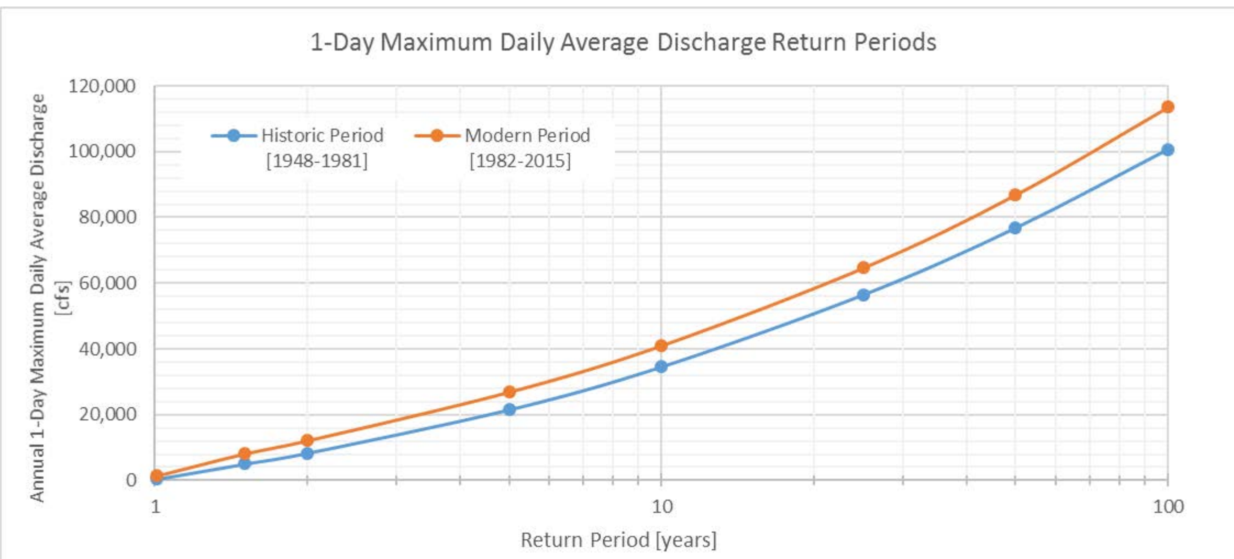

Figure E.5. Historical (1940-1975) versus modern (1980-2015) peak discharge return periods for Big Sioux River at Akron, IA.

In addition, the number of years with discharges exceeding the historic peak discharge within a period, the average number of days above the historic peak discharge rates, and the average cumulative volume of discharge above the historic peak discharges are provide (**Table E.7**).

Table E.7. Riparian floodplain connectivity metrics for the Big Sioux River at Akron, IA.

Flow Metric	Historic Period [1948-1981]	Modern Period [1982-2015]	% Diff.[1]	Altered Hydrology
5-Year Peak Discharge, Q(5) [cfs]	21,533	26,956	25.2%	+
Number of years with Discharge (Q) > Q_H (5)	6	10	66.7%	+
Average number of days per year Q > Q_H (5)	5	6	16.0%	+
Average annual cumulative volume > Q_H (5) [ac-ft]	161,359	116,070	-28.1%	-
10-Year Peak Discharge, Q(10) [cfs]	34,589	41,089	18.8%	+
Number of years with Discharge (Q) > Q_H (10)	3	5	66.7%	+
Average number of days per year Q > Q_H (10)	5	3	-40.0%	-
Average annual cumulative volume > Q_H (10) [ac-ft]	152,300	66,547	-56.3%	-
25-Year Peak Discharge, Q(25) [cfs]	56,428	64,690	14.6%	+
Number of years with Discharge (Q) > Q_H (25)	1	1	0.0%	o
Average number of days per year Q > Q_H (25)	4	2	-50.0%	-
Average annual cumulative volume > Q_H (25) [ac-ft]	98,160	98,468	0.3%	o
50-Year Peak Discharge, Q(50) [cfs]	76,743	86,937	13.3%	+
Number of years with Discharge (Q) > Q_H (50)	1	1	0.0%	o
Average number of days per year Q > Q_H (50)	1	1	0.0%	o
Average annual cumulative volume > Q_H (50) [ac-ft]	1,502	41,369	2655.0%	+
100-Year Peak Discharge, Q(100) [cfs]	100,614	113,598	12.9%	+
Number of years with Discharge (Q) > Q_H (100)	0	0	NA	o
Average number of days per year Q > Q_H (100)	0	0	NA	o
Average annual cumulative volume > Q_H (100) [ac-ft]	0	0	NA	o

[1]No events occurred above return period discharge.
+ symbol indicates metric exhibits altered hydrology and an increase for the modern period compared to the historic period
o symbol indicates fails to exhibit altered hydrology for the modern period compared to the historic period
- symbol indicates metric exhibits altered hydrology and a decrease for the modern period compared to the historic period

E.4 GEOMORPHIC STABILITY AND CAPACITY TO TRANSPORT SEDIMENT

The geomorphic stability and capacity to transport sediment metrics are related to the channel forming discharge. An increase in these metrics would be interpreted as an increase in the risk of the stream channel susceptibility to erosion. These metrics include changes to the flow duration curves, the 1.5-year peak flow, the 2-year peak flow. The 1.5-year to 2-year peak flows are generally consider the range of channel forming flow. In addition, the number of years within a period exceeding the historic peak flows, the average number of days above the historic peak flow rates, and the average volume of flow above the historic peak flows are provide (**Table E.8**). **Figure E.6** is the flow duration curves for the historic and modern periods and **Table E.8** provides a summary of flows for select percent exceedances. Both show that discharges across the flow spectrum have increased substantially, with the exception of the very high flows.

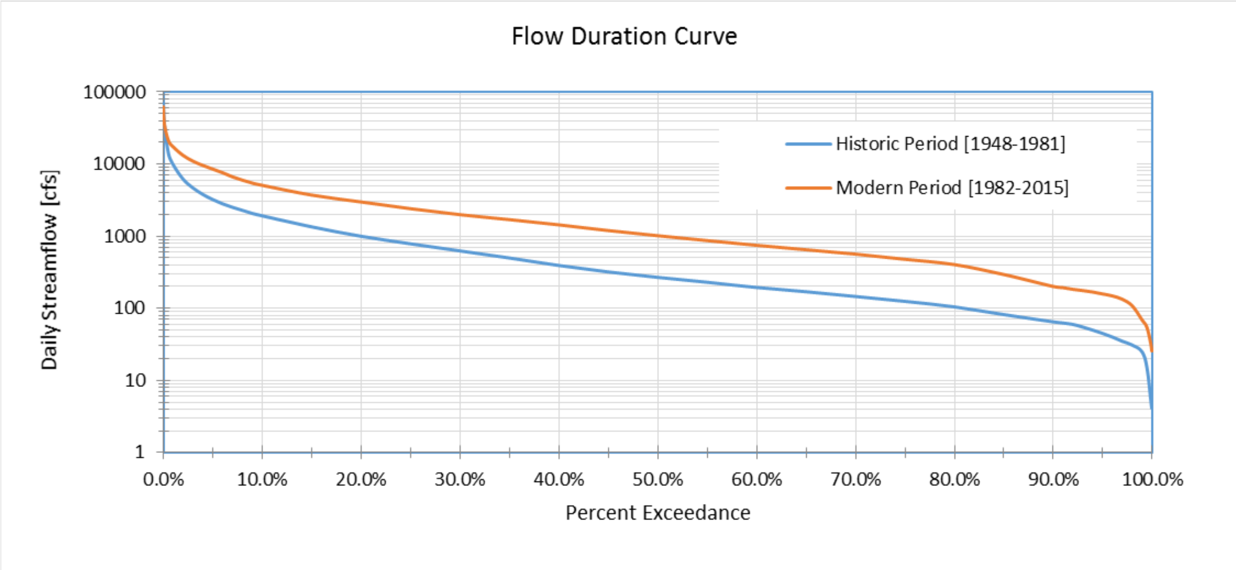

Figure E.6. Historical (1940-1975) versus modern (1980-2015) flow duration for Big Sioux River at Akron, IA.

Table E.8. Select summary of the flow duration curves for the Big Sioux River at Akron, IA.

Percent Exceedance	Historic Period [1948-1981]	Modern Period [1982-2015]	% Diff.	Altered Hydrology
0.10%	37,975	36,241	-4.6%	o
1.0%	9,818	17,200	75.2%	+
10.0%	1,920	5,060	163.5%	+
25.0%	785	2,408	206.7%	+
50.0%	269	1,020	279.2%	+
75.0%	146	567	288.4%	+
90.0%	65	203	212.3%	+
99.0%	25	70	180.0%	+
99.9%	5	32	527.5%	+

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o symbol indicates fails to exhibit altered hydrology for the modern period compared to the historic period
- symbol indicates metric exhibits altered hydrology and a decrease for the modern period compared to the historic period

Table E.9 provides the 1.5-year and 2-year annual peak flows and flow statistics, including peak discharge, number of years with flow rates above the historic return period flow, average number of days per year above the historic return period flow, and average volume above the historic return period flow.

Table E.9. Geomorphic stability and capacity to transport sediment metrics for the Big Sioux River at Akron, IA.

Flow Metric	Historic Period [1948-1981]	Modern Period [1982-2015]	% Diff.	Altered Hydrology
1.5-Year Peak Discharge, Q(1.5) [cfs]	5,031	8,142	61.9%	+
Number of years with Discharge (Q) > Q_H (1.5)	22	28	27.3%	+
Average number of days per year Q > Q_H (1.5)	16	45	187.9%	+
Average annual cumulative volume > Q_H (1.5) [ac-ft]	199,585	464,484	132.7%	+
2-Year Peak Discharge, Q(2) [cfs]	8,346	12,167	45.8%	+
Number of years with Discharge (Q) > Q_H (2)	17	21	23.5%	+
Average number of days per year Q > Q_H (2)	9	30	221.8%	+
Average annual cumulative volume > Q_H (2) [ac-ft]	167,683	341,561	103.7%	+

+ symbol indicates metric exhibits altered hydrology and an increase for the modern period compared to the historic period
o symbol indicates fails to exhibit altered hydrology for the modern period compared to the historic period
- symbol indicates metric exhibits altered hydrology and a decrease for the modern period compared to the historic period

E.5 SETTING GOALS

A summary of the storage goals is provided in **Table 7** in **Section 4.** The following are the methods used to develop those goals. Goals for addressing the change in hydrology were estimated using three methods. Each method is based on different assumptions and altered the metrics for a specific "altered hydrology" group (see Table 6). The first method is focused on the aquatic habitat and geomorphic and ability to transport sediment metric group and uses the change in the cumulative volume for mean daily discharges, exceeding the 1.5-year return period event. The cumulative total volume when the daily average discharge exceeds the 1.5-year peak discharge includes all flows above the 1.5-year peak, i.e. can include storms with much larger return periods. The change in average annual cumulative volume above the 1.5-year peak flow (see **Table E.9**) This method is based on the changes in the observed data and since it includes all flows above the 1.5-year flow relies on the two periods to have a similar distribution of flows.

The second method is based on the changes in hydrology across the entire annual hydrograph, and integrates the differences in return period discharges between the modern and historic period (see **Table E.10**) and finding a probability-weighted representative change in flow rate. A volume is then found by assuming a flow period equal to the change in flow period for the 1.5-year flow (i.e. the change in the number of days above the 1.5-year flow; see **Table E.9**).

Table E.10. Estimated goal for the drainage area of the Big Sioux River at Akron, IA using method 2.

Return Period	Historic Period Discharges (cfs)	Modern Period Discharges (cfs)	Difference (cfs)	Probability of Occurrence	Difference*Probability (cfs)
1.5	5,031	8,142	3112	0.67	2,074.4
2	8,346	12,167	3820	0.50	1,910.2
5	21,533	26,956	5423	0.20	1,084.6
10	34,589	41,089	6500	0.10	650.0
25	56,428	64,690	8262	0.04	330.5
50	76,743	86,937	10194	0.02	203.9
100	100,614	113,598	12983	0.01	129.8
				Sum (cfs):	6,383
				Sum (ac-ft/day):	12,665
		Number of days:	29	Total Volume Goal:	369,870 AF (0.88 in.)

The third method is also based on addressing the effects through the entire flow range and is a revision to Method 2. Method 3 considers incorporates the observed change in the timing of the peak discharge for each return period event. This method uses the probability-weighted representative change in flow rate and multiples the flow rates by the change in the number of days exceeding the return period flow for each return period (see **Table E.11**).

Table E.11. Estimated goal for the drainage area of the Big Sioux River at Akron, IA using method 3.

Return Period	Change in Flow (Q_m-Q_h) [cfs]	Probability of Occurrence	Probability Weighted Flow [AF/day]	Change in number of days above flow (days)	Storage Volume
1.5	3,112	0.67	4,115.7	29	120,197
2	3,820	0.50	3,789.8	21	79,607
5	5,423	0.20	2,151.9	1	1,721
10	6,500	0.10	1,289.6	0	0
25	8,262	0.04	655.7	0	0
50	10,194	0.02	404.5	0	0
100	12,983	0.01	257.6	0	0
				Total Volume Goal:	201,526 AF (0.48 in.)

APPENDIX F: A CHANGING HYDROLOGY-THE SCIENTIFIC DEBATE

It is the position of the authors that, although as helpful as it would be, understanding the causes of altered hydrology is not needed to quantify level of changes and develop mitigation goals. Although not necessary to quantify altered hydrology and set mitigation goals, understanding the causes of altered hydrology can be useful for water resources managers and stakeholders within a watershed. The following summarizes the ongoing discussion on the potential causes of altered hydrology in order to provide background on the research that has been conducted on the subject.

Numerous studies have investigated the links between changes in climate and the landscape to changes in the hydrologic response in a variety of watersheds (see References Section) but the science is not at point where causes of the alterations can be definitively linked to specific causes and quantified. The scientific discussion has circulated around two opposing viewpoints: altered hydrology is mainly driven by climatic changes, or is mainly driven by changes to the landscape, i.e. man-made or anthropomorphic changes. The complex nature of the relationship between precipitation and streamflow drives these conflicting viewpoints. *Poff et al.* (1996) summarizes the complex nature of streamflow as: *All river flow derives ultimately from precipitation but in any given time and place a river's flow is derived from some combination of surface water, soil water, and groundwater. Climate, geology, topography, soils, and vegetation help to determine both the supply of water and the pathways by which precipitation reaches the channel*.

Even though the main drivers of altered hydrology are still being debated, all agree that streamflow in Minnesota's streams, as well as the contiguous United States, have been increasing since the middle of the twentieth century (*Novotny and Stefan 2007, Lins and Slack 1999 & 2005*). *McCabe and Wolock* (2002) noticed a discernable step change in streams across the conterminous United States during the 1970s. The mid-1970s is typically viewed as the breakpoint in hydrology and corresponds to numerous compounding factors occurring, in general, around the same period. Those factors include the widespread replacement of grasses and small grains as the predominate crops to row crops, such as corn and soybeans in the Midwest (S*chilling, 2003, 2005; Zhang and Schilling, 2006; Foufoula-Georgiou et al.; 2016*), as well as the conversion of forest and wetlands to agricultural lands, and was accompanied by wide spread adoption of plastic tile drainage (*Gupta et al, 2015*). Artificial surface and subsurface drainage is viewed by many as a major contributor to increased streamflow (see *Shilling & Libra 2003; Raymond et al, 2008; Schottler et al, 2014* as examples). In addition, the following decades have seen documented climatic trends, including of warmer temperatures, earlier snowmelt, increased annual precipitation, and rainfall events of higher intensity and shorter duration (*Karl et al., 1996; Karl and Knight, 1998; Groisman et al., 2004; Villarinni et al., 2011; Danesh-Yazdi et al., 2016*). The following will discuss the literature linking climate changes to altered hydrology, followed by the literature linking anthropomorphic changes to altered hydrology, and a brief description of some issues within the current science.

Climate, specifically precipitation, is the main driver (over both space and time) for the generation of runoff, as all other components of runoff generation translate precipitation into runoff (see *Poff et al. 1996*). Increases in intensity, duration, and frequency of precipitation, changes in the timing of the spring snowmelt, and increases in magnitude and timing of seasonal temperatures can all play a role changing hydrology in a watershed. *Novonty and Stefan* (2007) correlated trends seen in Minnesota's streamflows to changes in observed climate. *Tomer and Schilling* (2009) concluded that climate change has been the larger of the two main drivers (climate change and land use change) for increased streamflows in the Midwestern United States. Using a non-linear water-balance approach, *Ryberg et al.* (2014) show that changes in precipitation and potential evapotranspiration explain the majority of multidecadal spatial/temporal variability in runoff and flood magnitudes, with precipitation being the main driver, and that historical changes in climate and runoff appear to be more consistent with complex transient shifts in seasonal climate conditions than with gradual climate changes. According to

Foufoula-Georgiou et al. (2015), two major trends have been observed: (1) higher temperatures leading to earlier snowmelt and a longer growing season and (2) an increase in precipitation with an intensification of extreme storms (e.g., Lettenmaier et al., 1994; Changnon and Kunkel, 1995; Karl et al., 1996; Angel and Huff, 1997; Michaels et al., 2004; Groisman et al., 2004, 2012; Pryor et al., 2009; Villarini et al., 2011; Higgins and Kousky, 2013; Walsh et al., 2014). Changes in evaporative and radiative cooling have also been reported and attributed to the enhanced seasonal precipitation signal (Milly and Dunne, 2001).

In addition to climatic changes, researchers have stipulated that streamflows have been increasing more than the increased precipitation alone can explain (*Raymond et al., 2008; Zhang and Schilling, 2006; Schillings et al., 2010*). Raymond et al. (2008) argued that changing agricultural practices have led to a 50 km^3 yr^{-1} increase in water flux from the Mississippi River from a pre- to post-disturbance period (before and after 1940). Zhang and Schilling (2006) concluded that increasing discharge since the 1940s was mainly due to an increase in baseflow resulting from the rapid expansion of soybean cultivation that occurred in the Mississippi River basin during the middle of the 20th century (343% increase from 1950 to 1992; Donner et. al., 2003). Agricultural landscape changes can significantly change seasonal evapotranspiration (ET) potential (Zhang and Schilling, 2006; Schilling et al., 2008). Wang and Hejazi (2011) found human activities contributed more to increasing flows than climate and showed the increases were correlated with the fractional area in cropland. Given the extent of past wetland drainage and current widespread use of tile drainage (Sugg, 2007; Blann et al., 2009), artificial drainage networks have the potential to alter the plumbing in a watershed. Schottler et al. (2014) examined the residuals of the water budget for 21 agricultural watersheds and determined that climate and crop conversion could explain less than half of the observed changes in streamflow and concluded that artificial tile drainage was the main driver behind increasing streamflows. In addition to agricultural landscape changes, numerous other factors may play a role in a changing hydrology, including impoundments and flow regulation (e.g. dams), increased imperviousness and urbanization, groundwater pumpage, and changes in alternative supplies (i.e. wastewater outflows or irrigation), to name a few.

Gupta et al. (2015) evaluated the findings of numerous papers claiming of the importance of landscape changes and the impacts of artificial drainage driving the observed changes in streamflow. The authors indicated that the majority of the research showing the impacts of agricultural influences (*Schilling, 2003; Schilling and Libra, 2003; Schilling et al., 2008; Zhang and Schilling, 2006*) are strictly based on empirical approaches that fail to account for the underlying principles of soil water storage, water infiltration, and surface runoff. *Schottler et al.* (2014) showed that runoff ratios increased primarily due to landscape modification, but failed to recognize that the changes could be due to increased soil wetness from the increased precipitation, leading to increased runoff (*Gupta et al., 2015*). The findings that wide spread adoption of soybeans reduced the ratio of annual ET to annual precipitation, leading to increased streamflows, is based on two observations: (1) an empirical relationship relating baseflow to fractional area under soybean production (*Zhang and Schilling, 2006*), and (2) an ET analysis that showed a decrease in the ratio of ET to precipitation. However, Baker et al (2012) showed that ET has remained relatively similiar since the 1960s in the Upper Mississippi River Basin. Gupta et al. (2015) questioned why ET has remained relatively constant over time even though there have been substantial changes in the landscape, including tile drainage, drainage of wetlands, cultivation of prairies, and adoption of different crops in the cropping system? Gupta et al. (2015) tested the assumptions of these papers and concluded, among others, that linear regression models showed no significant shift in the slope and intercept when comparing two periods (before and after 1975) and that added regression coefficients did not add statistical significance, concluding no significant change in the relationship between precipitation and streamflow and that the increases in streamflows are mainly due to increased precipitation, consistent with the principles of higher soil moisture conditions. But it is unknown how Gupta et al. (2015) accounted for the inter-annual dependency of streamflow (e.g. storages such as soil moisture) in their regressions. In addition, it is not surprising that precipitation is the only regression coefficient with statistical significance. Precipitation can be thought of as the only “independent” variable, in a physical sense all other potential variables are dependent on precipitation to generate runoff (e.g. soil moisture relies on the history of precipitation and evapotranspiration).

A common theme of, and a potential common problem with, most studies that have investigated the causes of the increased streamflow, regardless if it is a statistical analysis, developing empirical relationships, or a regression analysis, is the reliance and use of seasonal and annual relationships between precipitation and streamflow. On a large scale (both spatial and temporal), most runoff generation is ultimately driven by precipitation, and all other mechanisms in a watershed just translate precipitation into streamflow. In a sense, precipitation is the only independent variable and all other factors are part of the error in any regression equation. The large natural variation in annual climate and annual streamflow make it difficult to tease out any other potential causes of altered hydrology, leading the current debate on direct causes and lack of consensus in the science. The scientific debate has focused on which of the two leading candidate causes (climate or anthropomorphic changes) of altered hydrology. The science debate should continue to work towards a more rigorous understanding of altered hydrology causes. However, this paper provides a methodology to quantify changes in hydrology and sets mitigation goals without attempting to investigate causes.

Appendix K
Methodology:
Rural Land Stewardship

MISSOURI RIVER
WATERSHED
Comprehensive
Watershed
Management Plan

RURAL LAND STEWARDSHIP ANALYSIS

This plan frames the soil health measurable goal (3.2.17) around principles of rural land stewardship. For the purposes of this plan, “land stewardship” is defined as:

“creating solutions to water quality and quantity challenges using a combination of management and structural practices, in recognition that attaining short-term and long-term measurable goals cannot be accomplished though structural practices alone.”

Land stewardship is included as a measurable goal to promote:

- the protection of public health, through the presence of safe drinking water supplies, surface water quality suitable for public use, and the maintenance and protection of high-quality resources;
- a safe and secure food supply, achieved in part through maintaining and building soil health, reducing soil loss, and maintaining and increasing modern agricultural yields;
- the retention of water where it falls on the land surface, to the extent possible;
- the restoration and protection of the public uses of lake, streams and rivers;
- conservation delivered to the ground, preferentially at locations meeting the economic value proposition of the land owner; and
- the economic stability and viability of the community.

Land stewardship can be subdivided into three categories: urban, rural, and shoreland. These categories reflect not only where people live, interact with, and affect the environment, but also establish shared responsibility for achieving stewardship goals among all residents within a plan area. However, as only rural land stewardship emerged as a priority issue, only rural land stewardship has an associated measurable goal, and only the analysis and methodology for assessing rural stewardship is included here.

There are three main reasons for incorporating rural land stewardship as a measurable goal within this plan. First, priority issues are connected to the human activities that occur on the land. For example, in rural areas when the rate of soil loss is lower than the rate at which soil can naturally rebuild, the long-term productivity of the soil is maintained, as are agricultural yields. The second reason for framing implementation around rural land stewardship is creating a positive, solution-oriented dialogue about how to address issues impacting resources. The dialogue becomes focused on the long-term viability and benefits to the community resulting from implementation activities, while simultaneously improving resource conditions.

The final reason is to begin connecting stewardship to sustainability claims made by agribusiness. Many large agribusinesses are working toward verifying sustainability claims. The metrics used for stewardship are directly connected to water quality improvement and could be used as a surrogate for the water quality index within the Fieldprint calculator and Field to Market (see https://calculator.fieldtomarket.org/fieldprint-calculator/) and other tools.

Because the concept of rural stewardship in a watershed plan is relatively new—and the quality, amount, and types of existing data to apply the method are limited—considerable caution is needed when interpreting the rural land stewardship results. Although defining rural land stewardship seems reasonably straightforward, information and data gaps can limit the value of the approach. This plan includes a means to address the information and data gaps during plan implementation.

For purposes of this plan, “rural stewardship” is defined by creating solutions to water quality and quantity challenges using a combination of management and structural practices to increase soil health, thereby accruing positive environmental benefits and positive value propositions in terms of benefits for a producer or landowner. An increase of soil health can be associated with increased yields. An increase in soil health can also be associated with decreased sediment and nutrient delivery to surface waters and increased water holding capacity of the soils, resulting in decreases in runoff volume delivered to streams. These environmental benefits are a positive outcome of framing implementation around rural stewardship and can be important in achieving progress towards other plan measurable goals (e.g. sediment (3.2.4), phosphorus (3.2.5), or nitrogen (3.2.7) delivery and load measurable goal; natural storage and hydrology (3.2.10) measurable goal).

A suite of criteria has been established for this plan to define rural stewardship, estimate the current proportion of the plan area meeting rural stewardship, establish short-term and long-term rural stewardship measurable goals, and assess progress during plan implementation (**Table 1**). Rural stewardship criteria are categorized as a "vulnerability criteria" or a "management practice". Vulnerability criteria are numerical values, typically expressed as the amount of a substance leaving the landscape, which—when exceeded—is expected to diminish soil productivity and therefore, agricultural yields. Threshold criteria are intended to be agronomic, rather than resource[1] based.

An area of land that exceeds vulnerability criteria reflects both probable adverse agronomic outcomes and a greater potential to contribute runoff, sediment, nitrogen, or phosphorus either to surface water or groundwater. Evaluating cropland area based on these vulnerability criteria is useful in identifying "critical source areas" where above-average amounts of sediment or nutrients leave the landscape. Critical areas represent hotspots for the preferential implementation of on-the-ground management or structural practices to protect soil and reduce delivery of sediment and nutrients downstream.

Ideally the vulnerability criteria would be numeric values that represent some maximum "acceptable" agronomic value[2]. The values used within the plan instead represent a "benchmark" for the plan area. For example, the sediment and phosphorus criteria benchmark values represent the 75th percentile for fields within the plan area. Fields exceeding these values are considered "critical areas" for the purposes of further evaluation to assess whether loss rates are abnormally high.

Table 1 shows the specific criteria used to assess the proportion of land areas currently achieving rural stewardship in the plan area. No data are available for several of the vulnerability criteria or management practices. These data gaps are expected to be filled as the plan is implemented by cost-sharing field walkovers through the Structural and Management Practices Cost-Share Program (**Section 5**) and used to update the information within the plan.

[1] Agronomic criteria are related to yields. Resource based criteria are intended to protect or restore a downstream resource. Establishing agronomic criteria can be challenging. Consequently, a statistical benchmark approach is utilized by this plan.
[2] The Natural Resource Conservation Service Conservation Effects Assessment Project (CEAP), has established maximum values for sediment, surface nitrogen, surface phosphorus and subsurface nitrogen, but these are resource-based on national in scope.

Table 1: Criteria used to classify rural stewardship within the plan area. Current vulnerability values at the field scale defined through the Prioritize, Target and Measure Application (PTMApp).

Criteria	Criteria Value Used to Identify Critical Source Areas	Criteria Type	Used to Assess Stewardship? (Y/N)	Source
Sediment Loss Rate	Land equaling or exceeding the estimated 75th percentile annual soil loss rate (tons/acre/year), delivered to a waterway.	Vulnerability	Yes	Benchmark (not agronomic) value based the revised Universal Soil Loss Equation and sediment delivery estimate from PTMApp.
Phosphorus Loss Rate to Surface Waters	Land equaling or exceeding the estimated 75th percentile annual surface total phosphorus loss rate (lbs./acre/year), delivered to a waterway.	Vulnerability	Yes	Benchmark (not agronomic) value based on the total phosphorus annual yield delivered to a waterway. Total phosphorus estimated from PTMApp.
Nitrogen (Surface) Loss Rate to Surface Waters	Land equaling or exceeding the estimated 75th percentile annual total nitrogen loss rate (lbs./acre/year), delivered to a waterway.	Vulnerability	No	Develop in the future.
Nitrogen-Subsurface Leaching Rate	No criterion	Vulnerability	No	Develop in the future.
Nutrient Management	4R nutrient stewardship certification, Minnesota Department of Agriculture or University of MN Extension recommendations	Management Practice	No	4R certification (http://4rcertified.org/); MDA Nitrogen Fertilizer Management Plan (2015); University of Minnesota Extension (2011).
Soil Health/ Tillage	Non-conventional tillage practices (no-till, ridge till, strip-till and mulch-till) which improve soil heath by increasing soil organic content and decrease the sediment loss rate vulnerability criterion (above)	Management Practice	No	Acres subject to no-till, ridge till, strip-till and mulch-till; assumed to increase organic matter content by 1% from current condition.
Manure Management	Permit Conditions	Management Practice	Yes	Minnesota Rules Chapter 7020; all lands subject to a NDPES permit are assumed compliant with application location and rate conditions.
Pesticide Application	Licensed/Certified Applicators	Management Practice	Yes	Minnesota Department of Agriculture (2016); University of Minnesota Extension (2011); all lands subject to a NDPES permit are assumed compliant with application location and rate conditions.

Criteria	Criteria Value Used to Identify Critical Source Areas	Criteria Type	Used to Assess Stewardship? (Y/N)	Source
Irrigation	Irrigation Best Management Practices	Management Practice	No	Irrigation Best Management Practices are currently lacking for Minnesota. Criterion could be use of water conservation measures on areas exhibiting high nitrogen infiltration risk.

METHODOLOGY FOR ANALYZING RURAL STEWARDSHIP

This plan analyzed rural stewardship within the plan area at the field scale, using cropland “common land unit” data. Results from the Prioritize, Target and Measure Application (PTMApp) were used to analyze and map the critical source areas for sediment and total phosphorous loss rate vulnerability metrics, or those cropland areas that were in the highest 75th percentile for sediment and total phosphorus yields. This analysis was done relative to other fields within each planning region.

Sediment and total phosphorous loss rate vulnerability metrics were the first criteria used to initially place a field in one of three stewardship categories (**Table 2**):

1. Rural stewardship “Probability Low”;
2. Rural stewardship “Probability Depends on Practice Effectiveness”; and
3. Rural stewardship “Probability Likely”.

Those cropland fields that exceeded the 75th percentile for sediment or total phosphorus were placed in rural stewardship category “Probability Low”. The presence of existing management and/or structural practices mitigate the amount of sediment, phosphorus, and nitrogen reaching the field edge and a waterway. Therefore, fields that were categorized in the “Probability Low” category could be promoted up from this category to rural stewardship “Probability Depends on Practice Effectiveness”, based on the presence of existing management or structural practices.

The stewardship approach considers the benefits of structural practices through use of BWSR eLINK data (**Table 2**). Cropland fields in the “Probability Low” category were moved up to “Probability Depends on Practice Effectiveness” if BWSR eLINK data references a practice already in place on the field.

In the absence of field scale data to assess management practices, county level data on fertilizer management was used to adjust acres in each stewardship category for each planning region, based on likely coverage of management practices.

Table 2: Rural stewardship categories derived from the stewardship criteria and information about existing Best Management Practice locations within Board of Water & Soil Resources (BWSR) online eLINK database.

Rural Stewardship Category	Conditions Used to Assess Stewardship	
	Sediment and Phosphorus Vulnerability Criteria	Best Management Practice (BMP) Information from eLINK
Probability Low	Land exceeding vulnerability criteria, meaning amount of **sediment or phosphorus** leaving field is relatively High	No BMPs in field determined from existing databases (e.g., eLINK)
Probability Depends on Practice Effectiveness	Land exceeding vulnerability criteria, meaning amount of **sediment or phosphorus** leaving field is relatively High	BMPs in field determined from existing databases (e.g., eLINK)
Probability Likely	Land is not exceeding vulnerability criteria, meaning amount of **sediment *and* phosphorus** leaving field is relatively Low	BMPs in field determined from existing databases (e.g., eLINK)

Some lands within the plan area have conservation plans completed by the NRCS or are "certified" by the MDA. If data becomes available, those lands with conservation plans or certified can be automatically considered in the "Probability Likely" rural stewardship category. However, information about lands covered by farm plans is subject to privacy protection.

RURAL STEWARDSHIP MEASURABLE GOALS

Setting short-term and long-term measurable goals for rural stewardship is a two-step process. The measurable goals are focused on increasing the proportion of the plan area that meets principles of rural stewardship. Thus, the first step in defining the rural stewardship measurable goal focuses only on those acres in the rural stewardship categories "Probability Low" and "Probability Depends on Practice Effectiveness."

Protecting and improving soil health is a key component of rural stewardship. The Soil Organic Matter (SOM) content is used as a surrogate for soil health. Therefore, the second step in defining the rural stewardship measurable goal is focused on cropland with estimated SOM > 1% and =< 4 %. The SOM range of > 1% and =< 4 % was based on an evaluation of soils in the watershed area through Soil Survey Geographic Database (SSURGO) soils data.

Based on the rural stewardship analysis for the MRW 1W1P planning area, the estimated area of each planning region by rural stewardship category is shown in **Table 3**.

Table 3: Estimated cropland acres in each planning region by rural stewardship category.

Planning Region	Total Cropland Acres with SOM 1-4%	Estimated Acres Probability Low	Estimated Acres Depends on Practice Effectiveness	Estimated Acres Probability Likely
Upper Big Sioux River	16,289	8,157	4,170	3,962
Lower Big Sioux River	229,252	63,494	72,956	92,803
Rock River	419,432	134,044	88,732	196,657
Little Sioux River	94,120	28,689	30,619	34,812
Total for Plan Area	**759,093**	**234,384**	**196,477**	**328,234**
Total Percentage of Plan Area		**30.88%**	**25.88%**	**43.24%**

Based on an analysis of SSURGO soils, there are ***430,900 acres of cropland in the watershed area*** that are in rural stewardship categories of “Probability Low” and “Probability Depends on Practice Effectiveness” which also have SOM content > 1% and =< 4 %. This represents 45% of the total cropland area.

To increase the SOM by 1% for these acres, management practices such as cover crops, conservation tillage to increase residue, and permanent cover (e.g., alfalfa, prairie grass) could be implemented. Therefore, the watershed-wide measurable goal for rural stewardship has been defined as the following:

- **Short-Term Measurable Goal:** Implement management practices in 0.65% (6,150 acres) of all cropland areas in the watershed to increase Soil Organic Matter (SOM) content 1%. Areas to be managed are cropland areas categorized as rural stewardship “Probability Low” and “Probability Depends on Practice Effectiveness” that have SOM content > 1% and =< 4 %.
- **Long-Term Measurable Goal**: Implement management practices in 45% (430,900 acres) of all cropland areas in the watershed to increase Soil Organic Matter (SOM) content 1%. Areas to be managed are cropland areas categorized as rural stewardship “Probability Low” and “Probability Depends on Practice Effectiveness” that have SOM content > 1% and =< 4 %.
    - **Metric:** Percentage of applicable cropland acres treated with management practices

Appendix L

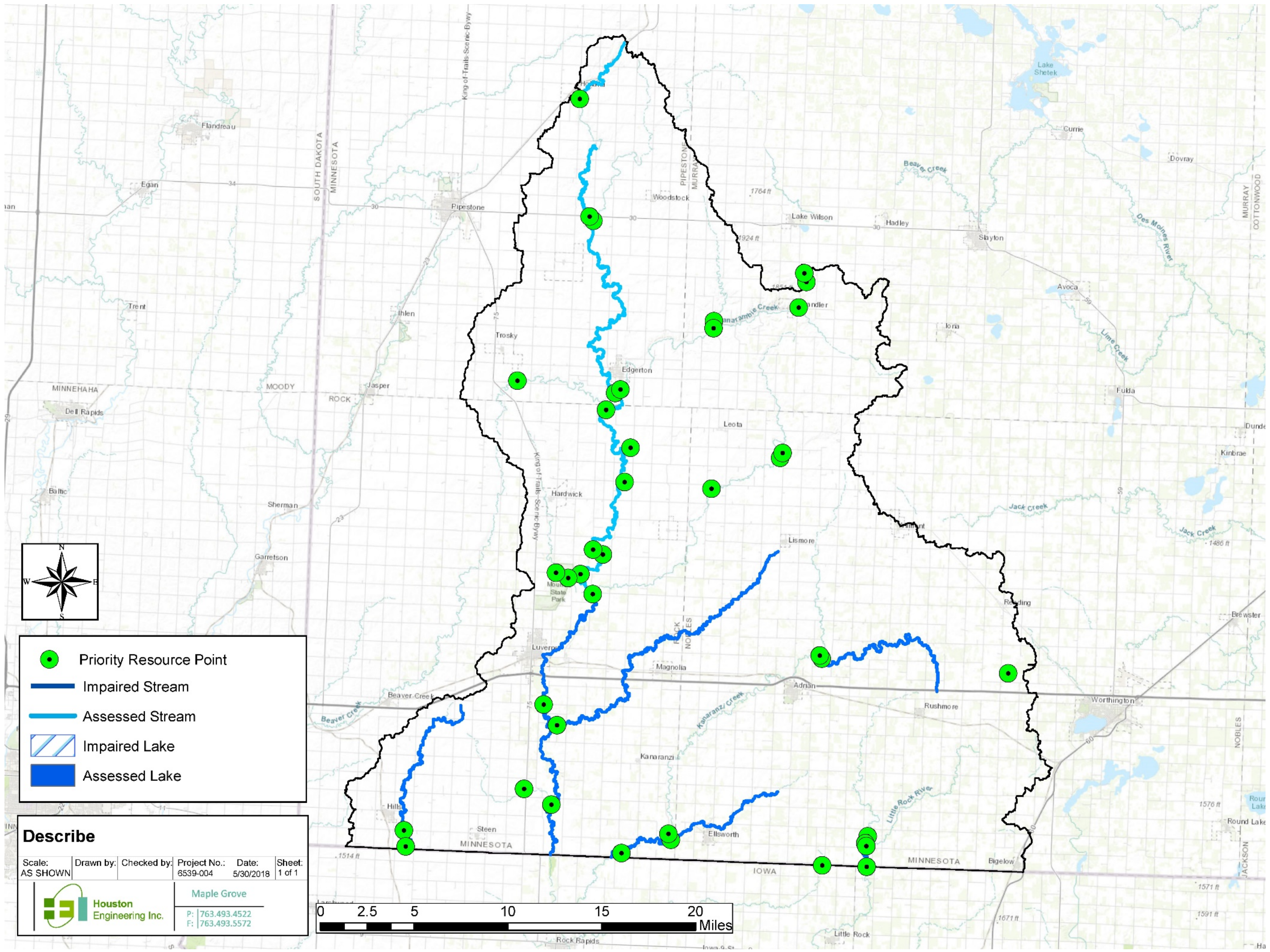
Prioritize, Target, and Measure Application (PTMApp) Standard Products: Rock River Planning Region and Field Scale Products

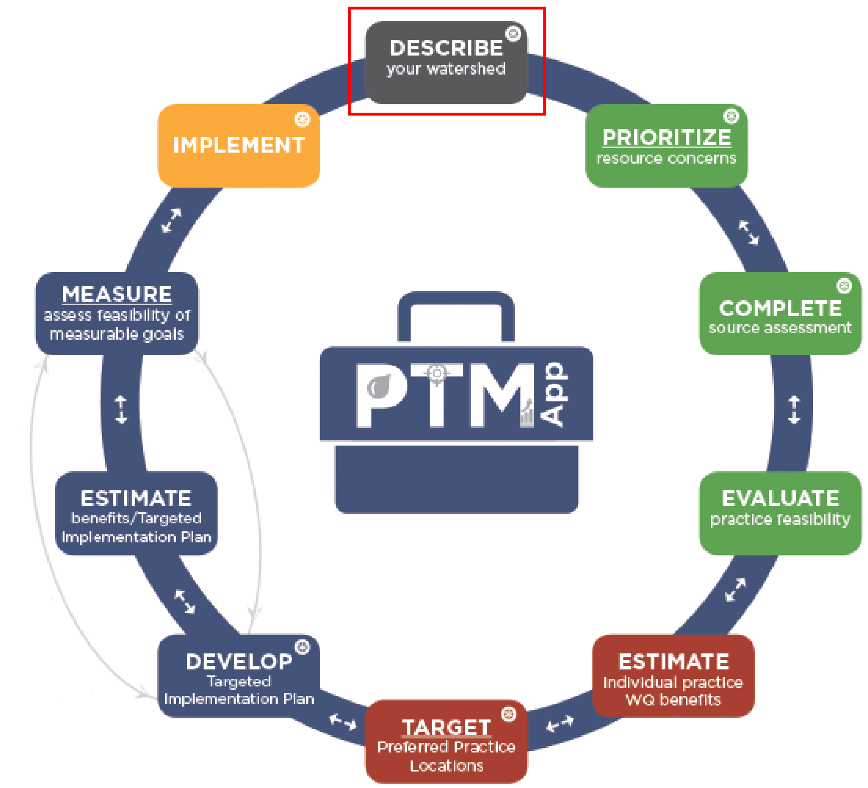
MISSOURI RIVER WATERSHED
Comprehensive Watershed Management Plan

DESCRIBE YOUR WATERSHED

Describing your watershed is the process of identifying and describing important resources, features, and factors (e.g. socioeconomics) associated with your watershed. PTMApp provides base outputs of publicly available statewide data that are set to the extent of your watershed, such as watershed boundaries of different scales, assessed streams and lakes, impaired streams and lakes, ecological regions, and monitoring locations. This information is intended to simplify the process of gathering and summarizing some of the common information needs associated with watershed management. **Figure 1** below is an example for the Rock River planning region, where assessed and impaired lakes and streams are displayed based on current geospatial data from the Minnesota Pollution Control Agency. This data can help to visualize and summarize the number of impaired waters and assessed waters within the project area.

Figure 1: Assessed and impaired streams and lakes in the Rock River planning region

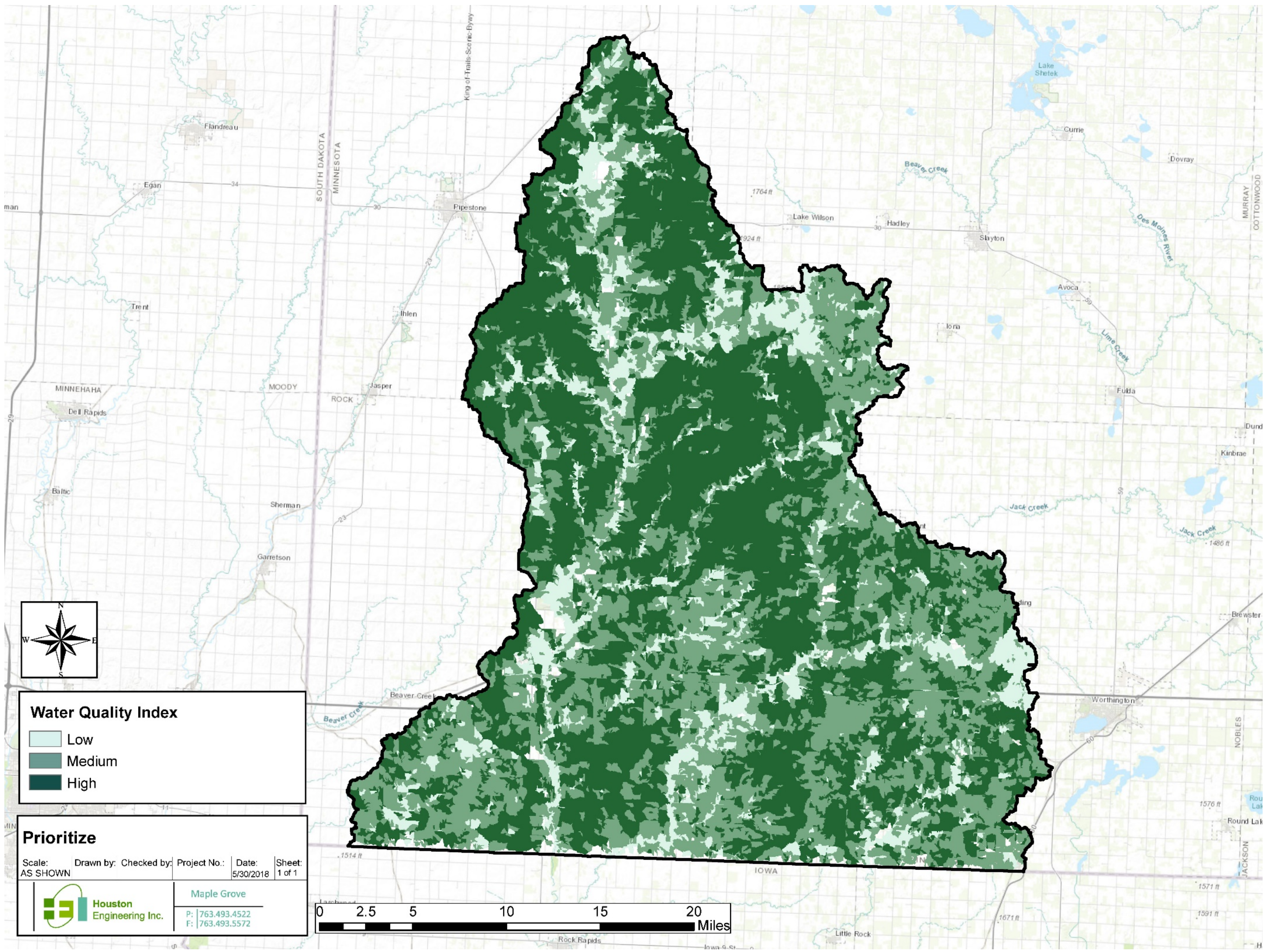


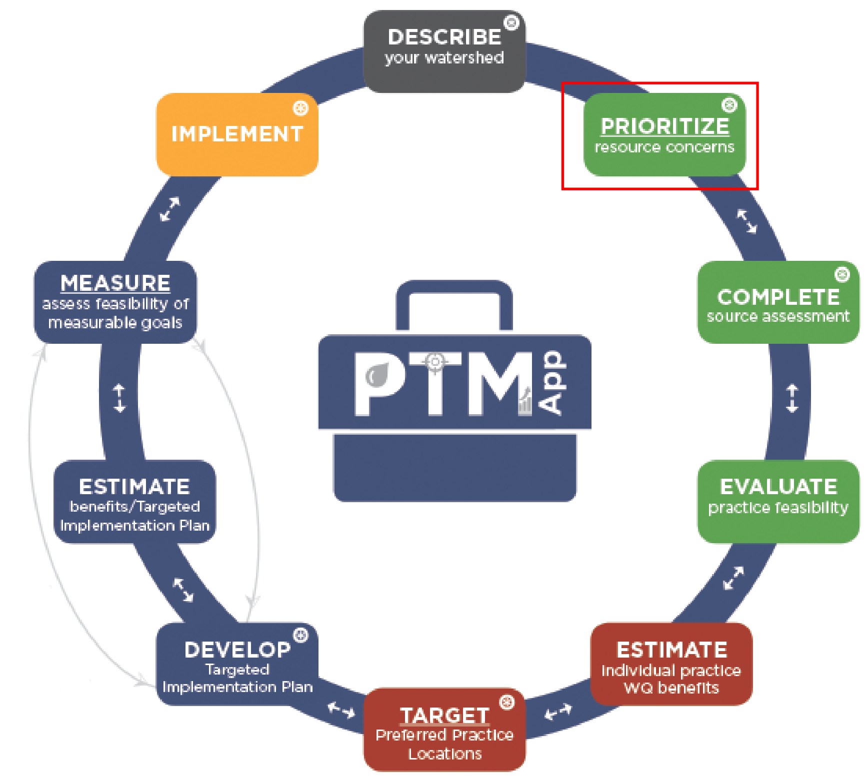


PRIORITIZE RESOURCE CONCERNS

Prioritizing resource concerns is the process by which practitioners establish the relative importance of resources within their area of management. Frequently in Minnesota, water quality is a potential resource concern included in prioritization processes. Products from PTMApp can be used in conjunction with other information, such as Hydrologic Simulation-Fortran Program (HSPF) models to aid in the process of prioritizing resource concerns. For example, PTMApp outputs can be used to show the ranks of field scale catchments based on their delivery of sediment and nutrients, called a water quality index (50% sediment and 50% nutrients), to areas of channelized flow (**Figure 2**). These ranks can help the prioritization in types of resources that are selected as priorities and locations in which management actions are undertaken.

Figure 2: Water quality index (50% sediment and 50% nutrients) for sediment, total nitrogen, and total phosphorus delivered to a catchment's edge of the field within the Rock River planning region

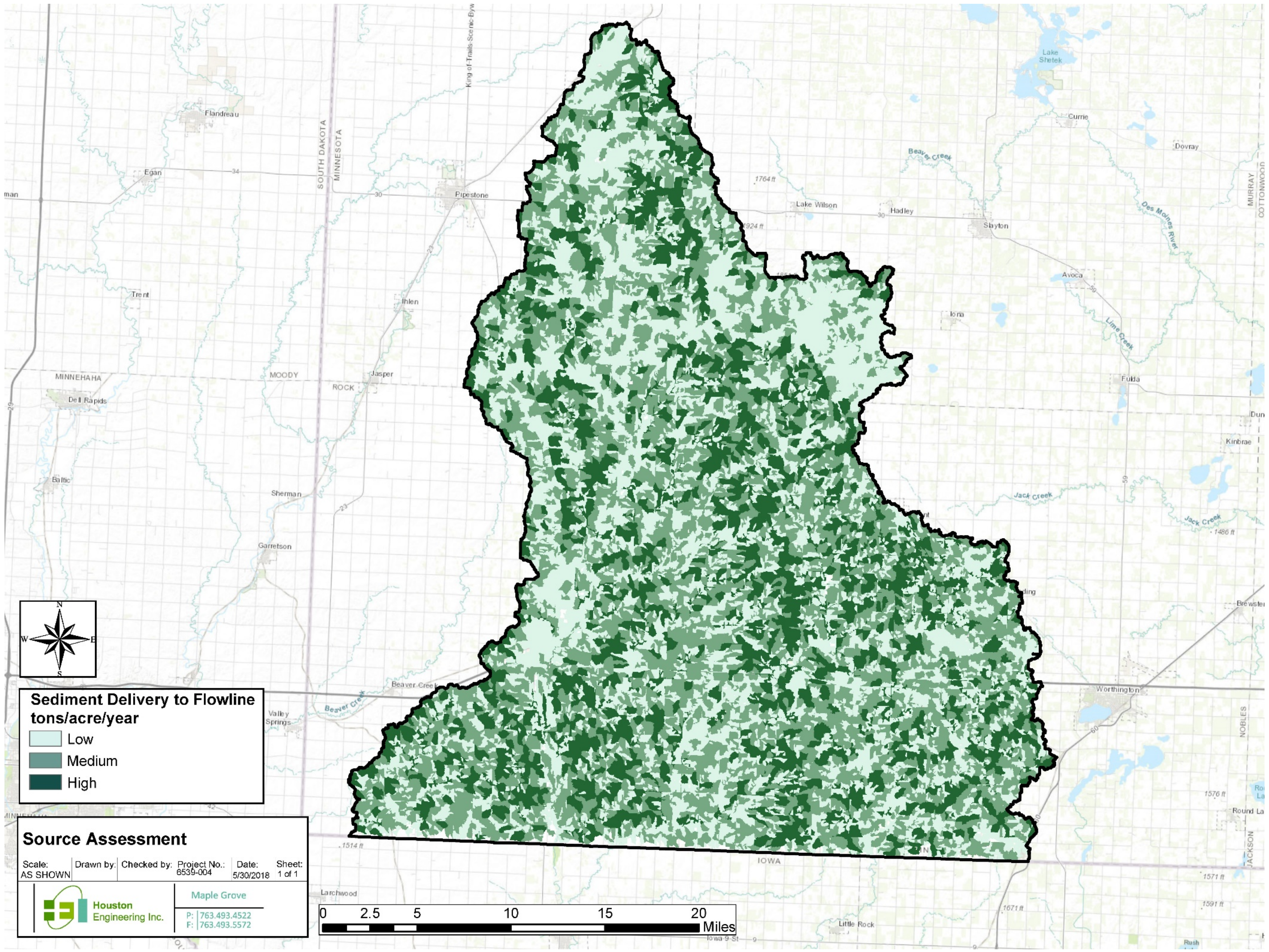


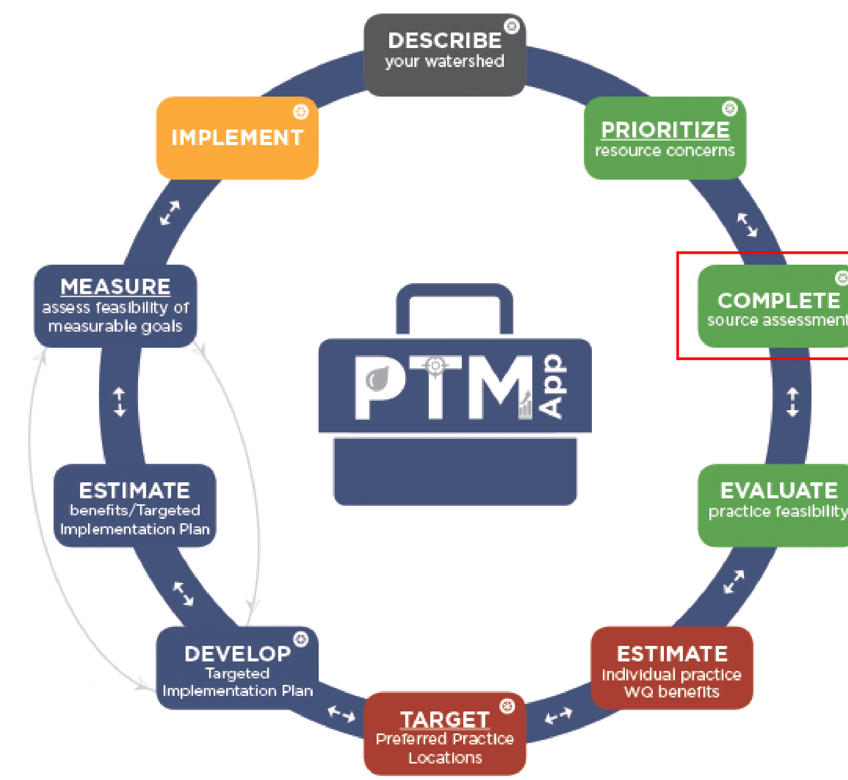


COMPLETE SOURCE ASSESSMENT

The source assessment identifies the magnitude and spatial distribution of potential pollution sources across the landscape. PTMApp creates three source assessment products: (1) load and yields leaving the landscape, (2) loads delivered to a waterway, and (3) loads delivered to a downstream resource of interest (such as a lake or river reach). The source assessment provides an understanding of how various parts of the watershed affect a resource while identifying problem locations. The sediment yield (tons/acre/year) delivered to the field scale catchment flowline is shown in **Figure 3**. Similar products can be developed for total nitrogen (TN) and total phosphorus (TP) for any priority resource point. For strategies aimed at reducing sediment delivered to the edge of the field within the Rock River planning region, the **"High"** sediment yield areas would provide ideal locations to prioritize and target practices. However, practitioners must first evaluate the feasibility of implementing management practices and structural BMPs in those areas. In other words, the highest loading (sediment, TN, or TP) areas on the landscape might have limited opportunities for implementing a practice to address the issue.

Figure 3: Rock River planning region source assessment for sediment yield delivered to the field scale catchment flowline (edge of field). Total nitrogen and total phosphorus were also assessed (not shown in map).

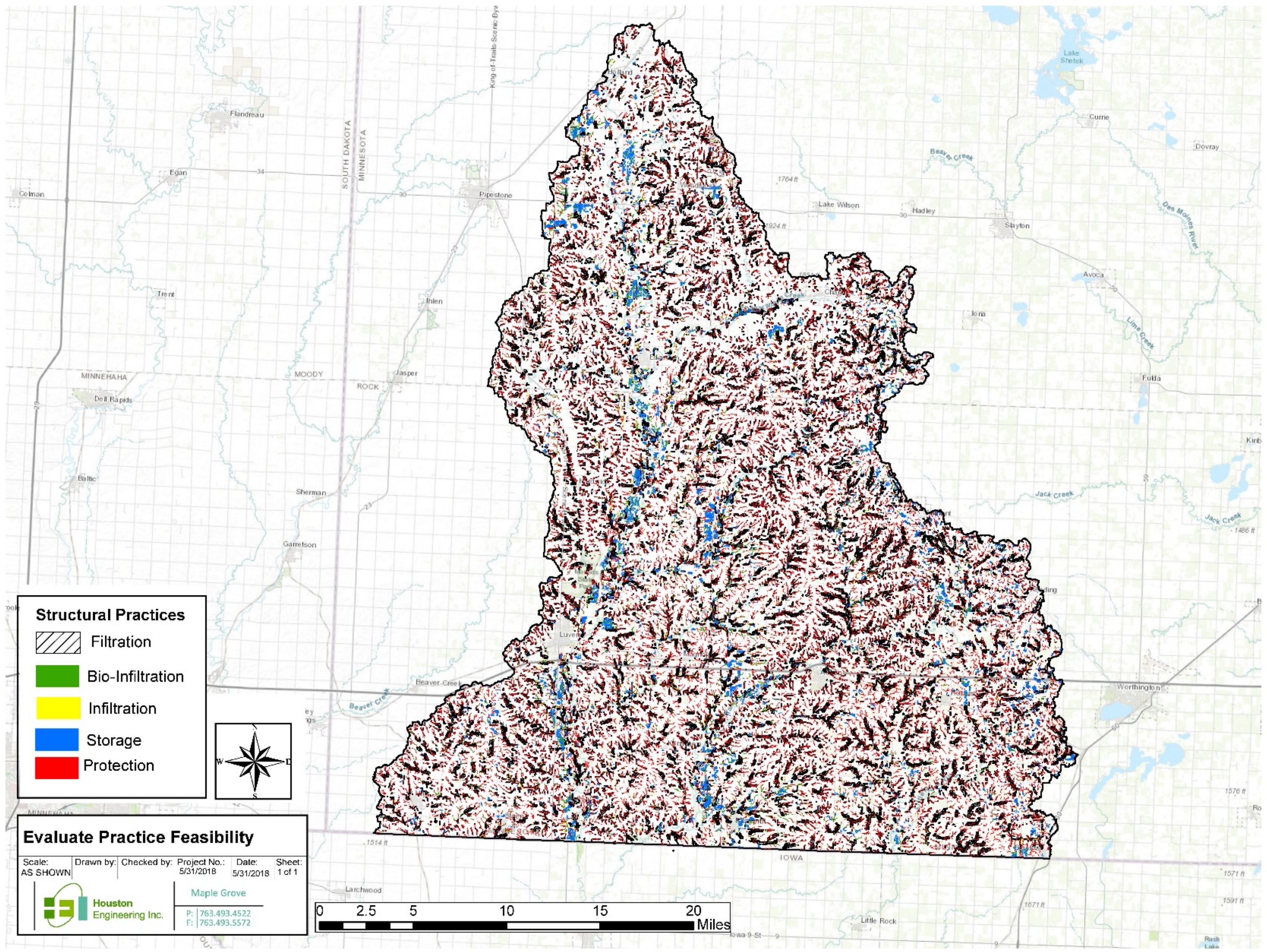




EVALUATE PRACTICE FEASIBLITY

The feasibility of placing a management practice or structural BMP on the landscape depends on several factors. These factors include the size of the contributing drainage area, the land slope, the type of flow regime, and local topography. Practice feasibility is based solely on technical factors largely based on field office technical guides developed by the Natural Resource Conservation Service (NRCS) and excludes social factors like landowner willingness. Locations shown as "feasible" are candidates for implementing practices and require further technical evaluation to confirm feasibility. The potential opportunities for structural BMPs in the Rock River planning region are shown in **Figure 4**, and the opportunities for management practices are shown in **Figure 5**. The opportunities are displayed by PTMApp treatment group types included in this plan. It's important to note that that these are only **potential locations** at this point in the business workflow. Local knowledge is still needed to refine the locations to identify a realistic set of targeted practices. These management practices and structural BMP opportunities can be combined with the source assessment data in PTMApp to estimate the "measurable" water quality benefits for implementing the practices.

Figure 4: Feasible structural BMPs within the Rock River planning region



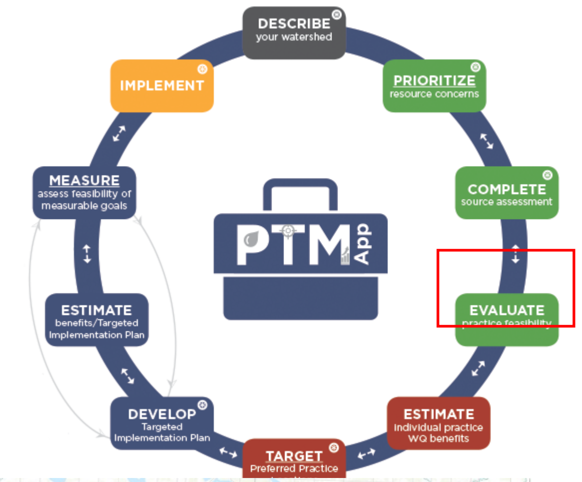
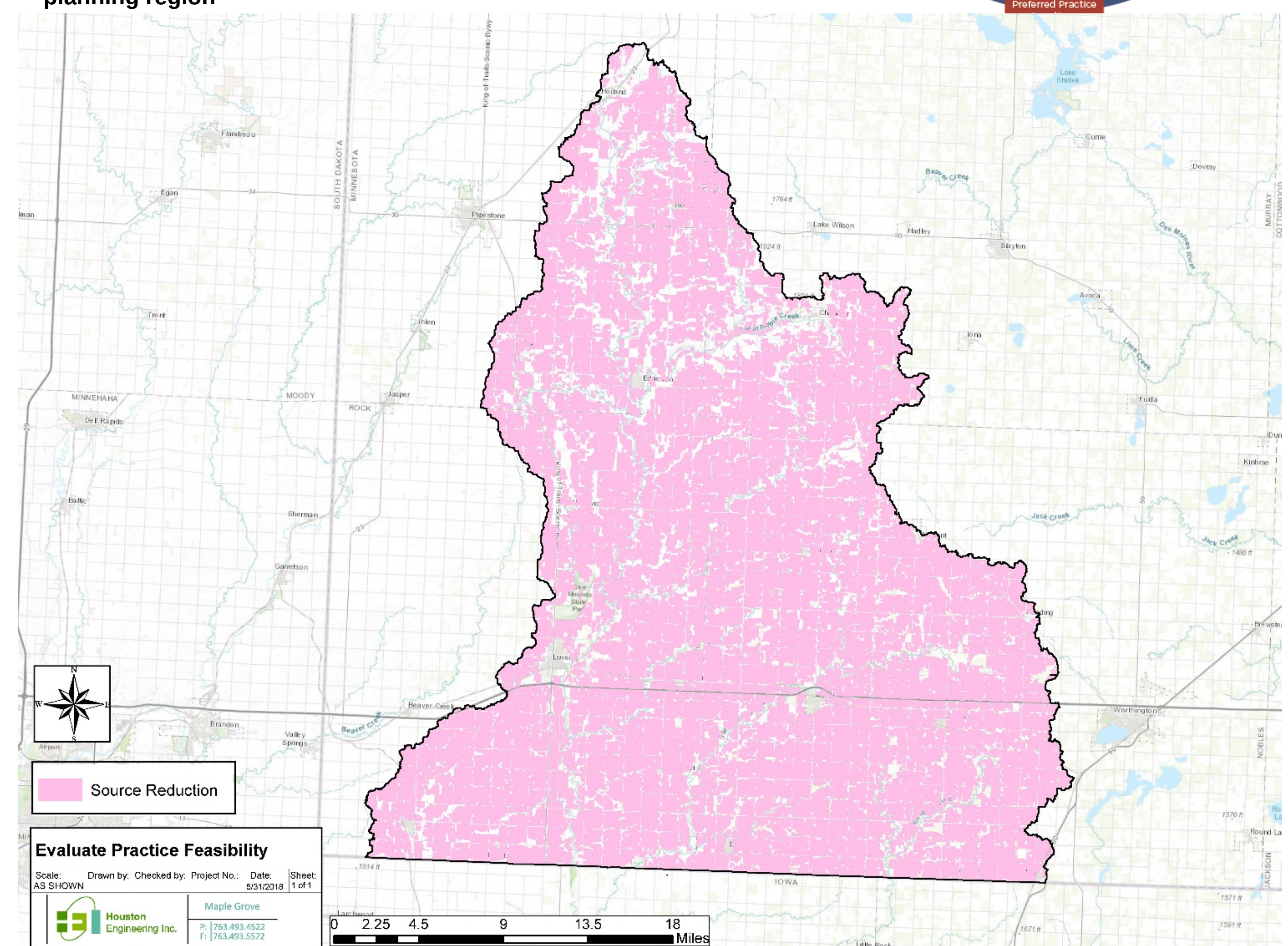


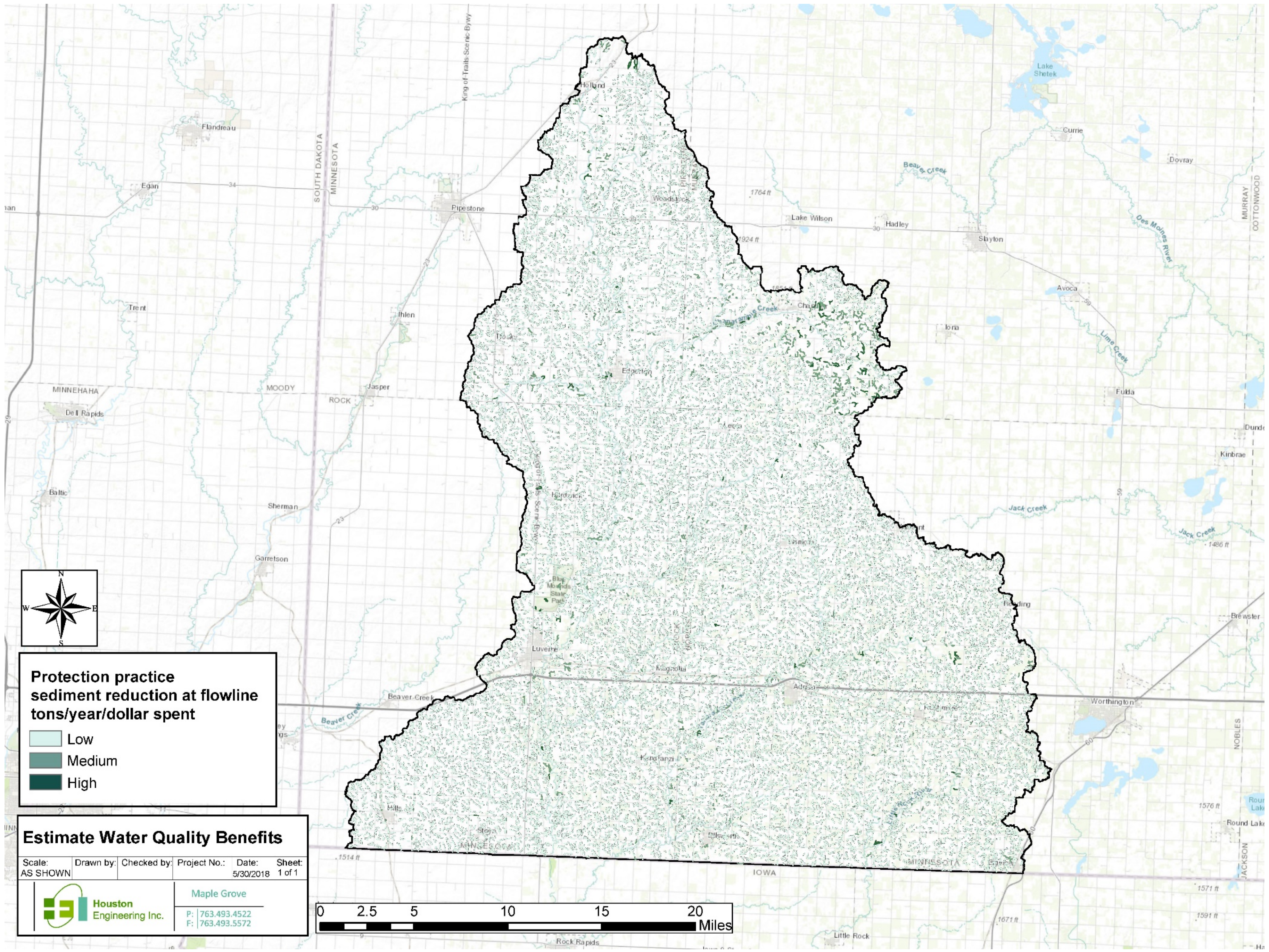
Figure 5: Feasible management practices within the Rock River planning region

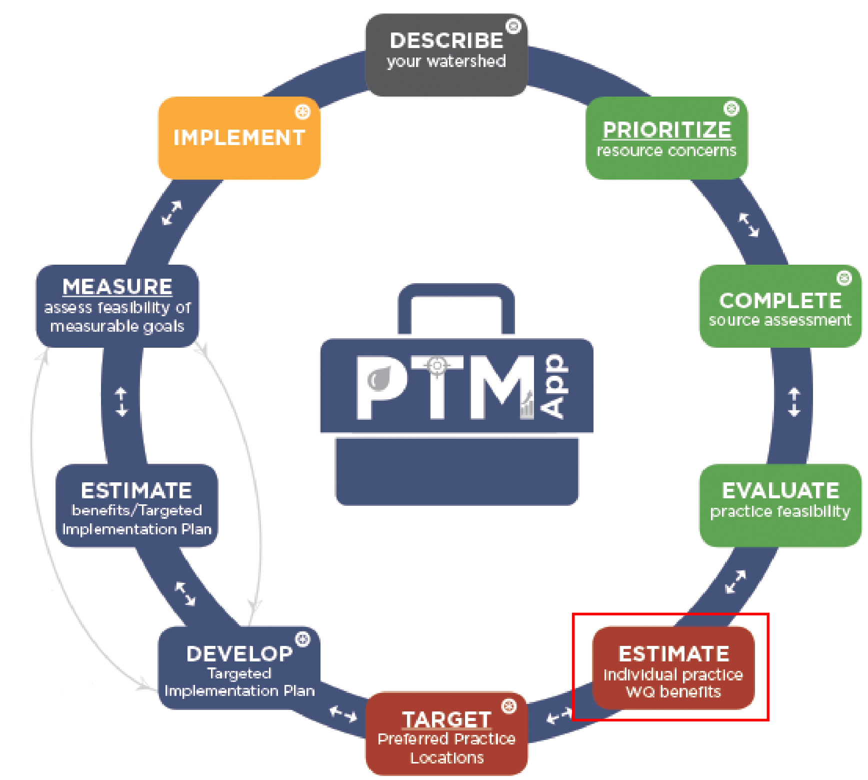


ESTIMATE WATER QUALITY BENEFITS

One of the ways to select specific practices for implementation is based on their probable benefits. The probable benefits of a practice can be described by either the amount of a parameter (like sediment or phosphorus) removed, or the cost to remove one unit of the parameter (e.g., dollars per pound of phosphorus annually reduced). Practice benefits can be estimated at the location of the practice or a downstream resource. The estimated benefits at a lake or river are more valuable from a decision-making perspective. **Figure 6** shows the treatment cost (in tons/year/dollar spent) of reducing sediment delivered to the catchment edge of field within the Rock River planning region, using protection practices (bank stabilization, critical planting, etc.). The areas providing the largest "bang for the buck" are in the "High" category, while areas that are cost ineffective are in the "Low" category. The most cost-effective areas for sediment reductions do not correspond exactly to the highest source load areas (see **Figure 3**). These results can be used to target practice locations to implement management practices and structural BMPs that provide the most cost-effective avenue to make progress towards local, state, and regional water quality management goals.

Figure 6: The treatment cost (tons/year/dollar) of reducing sediment delivered to catchment edge of field within the Rock River planning region using protection practices. Similar products can be developed for total nitrogen and total phosphorus.

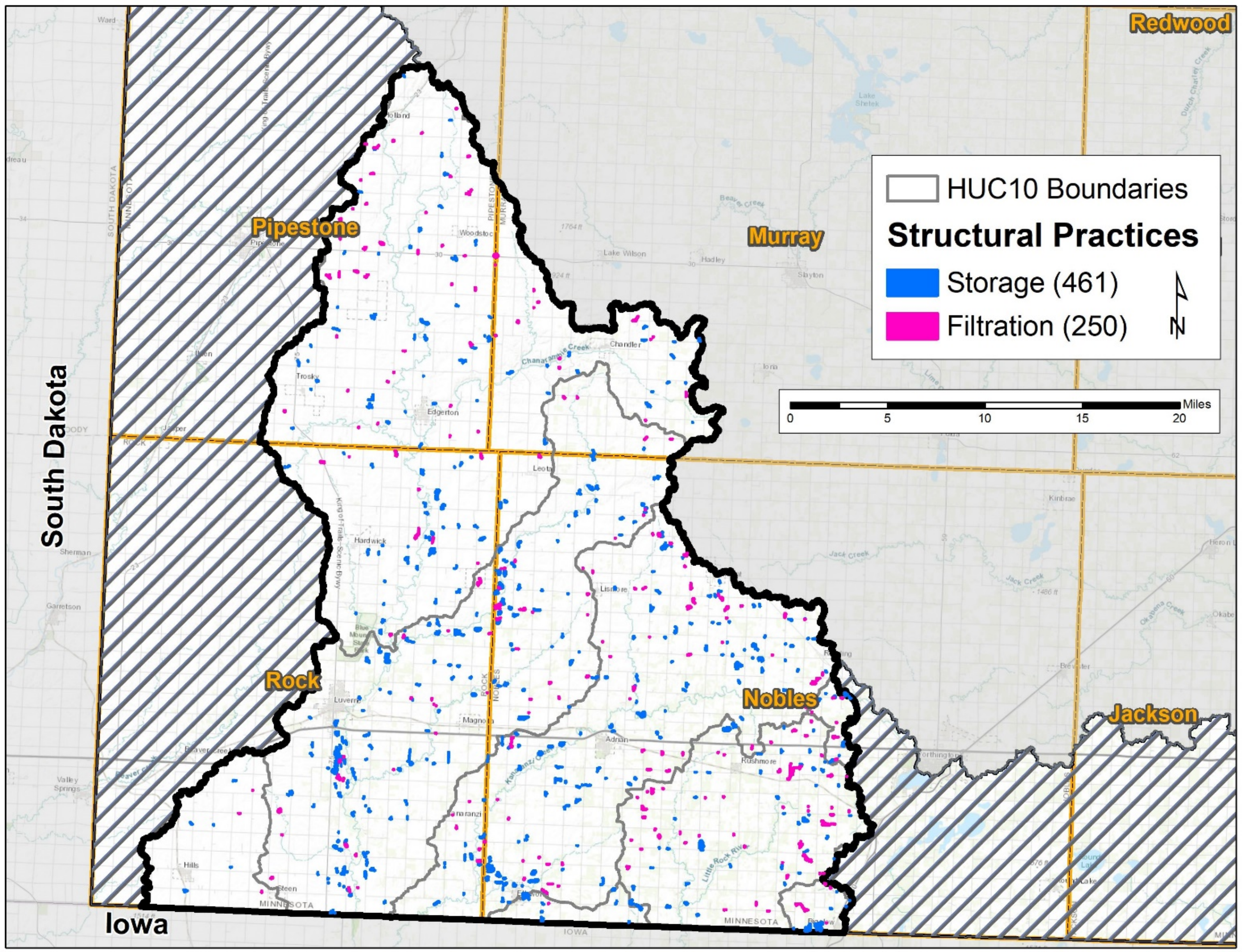


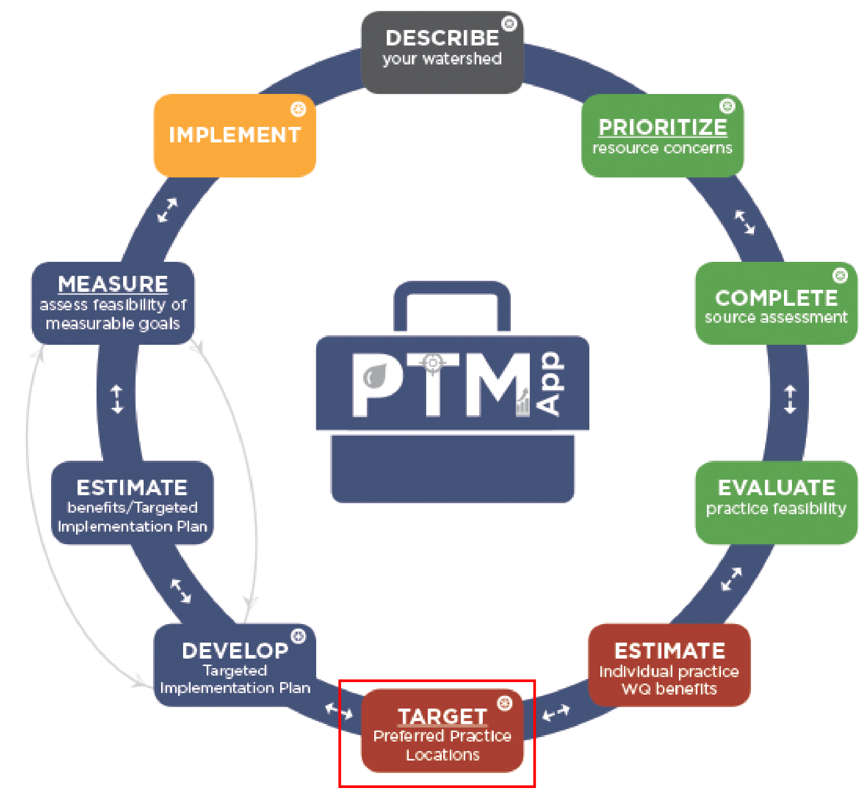


TARGET PREFERRED PRACTICE LOCATIONS

Once possible management practice and structural BMP locations are identified based on technical feasibility, the potential locations need to be assembled into an implementation approach to evaluate effectiveness. The range of management practice and structural BMP locations based solely on technical feasibility is reduced, by applying conditions like a minimum size requirement, minimum treatment effectiveness, or minimum cost-effectiveness. The best structural BMPs targeted for implementation in the Rock River planning region are shown in **Figure 7**. This targeted implementation approach is focused on targeting the most cost-effective storage and filtration practices within the Rock River planning region, up to a maximum annual cost of $813,000. This step in the business workflow is based on queries of the data generated by PTMApp. It is intended to provide feasible locations for implementing practices that will provide measurable water quality improvements for local priority resources. However, there are a number of factors that might influence the practices that end up being implemented. These include existing practices already in place or willingness of the landowner to participate. The inclusion of such factors is discussed in the next business workflow section, Develop Targeted Implementation Plan.

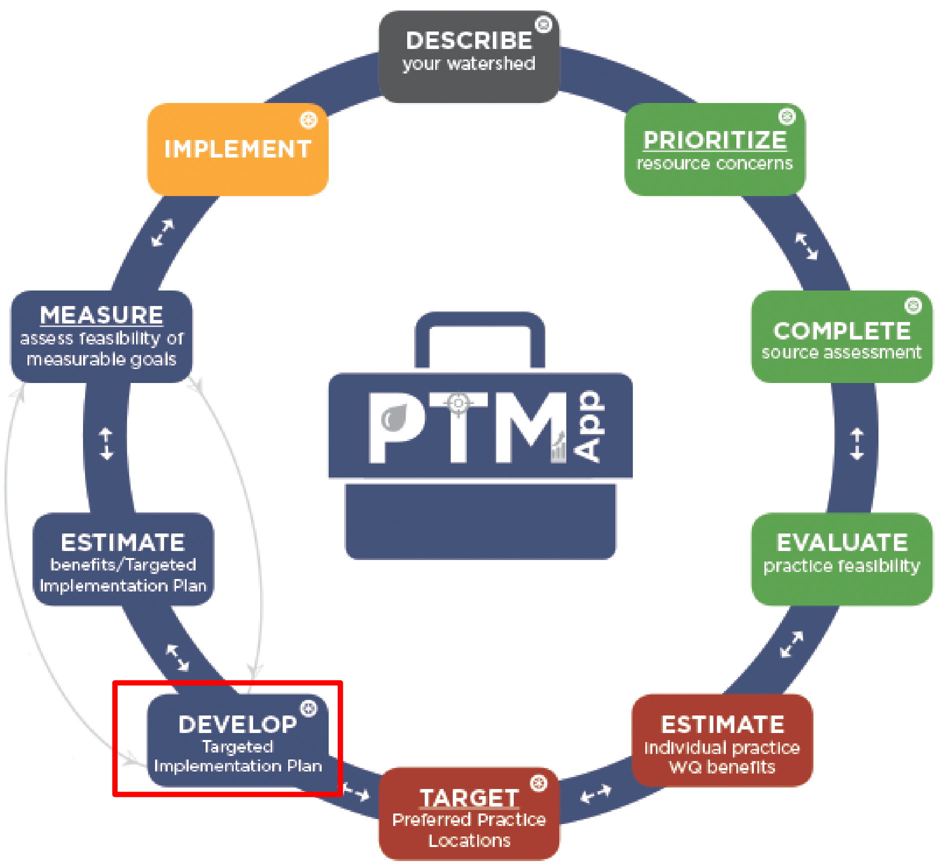
Figure 7: **Structural BMPs in the Rock River planning region targeted implementation approach.**





DEVELOP TARGETED IMPLEMENTATION PLAN

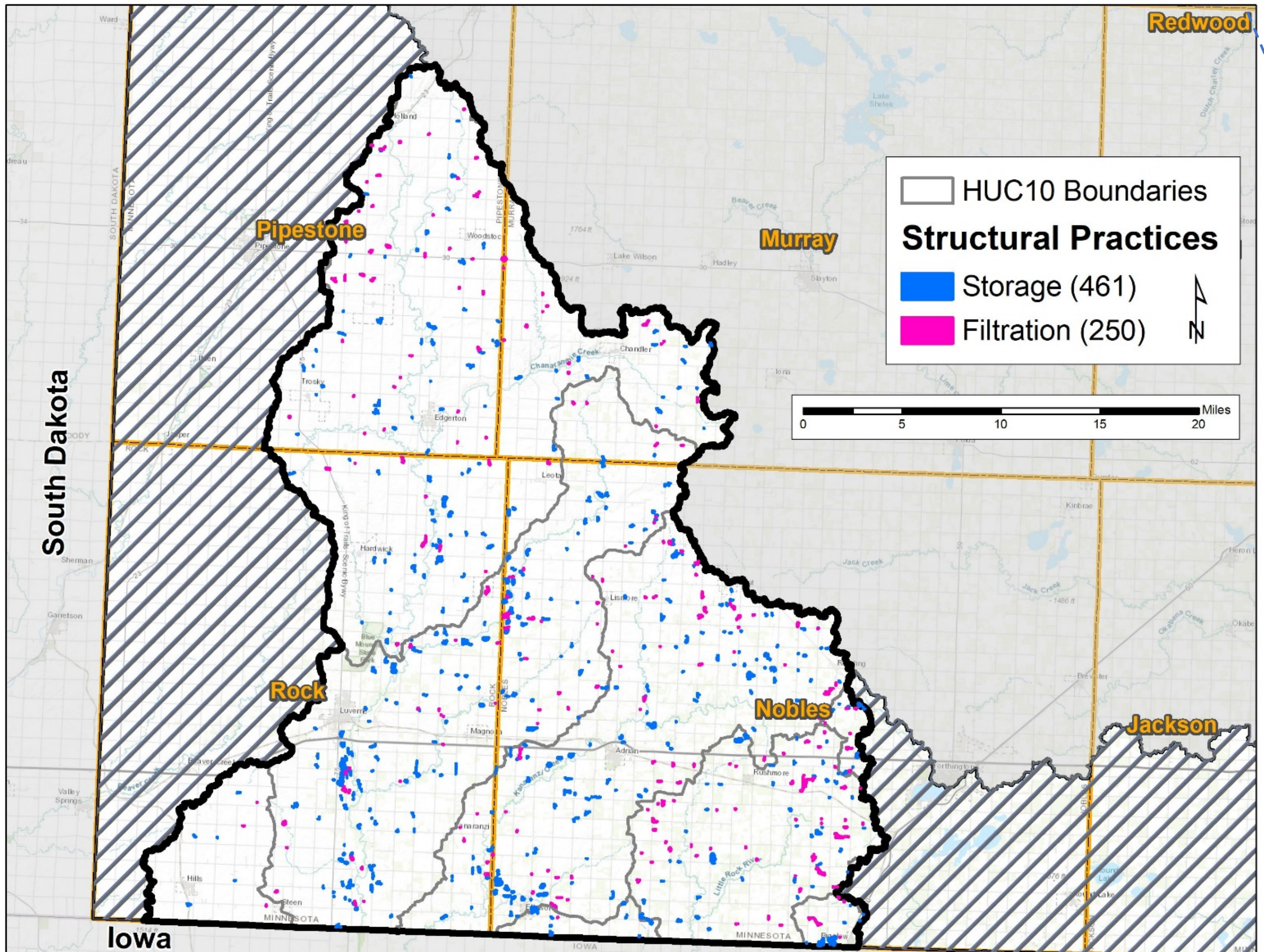
Specific locations to place practices need to be targeted based on other factors, including practical and social factors. Practical factors include landowner acceptance of specific types of practices and landowner willingness to place a practice on a field. Additional information can be incorporated to refine the practices targeted based on PTMApp data. It's likely that many areas in watersheds might already have numerous management practices or structural BMPs implemented, lack landowners who are willing to participate in additional management practices or structural BMPs, or have benefits outside of water quality (such as water quantity, wildlife habitat, and aquatic habitat) that adjust the targeted locations for practices.

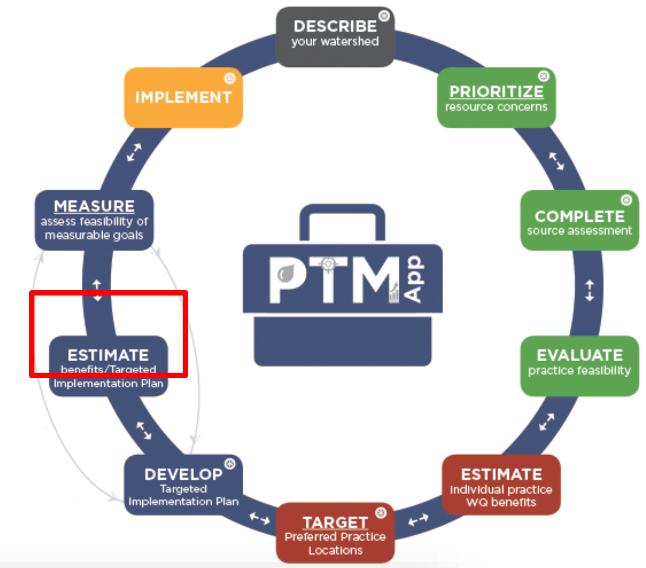


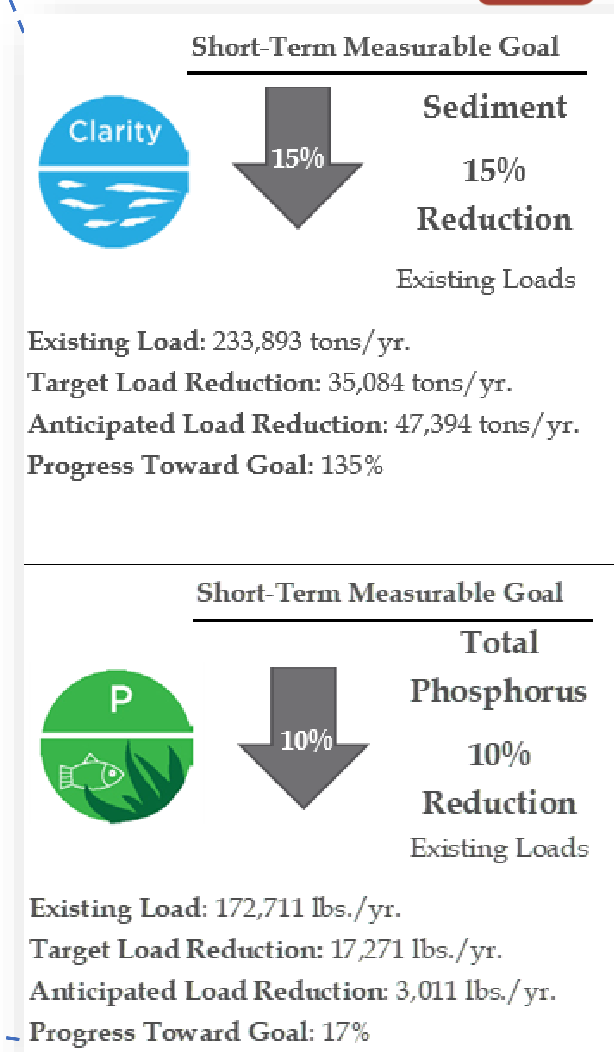
BENEFITS OF TARGETED IMPLEMENTATION PLAN

The structural BMP benefits expressed as the amount of load reduction at the resource location being restored or protected can be compared to a goal. The goal may be the load reduction necessary to reach the loading capacity for an impaired surface water or the existing load. The annual sediment and total phosphorus load reduction estimates based on implementation of structural practices within the Rock River planning region targeted implementation approach are shown in **Figure 8.** The load reductions are calculated at the edge of the field and can be used to assess progress towards and feasibility of a short-term measurable water quality goal.

Figure 8: Estimated sediment and total phosphorus load reductions based upon implementation of all structural practices within the Rock River planning region targeted implementation approach



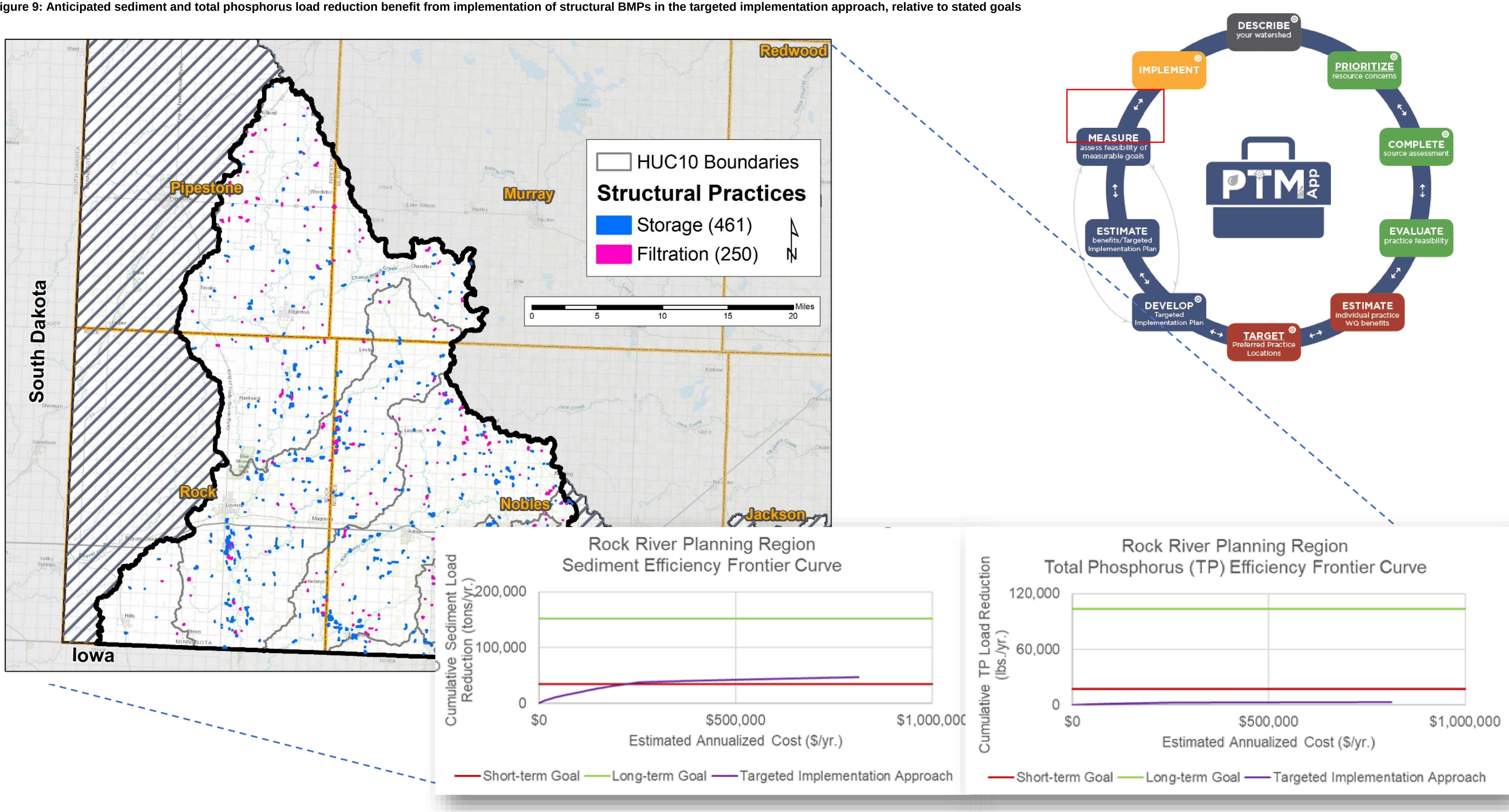


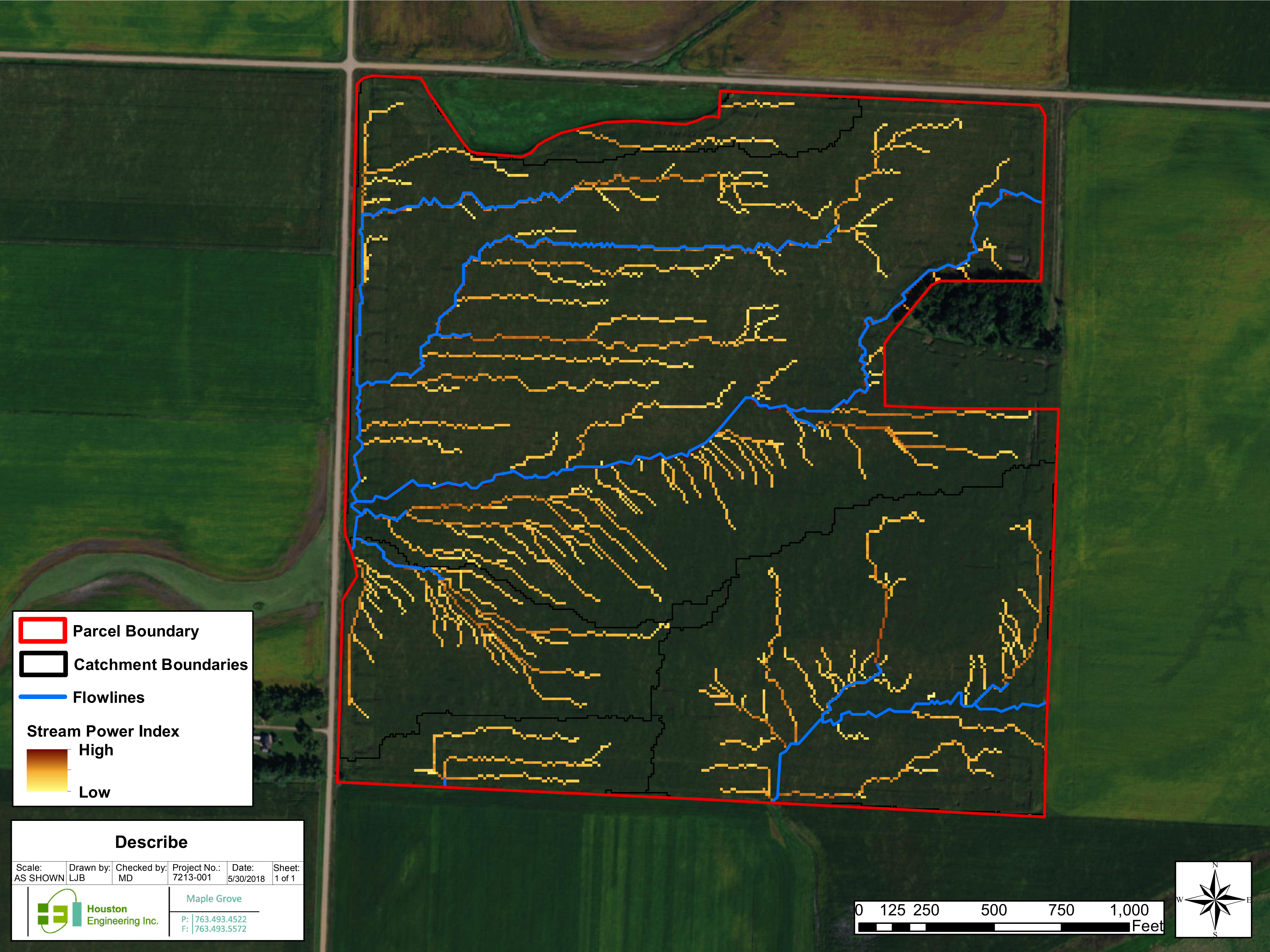


ASSESS FEASIBILTY OF MEASURABLE GOALS

A measurable goal may be the load reduction needed to restore a lake or river reach or a maximum load to protect a resource. The benefits of the implementation plan can be compared to stated measurable goals. The estimated benefits of the targeted implementation plan can be compared to water quality goals from watershed, state, or regional strategies, such as those found in the States Nutrient Reduction Strategy or a local WRAPS. For example, **Figure 9** shows the anticipated sediment and total phosphorous load reduction benefit from implementation of structural BMPs in the targeted implementation approach within the Rock River planning region in relation to cost and the target short-term measurable goal (red horizontal line in Efficiency Frontier Curves), and long-term measurable goal (green line in Efficiency Frontier Curves).

Figure 9: Anticipated sediment and total phosphorus load reduction benefit from implementation of structural BMPs in the targeted implementation approach, relative to stated goals




Parcel Boundary
Catchment Boundaries
Flowlines
Stream Power Index
High
Low
Describe
Scale: AS SHOWN
Drawn by: LJB
Checked by: MD
Project No.: 7213-001
Date: 5/30/2018
Sheet: 1 of 1
Houston Engineering Inc.
Maple Grove
P: 763.493.4522
F: 763.493.5572
0 125 250 500 750 1,000
Feet
N
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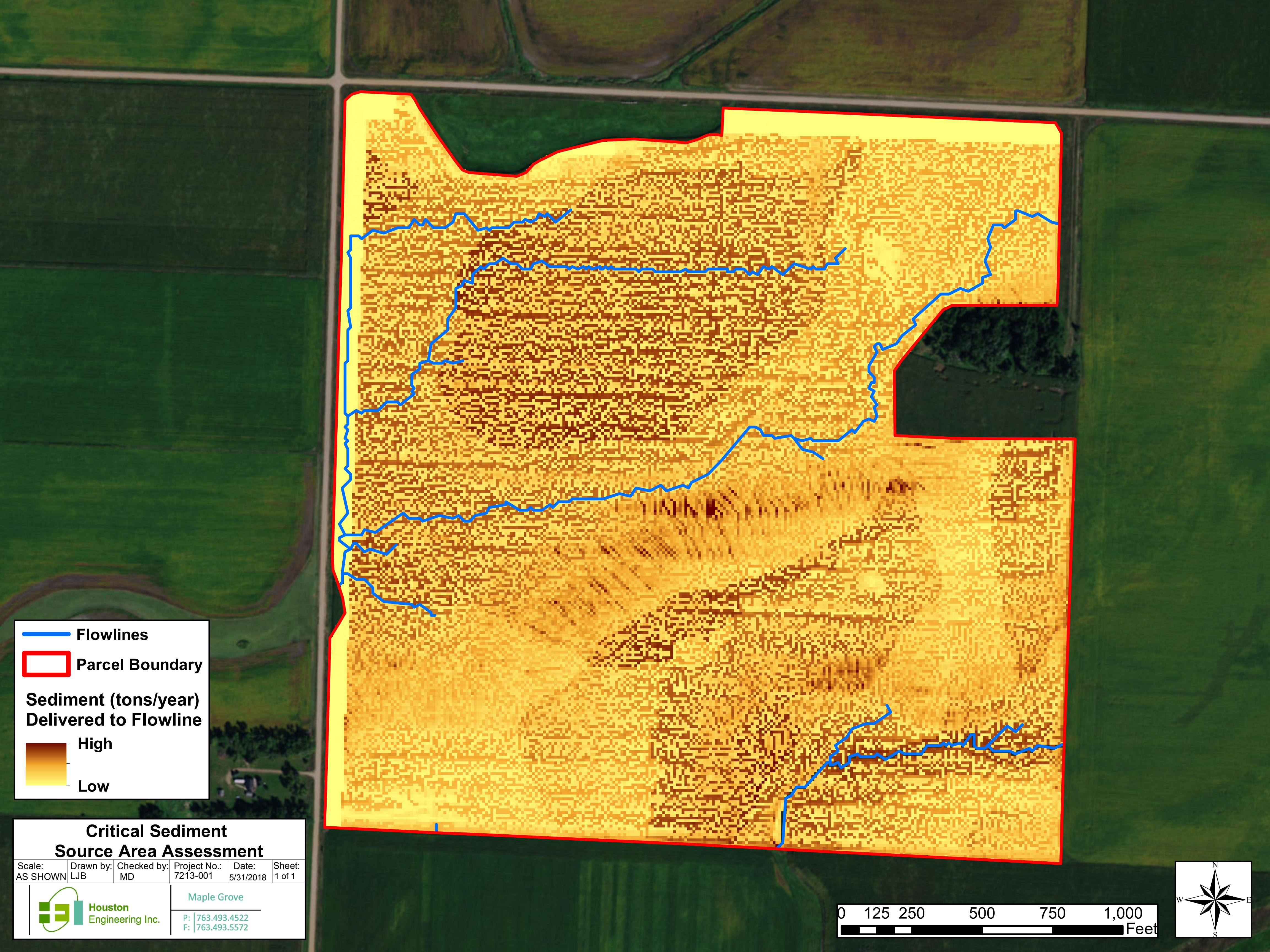
Flowlines
Parcel Boundary
Sediment (tons/year) Delivered to Flowline
High
Low
Critical Sediment Source Area Assessment
Scale: AS SHOWN
Drawn by: LJB
Checked by: MD
Project No.: 7213-001
Date: 5/31/2018
Sheet: 1 of 1
Houston Engineering Inc.
Maple Grove
P: 763.493.4522
F: 763.493.5572
0 125 250 500 750 1,000
Feet
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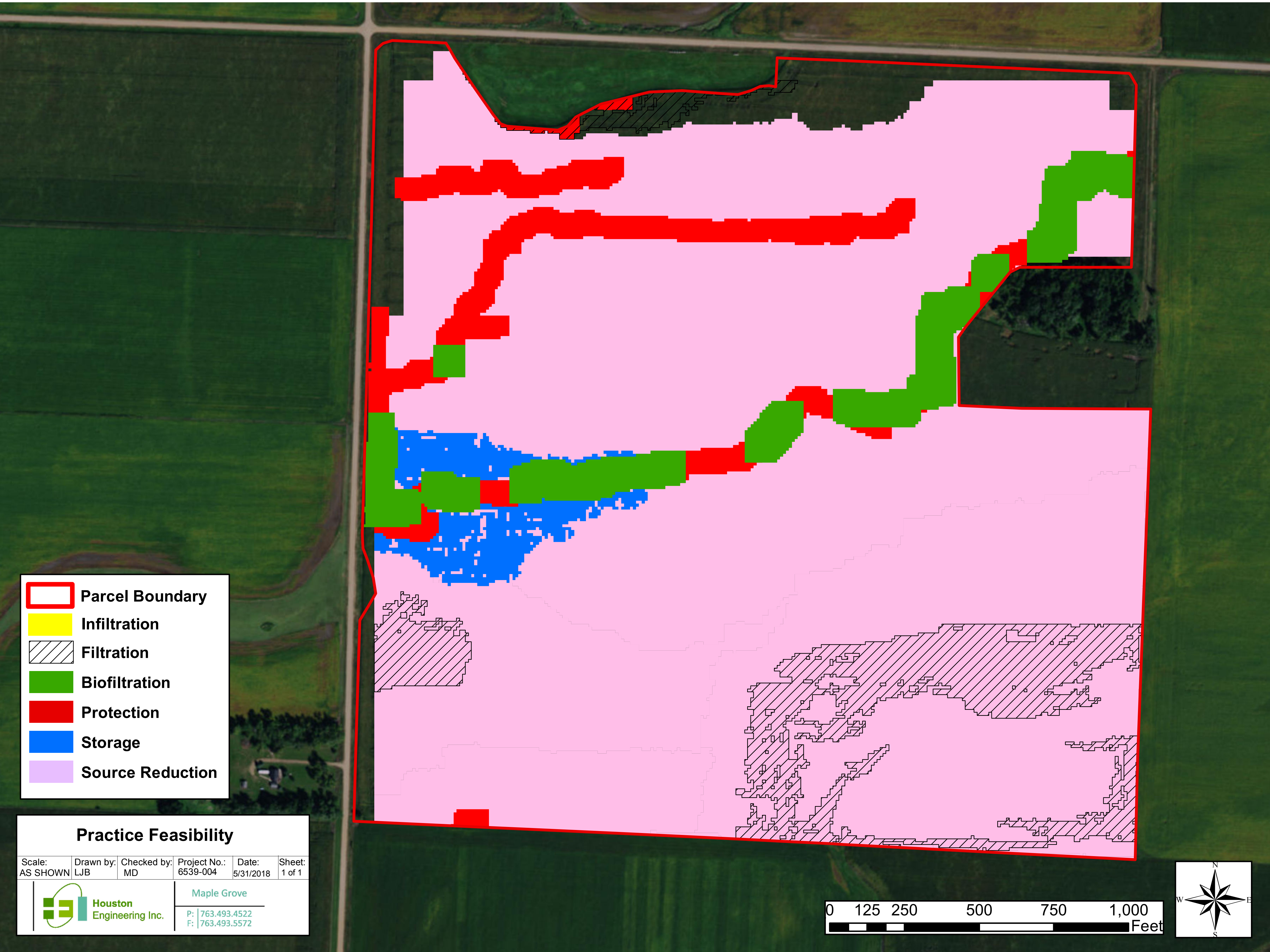
Parcel Boundary
Infiltration
Filtration
Biofiltration
Protection
Storage
Source Reduction
Practice Feasibility
Scale: AS SHOWN
Drawn by: LJB
Checked by: MD
Project No.: 6539-004
Date: 5/31/2018
Sheet: 1 of 1
Houston Engineering Inc.
Maple Grove
P: 763.493.4522
F: 763.493.5572
0 125 250 500 750 1,000
Feet
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Parcel Boundary
Annual Sediment Reduction at Flowline (tons)
Low
Medium
High
Target
Scale: AS SHOWN
Drawn by: LJB
Checked by: MD
Project No.: 6539-004
Date: 5/31/2018
Sheet: 1 of 1
Houston Engineering Inc.
Maple Grove
P: 763.493.4522
F: 763.493.5572
0 125 250 500 750 1,000
Feet
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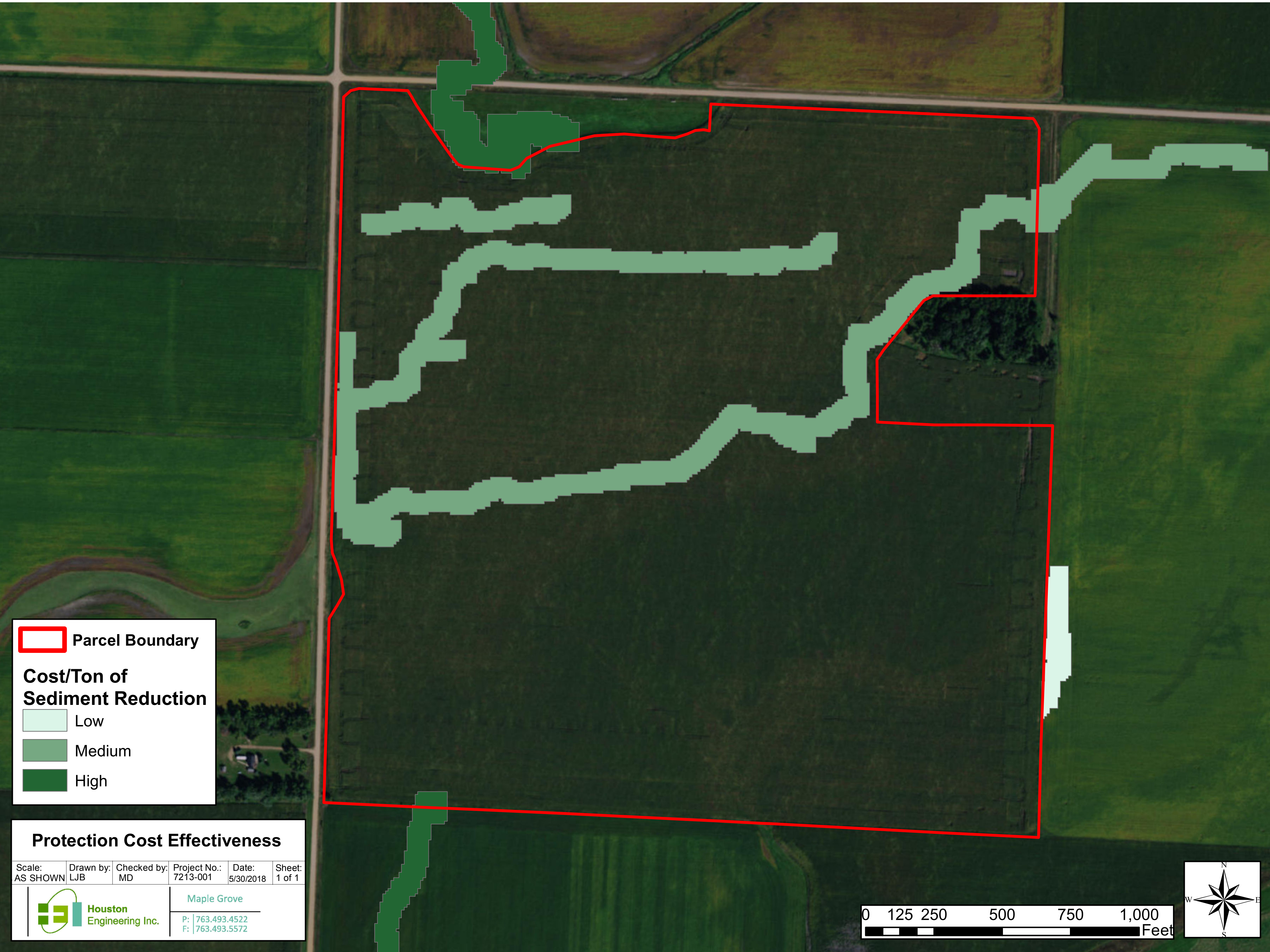
Parcel Boundary
Cost/Ton of Sediment Reduction
Low
Medium
High
Protection Cost Effectiveness
Scale: AS SHOWN
Drawn by: LJB
Checked by: MD
Project No.: 7213-001
Date: 5/30/2018
Sheet: 1 of 1
Houston Engineering Inc.
Maple Grove
P: 763.493.4522
F: 763.493.5572
0 125 250 500 750 1,000
Feet
N
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ATTACHMENT A

HoustonEngineering Inc.

Technical Memorandum

PTMAPP-DESKTOP PERFORMANCE EVALUATION

BACKGROUND

An inherent interest in the application of any tool or model is understanding the quality of the prediction (coined here as "performance"). This interest is spurred in part because resource management decisions and the expenditure of funds rely at least in part on the use of these tools and models to guide and assess the benefits of fiscal investments. The Prioritize, Target, and Measure Application is comprised of a set of commonly used mathematical equations for estimating the movement (i.e., fate and transport) of sediment (e.g., Revised Universal Soil Loss Equation (RUSLE) for sediment detachment), total phosphorus (TP) and total nitrogen (TN) across the landscape. The primary value of PTMApp is using the results to compare and contrast various decisions about the locations, probable performance, and likely value/benefits of management and structural conservation practices. Use of the PTMApp products for these purposes is expected to result in a reasonable and objective decision, and certainly a better-informed decision than one made in the absence of information.

Also of interest in this evaluation is the performance of PTMApp in an absolute sense. Assessing the performance in an absolute sense helps ascertain whether specific equations within PTMApp reflect mechanistic processes related to the fate and transport of sediment, TP, TN from the landscape to receiving waterbodies. Through time, performance assessments will allow specific parameters or equations to be modified (if necessary), leading to improved understanding of the biogeochemical processes that drive sediment and nutrient fate and transport in aquatic systems. However, assessing performance is challenging for a variety of reasons, including sampling and measurement methods, complexities associated with spatial scale, and a lack of understanding about watershed scale mass balances among other issues.

This document begins the process of assessing PTMApp performance. The vision of this process is that as PTMApp use continues, a set of regionalized parameters will be developed and provided as guidance to the user. Should the PTMApp data need to reflect specific (e.g. annual) monitoring results, the "scale loads" feature within PTMApp should be used.

INTRODUCTION

To assess performance, PTMApp for Desktop (PTMApp-Desktop) results were compared to independently collected monitoring data at several spatial scales. Monitoring data were categorized as one of three spatial scales; i.e., the field scale (generally contributing drainage area of ~ 40 acres or less), the small subwatershed scale (~1 – 50 mi^2), and the large subwatershed scale (> 50 mi^2). The loads (mass per time) and yields (mass per unit area per time) estimated[1] from the monitoring data, at their respective scales, were then compared with PTMApp results estimated for sediment, TP, and TN delivered to the catchment outlet and downstream priority resource. Data sources used in this analysis, and the spatial scale they relate to, include a Discovery Farms

[1] It is important to realize and understand that monitoring data also contain error. Errors commonly result from one or all of the sampling process, the analytical procedure, and/or the load estimation process. Errors approaching 20-30% when estimating annual loads are common. Our analysis includes annual loads and yields based on regression analysis, which includes additional errors.

site representing the field scale, the U.S. Geological Survey (USGS) Missouri River Basin SPAtially-Referenced Regression On Watershed attributes (SPARROW) model catchments for the large subwatershed scale, a Minnesota Pollution Control Agency (MPCA) FLUX32 model, and a sediment transport study based on Level III Ecoregions, each at the large subwatershed scale. No independent data sources were found in this watershed at the small subwatershed scale.

There are numerous challenges with comparing PTMApp-Desktop results with other datasets. For example, PTMApp-Desktop estimates sediment field loss from sheet and rill erosion. Nutrient loading is estimated based on land cover type and represents surface transport. Loads are "conveyed" downstream via first-order equations as a function of travel time. PTMApp-Desktop is not able to estimate pollutants from other sources, such as bank/channel erosion or anthropogenic diffuse (e.g. manure application) or point (e.g. waste water treatment plant) sources. Processes including lotic aggradation, sedimentation, nutrient bioassimilation, and any of the other complex biogeochemical processes are lumped and represented within the first order decay function. When comparing to models calibrated to stream gage data (e.g. SPARROW or FLUX), it can be a challenge to determine the provenance of sediment or nutrients. Comparing PTMApp-Desktop results to monitoring data can be difficult, as various methods for collecting and analyzing data may result in slightly (yet significantly) different measurement results. For example, sediment in aquatic systems can be measured as total suspended solids, suspended sediment concentration, or washload among others, and reported as "sediment loss" as if each method is interchangeable.

Despite these challenges, it is still valuable in assessing the technical defensibility of the data products generated by PTMApp-Desktop to compare them with other published datasets. The following subsections, organized by spatial scale, describe the processes PTMApp-Desktop uses to estimate sediment, TP, and TN yield and load, results for the Rock County Watershed, and relatability to independent datasets within this particular watershed. This assessment is only intended to gauge the performance of PTMApp-Desktop in the Rock County Watershed, and will not prescribe adjustments for model runs on this project. This exercise is aimed at establishing parameter guidance through comparison with other datasets and building experience at multiple spatial scales so that future recommendations can be made when a sufficient number of performance evaluations for a variety of areas has been gathered.

Results from PTMApp-Desktop and other data sources were generally expressed as either annual yield, defined in this analysis as tons/acre/year for sediment and lbs/acre/year for TP and TN, or annual load, defined in this analysis as tons/year for sediment and lbs/year for TP and TN. These were compared between datasets as either an absolute difference, defined as [Independent Source Value – PTMApp-Desktop Value], or as a percent difference, defined as [(Independent Source Value – PTMApp-Desktop Value)/Independent Source Value * 100].[2] Statistics used to describe the datasets generally included the mean, median, minimum, maximum, first quartile, and third quartile. Box and whisker plots were also generated to illustrate the distribution of data values within and across datasets. Significant differences between datasets were determined using the rank-based Kruskal-Wallis test at a 5% significance level.

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[2] These equations assume the independent data source (typically monitoring data) is accurate, which may not always be the case (see footnote #1). This assumption was necessary to evaluate the performance of PTMApp-Desktop within this analysis.

FIELD-SCALE DELIVERY

Background

Field-scale delivery is defined as the generation and transport of sediment, TP, and TN from the land surface to the nearest concentrated flow path or flowline. PTMApp catchments average about 40 acres in size, which is often the size of a small agricultural field, and were therefore characterized as field-scale. Within the Rock County Watershed, only a single Discovery Farms site was found to contain data sufficient to consider field-scale. Information on this site, data generated at this site, and comparison to PTMApp data is summarized below, along with background information on the algorithms and input data PTMApp uses to determine pollutant load and transport to the catchment outlet.

PTMApp Technical Processes at the Field-Scale

At the field-scale, PTMApp-Desktop utilizes RUSLE to estimate total suspended solids (TSS) yields and loads. These are delivered to a flowline based on a sediment delivery ratio (SDR), which is a function of the catchment drainage area,

$$Overland\ SDR = 0.41 * [Catchment\ Drainage\ Area\ (sq - km)]^{-0.3}$$

The overland SDR for each cell is estimated as a function of the catchment SDR adjusted by the distance from a cell to the flowline, such that,

$$Overland\ SDR(for\ the\ cell) = Overland\ SDR(for\ the\ catchment) * Overland\ SDR\ Adjustment\ Factor$$

Where,

$$Overland\ SDR\ Adjustment\ Factor = 1 - \frac{\dfrac{Flow\ Length}{Maximum\ Flow\ Length\ in\ Catchment}}{0.75 + \dfrac{Flow\ Length}{Maximum\ Flow\ Length\ in\ Catchment}}$$

Collectively, two raster data products are generated describing sediment load generated within each raster cell: (1) sediment yield leaving the landscape and (2) sediment yield delivered to the catchment outlet.

To determine the fate and transport of TP and TN, export coefficients for specific National Land Cover Data (NLCD) dataset land cover categories were applied to a 3m x 3m raster to estimate annual loads and yields (**Tables 1 and 2**). The raster values aggregated across all locations within a catchment were used to estimate the annual load and yield delivered to the edge of field, or in the terminology of PTMApp-Desktop, at the catchment outlet. Similar to sediment, raster products are generated for TP and TN describing the amount of each nutrient leaving the landscape and delivered to the catchment outlet.

A first-order loss equation was used to estimate the amount of TP and TN moving from the raster cell to the flowline (or catchment outlet),

$$W = e^{-kT}$$

Where *W* is the portion of yield leaving the landscape cell and delivered to the catchment outlet, *k* is the decay rate, and *T* is the travel time from the cell to a catchment outlet. For travel from the raster cell to the catchment outlet, a default value of 0.1 was used for *k*. Coefficients used for estimating the delivery of sediment, TP, and TN to either the catchment outlet or priority resource are summarized in **Table 3**.

Table 1: Total phosphorus (TP) yield export coefficients based on their respective National Land Cover Database (NLCD) land cover classification.

NLCD Code	NLCD Name	TP Yield Export Coefficient		Source
		kg/ha/yr	*lbs/acre/yr*	
11	Open Water	0.00	0.00	
21	Developed, Open Space	1.00	0.89	
22	Developed, Low Intensity	0.91	0.81	LimnoTech 2007
23	Developed, Medium Intensity	1.15	1.03	LimnoTech 2007
24	Developed, High Intensity	1.50	1.34	LimnoTech 2007
31	Barren Land	1.35	1.20	
41	Deciduous Forest	0.08	0.07	LimnoTech 2007
42	Evergreen Forest	0.08	0.07	LimnoTech 2007
43	Mixed Forest	0.08	0.07	LimnoTech 2007
52	Shrub/Scrub	0.08	0.07	LimnoTech 2007
71	Grassland/Herbaceous	0.17	0.15	LimnoTech 2007
81	Pasture/Hay	0.17	0.15	LimnoTech 2007
82	Cultivated Crops	0.38	0.34	LimnoTech 2007
90	Woody Wetlands	0.00	0.00	LimnoTech 2007
95	Emergent Herbaceous Wetlands	0.00	0.00	LimnoTech 2007

Table 2: Total nitrogen (TN) yield export coefficients based on their respective National Land Cover Database (NLCD) land cover classification.

NLCD Code	NLCD Name	TN Yield Export Coefficient		Source
		kg/ha/yr	*lbs/acre/yr*	
11	Open Water	3.5	3.1	Atmospheric Deposition
21	Developed, Open Space	3.5	3.1	Atmospheric Deposition
22	Developed, Low Intensity	5.4	4.8	USEPA 1983
23	Developed, Medium Intensity	9.6	8.6	USEPA 1983
24	Developed, High Intensity	18.0	16.1	USEPA 1983
31	Barren Land	3.5	3.1	Atmospheric Deposition
41	Deciduous Forest	2.0	1.8	USEPA 1999
42	Evergreen Forest	2.0	1.8	USEPA 1999
43	Mixed Forest	2.0	1.8	USEPA 1999
52	Shrub/Scrub	2.0	1.8	USEPA 1999
71	Grassland/Herbaceous	1.3	1.2	USDA MANAGE database
81	Pasture/Hay	2.4	2.1	USDA MANAGE database
82	Cultivated Crops	7.8	7.0	USDA MANAGE database
90	Woody Wetlands	3.5	3.1	Atmospheric Deposition
95	Emergent Herbaceous Wetlands	3.5	3.1	Atmospheric Deposition

Table 3: Prioritize, Target, and Measure Application for Desktop (PTMApp-Desktop) coefficients for estimating the fate and transport of sediment, total phosphorus (TP), and total nitrogen (TN) from the cell to a flowline (or PTMApp-Desktop catchment outlet) and from the flowline to a downstream priority resource point. Each coefficient, with exception to the sediment delivery ratio, is a constant for calculations at each raster cell. The sediment delivery ratio is a function of catchment drainage area and flow length from the cell to the catchment outlet and thus varies from cell to cell.

PTMApp-Desktop Watershed	Delivery from cell to flowline			Delivery from flowline to resource point		
	Sediment Delivery Ratio*	TP Decay Rate	TN Decay Rate	Sediment Transport Coefficient	TP Decay Rate	TN Decay Rate
Rock County	0.6	0.1	0.1	0.2	0.4	0.4

** Value is the mean of the overland sediment delivery ratio for each 3 meter x 3 meter cell across the watershed*

Comparison to a Field-scale Source – Discovery Farms

The single Discovery Farms site in the Rock County Watershed, designated 'RO1-F' on the Blac-X Farm, is a 25.2-acre agricultural field draining to a single culvert along County-State Aid Highway 5 (CSAH 5)/111th St. approximately 4 miles northwest of the City of Beaver Creek (**Figure 1;** Radatz 2017). Automatic surface water monitoring on the site occurred in years 2014 and 2015 for constituents including sediment, TP, phosphate-P, total Kjeldahl-N (TKN), ammonia-N, and nitrate-N. Flow is also recorded to determine total volume and to estimate annual load leaving the site. Due to data collection issues in 2015, annual monitoring and flow data were not available to be compared with PTMApp-Dekstop results (Tim Radatz, personal communication, January 27, 2017). Annual yields estimated on this site on the Blac-X Farm were therefore only available during 2014, and are shown in **Table 4**, along with the annual yields estimated by PTMApp-Desktop for the catchment this Discovery Farms site lies within.

Table 4: Summary of field-scale sediment, total nitrogen, (TN), and total phosphorus (TP) yields (lbs/acre/year) for a Discovery Farms site (RO1-F) and for the Prioritize, Target, and Measure Application for Desktop (PTMApp-Desktop) catchment (ID 511952) the site is within.

Source	Drainage Area	Pollutant Loading		
		Sediment	TN	TP
	acres	*lbs/acre/year*		
PTMApp (Catchment ID 511952)	119.9	12,058.1	6.7	0.3
Discovery Farms (Site RO1-F)	25.2	47.2	1.8	0.4

At this scale, PTMApp-Desktop nutrient yields are far more "comparable" to estimates at the Discovery Farms site than sediment yields for the two datasets. The high sediment yield in PTMApp-Desktop is partially due to the ravine within this PTMApp-Desktop catchment downstream (south of 111th St.) of the Discovery Farms site. This feature can be seen on **Figure 1** south of 111th St., and is characterized by more than a 20 foot drop in elevation from the surface of 111th St. (at the RO1-F monitoring station) to the catchment outlet on the lower portion of the map. This feature was likely disproportionately increasing PTMApp-Desktop loads to the catchment outlet, as compared to the rest of the predominately-farmed catchment area. The ravine's impact on

PTMApp-Desktop inputs is shown in **Table 5**, where the only significant difference in RUSLE factors between areas within the Discovery Farms watershed and its larger PTMApp-Desktop catchment is the RUSLE ls-factor, which effectively describes the slope of the land surface. Mean sediment mass delivered to the catchment outlet on a cell-by-cell basis (as represented in the PTMApp-Desktop raster 'Sed_mass_fl') in the Discovery Farms catchment is just 3.3 tons/acre/year. For the larger PTMApp-Desktop catchment, mean sediment mass to the catchment on a cell-by-cell basis nearly doubles to 6.0 tons/acre/year. This catchment also has a higher mean slope across the catchment, as compared to (1) just the RO1-F watershed and (2) to all other areas in the watershed (**Table 5**).

Table 5: Mean slope and Revised Universal Soil Loss Equation (RUSLE) factors for the Discover Farms Watershed, the Prioritize, Target, and Measure Application for Desktop (PTMApp-Desktop) catchment that encompasses it (ID 511952), and for the full Rock County Watershed. The standard deviation for each mean is shown in parentheses.

Source	Total Area (acres)	slope (%)	RUSLE Factors				
			kw	c	ls	r	p
Discovery Farms (Site RO1-F)	25.20	4.85 (1.84)	0.37 (0.02)	0.18 (0.08)	0.91 (0.70)	117.00 (0.03)	1 (0)
PTMApp Catchment ID 511952	119.85	5.86 (2.86)	0.36 (0.02)	0.19 (0.05)	1.19 (1.07)	117.11 (0.09)	1 (0)
Rock County Watershed (All PTMApp Catchments)	168,144.24	3.58 (1.55)	0.29 (0.03)	0.16 (0.05)	0.67 (0.32)	117.20 (2.14)	1 (0)

This difference could also be explained by local conditions, including improved field and tillage management on the site. The Blac-X farm uses cover crops and rotational tillage techniques across all of its 1,600 acres of farmland, including this plot (Radatz 2017). In 2014 specifically, the single water year data was collected and analyzed at this site by Discovery Farms, soybeans were planted into existing corn stalks (Tim Radatz, personal communication, January 27, 2017). This strategy of planting soybeans into the previous year's crop is an example of no-till field management. In addition, a perennial grassed waterway upstream of the RO1-F monitoring station further decreased soil export from the field (**Figure 1**; Tim Radatz, personal communication, January 27, 2017). The effect of on-field management and this structural practice is resolved within two RUSLE factors in PTMApp-Desktop; i.e., the C-factor and the P-factor, respectively (**Table 5**). For this study, all areas identified as pasture or agricultural in the NLCD database were given a C-factor value of 0.2. Values in **Table 5** list the mean C-factor value across the respective watersheds. As limited data was available watershed-wide on existing conservation practices, a uniform P-factor value of 1 (meaning no effect from existing practices) was applied across the entire project area (**Table 5**). For this particular site, both the C-Factor and P-Factor would be reduced with this field-specific information. The C-factor would likely be reduced from 0.2 to 0.03 for soybeans following corn with no-till and approximately 20-30% cover (Institute of Water Research at Michigan State University 2002). The watershed-wide P-Factor would also be at least halved, as the entire 25-acre Discovery Farms watershed drains to the grassed waterway. Reducing the C-factor and P-factor to 0.03 and 0.5, respectively, could have reduced the PTMApp-estimated sediment load by two orders of magnitude, bringing the estimate much more in-line with what was measured at the Discovery Farms monitoring station. These differences illustrate the importance of on-field tillage, cropping, and structural practices and convey the importance of providing accurate input data to the model. A database of existing agricultural conservation practices or information on cropping practices and field management techniques (along with estimates of their impact on sediment, TP, and TN runoff) would have greatly improved PTMApp-Desktop's ability to accurately model sediment and nutrient runoff from this field.

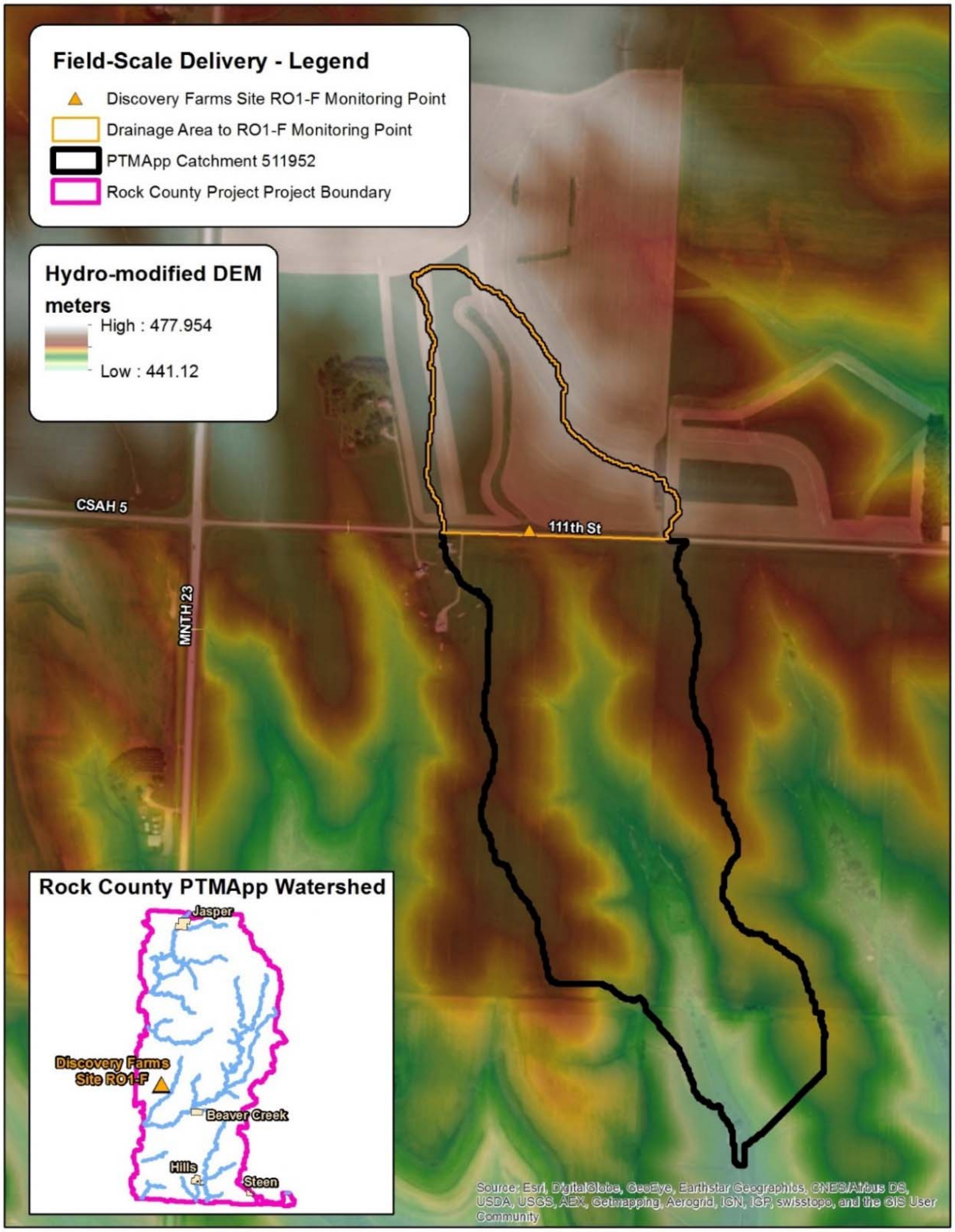

Figure 1: Location of the Discovery Farms Site RO1-F, its upstream drainage, area, and its surrounding Prioritize, Target, and Measure Application for Desktop (PTMApp-Desktop) catchment (ID 511952) within the Rock County PTMApp watershed. The hydro-modified digital elevation model (DEM), shown with a color gradient from blue and green in low areas to red and white in high areas, overlays a current aerial photograph.

Sediment and nutrient loading values shown in **Table 4** are not just a summation of RUSLE outputs across the catchment, but consider an overland sediment delivery ratio that estimates the amount of sediment generated by each cell[3] which are delivered to the flowline (~ field edge / concentrated flow path). Cell sediment delivery ratio estimates within this catchment ranged from 0.43 to 1 based on the distance from the cell to the flowline (mean = 0.61, standard deviation = 0.12). These values are within ranges of other estimated and measured values using a variety of methods (Fernandez et al. 2003; Smith et al. 2011).

Lastly, it is also worth noting the variation in the analytical methods used to determine "sediment loss" within these two datasets. Discovery Farms measures suspended solids concentration from samples acquired at its monitoring station and converts it to a sediment load based on flow data, whereas PTMApp-Desktop estimates soil erosion load and yield based on the detachment of soil particles as calculated by the RUSLE equation. RUSLE estimates field soil losses based solely on sheet and rill erosion from the land surface, while Discovery Farms monitoring equipment measures all sediment eroded from the soil and carried to the field outlet. This sediment may have been generated through a variety of erosive processes, including sheet, rill, gully, and mass wasting (e.g. from slumps).

TP and TN yield estimated at the outlets of the PTMApp-Desktop catchment 511592 and the Discovery Farms watershed outlet were generally more in line than sediment yield estimates (**Table 4**). PTMApp-Desktop TP annual yield was only 15% lower than the Discovery Farms TN annual yield measured at the RO1-F monitoring station, while PTMApp-Desktop TN annual yield was 266% higher than values measured on the RO-1 farm (**Table 4**). The lower Discovery Farms TN value could be explained by the decreased fertilizer rate being applied to this catchment due to the nitrogen-fixing crop planted while measurements were occurring in 2014 (Tim Radatz, personal communication, January 27, 2017). The PTMApp-Desktop and Discovery Farms data, though, are both low when compared to yield coefficients measured in the MRB4 SPARROW model, which are discussed in the next section.

Overall, a comparison of PTMApp-Desktop data with Discovery Farms data on this site is tenuous as monitoring data was only available for this field in a single year, 2014. Water year 2014 in Rock County was climatically near average in terms of precipitation (MNDNR 2015) but other inter-annual factors such as rainfall intensity and crop nutrient assimilation could also play a significant role in such a short time span. Without any more robust datasets to compare with at this spatial scale, this single year's worth of data on this individual farm remains our best comparison but results should be taken wearily.

LARGE SUBWATERSHED-SCALE DELIVERY

Background

To evaluate the performance of PTMApp-Desktop at the large subwatershed scale, three independent datasets were compared with PTMApp-Desktop results in similar subwatersheds. Each dataset used water quality monitoring and gaged flow data to estimate annual sediment loads and/or yields on the landscape. The first dataset , the USGS SPARROW model results, also utilized geospatial datasets to relate landscape characteristics (e.g. land cover, soil) to sediment, TP, and TN sources and applied statistical models to establish a relationship between the sources and subsequent downstream loads (Preston et al. 2009). The second

[3] The RUSLE equation and nutrient yields are estimated for each 3 meter by 3 meter cell in the raster and delivery to a concentrated flow path is estimated.

dataset, MPCA FLUX modeling results, relied on monitoring data and utilized the Army Corps of Engineers' FLUX32 model to estimate annual loads and yields. Lastly, the third dataset established "reference" values for sediment yield and transport rates in fluvial systems based on Level III Ecoregion (Klimetz & Simon 2009). Annual load and yield results from these three datasets were compared with PTMApp-Desktop results to assess the effectiveness of the transport equations listed below, which deliver load from the catchment outlet to a downstream location (called a priority resource point in PTMApp-Desktop), including subwatershed outlets, receiving waterbodies, and the watershed outlet.

PTMApp Technical Processes at the Large Subwatershed Scale

At a larger scale, sediments and nutrients delivered to the edge of field or flowline (or catchment outlet in PTMApp-Desktop) are conveyed in-channel to downstream priority resource points, eventually reaching the watershed outlet. Along the way, many sediments drop out of solution and are deposited in the stream/river channel, a lake or wetland, or are otherwise lost in transport. Nutrients can also be bio-assimilated by aquatic plants and animals or permanently removed through biogeochemical processes such as denitrification (in the case of nitrogen). These processes are resolved in PTMApp-Desktop for each constituent by first-order loss equations. For sediment, in-channel downstream transport and loss is described by the equation,

$$SY = Y * e^{-\beta T \sqrt{d_{50}}}$$

Where *Y* is the sub-basin sediment yield, β is the transport coefficient, *T* is the travel time, and d_{50} is the mean sediment diameter. Default values of 0.2 and 0.1 were used for β and d_{50}, respectively.

For TN and TP, a first-order loss equation, like the one used to estimate the amount of TP and TN moving from the raster cell to the PTMApp-Desktop catchment outlet, estimates the magnitude of nutrients reaching the priority resource point from the catchment outlet,

$$W = e^{-kT}$$

Where *W* is the portion of yield leaving the catchment outlet and delivered to the priority resource point, *k* is the decay rate, and *T* is the travel time from catchment outlet to the priority resource point. For travel from the catchment outlet to the priority resource point, a default value of 0.4 was used for *k*. Each of the first-order decay rate coefficients governing sediment, TP, and TN delivery from the catchment outlet to the downstream priority resource point in PTMApp-Desktop are also summarized in **Table 3**.

Comparison to a Large Subwatershed Scale Source – SPARROW MRB4 Model

The Rock County Watershed lies within the northeastern extent of the Missouri River Basin, with the watershed's major creeks (including Beaver Creek, Split Rock Creek, Fourmile Creek, and Blood Run) acting as tributaries to the Big Sioux River. The USGS refined their national SPARROW models to create regional models for TN and TP within the Missouri River Valley (named the 'MRB4' SPARROW model; Brown et al. 2011). Like PTMApp-Desktop, pollutant loads in SPARROW are first estimated at the catchment scale, termed 'incremental loads', and represent load estimates for low-order stream systems. Also similar to PTMApp-Desktop, these are converted into yields by dividing by the catchment area. SPARROW allocates incremental catchment yield from various sources within each stream reach which were deemed significant across the Missouri River Watershed. Significant nitrogen sources included (1) point sources (e.g. permitted dischargers such as waste water treatment plants and industrial facilities), (2) fertilizer applied to agricultural lands, (3) confined and unconfined manure operations and applications to agricultural fields, (4) atmospheric deposition, and (5) inputs from developed lands (Brown et al. 2011). Significant phosphorus sources were analogous to nitrogen sources, except phosphorus stream channel contributions replaced those from atmospheric sources of nitrogen. As SPARROW is a mass-balance model, significant sources listed here also cover the combined impacts of other non-significant sources. These non-significant sources may have included inputs from undeveloped and natural lands, such as wetlands and forests, diffuse septic leaks, nitrogen deposition from vehicle emissions, and others (Brown et al. 2011). As PTMApp-Desktop is only able to estimate TP and TN generated from the land surface, SPARROW incremental yields were only comparable for sources generated from land application activities. This included only fertilizer applied to agricultural fields and nutrient sources generated from developed lands. In the case of manure, MRB4 SPARROW results did not differentiate between manure generated by livestock on unconfined or confined animal operations, or what fraction of manure was applied to nearby fields and lost in runoff to downstream waterbodies, lost directly form the operation to the nearby stream, or lost in transport (Preston et al. 2009). Preston and others (2009) theorized that the 'fertilizer' source term likely accounts for inputs from manure application to fields and certain cropping practices, making it the best proxy to determine nutrient loads from agricultural fields. Thus, fertilizer and developed land sources were only used to compare SPARROW incremental yields to PTMApp-generated catchment yields.

A SPARROW model was also created and refined to estimate the fate and transport of suspended sediment across the conterminous US (Schwarz 2008). This analysis followed a similar methodology to the SPARROW MRB4 nutrient study, including development of regression equations to estimate pollutant load carried in streams and rivers based on water quality monitoring and flow data, as well as geospatially-relevant sediment source information. Sediment sources were more land use-specific and included urban, forested, federal nonforested, agricultural, and "other" land uses. A sixth source included sediment generated within the channel. Results from this study were also summarized as loads and yields delivered to the catchment outlet (incremental loads and yields) and to the Missouri River outlet (total loads and yields). Like the MRB4 study, catchments in the Schwarz (2008) study were delineated from the USGS Enhanced River Reach File (Nolan et al. 2002; Brakebill et al. 2011) so incremental yields for sediment and nutrients relate to the same catchments across these studies. SPARROW incremental sediment loads and yields, for comparative purposes with PTMApp-Desktop data, were considered the summation of the urban, agricultural, forested, federal nonforested, and "other" land use sources.

SPARROW catchments, although much larger than PTMApp-Desktop catchments (mean area of 38 mi^2 compared to 0.07 mi^2 (43 acres) for PTMApp-Desktop catchments), still apply many of the same processes when estimating the fate and transport of sediment and nutrients to downstream points (Preston et al. 2009). In the Rock County Watershed, PTMApp-Desktop delineated 3,952 catchments (**Figure 2**). These lie within 20 of the SPARROW MRB4 catchments, noted in **Figure 2** with their respective SPARROW reach name and catchment ID. To ensure for a reasonable comparison between yield values from each model's catchments, results were only compared when sufficient overlap occurred between each model's catchments. For this analysis, significant overlap was defined as at least 75% of the SPARROW catchment's area covered by PTMApp-Desktop catchments. SPARROW catchments which met this standard are signified in **Figure 2** with a blue hash. As PTMApp-Desktop catchment area rarely fully covered SPARROW catchment area, yield values (as opposed to the area-independent load values) were used to compare sediment and nutrient export in the datasets. SPARROW yield measured at the catchment outlet was compared to PTMApp-estimated yields measured at the nearest priority resource point to the SPARROW catchment outlet (**Figure 2**). Comparing these data should give a reasonable comparison of the in-channel transport processes in each model that convey sediment and nutrients to downstream resources.

PTMApp-Desktop sediment, TP, and TN yield delivered from catchment outlets to priority resource points nearest to the SPARROW catchment's outlet is summarized in box and whisker plots in **Figure 3**. Median SPARROW sediment yield was not significantly different from PTMApp-Desktop sediment yield (Kruskal-Wallis test, $p > 0.05$), with a median yield value of 0.48 tons/acre/year from the SPARROW catchments and 0.67 tons/acre/year delivered to priority resource points from PTMApp-Desktop catchments (**Figure 3**). Conversely, SPARROW TP and TN yield were both significantly larger than PTMApp-Desktop nutrient yield delivered to priority resource points (Kruskal-Wallis test, $p < 0.05$). In fact, median SPARROW catchment yield was at least two orders of magnitude larger than both TP and TN median yields estimated by PTMApp-Desktop at the nearest priority resource point to the SPARROW catchment outlet (**Figure 3**). Further upstream, this discrepancy in nutrient yields is less apparent when looking at the delivery of sediment and nutrients generated on the landscape to the flowline (or catchment outlet; **Figure 4**). This is again compared to SPARROW catchment yield, as this is the smallest scale SPARROW data was resolved at. In this case, TP yield was not considered significantly different from SPARROW TP yield (Kruskal-Wallis test, $p > 0.05$). SPARROW TN yield was still significantly larger than PTMApp-Desktop TN yield (Kruskal-Wallis test, $p < 0.05$), but median PTMApp-Desktop yield (6.6 lbs/acre/year) was only 64% smaller than median SPARROW yield (18.1 lbs/acre/year).

This large difference in nutrient yields is likely explained by the first order decay rate that reduces pollutant loading in PTMApp-Desktop from the catchment outlet to the priority resource point based on the pollutant-specific first-order loss equation (**Table 3**). Averaged across PTMApp-Desktop catchments, the sediment delivery ratio was 0.748 (meaning the fraction of sediment reaching the priority resource point was 0.748 of what was delivered to the catchment outlet, i.e. a 25.2% reduction in transport). For TP and TN the delivery ratios were both 0.234. Each of these delivery ratios are calculated using the sediment-specific or nutrient-specific first-order loss equation detailed on page 9 and with its respective decay coefficient listed in **Table 3**. The SPARROW nutrient model estimated in-stream losses to be 0.150 day^{-1} for small streams (defined as annual discharge <3.1 m^3/s) and insignificant for larger streams and rivers (Brown et al. 2011). In-stream TP loss was found to be insignificant for streams and rivers of any size (Brown et al. 2011). This resulted in little to no in-stream loss in TN and no in-stream loss of TP in the SPARROW data, whereas PTMApp-Desktop nutrient loading was reduced by 77% on average at priority resource points as compared to catchment outlets.

Lastly, similar to the monitoring data used to estimate sediment erosion on the Discovery Farms site, monitoring data from both the sediment and nutrient SPARROW studies were based on measurements of in-channel, flow-weighted suspended sediment, TP, and TN concentrations. For TP and TN, PTMApp-Desktop estimates loads and yields from export coefficients with terms that lump all species of each constituent. Sediment, on the other hand, is estimated in PTMApp-Desktop based on soil erosion calculated by the RUSLE equation. As this equation is only able to determine soil loss from sheet and rill erosion, it cannot estimate field losses from other processes such as wind erosion, gully erosion, or mass wasting which could reach the downstream monitoring station and be "fingerprinted" as field losses based on its provenance. For purposes of this analysis PTMApp-Desktop soil loss was estimated to be equivalent to suspended sediment load but may not be directly comparable in all cases or at all scales.

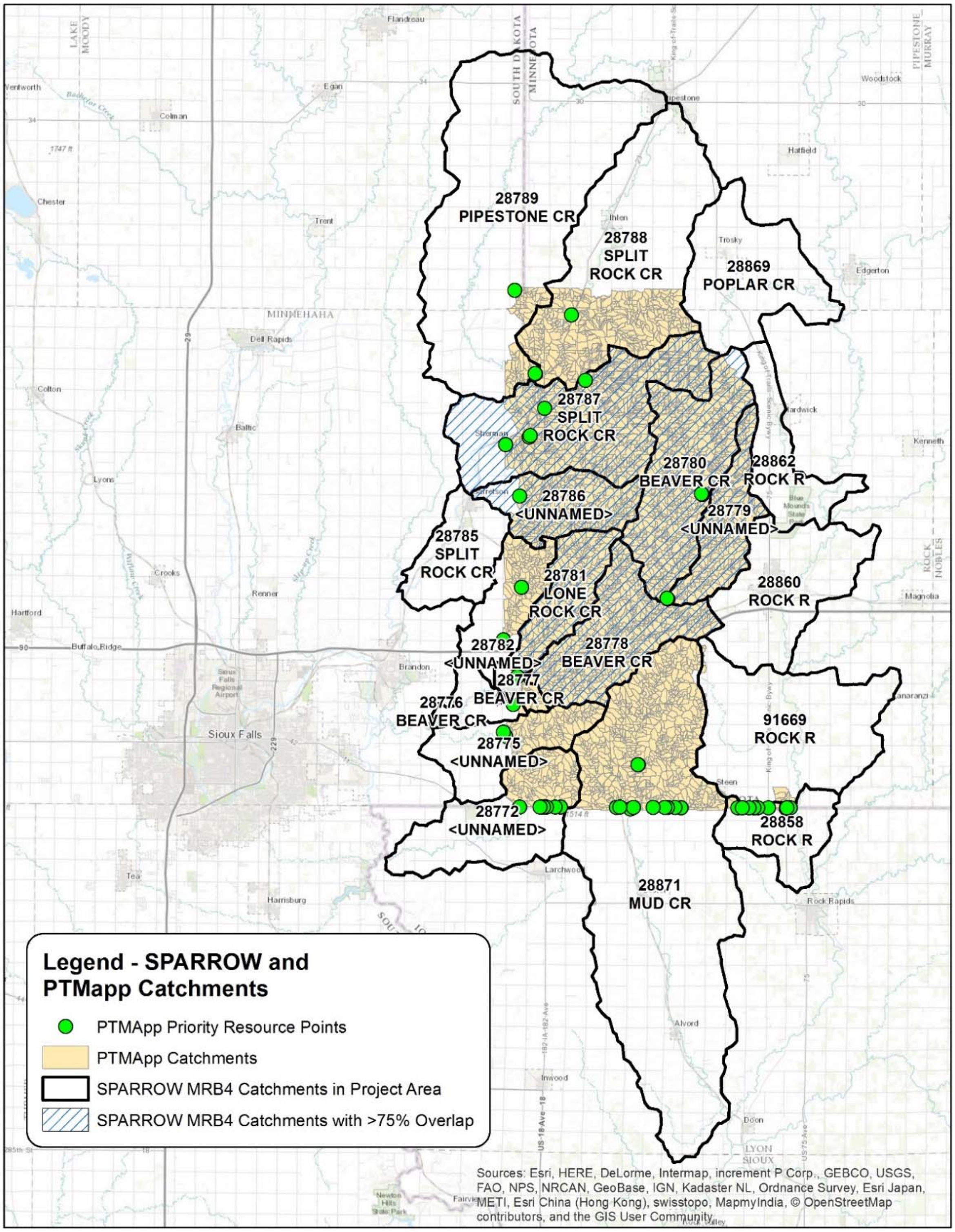

Figure 2: SPAtially Referenced Regression on Wateshed Attributes (SPARROW) Missouri River Basin Model 4 (MRB4) catchments, labeled with their respective I.D. and reach name, overlaying the Prioritize, Target, and Measure Application (PTMApp) catchments in the Rock County Watershed. SPARROW catchments with >75% of their area covered by PTMApp catchments area displayed in a blue hash.

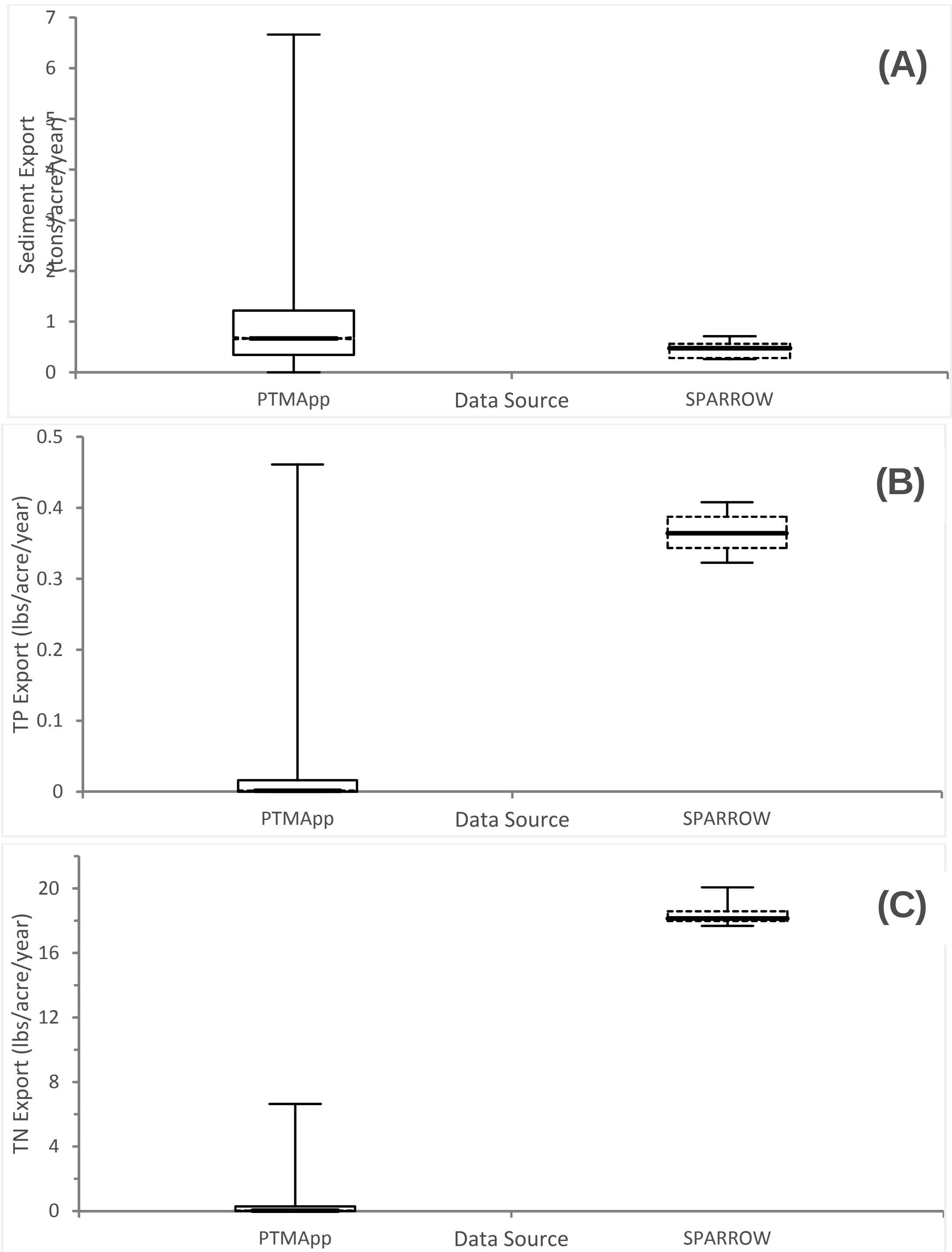

Figure 3: Box and whisker plots of (A) sediment, (B) total phosphorus (TP), and (C) total nitrogen (TN) export delivered to priority resource points in the Prioritize, Target, and Measure Application (PTMApp), compared to incremental catchment yields from the SPAtially-Referenced Regression On Watershed attributes (SPARROW) Missouri River Basin (MRB4) model. The height of each box spans the interquartile range (25th percentile to 75th percentile) with the interior line representing the median (50th percentile). Endpoints of each whisker signify the minimum and maximum values in the dataset.

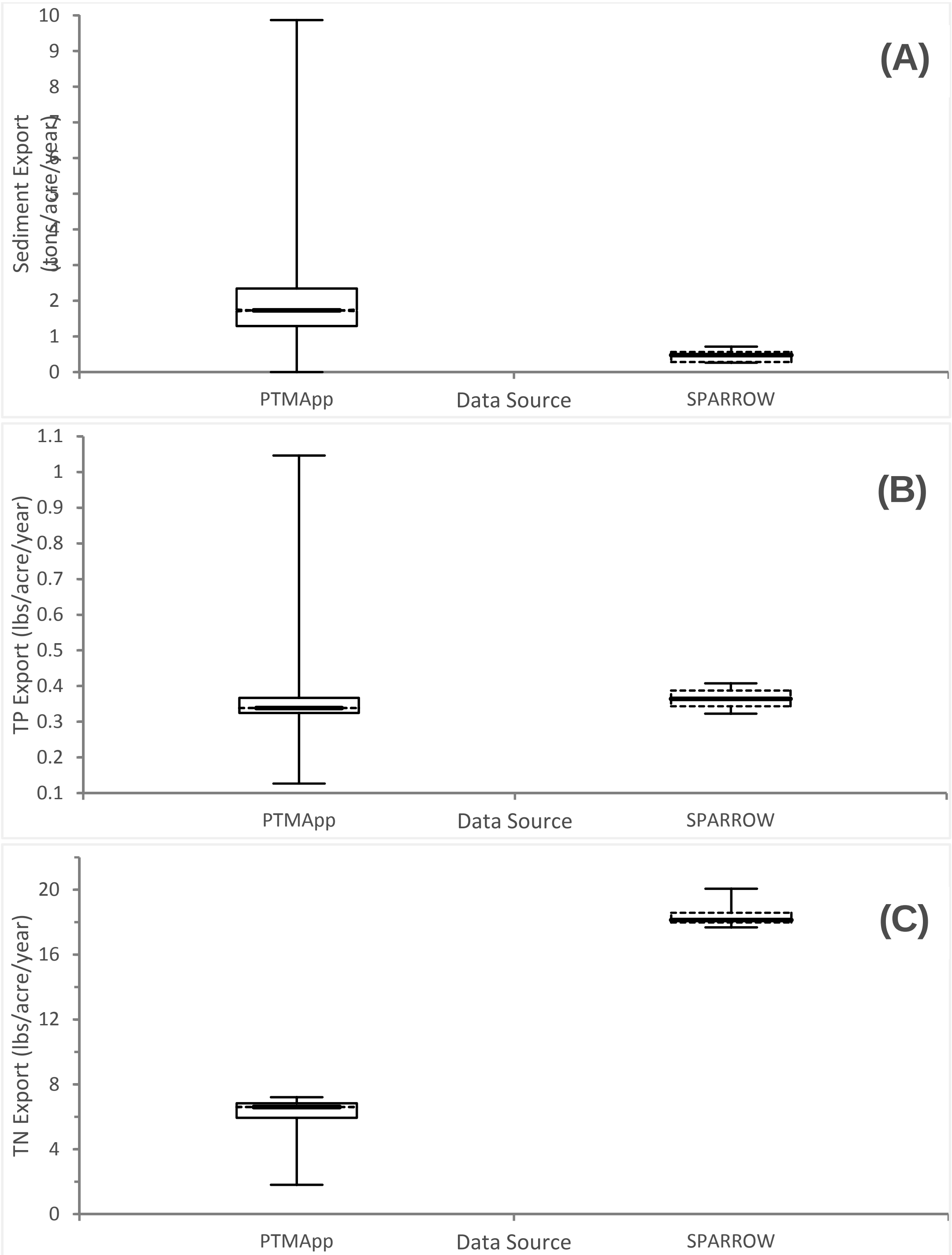

Figure 4: Box and whisker plots of (A) sediment, (B) total phosphorus (TP), and (C) total nitrogen (TN) export delivered to catchment outlets in the Prioritize, Target, and Measure Application (PTMApp), compared to incremental catchment yields from the SPAtially-Referenced Regression On Watershed attributes (SPARROW) Missouri River Basin (MRB4). The height of each box spans the interquartile range (25th percentile to 75th percentile) with the interior line representing the median (50th percentile). Endpoints of each whisker signify the minimum and maximum values in the dataset.

Comparison to a Large Subwatershed Scale Source – MPCA FLUX Model

MPCA stations S004-528 (Split Rock Creek near Jasper, 201st St.) and S004-811 (Beaver Creek near Valley Springs, 10th Ave.) both fall within the Rock County PTMApp-Desktop watershed boundary. Of these two sites, load modeling (performed by the MPCA using FLUX32) had already been completed for station S004-528 (**Figure 5**), which had sufficient flow and water quality monitoring data to characterize TSS, TKN, and dissolved inorganic nitrogen (DIN; nitrate plus nitrite) loadings for 4 years and total TP loading for 3 years. Station S004-811 only had flow and water quality monitoring data for 2 years and the data had not yet been modeled by the MPCA with FLUX32. As FLUX32 analysis is outside the scope of this project, pollutant load modeling was not completed for this site. Therefore, only data gathered and analyzed at MPCA station S004-528 was compared with PTMApp-Desktop data. Station S004-528 and its upstream drainage area are shown in **Figure 5**, along with the nearest PTMApp priority resource point (PTMApp-Desktop p_res_pt = 40) and its drainage area. The PTMApp-Desktop drainage area only extends slightly north of the county boundary per the client's request to have analysis focus on Rock County. As the MPCA station's drainage area is significantly larger than its nearest PTMApp-Desktop priority resource point (310 mi^2 to 58 mi^2, respectively), yield values were used to compare the two datasets instead of load values.

For this analysis, TN annual loads and yields at MPCA stations were estimated by the summation of TKN and DIN annual loads. Combined, these two parameters measure the mass load of organic nitrogen, ammonia/ammonium, nitrate, and nitrite, which make up the majority of nitrogen mass in aquatic systems (Kalff 2002). TP loads and yields were provided from the FLUX32 results. The fraction of TN and TP measured at the MPCA monitoring station which was generated from the landscape, as opposed to what was generated from other sources such as atmospheric deposition, livestock manure, the channel bank, or point sources, was estimated from the SPARROW MRB4 datasets (Brown et al. 2011) as the summation of TP and TN from the developed land and fertilizer source categories. Across the six SPARROW catchments noted in **Figure 2** which have over 75% of their area covered by PTMApp-Desktop catchments (and therefore have comparable landscape features to those in analyzed in PTMApp-Desktop), 62% of the TN yield and 55% of the TP yield were generated from landscape sources. These fractions were multiplied by the annual TP and TN yields determined from the FLUX32 model results to obtain TP and TN yields comparable to those estimated by PTMApp-Desktop.

MPCA monitoring protocols measure suspended solids as 'TSS', which is different from the soil detachment estimates resulting from sheet and rill erosion within RUSLE. Combined with the transport equations that govern sediment movement in PTMApp-Desktop, soil erosion estimated in PTMApp-Desktop most closely resembles suspended sediment. No conversion was made to transform TSS values to suspended sediment values as sands, typically the material missed most often following TSS analytical protocols, were not a significant portion of the sediment load for streams and rivers in this area of southern Minnesota (Gray et al. 2000; Ellison et al. 2014). MPCA yield values were multiplied by the fraction of sediment generated on the landscape, estimated to be 50%, based on a series of sediment geochemical fingerprinting studies which found fluvial sediment loads originating from channel erosion typically ranged from 31-70% for streams and rivers in southern Minnesota (Sekely et al. 2002; Belmont et al. 2011). The fraction of landscape-generated sediment in the SPARROW sediment study for catchments shown in **Figure 2** (0.87; Schwarz 2008) was not used as it was much larger than direct measurements made in watersheds near the Rock County project area.

Comparisons between the two datasets are shown in the box and whisker plots in **Figure 6**. Sediment, TP, and TN yield were significantly different for each constituent across each of the datasets (Kruskal-Wallis test, $p < 0.05$; **Figure 6**). PTMApp-Desktop sediment yield measured at priority resource point 40 (**Figure 5**) was significantly larger than yields measured at the MPCA monitoring station, with a median PTMApp-Desktop sediment yield of 0.57 tons/acre/year compared to 0.09 tons/acre/year across the 4 years MPCA gathered and analyzed data (2009-2012; **Figure 6**). Conversely, and similar to the SPARROW results (**Figure 3**), PTMApp-Desktop TP and TN yields measured at priority resource point 40 were orders of magnitude lower than yields found at the MPCA monitoring site (**Figure 6**). Comparing median MPCA nutrient yield values with median PTMApp-Desktop nutrient yields measured at upstream catchment outlets (comparable to analysis between SPARROW and PTMApp-Desktop catchments in **Figure 4**), median TP and TN yields were not significantly different between the two datasets (Kruskal-Wallis test, $p > 0.05$; **Figure 7**). PTMApp-Desktop sediment yield was still significantly higher than MPCA-estimated sediment yield (**Figure 7**). This is unsurprising considering PTMApp-Desktop downstream yields were also higher following reductions applied by the first-order loss equation that determines sediment fate from the catchment outlet to the resource point in PTMApp-Desktop (**Figure 6**). This loss is described in the sediment delivery ratio, or the ratio of sediment delivered to the resource point to the amount delivered to the catchment outlet. For the 861 PTMApp-Desktop catchments delivering sediment to priority resource point 40, the mean sediment delivery ratio averaged across all catchments was 0.48. Similarly, mean delivery ratios for TP and TN were both 0.05. Considering the discrepancy between TP and TN yields in **Figures 6** and **7**, its probable the non-zero PTMApp-Desktop delivery ratio for each nutrient contributed greatly to the large difference between yields measured at the MPCA monitoring station and its nearest PTMApp-Desktop priority resource point.

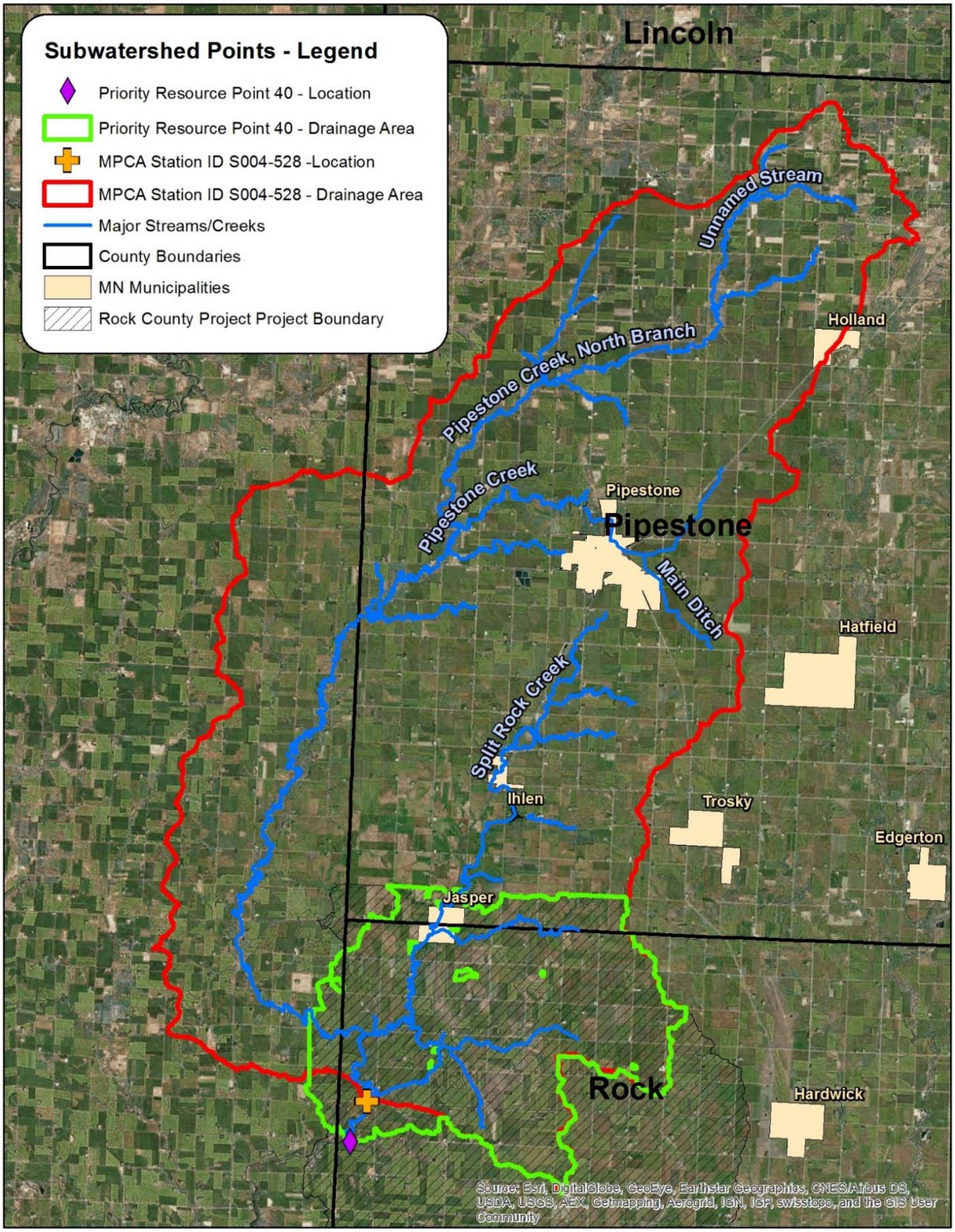

Figure 5: Location of the Minnesota Pollution Control Agency (MPCA) station ID S004-528, the nearest Priority, Target, and Measure Application (PTMApp) priority resource point, and each point's contributing drainage area.

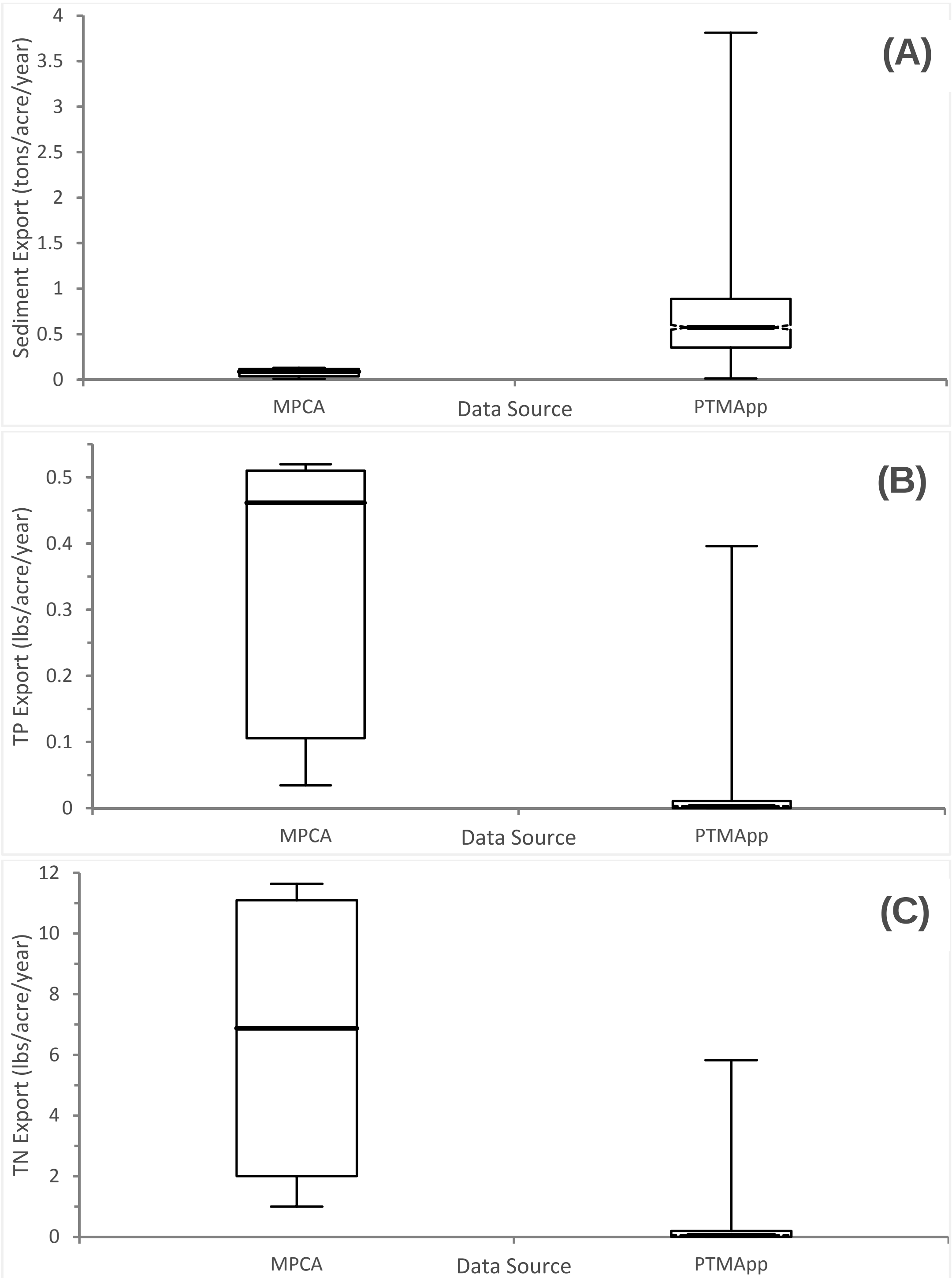

Figure 6: Box and whisker plots of (A) sediment, (B) total phosphorus (TP), and (C) total nitrogen (TN) export delivered to priority resource point 40 in the Prioritize, Target, and Measure Application (PTMApp), compared to annual yield estimates at Minnesota Pollution Control Agency (MPCA) station S004-528 for years 2009-2012. The height of each box spans the interquartile range (25th percentile to 75th percentile) with the interior line representing the median (50th percentile). Endpoints of each whisker signify the minimum and maximum values in the dataset.

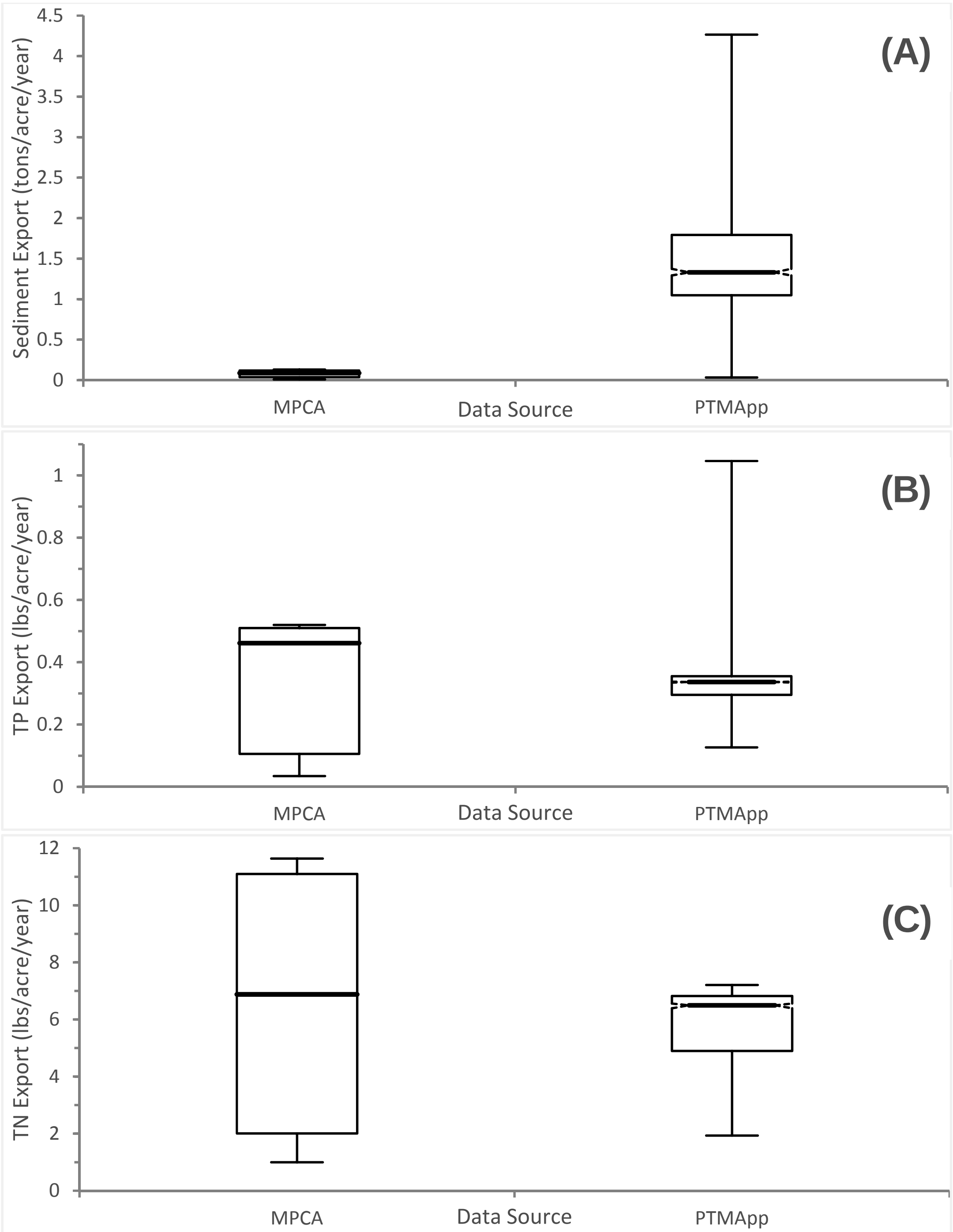

Figure 7: Box and whisker plots of (A) sediment, (B) total phosphorus (TP), and (C) total nitrogen (TN) export delivered to catchment outlets within the drainage area of priority resource point 40 in the Prioritize, Target, and Measure Application (PTMApp), compared to annual yield estimates at Minnesota Pollution Control Agency (MPCA) station S004-528 for years 2009-2012. The height of each box spans the interquartile range (25th percentile to 75th percentile) with the interior line representing the median (50th percentile). Endpoints of each whisker signify the minimum and maximum values in the dataset.

Comparison to a Large Subwatershed Scale Source – Klimetz & Simon, 2009

A US Department of Agriculture (USDA) Agricultural Resource Service sediment study sought to determine "reference" transport rates for suspended sediments in Minnesota based on Level III Ecoregions, as well as gauge channel stability and stages of evolution which may be specific to each ecoregion (Klimetz & Simon 2009). "Reference" conditions were defined as those characteristic to stable stream systems which are in dynamic equilibrium (conveys sediment without altering its dimensions over time) over a sufficiently long reach. Channel-forming discharges (or effective discharge, statistically the 1 in 1.5-year discharge event ($Q_{1.5}$)) and mean annual yields were estimated for each Level III Ecoregion. Channel stability was also characterized using Rapid Geomorphic Assessments (RGAs) at various sites within each ecoregion (Klimetz & Simon 2009).

The Rock County Watershed lies within Ecoregion 47, the Western Corn Belt Plains (WCBP) Ecoregion. Results from Klimetz and Simon (2009) found the WCBP Ecoregion had the largest "reference" suspended sediment yield of ecoregions in Minnesota, with a median yield of 0.08 tons/acre/year across all sites and a much larger interquartile range compared to other ecoregions, suggesting a wide range of sediment conveyance potential across stable streams in the ecoregion (**Table 6**). Percentiles of mean sediment yield at each site for all sites, only stable sites, and only unstable sites within the WCBP Ecoregion are shown in **Table 6**, along with values generated by PTMApp-Desktop, the SPARROW MRB4 model, and MPCA's FLUX32 model at site S004-528. Median PTMApp-Desktop sediment yield (0.67 tons/acre/year) in the Rock County Watershed lies within the interquartile range of the unstable sites and "all" sites, but is above the range for stable sites (**Table 6**). To allay potential biases when estimating sediment yield across a large range of watershed areas, data was also grouped and analyzed based on watershed size, ranging in orders of magnitude from 100 km^2 up to 100,000 km^2. The Rock County Watershed is most comparable to the smallest of these groups, those watersheds with drainage areas of up to 100 km^2. Median annual yield and the inter-quartile range for all sites and for only the unstable sites in these watersheds was very comparable to values estimated at priority resource points in PTMApp-Desktop (**Table 6**). In both cases PTMApp-Desktop sediment yield were less than 35% different than either the unstable sites (PTMApp data 26% lower) or all sites (PTMApp data 34% higher) with less than 100 km^2 in drainage area and were well within both dataset's interquartile range (**Table 6**).

Table 6: Mean annual sediment yields (tons/acre/year) from Klimetz & Simon (2009), Prioritize, Target, and Measure Application (PTMApp) yields to the priority resource point for in the Rock County Watershed, SPAtially-Referenced Regression On Watershed attributes (SPARROW) Missouri River Basin (MRB4) catchment incremental yields, and Minnesota Pollution Control Agency (MPCA) FLUX model results for monitoring station S004-528. The number (n) of sites used to determined percentiles (10th, 25th, 50th, 75th, and 90th) and the interquartile range (IQR; 25th to 75th percentiles) are also shown.

Klimetz and Simon (2009) Stability Category	n	Percentiles (tons/acre/year) 10	25	50	75	90	IQR
Klimetz & Simon, 2009 - All Drainage Area Sizes							
Stable Sites	19	0.03	0.06	0.08	0.20	0.35	0.14
Unstable Sites	23	0.05	0.15	0.98	2.30	2.63	2.15
All Sites	48	0.03	0.07	0.20	1.03	2.40	0.96
Klimetz & Simon, 2009 - Drainage Areas Less Than 100 km^2							
Stable Sites			Insufficient data to analyze				
Unstable Sites	4	0.22	0.45	0.91	1.36	1.55	0.90
All Sites	6	0.11	0.23	0.50	1.08	1.46	0.85
Other Data Sources							
PTMApp (Rock County Watershed)	4266	0.17	0.35	0.67	1.22	1.98	0.87
SPARROW MRB4 Model	6	0.27	0.28	0.48	0.56	0.63	0.28
MPCA FLUX Modeling at Site S004-528	4	0.03	0.04	0.09	0.12	0.12	0.08

CONCLUSIONS

In this section, PTMApp-Desktop results were compared to independent datasets measured at various scales to evaluate the performance of PTMApp-Desktop. PTMApp-Desktop sediment and nutrient loading at the field-scale, which measures the amount of pollutants leaving the landscape and delivered to the catchment outlet, was compared to data gathered at a single Discovery Farms site in the watershed. The datasets had comparable annual TN and TP yields, but sediment yield on the Discovery Farms site was two orders of magnitude less than loading exported from the PTMApp-Desktop catchment. This discrepancy could have been explained by (1) the ravine located in the downstream portion of the PTMApp-Desktop catchment, outside of the Discovery Farms contributing drainage area, and/or (2) the tillage and field management practices on the Discovery Farms field that would have promoted better soil health and reduced sediment erosion, which were not reflected in the input data available for PTMApp-Desktop RUSLE inputs.

At the large subwatershed scale, PTMApp-Desktop results were compared to three other independent datasets to assess the performance of the transport equations that deliver sediment, TP, and TN from catchment outlets to downstream priority resources. PTMApp-Desktop sediment yields at this scale were comparable with incremental catchment yields measured in the SPARROW MRB4 model and with many of the site categories in the Klimetz & Simon (2009) study within the WCBP Level III Ecoregion, but were significantly larger than median annual yields estimated from a single MPCA monitoring station in the county. Median TP and TN yields measured at priority resource points in PTMApp-Desktop were significantly greater (often more than two orders of magnitude) than median yields measured at geographically similar locations in either the SPARROW MRB4 or MPCA FLUX models. This discrepancy disappeared when these independent datasets were instead compared to PTMApp-Desktop yields delivered to the catchment outlet. Median MPCA yields for TP and TN were not significantly different from PTMApp-Desktop median TP and TN yields delivered to the catchment outlet. Similarly, median TP yields measured in the SPARROW MRB4 model were not significantly different from median PTMApp-Desktop yields delivered to the catchment outlet. The difference between median TN yield values in the SPARROW MRB4 and PTMApp-Desktop dataset (again measured at the catchment outlet), although statistically significant, was also only 64%.

Overall, nutrient loading at the field-scale and sediment loading at the large subwatershed scale were comparable to their respective independent datasets. The difference in the sediment loading between the PTMApp-Desktop results and the independent dataset (Discovery Farms Site RO1-F) could be explained by field-specific factors which were not captured by geospatial inputs utilized by PTMApp-Desktop to estimate sediment export. Differences between nutrient yields in these datasets at the large subwatershed scale could be due to the first-order loss equation removing more nutrients in transport from the catchment outlet to the priority resource point than what is physically occurring in the natural stream systems. The decay coefficient, which along with travel time governs the fate and transport of in-channel nutrients in PTMApp-Desktop, is an aggregation and simplification of many biogeochemical (and oftentimes stream-specific) processes. It is possible that for this watershed the nutrient coefficients were too large and effectively "removed" too much in-stream nutrient load. Additional comparisons must be made with other, independent, datasets within and around this area to verify this difference is tangible before any recommendations can be made to adjust default values used in PTMApp-Desktop.

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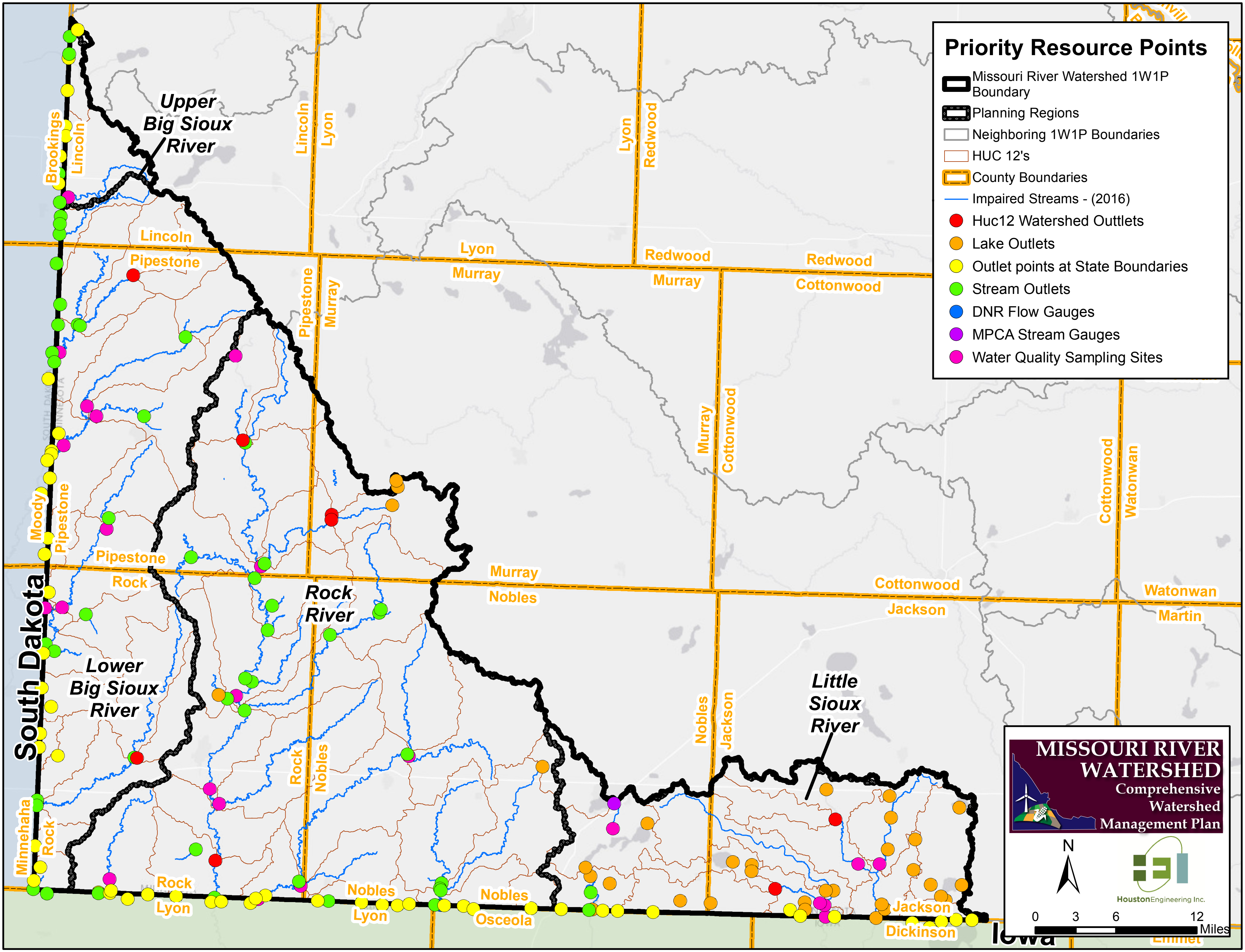
Appendix M

Prioritize, Target, and Measure Application (PTMApp) Priority Resource Points

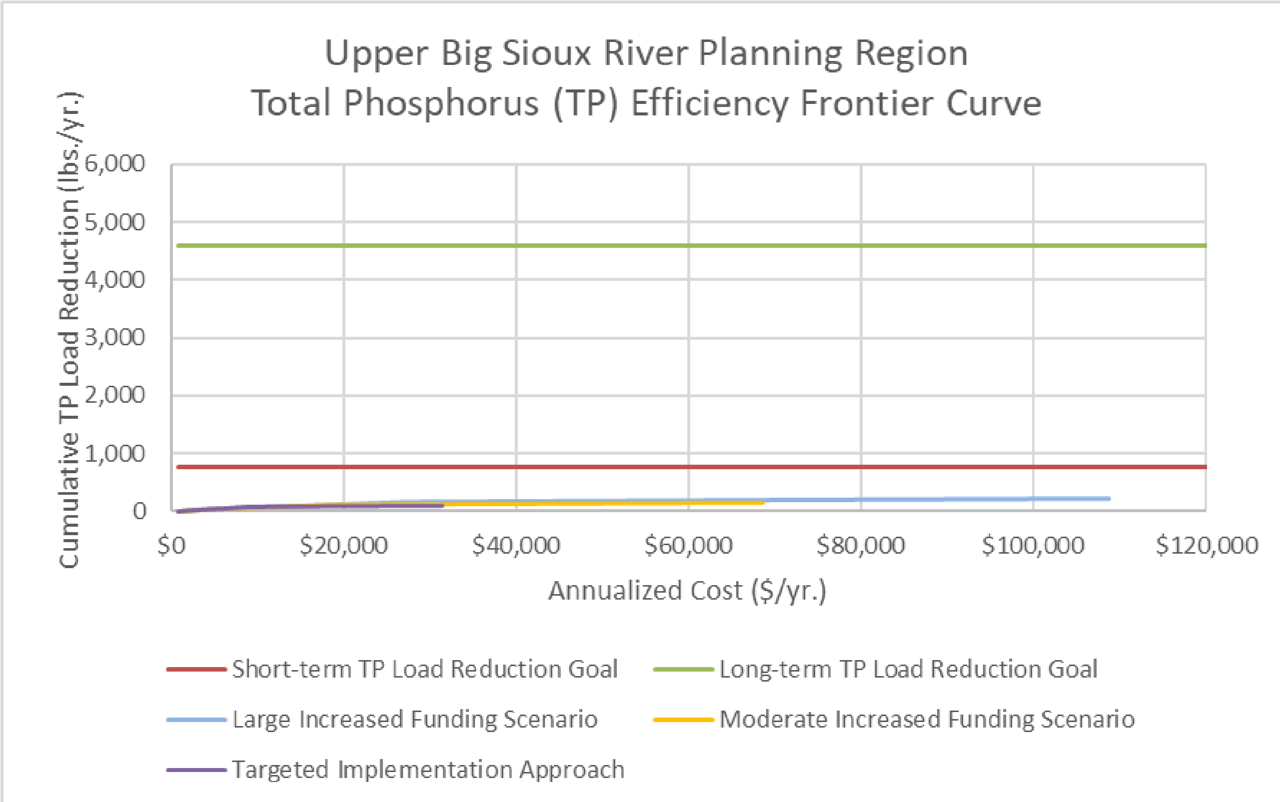
MISSOURI RIVER WATERSHED
Comprehensive Watershed Management Plan

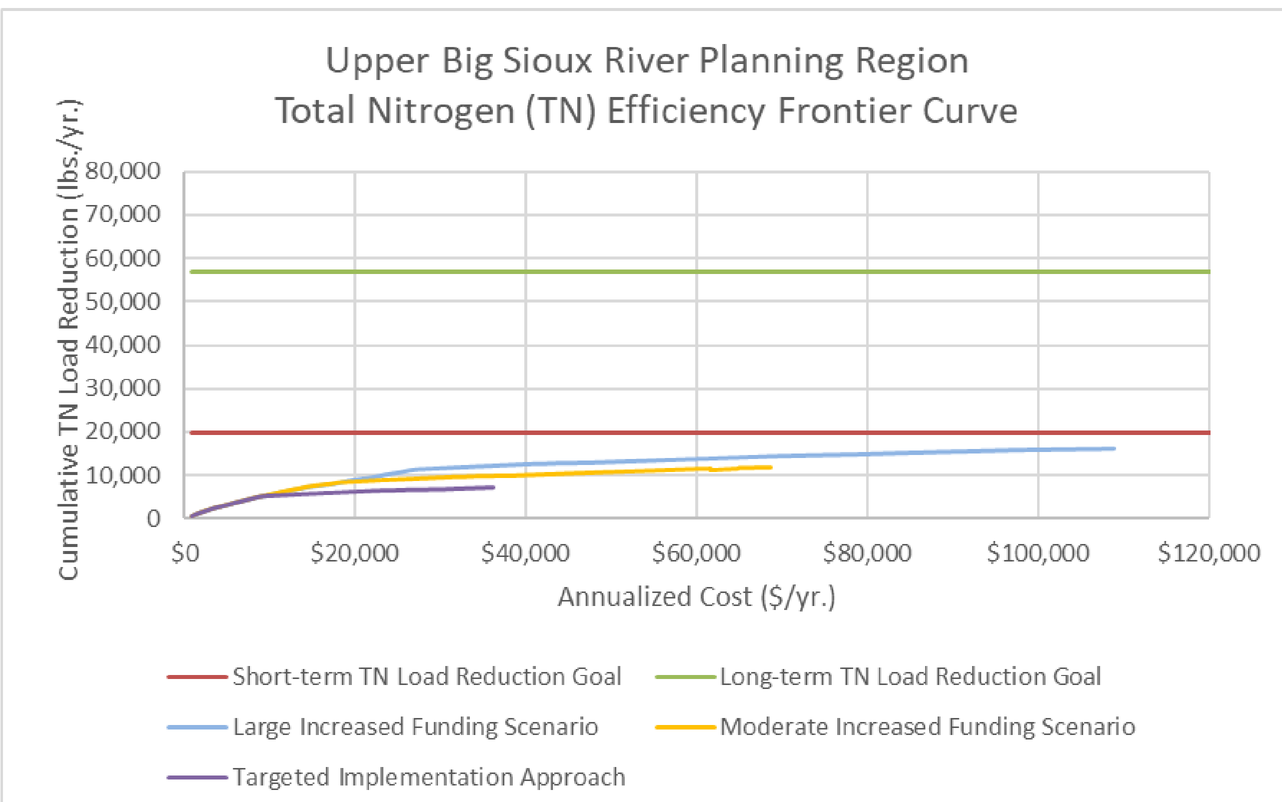

Priority Resource Points
Missouri River Watershed 1W1P Boundary
Planning Regions
Neighboring 1W1P Boundaries
HUC 12's
County Boundaries
Impaired Streams - (2016)
Huc12 Watershed Outlets
Lake Outlets
Outlet points at State Boundaries
Stream Outlets
DNR Flow Gauges
MPCA Stream Gauges
Water Quality Sampling Sites
Upper Big Sioux River
Rock River
Lower Big Sioux River
Little Sioux River
South Dakota
Iowa
Brookings
Lincoln
Lyon
Redwood
Murray
Pipestone
Cottonwood
Watonwan
Moody
Rock
Nobles
Jackson
Martin
Minnehaha
Osceola
Dickinson
Emmet
MISSOURI RIVER WATERSHED
Comprehensive Watershed Management Plan
N
HoustonEngineering Inc.
0 3 6 12 Miles

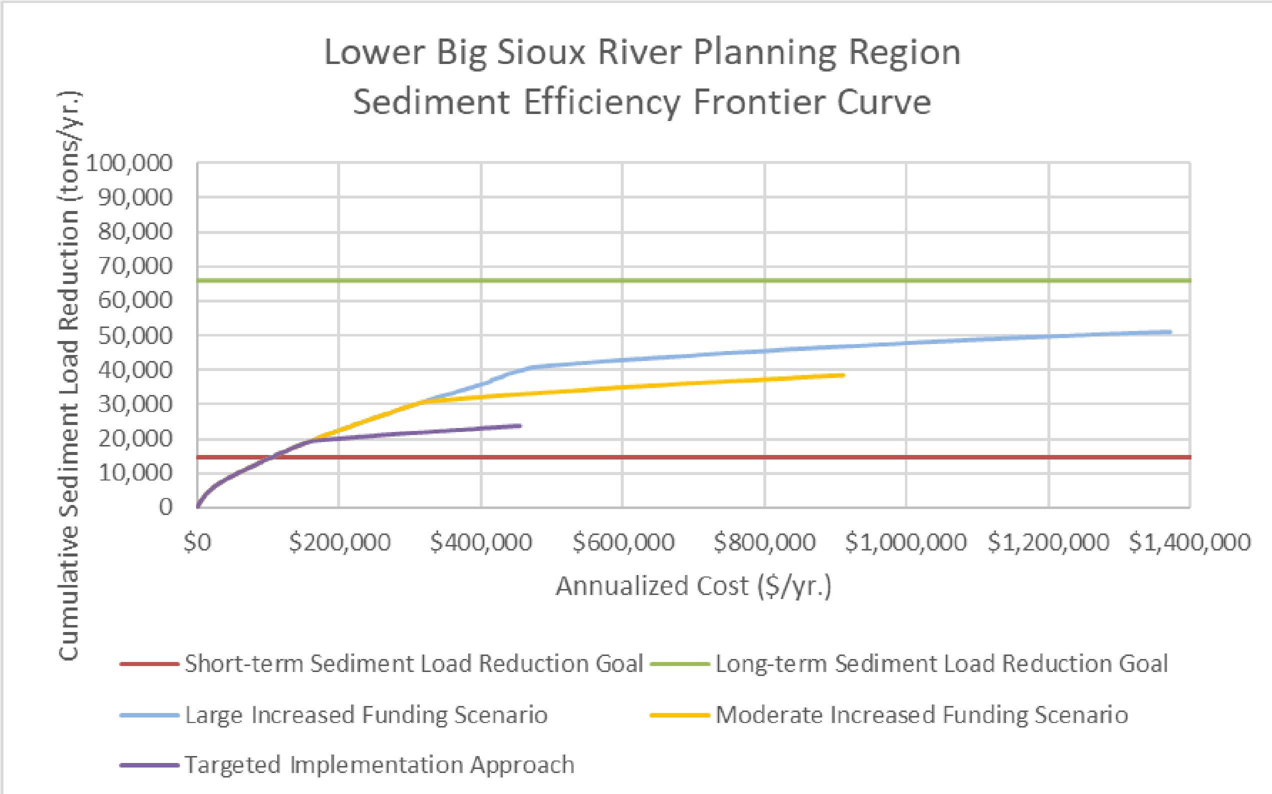
Appendix N

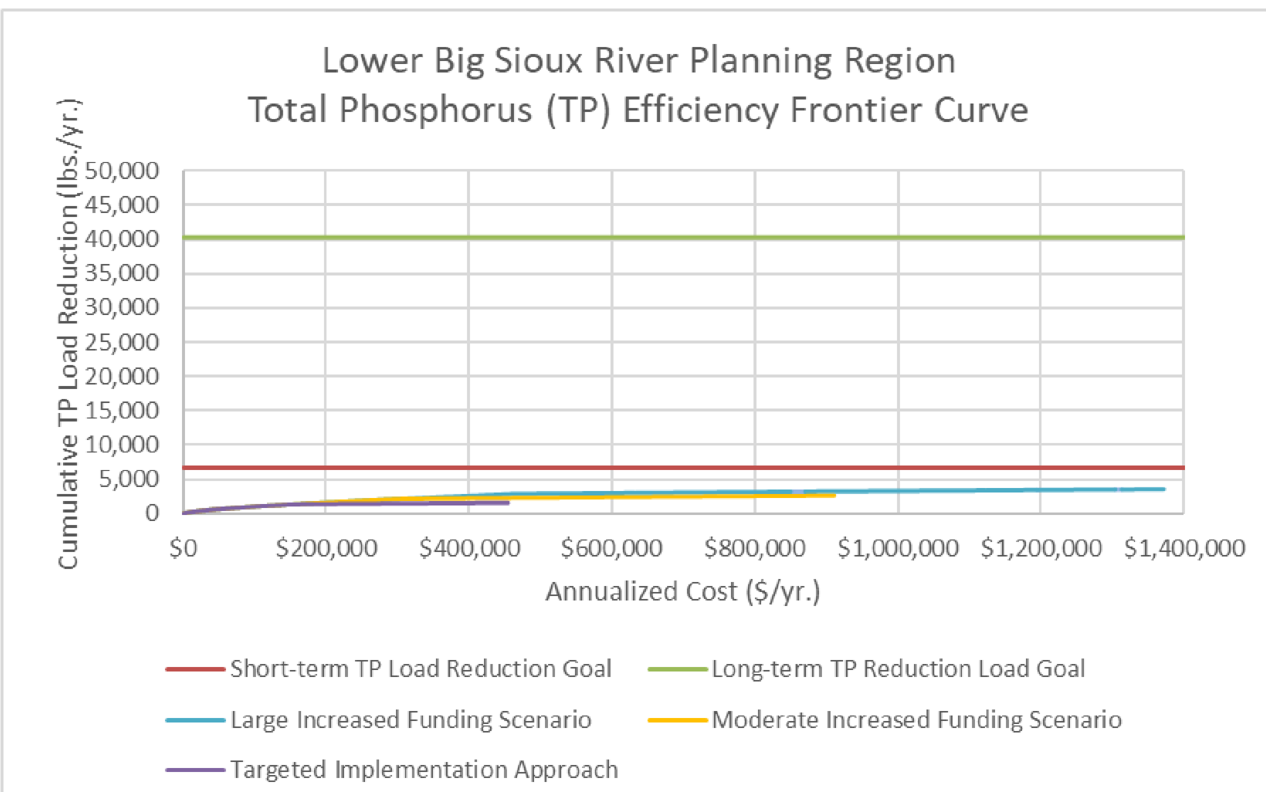
Implementation Funding Scenario Efficiency Frontier Curves

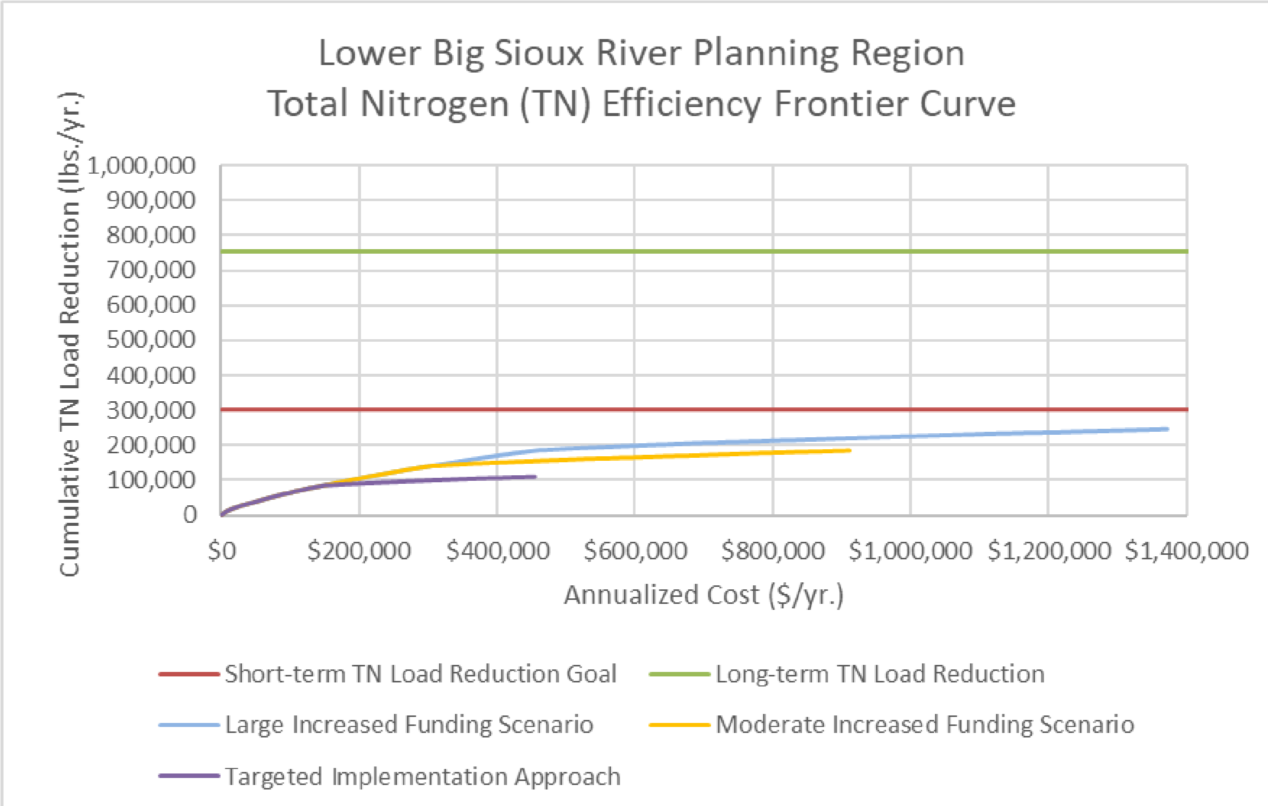
MISSOURI RIVER WATERSHED
Comprehensive Watershed Management Plan

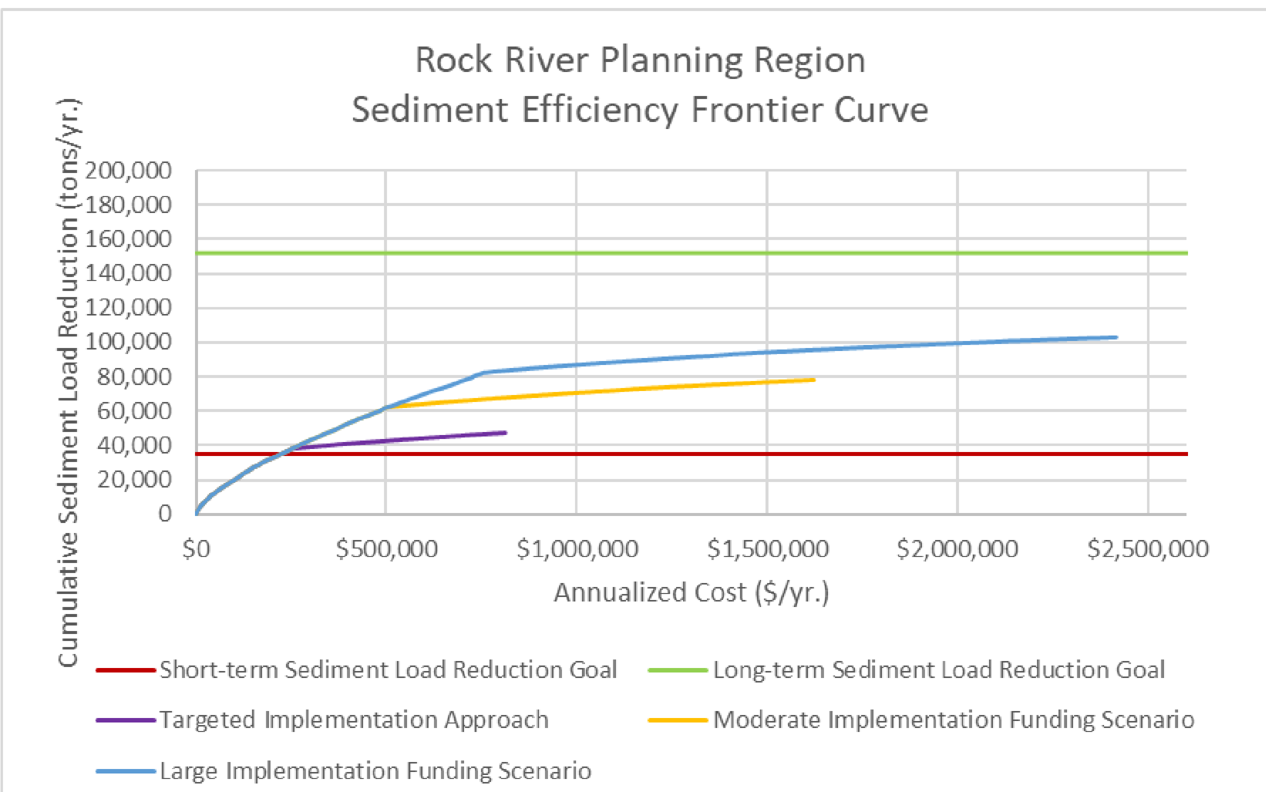

Upper Big Sioux River Planning Region
Total Phosphorus (TP) Efficiency Frontier Curve
Cumulative TP Load Reduction (lbs./yr.)
6,000
5,000
4,000
3,000
2,000
1,000
0
$0
$20,000
$40,000
$60,000
$80,000
$100,000
$120,000
Annualized Cost ($/yr.)
Short-term TP Load Reduction Goal
Long-term TP Load Reduction Goal
Large Increased Funding Scenario
Moderate Increased Funding Scenario
Targeted Implementation Approach

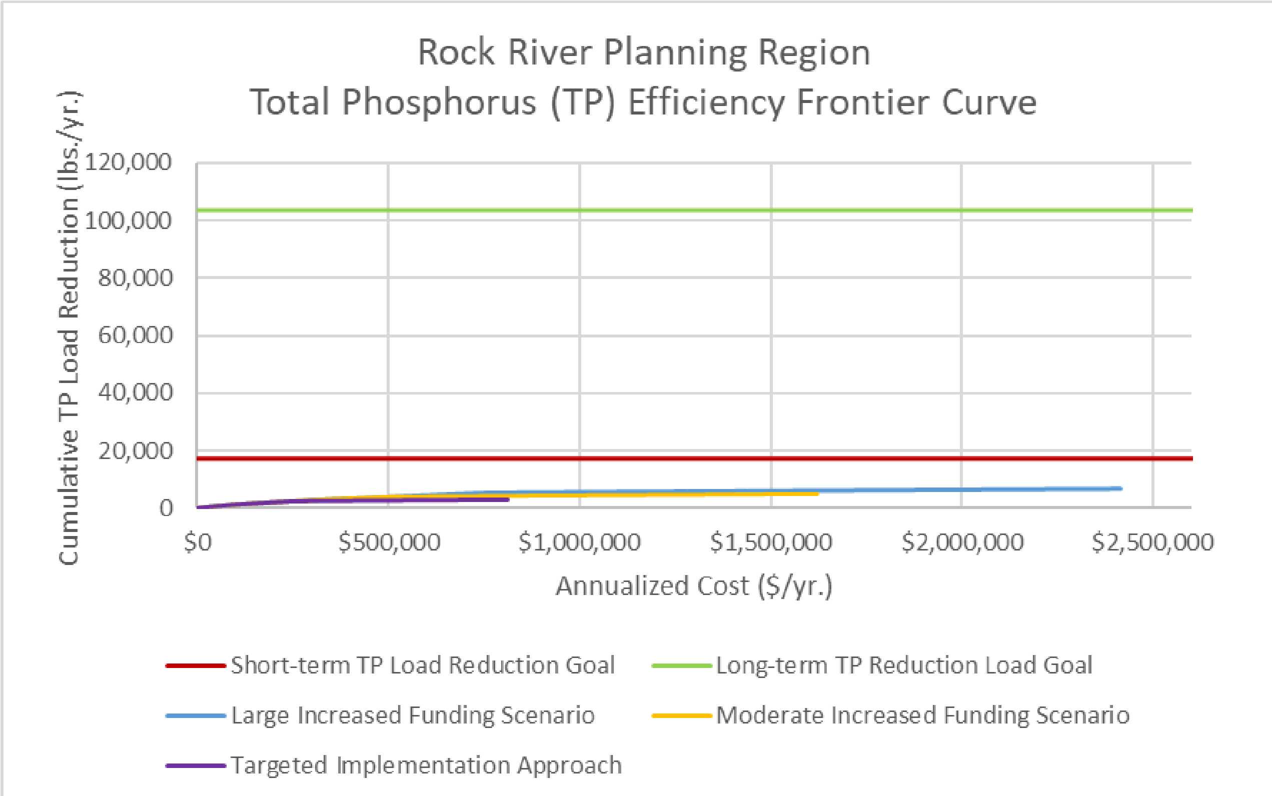

Upper Big Sioux River Planning Region
Total Nitrogen (TN) Efficiency Frontier Curve
Cumulative TN Load Reduction (lbs./yr.)
80,000
70,000
60,000
50,000
40,000
30,000
20,000
10,000
0
$0
$20,000
$40,000
$60,000
$80,000
$100,000
$120,000
Annualized Cost ($/yr.)
Short-term TN Load Reduction Goal
Long-term TN Load Reduction Goal
Large Increased Funding Scenario
Moderate Increased Funding Scenario
Targeted Implementation Approach

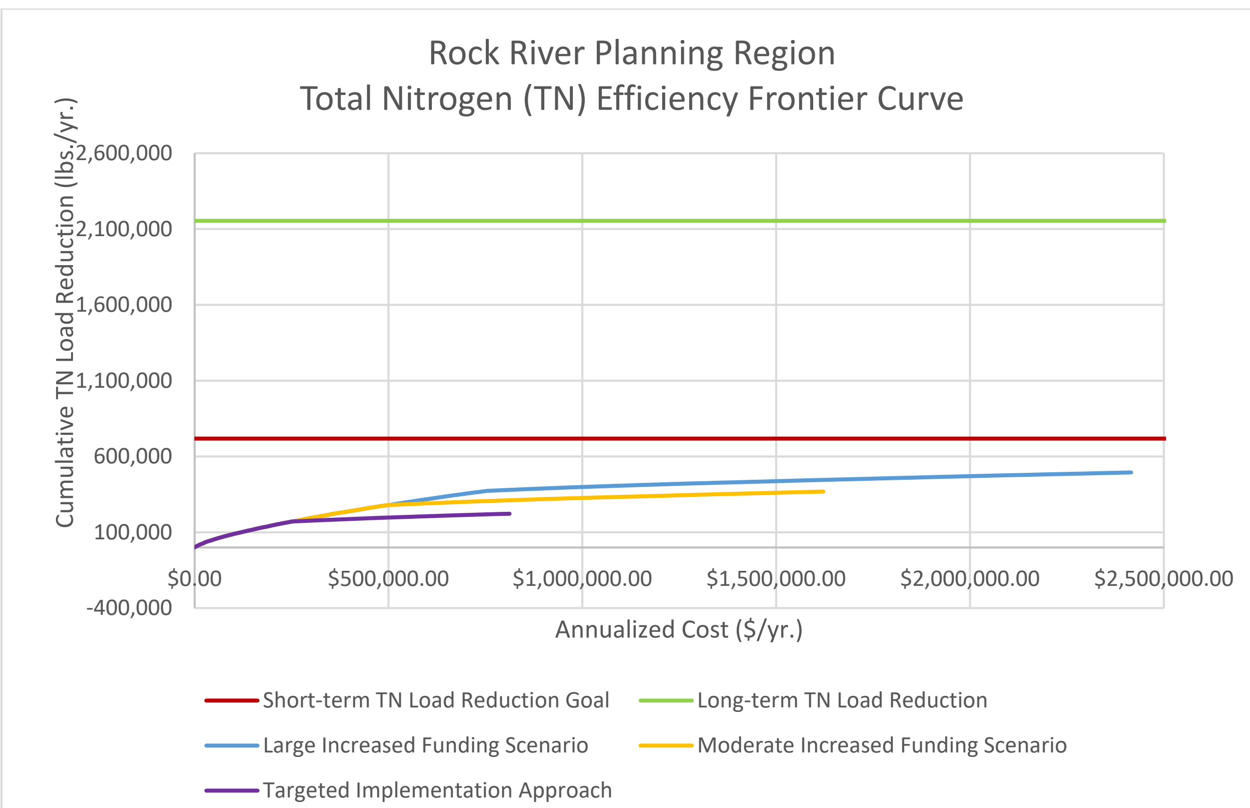

Lower Big Sioux River Planning Region
Sediment Efficiency Frontier Curve
Cumulative Sediment Load Reduction (tons/yr.)
100,000
90,000
80,000
70,000
60,000
50,000
40,000
30,000
20,000
10,000
0
$0
$200,000
$400,000
$600,000
$800,000
$1,000,000
$1,200,000
$1,400,000
Annualized Cost ($/yr.)
Short-term Sediment Load Reduction Goal
Long-term Sediment Load Reduction Goal
Large Increased Funding Scenario
Moderate Increased Funding Scenario
Targeted Implementation Approach

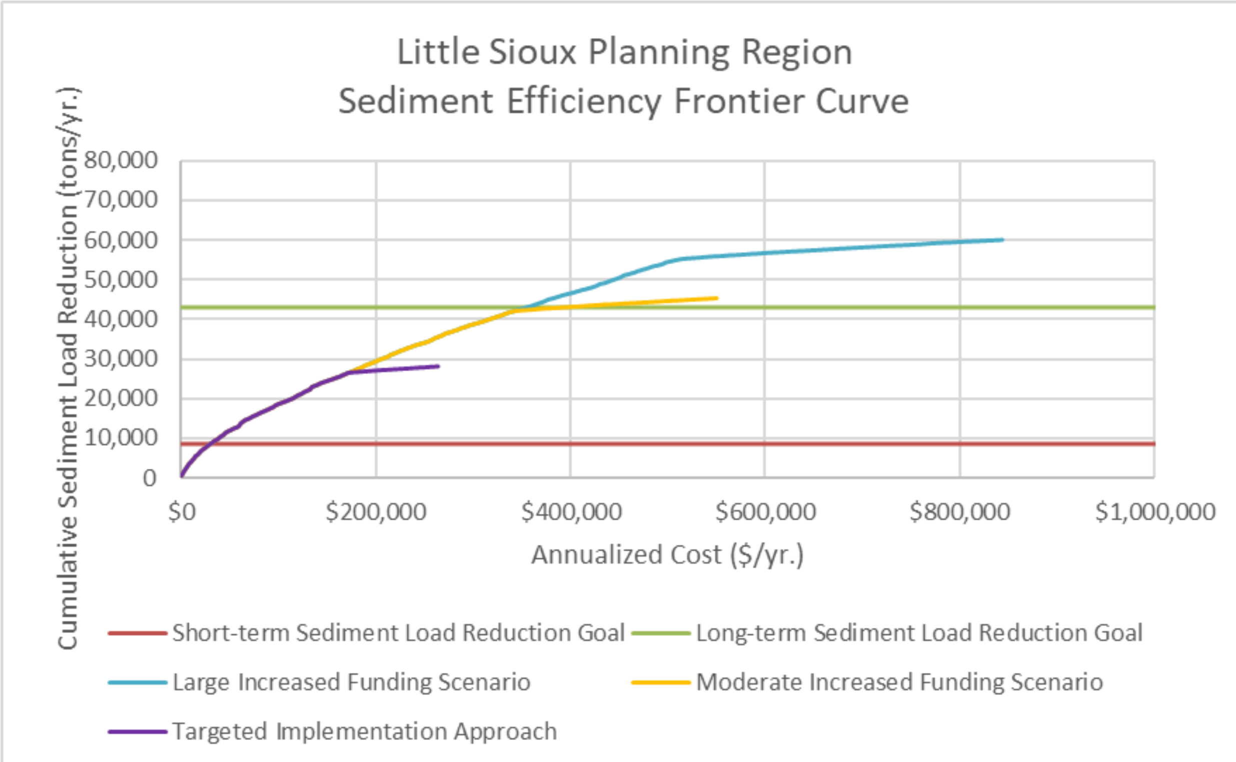

Lower Big Sioux River Planning Region
Total Phosphorus (TP) Efficiency Frontier Curve
Cumulative TP Load Reduction (lbs./yr.)
50,000
45,000
40,000
35,000
30,000
25,000
20,000
15,000
10,000
5,000
0
$0
$200,000
$400,000
$600,000
$800,000
$1,000,000
$1,200,000
$1,400,000
Annualized Cost ($/yr.)
Short-term TP Load Reduction Goal
Long-term TP Reduction Load Goal
Large Increased Funding Scenario
Moderate Increased Funding Scenario
Targeted Implementation Approach

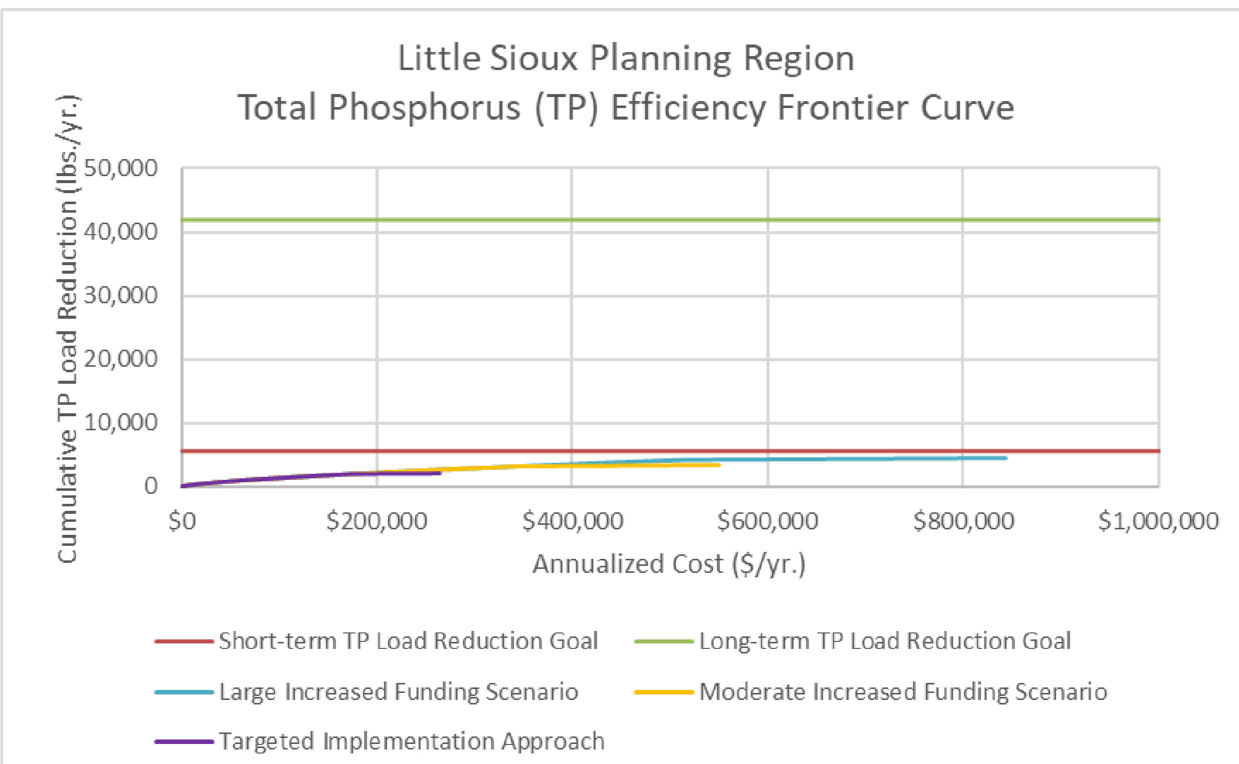

Lower Big Sioux River Planning Region
Total Nitrogen (TN) Efficiency Frontier Curve
Cumulative TN Load Reduction (lbs./yr.)
1,000,000
900,000
800,000
700,000
600,000
500,000
400,000
300,000
200,000
100,000
0
$0
$200,000
$400,000
$600,000
$800,000
$1,000,000
$1,200,000
$1,400,000
Annualized Cost ($/yr.)
Short-term TN Load Reduction Goal
Long-term TN Load Reduction
Large Increased Funding Scenario
Moderate Increased Funding Scenario
Targeted Implementation Approach

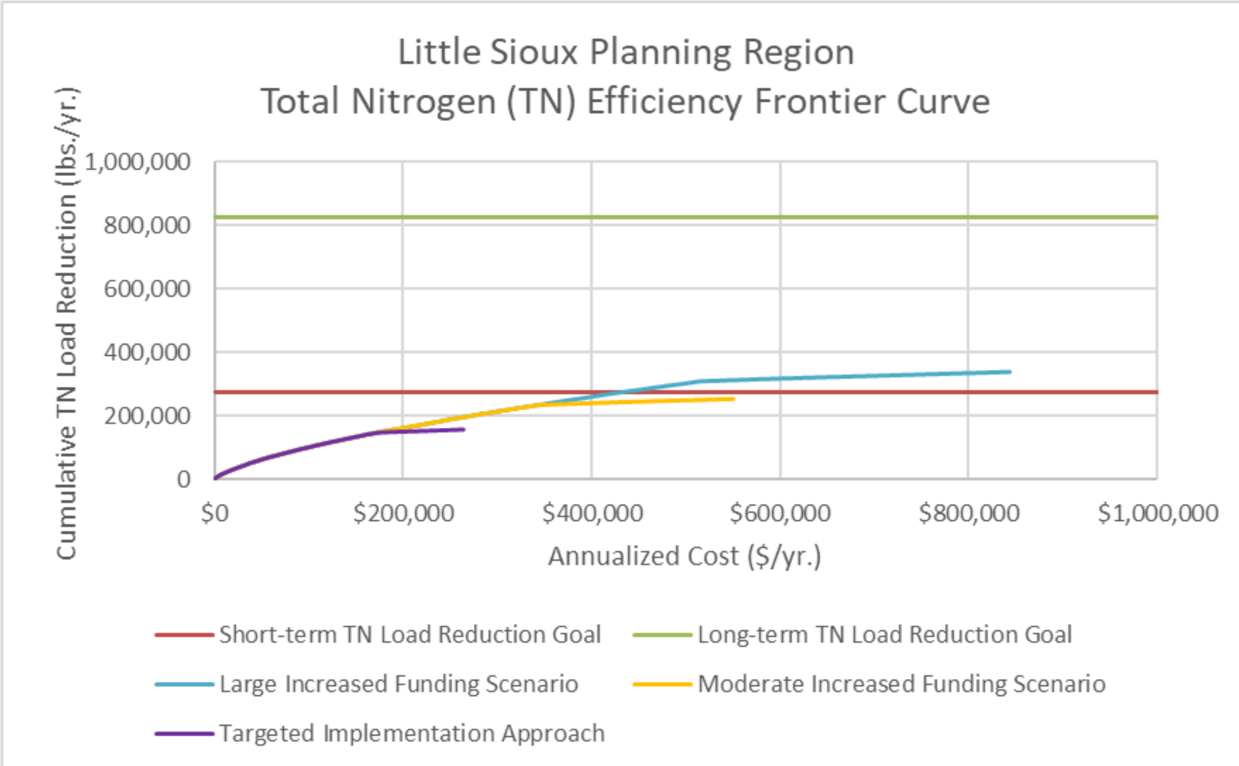

Rock River Planning Region
Sediment Efficiency Frontier Curve
Cumulative Sediment Load Reduction (tons/yr.)
200,000
180,000
160,000
140,000
120,000
100,000
80,000
60,000
40,000
20,000
0
$0
$500,000
$1,000,000
$1,500,000
$2,000,000
$2,500,000
Annualized Cost ($/yr.)
Short-term Sediment Load Reduction Goal
Long-term Sediment Load Reduction Goal
Targeted Implementation Approach
Moderate Implementation Funding Scenario
Large Implementation Funding Scenario


Rock River Planning Region
Total Phosphorus (TP) Efficiency Frontier Curve
Cumulative TP Load Reduction (lbs./yr.)
120,000
100,000
80,000
60,000
40,000
20,000
0
$0
$500,000
$1,000,000
$1,500,000
$2,000,000
$2,500,000
Annualized Cost ($/yr.)
Short-term TP Load Reduction Goal
Long-term TP Reduction Load Goal
Large Increased Funding Scenario
Moderate Increased Funding Scenario
Targeted Implementation Approach


Rock River Planning Region
Total Nitrogen (TN) Efficiency Frontier Curve
Cumulative TN Load Reduction (lbs./yr.)
2,600,000
2,100,000
1,600,000
1,100,000
600,000
100,000
-400,000
$0.00
$500,000.00
$1,000,000.00
$1,500,000.00
$2,000,000.00
$2,500,000.00
Annualized Cost ($/yr.)
Short-term TN Load Reduction Goal
Long-term TN Load Reduction
Large Increased Funding Scenario
Moderate Increased Funding Scenario
Targeted Implementation Approach


Little Sioux Planning Region
Sediment Efficiency Frontier Curve
Cumulative Sediment Load Reduction (tons/yr.)
80,000
70,000
60,000
50,000
40,000
30,000
20,000
10,000
0
$0
$200,000
$400,000
$600,000
$800,000
$1,000,000
Annualized Cost ($/yr.)
Short-term Sediment Load Reduction Goal
Long-term Sediment Load Reduction Goal
Large Increased Funding Scenario
Moderate Increased Funding Scenario
Targeted Implementation Approach


Little Sioux Planning Region
Total Phosphorus (TP) Efficiency Frontier Curve
Cumulative TP Load Reduction (lbs./yr.)
50,000
40,000
30,000
20,000
10,000
0
$0
$200,000
$400,000
$600,000
$800,000
$1,000,000
Annualized Cost ($/yr.)
Short-term TP Load Reduction Goal
Long-term TP Load Reduction Goal
Large Increased Funding Scenario
Moderate Increased Funding Scenario
Targeted Implementation Approach


Little Sioux Planning Region
Total Nitrogen (TN) Efficiency Frontier Curve
Cumulative TN Load Reduction (lbs./yr.)
1,000,000
800,000
600,000
400,000
200,000
0
$0
$200,000
$400,000
$600,000
$800,000
$1,000,000
Annualized Cost ($/yr.)
Short-term TN Load Reduction Goal
Long-term TN Load Reduction Goal
Large Increased Funding Scenario
Moderate Increased Funding Scenario
Targeted Implementation Approach

Appendix O

Comprehensive Subwatershed Implementation Prioritization

MISSOURI RIVER WATERSHED
Comprehensive Watershed Management Plan

Comprehensive Subwatershed Implementation Prioritization Methods

During the 60-day public notification process, it was identified the Partnership needed a way to bridge from the planning to implementation process to better identify where to start work. The Partnership concluded that prioritization should occur at a HUC-12 scale, consistent with other local planning and implementation work and tasked Houston Engineering, Inc. (HEI) with developing a methodology built off work completed in the One Watershed, One Plan (1W1P).

For ease of implementation, the group sought one composite ranking which could encompass the most pertinent factors used in the issue prioritization and goal setting process. Ranking criteria were drawn from information used in plan content for measurable goals. The ranking criteria were organized by the resource concerns they most impacted. Ranking criteria were not meant to be comprehensive representations of the issues impacting resource concerns, but were meant to be simple representations using the best available geospatial data.

The ranking criteria and resource concerns are shown in **Table A1**. For each resource concern, a ranking was established which used either an equal weighting of each resource criteria or, in the case on the Groundwater Resource Concern, a weighted breakdown that would better emphasize protection of drinking water supply management areas (DWSMAs), which is a priority of the Partnership. Resource concern ranks, which are shown individually in the maps attached, were combined in a final composite factor using the ‘Weighting Factor for Final Composite Ranking’ shown in Table A1. The composite factors were developed based on the final scoring of issues by public vote during the kickoff meetings as well as the Policy, Advisory, and Public Work Group Committee member votes. Figures displaying the final composite HUC-12 ranks can be found for each planning region in their respective implementation profile. In each of these maps, high priority subwatersheds are colored using the following scale:

1) High priority: HUC-12’s with priority ranks 1-13; Top 20%
2) Medium-high priority: HUC-12’s with priority ranks 14-26; Top 20% - 40%
3) Medium priority: HUC-12’s with priority ranks 27-39; Top 40% - Bottom 40%
4) Medium-low priority: HUC-12’s with priority ranks 40-52; Bottom 20% - 40%
5) Low priority: HUC-12’s with priority ranks 53-65; Bottom 20%

One exception to this scale is the Fish & Wildlife Habitat prioritization. There were no priority habitat features (i.e. core areas, corridors, strategic habitat complexes, or agricultural matrix areas as identified in the DNR Prairie Plan) in 18 HUC-12 subwatersheds in the Missouri River Watershed, so these 18 subwatersheds were placed into the ‘Low’ prioritization category.

This information was compiled in a geographic information systems (GIS) feature class and provided to the Partnership. A summary of the attributes in that feature class is provided in **Table A2**.

Table A1: Prioritization ranking developed for 12-digit hydrologic unit code (HUC-12) subwatersheds in the Missouri River Basin One Watershed, One Plan (1W1P)

Composite Ranking Category	Surface Water	Groundwater	Local Development and Stewardship	Fish and Wildlife Habitat	Targeted Implementation Practices *
Ranking Criteria (weighted evenly across criteria within category unless otherwise noted)	Sediment yield [tons/acre/year]	Percent of HUC-12 area as DWSMA (weight = 70%)	Percent of HUC-12 area in agricultural lands	Prairie Plan Core Areas	# of practices in targeted implementation scenario
	TP yield [lbs/acre/year]	Percent of DWSMA area as agricultural lands (weight = 10%)	Percent of agricultural fields identified as a high priority in stewardship criteria	Prairie Plan Corridors	
	TN yield [lbs/acre/year]	High' and 'Moderately High' nitrate infiltration risk (weight = 20%)	Livestock accessibility to riparian areas	Prairie Plan Strategic Habitat Complexes	
	Length of nearly or barely impaired stream reaches			Prairie Plan Agricultural Matrix	
Weighting Factor for Final Composite Ranking **	35%	35%	10%	10%	10% †

* Used in lieu of Local Capacity Resource Concern as (1) no geospatial data could support its application for prioritization purposes and (2) inclusion of identified targeted practices was preferred during the prioritization process.

** Composite weighting factors loosely based on final issue voting results

† Based on Local Capacity share of final issues vote

Table A2: Attribute catalog developed for the final 12-digit hydrologic unit code (HUC-12) implementation prioritization feature class.

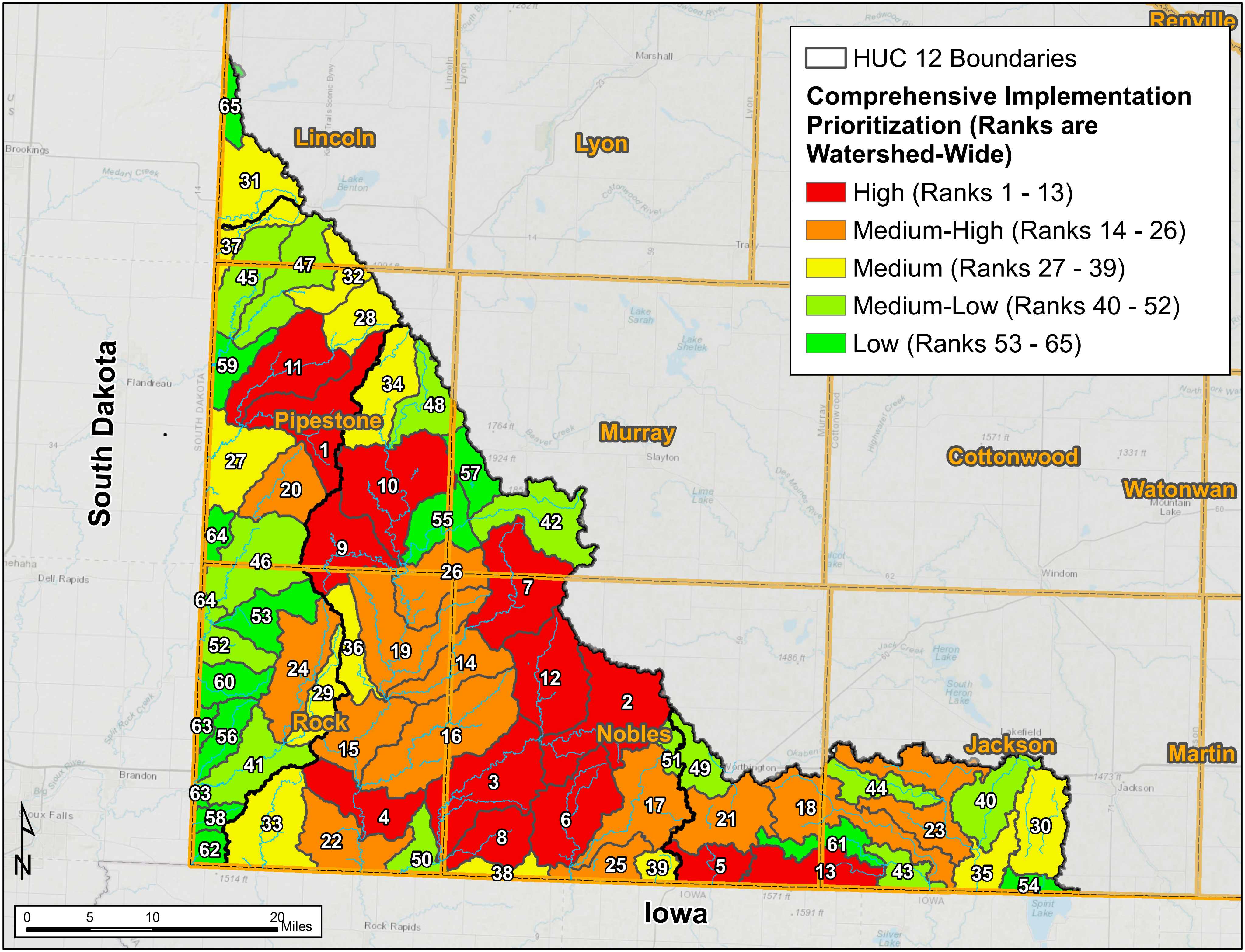
Alias	Field Name	Field Type	Description	Resource Concern Pertaining to Criteria
HUC-12 Number	HUC_12	String	HUC-12 watershed number	Surface Waters
HUC-12 Name	HU_12_Name	Text	HUC-12 Name	
HUC-12 area in square miles	Area_sqmi	Float	HUC-12 area in acres	
HUC-12 area in acres	Area_acres	Float	HUC-12 area in acres	
Planning Region	PlanRegion	Text	Missouri River Watershed 1W1P Planning Region Name	
HUC-12 Sediment Load [tons/yr]	SedLoad_12	Float	Total sediment load [tons/year] delivered to catchment outlets within the HUC-12	
HUC-12 Sediment Yield Rank [tons/ac/yr]	SedYield12	Float	Average sediment yield [tons/acre/year] delivered to catchment outlets across the HUC-12	
HUC-12 Sediment Yield Rank	SedYldRank	Short Integer	Rank of HUC-12 watershed's sediment yield [tons/acre/year] relative to other HUC-12 watersheds in the plan area	
HUC-12 TP Load [lbs/yr]	TPLoad12	Float	Total TP load [lbs/year] delivered to catchment outlets within the HUC-12	
HUC-12 TP Yield Rank [lbs/ac/yr]	TP_Yield12	Float	Average TP yield [lbs/acre/year] delivered to catchment outlets across the HUC-12	
HUC-12 TP Yield Rank	TPYld_Rank	Short Integer	Rank of HUC-12 watershed's TP yield [lbs/acre/year] relative to other HUC-12 watersheds in the plan area	
HUC-12 TN Load [lbs/yr]	TNLoad_12	Float	Total TN load [lbs/year] delivered to catchment outlets within the HUC-12	
HUC-12 TN Yield Rank [lbs/ac/yr]	TN_Yield12	Float	Average TN yield [lbs/acre/year] delivered to catchment outlets across the HUC-12	

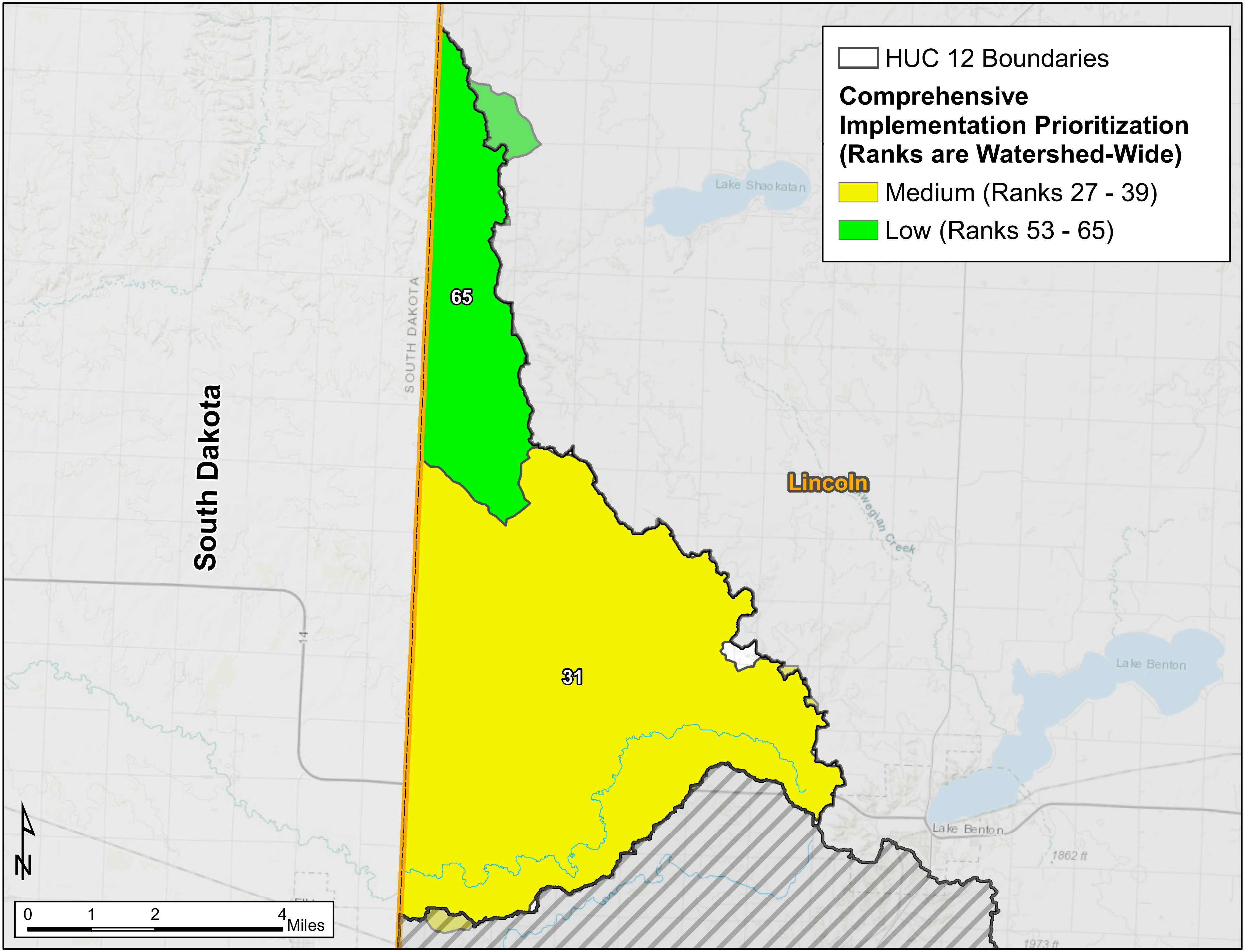
Alias	Field Name	Field Type	Description	Resource Concern Pertaining to Criteria
HUC-12 TN Yield Rank	TNYld_Rank	Short Integer	Rank of HUC-12 watershed's TN yield [lbs/acre/year] relative to other HUC-12 watersheds in the plan area	
Composite Yield Value	CmpYldValu	Float	Composite ranking value combining sed, TP, and TN yield values into a weighted index.	
Composite Yield Rank	CmpYldRank	Float	Composite ranking of Sediment, TP, and TN Yield delivered to catchment outlets across the HUC-12. For the Upper Big Sioux, Lower Big Sioux, and Rock River Planning Regions sediment, TP, and TN was weighted evenly (i.e. each 33%). For the Little Sioux Planning Region sediment was weighted at 50% while both TP and TN were weighted at 25%.	
Number of nearly or barely impaired stream reaches	NorB_Impar	Short Integer	Number of nearly or barely impaired stream reaches within the HUC-12	
Stream miles of nearly or barely impaired stream reaches	ImpairLeng	Float	Stream miles of nearly or barely impaired stream reaches within the HUC-12	
Length of nearly or barely impaired stream miles per HUC-12 area (sq-miles)	ImpairDens	Float	Nearly or Barely impaired stream miles per square mile in each HUC-12 watershed.	
HUC-12 Impairment Rank	ImpairRank	Short Integer	Rank of HUC-12 watershed's length of nearly or barely impaired stream miles per square mile of area.	
Composite value Used for Surface Water Prioritization Ranking	SWCompValu	Float	Composite ranking value combining sed, TP, and TN yield with nearly or barely impaired rankings.	
Composite Rank for Surface Water Prioritization	SWCompRank	Short Integer	Composite Rank for Surface Water Prioritization	
Acres of Area Covered By DWSMAs in the HUC-12	DWSMA_Area	Float	Acres of Area Covered By DWSMAs in the HUC-12	Groundwater

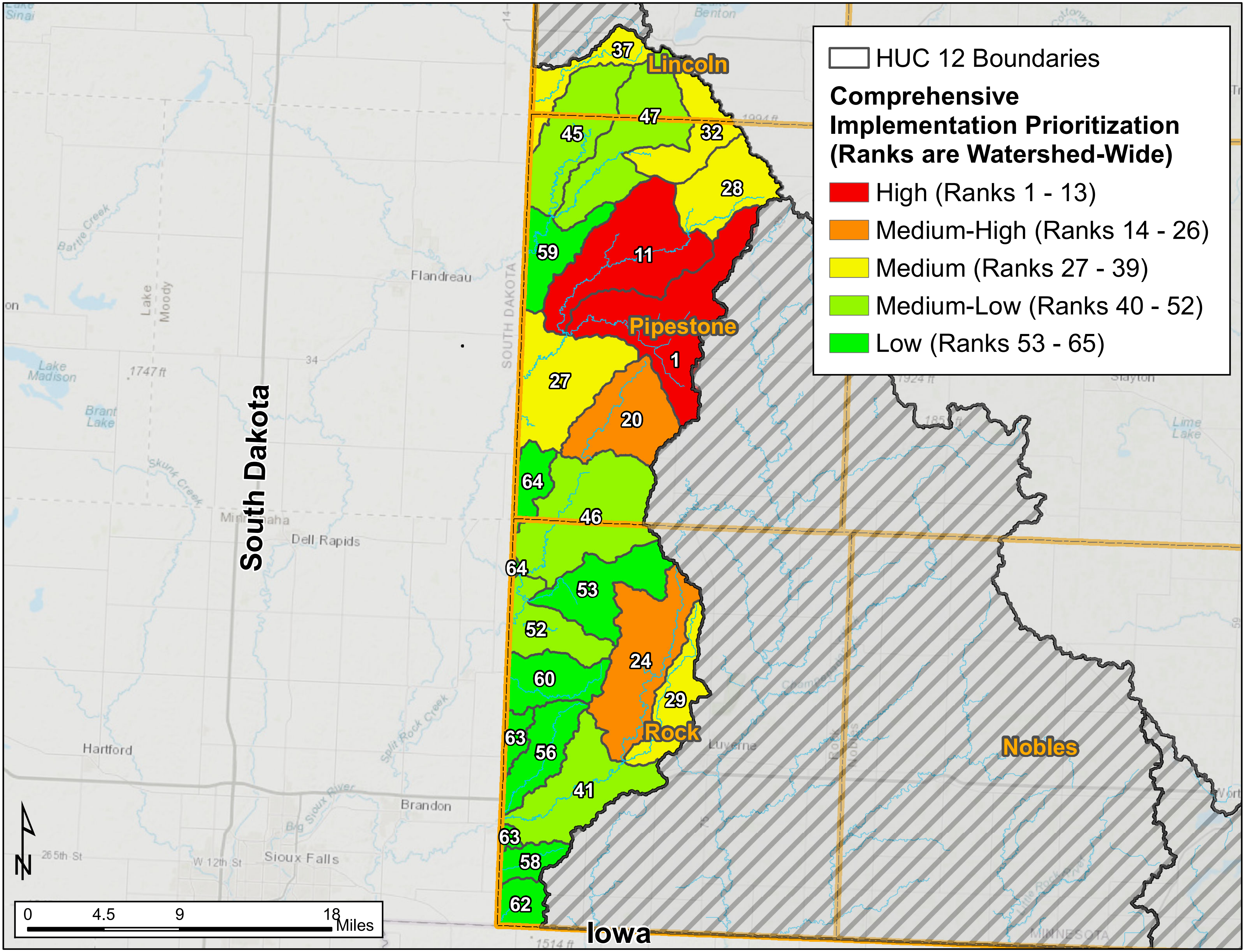
Alias	Field Name	Field Type	Description	Resource Concern Pertaining to Criteria
Percent of HUC-12 Area as DWSMA	DWSMAPctAr	Float	Percent of HUC-12 Area as DWSMA	
Rank of HUC-12 Area as DWSMA	DWSMA_%_Area_Rank	Short Integer	Rank of HUC-12 watershed's area covered by DWSMAs relative to other HUC-12 watersheds.	
% of DWSMAs within HUC-12 covered by agricultural land.	DWSMAagPas	Float	% of DWSMAs within HUC-12 covered by agricultural land.	
Rank of HUC-12 DWSMA area covered by agricultural land.	DWSMAagRnk	Short Integer	Rank relative to other HUC-12 watersheds of DWSMA area within each HUC-12 watershed which is also covered by either agricultural and pastoral land uses.	
% of HUC-12 with a High or Moderately High nitrate infiltration Risk	NO3_Risk	Float	% of HUC-12 watershed with a High or Moderately High nitrate infiltration Risk	
HUC-12 NO3 Risk Rank	NO3RskRank	Float	Rank of HUC-12 watershed's risk to contaminating unconfined aquifers through nitrate leaching relative to other HUC-12 watersheds in the plan area.	
Composite Value Used for Groundwater Prioritization Ranking	GWCompValu	Float	Composite ranking value combining Groundwater criteria rankings.	
Composite Rank for Groundwater Prioritization	GWCompRank	Short Integer	Composite Rank for Groundwater Prioritization	
% of HUC-12 covered by agricultural fields.	AgFldPct	Float	% of HUC-12 watershed covered by agricultural fields.	Local Development and Stewardship
Rank of HUC-12 area covered by agricultural fields.	AgFldRank	Short Integer	Rank of agricultural lands within each HUC-12 watershed relative to other HUC-12 watersheds	
Acreage in HUC-12 covered by agricultural fields.	AgFldAcre	Float	Acreage in HUC-12 watershed covered by agricultural fields.	

Alias	Field Name	Field Type	Description	Resource Concern Pertaining to Criteria
Acres of fields considered a high priority	HighPrAcre	Float	Acres across HUC-12 identified as a high priority based on stewardship criteria.	
Rank of HUC-12 area covered by high priority agricultural fields.	HghPrAcRnk	Short Integer	Rank of high priority agricultural fields within each HUC-12 watershed relative to other HUC-12 watersheds	
Stream miles through pasturelands	PastStr_Mi	Float	Summary of stream miles within each HUC-12 watershed which travel through pasturelands	
Rank of stream miles through pasturelands	PastStrRnk	Short Integer	Rank of length of stream miles which travel through pasturelands within each HUC-12 watershed	
Composite Value Used for Groundwater Prioritization Ranking	DSCompValu	Float	Composite ranking value combining Local Development and Steward criteria rankings.	
Composite Rank for Local Development and Stewardship Prioritization	DSCompRank	Short Integer	Composite Rank for Local Development and Stewardship Prioritization	
Acreage of Prairie Plan Core Areas within each HUC-12	PrPnCoreAc	Float	Acreage of Prairie Plan Core Areas within each HUC-12	Fish and Wildlife Habitat
HUC-12 Rank of Acreage of Prairie Plan Core Areas	PrPnCoreRk	Short Integer	HUC-12 Rank of Acreage of Prairie Plan Core Areas	
Acreage of Prairie Plan Corridors within each HUC-12	PrPnCrdrAc	Float	Acreage of Prairie Plan Corridors within each HUC-12	
HUC-12 Rank of Acreage of Prairie Plan Corridors	PrPnCrdrRk	Short Integer	HUC-12 Rank of Acreage of Prairie Plan Corridors	
Acreage of Prairie Plan Strategic Habitat Complexes within each HUC-12	PrPnSHCAc	Float	Acreage of Prairie Plan Strategic Habitat Complexes within each HUC-12	
HUC-12 Rank of Acreage of Prairie Plan Strategic Habitat Corridors	PrPnSHCRk	Short Integer	HUC-12 Rank of Acreage of Prairie Plan Strategic Habitat Corridors	

Alias	Field Name	Field Type	Description	Resource Concern Pertaining to Criteria
Acreage of Prairie Plan Matrix Habitat Complexes within each HUC-12	PrPnMHCAc	Float	Acreage of Prairie Plan Matrix Habitat Complexes within each HUC-12	
HUC-12 Rank of Acreage of Prairie Plan Matrix Habitat Corridors	PrPnMHCRk	Short Integer	HUC-12 Rank of Acreage of Prairie Plan Matrix Habitat Corridors	
Composite Value Used for Fish and Wildlife Habitat Prioritization	HBCompValu	Float	Composite ranking value combining Prairie Plan ranking factors.	
Composite Rank for Fish and Wildlife Habitat Prioritization	HBCompRank	Short Integer	Composite Rank for Fish and Wildlife Habitat Prioritization	
Number of targeted practices in HUC-12	Target_Imp	Short Integer	Number of practices in the baseline funding scenario of the targeted implementation schedule for each HUC-12	Other: Target Implementation Practices
Composite Rank for Targeted Implementation	TargetRank	Short Integer	HUC-12 watershed rank of baseline funding scenario practices from the target implementation schedule	
Composite Value Used for Prioritizing all Resource Concerns	TotCompVal	Float	Composite Value Used for Prioritizing all Resource Concerns	Combined
Composite Rank for Prioritizing all Resource Concerns	TotCompRnk	Short Integer	Composite Rank for Prioritizing all Resource Concerns	


HUC 12 Boundaries
Comprehensive Implementation Prioritization (Ranks are Watershed-Wide)
High (Ranks 1 - 13)
Medium-High (Ranks 14 - 26)
Medium (Ranks 27 - 39)
Medium-Low (Ranks 40 - 52)
Low (Ranks 53 - 65)
South Dakota
Lincoln
Lyon
Pipestone
Murray
Cottonwood
Watonwan
Renville
Rock
Nobles
Jackson
Martin
Iowa
0 5 10 20 Miles
N


HUC 12 Boundaries
Comprehensive Implementation Prioritization (Ranks are Watershed-Wide)
Medium (Ranks 27 - 39)
Low (Ranks 53 - 65)
65
31
South Dakota
SOUTH DAKOTA
Lincoln
Lake Shaokatan
Lake Benton
Lake Benton
Norwegian Creek
14
1862 ft
1973 ft
0
1
2
4
Miles
N


HUC 12 Boundaries
Comprehensive Implementation Prioritization (Ranks are Watershed-Wide)
High (Ranks 1 - 13)
Medium-High (Ranks 14 - 26)
Medium (Ranks 27 - 39)
Medium-Low (Ranks 40 - 52)
Low (Ranks 53 - 65)
Lincoln
Pipestone
Rock
Nobles
South Dakota
Iowa
Flandreau
Dell Rapids
Hartford
Brandon
Sioux Falls
Luverne
37
47
32
45
28
59
11
1
27
20
64
46
64
53
52
24
60
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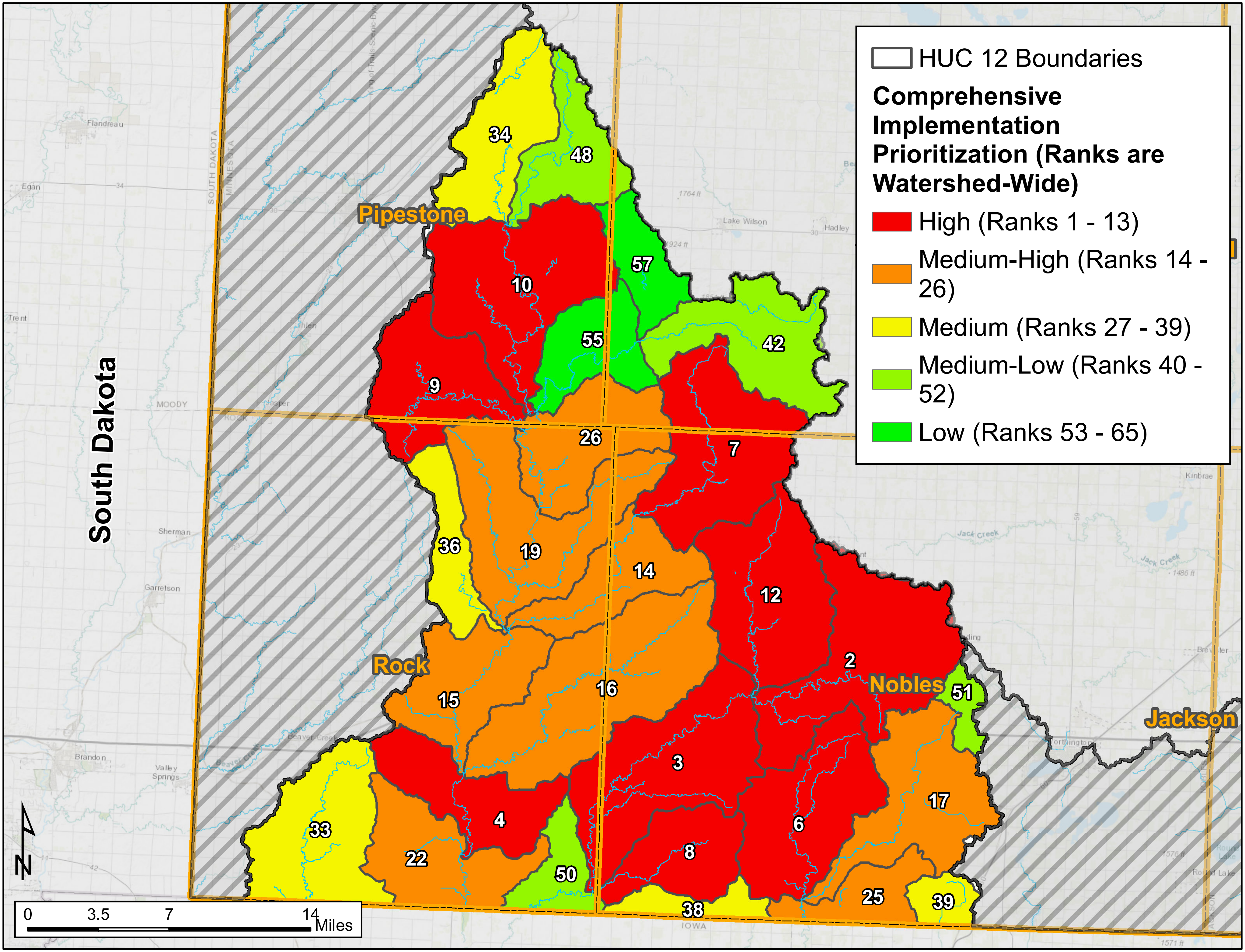
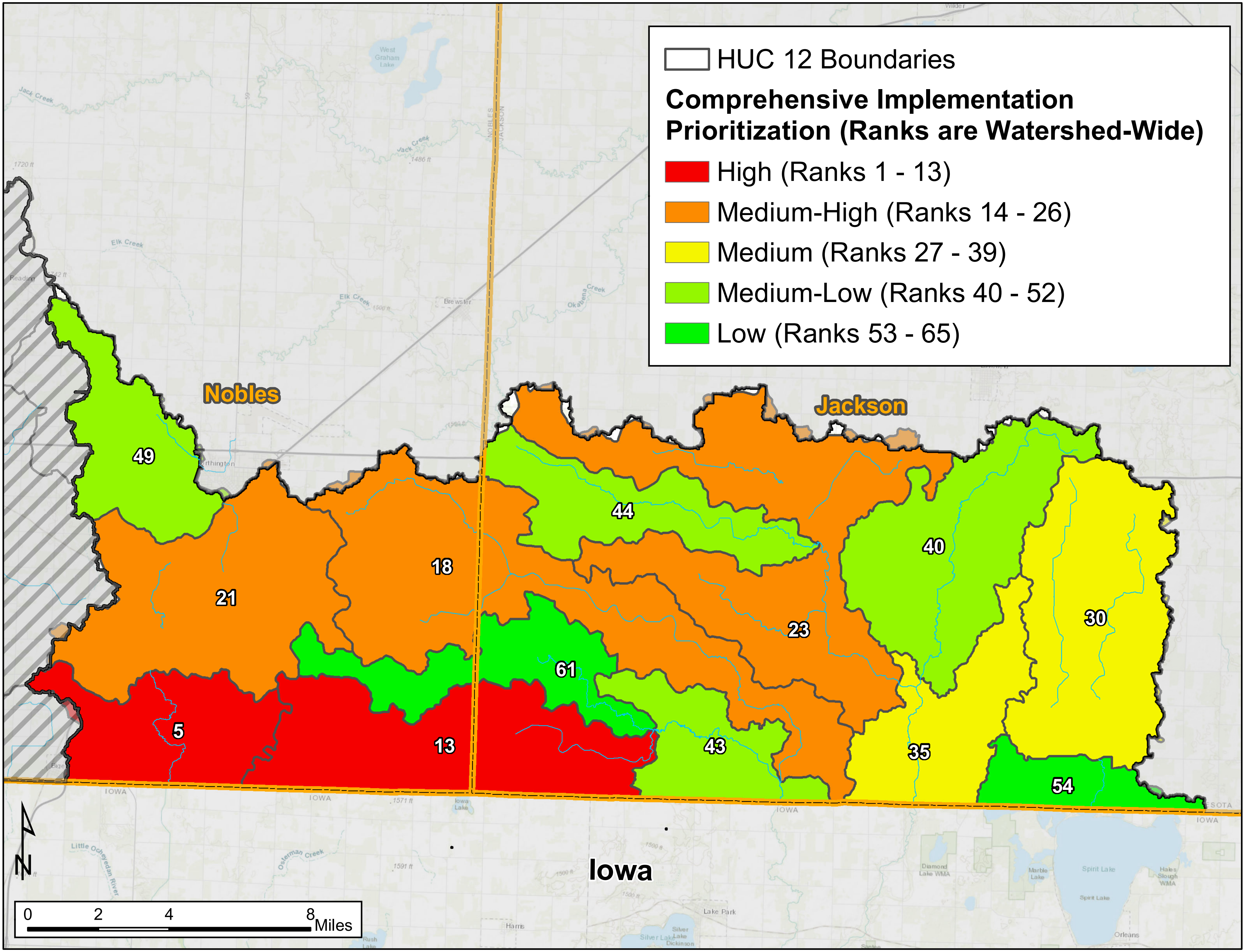
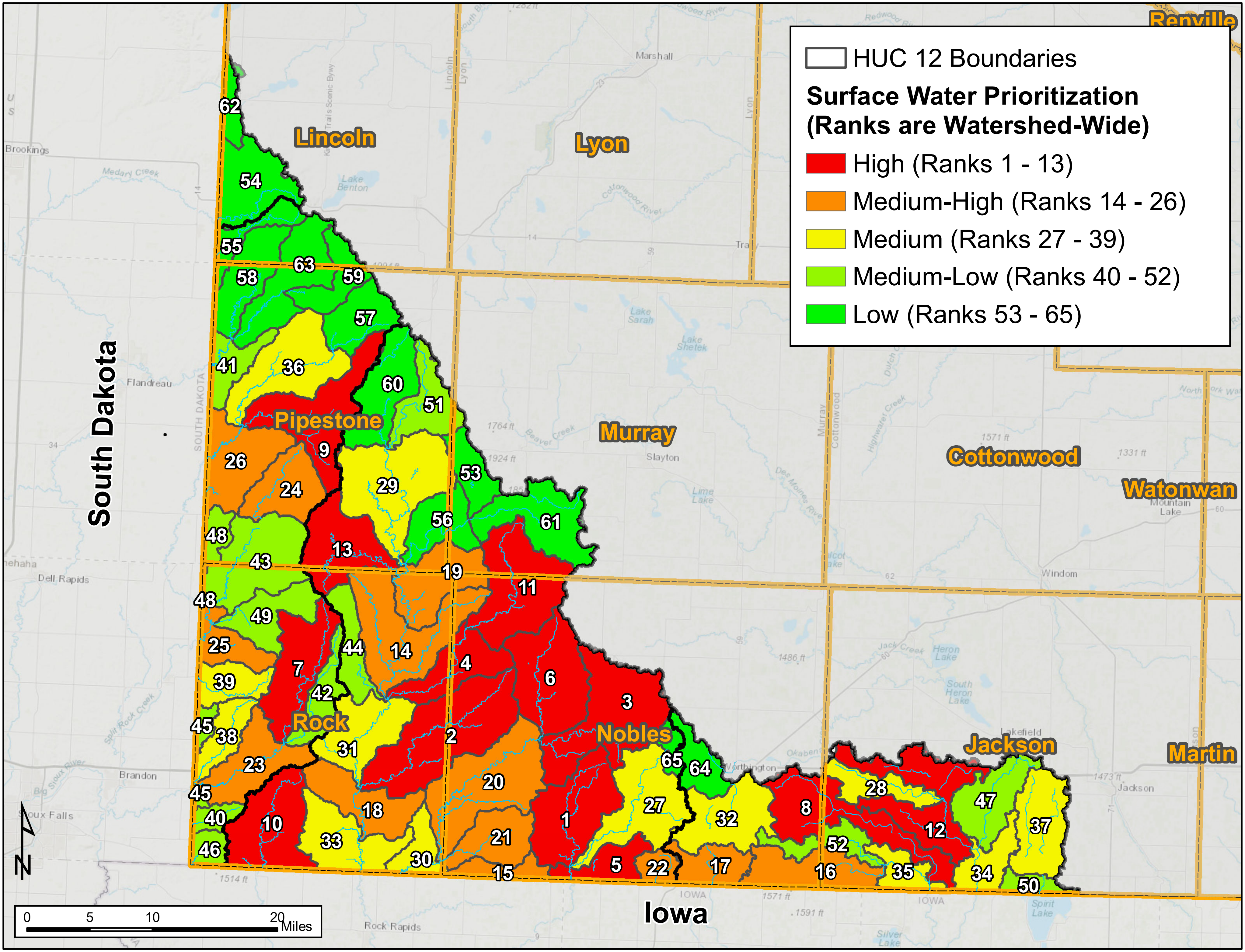
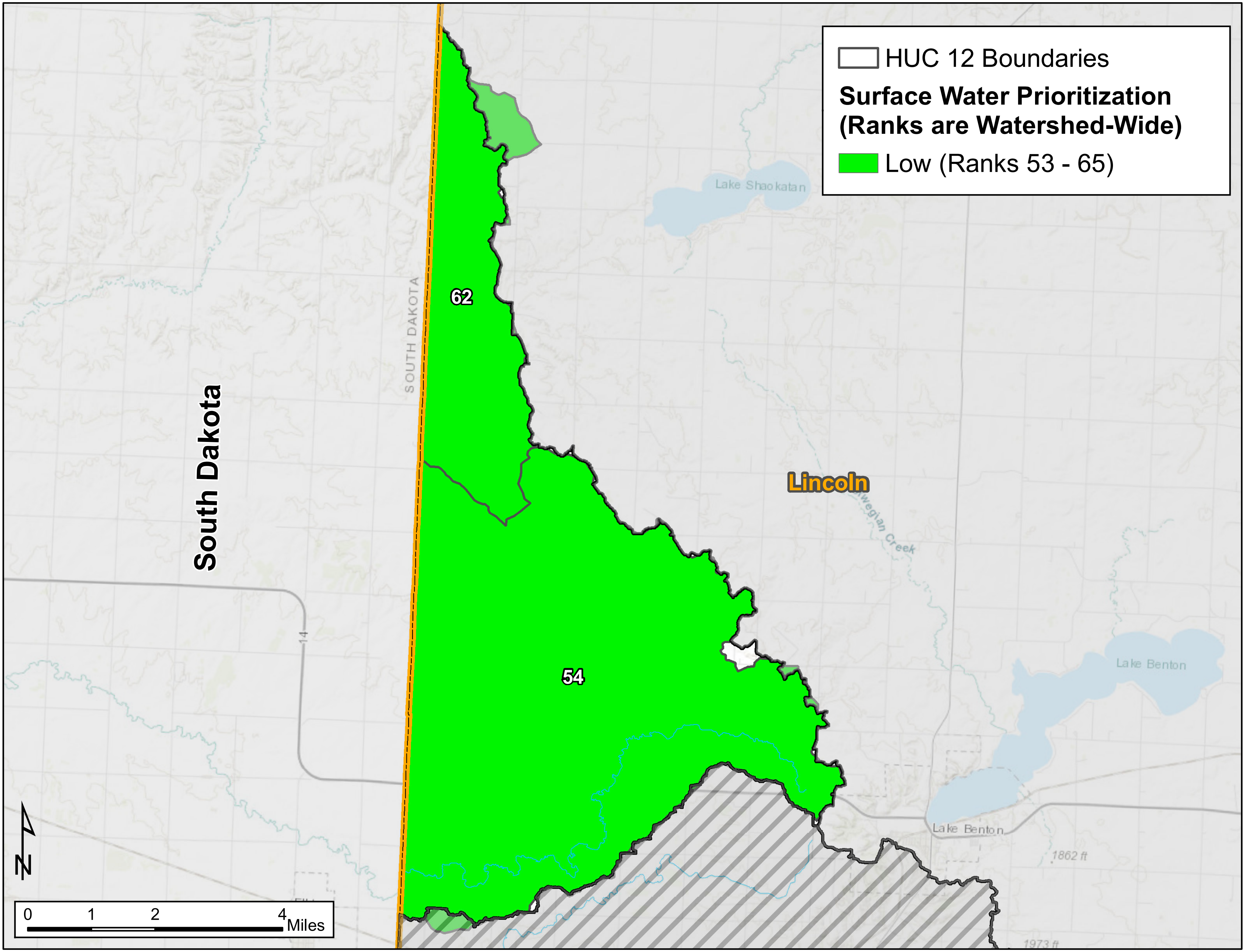
9
18
Miles
N

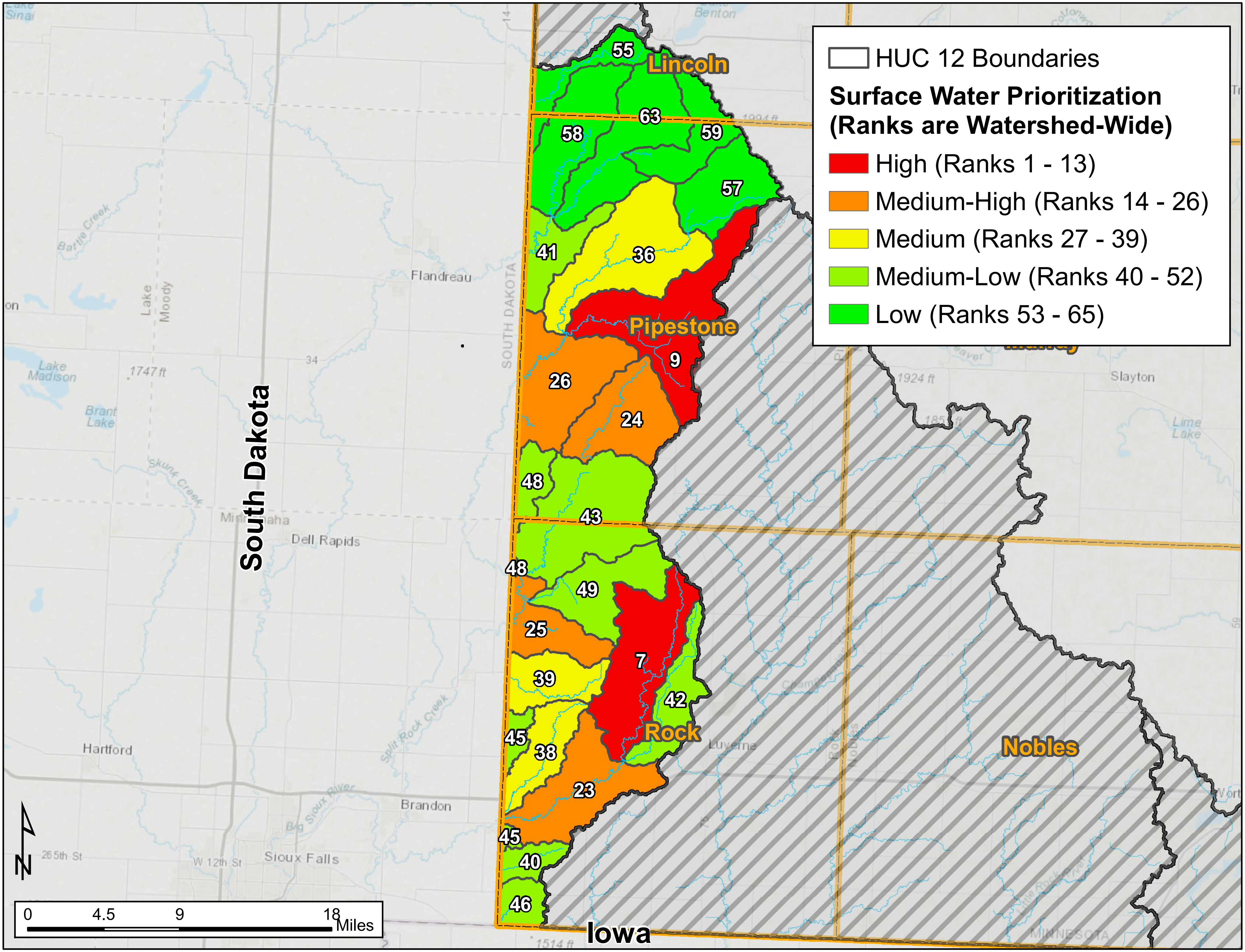


HUC 12 Boundaries
Comprehensive Implementation Prioritization (Ranks are Watershed-Wide)
High (Ranks 1 - 13)
Medium-High (Ranks 14 - 26)
Medium (Ranks 27 - 39)
Medium-Low (Ranks 40 - 52)
Low (Ranks 53 - 65)
South Dakota
Pipestone
Rock
Nobles
Jackson
34
48
57
10
55
42
9
26
7
36
19
14
12
2
51
15
16
3
17
33
4
22
50
8
6
25
39
38
0
3.5
7
14
Miles
N

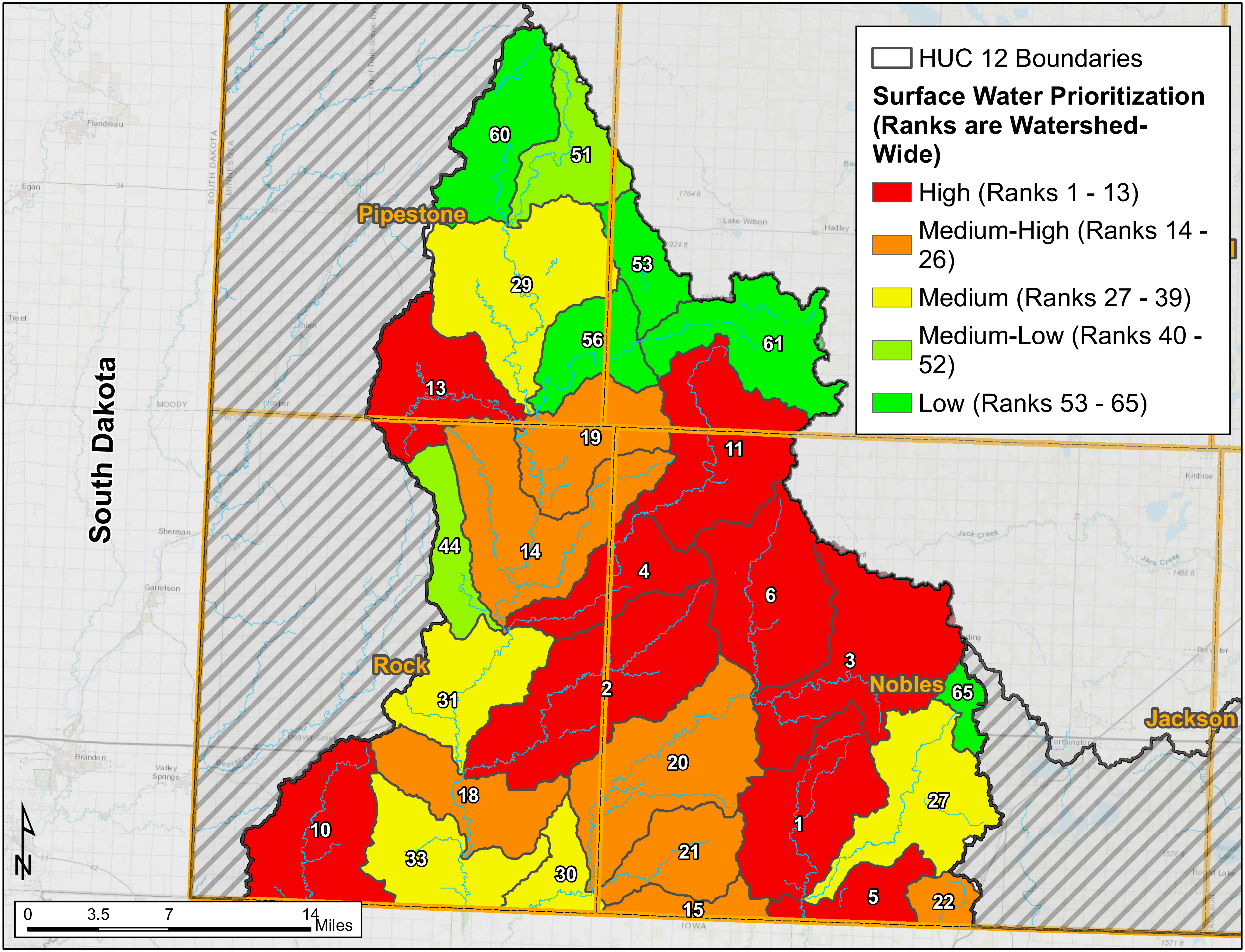

HUC 12 Boundaries
Comprehensive Implementation Prioritization (Ranks are Watershed-Wide)
High (Ranks 1 - 13)
Medium-High (Ranks 14 - 26)
Medium (Ranks 27 - 39)
Medium-Low (Ranks 40 - 52)
Low (Ranks 53 - 65)
Nobles
Jackson
Iowa
49
21
18
44
40
30
23
61
5
13
43
35
54
N
0
2
4
8
Miles


HUC 12 Boundaries
Surface Water Prioritization
(Ranks are Watershed-Wide)
High (Ranks 1 - 13)
Medium-High (Ranks 14 - 26)
Medium (Ranks 27 - 39)
Medium-Low (Ranks 40 - 52)
Low (Ranks 53 - 65)
South Dakota
Iowa
Lincoln
Lyon
Pipestone
Murray
Cottonwood
Watonwan
Renville
Rock
Nobles
Jackson
Martin
Miles
0
5
10
20

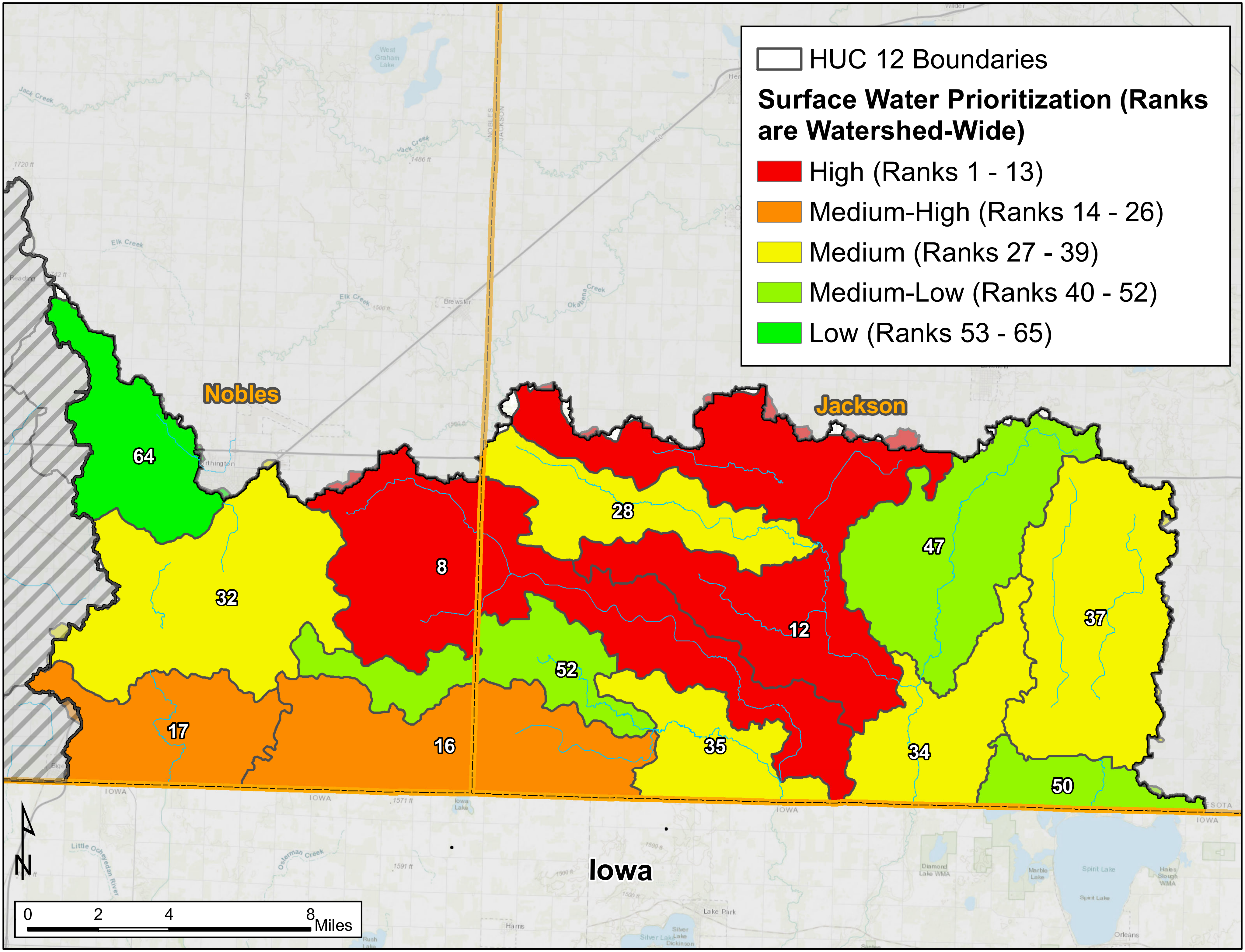

HUC 12 Boundaries
Surface Water Prioritization
(Ranks are Watershed-Wide)
Low (Ranks 53 - 65)
Lake Shaokatan
South Dakota
SOUTH DAKOTA
62
54
Lincoln
Lake Benton
Lake Benton
1862 ft
1973 ft
14
0
1
2
4
Miles

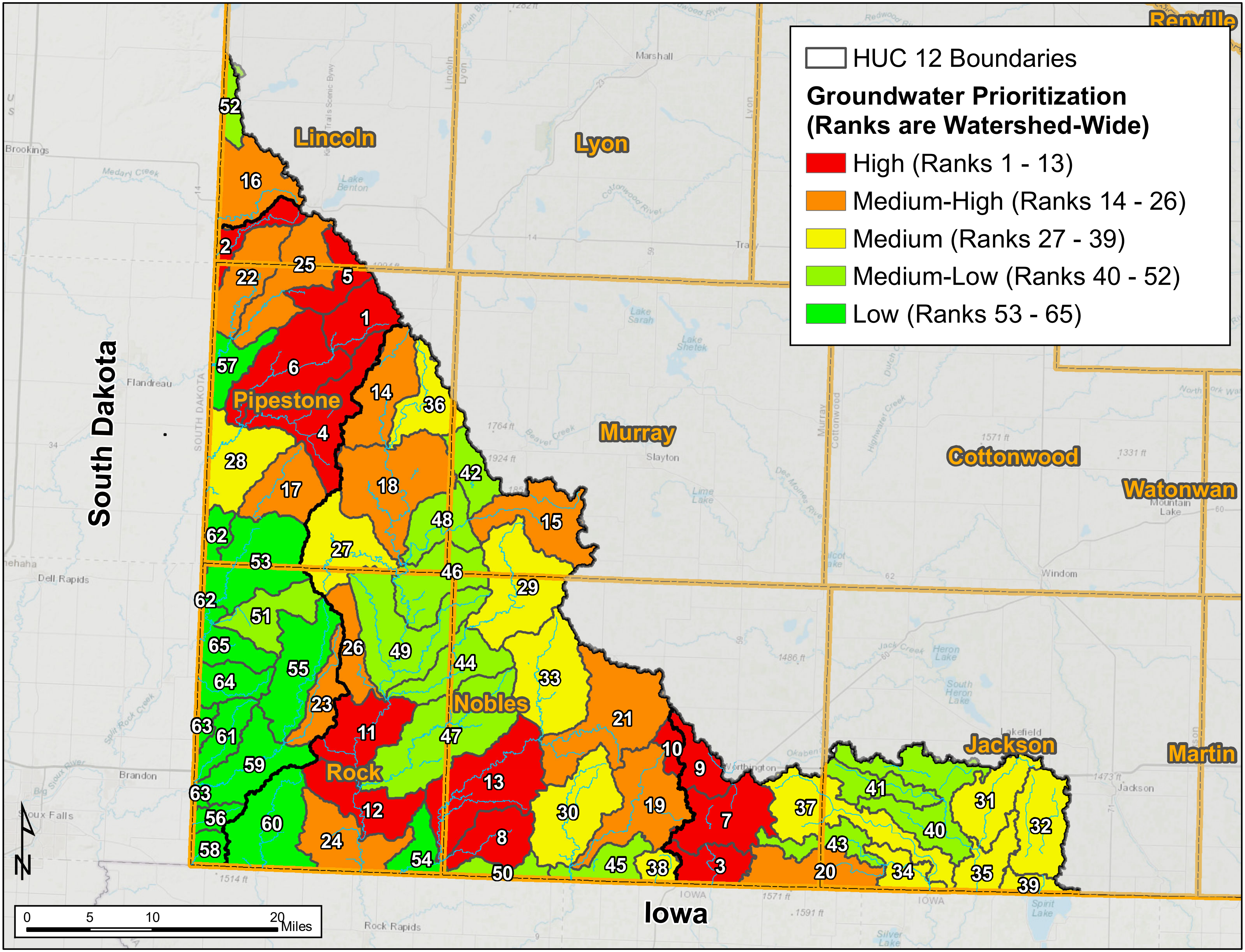


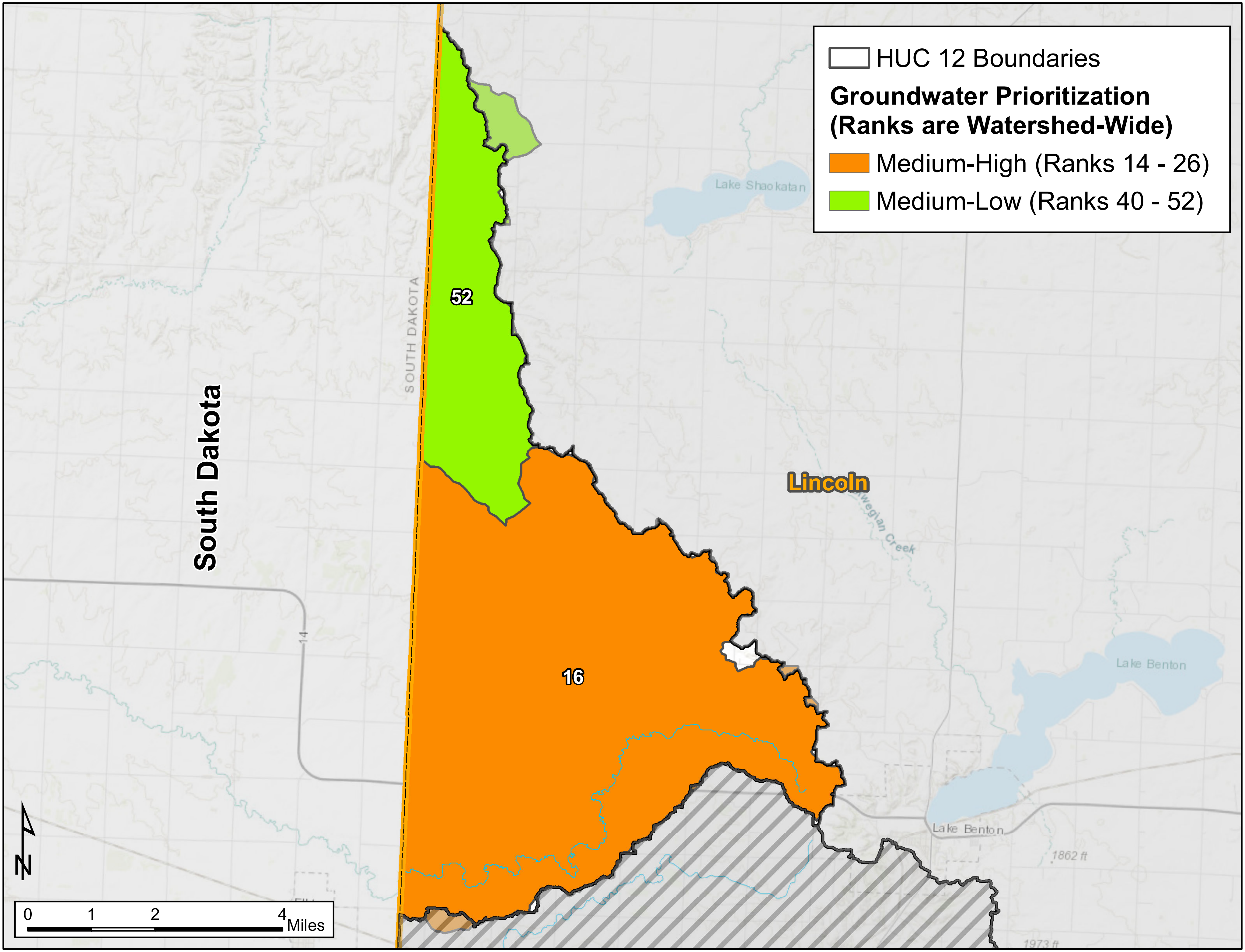
HUC 12 Boundaries
Surface Water Prioritization
(Ranks are Watershed-Wide)
High (Ranks 1 - 13)
Medium-High (Ranks 14 - 26)
Medium (Ranks 27 - 39)
Medium-Low (Ranks 40 - 52)
Low (Ranks 53 - 65)
Lincoln
Pipestone
Rock
Nobles
South Dakota
Iowa
55
63
58
59
57
41
36
9
26
24
48
43
48
49
25
7
39
42
45
38
23
45
40
46
Flandreau
Dell Rapids
Hartford
Brandon
Sioux Falls
Luverne
Slayton
0
4.5
9
18
Miles



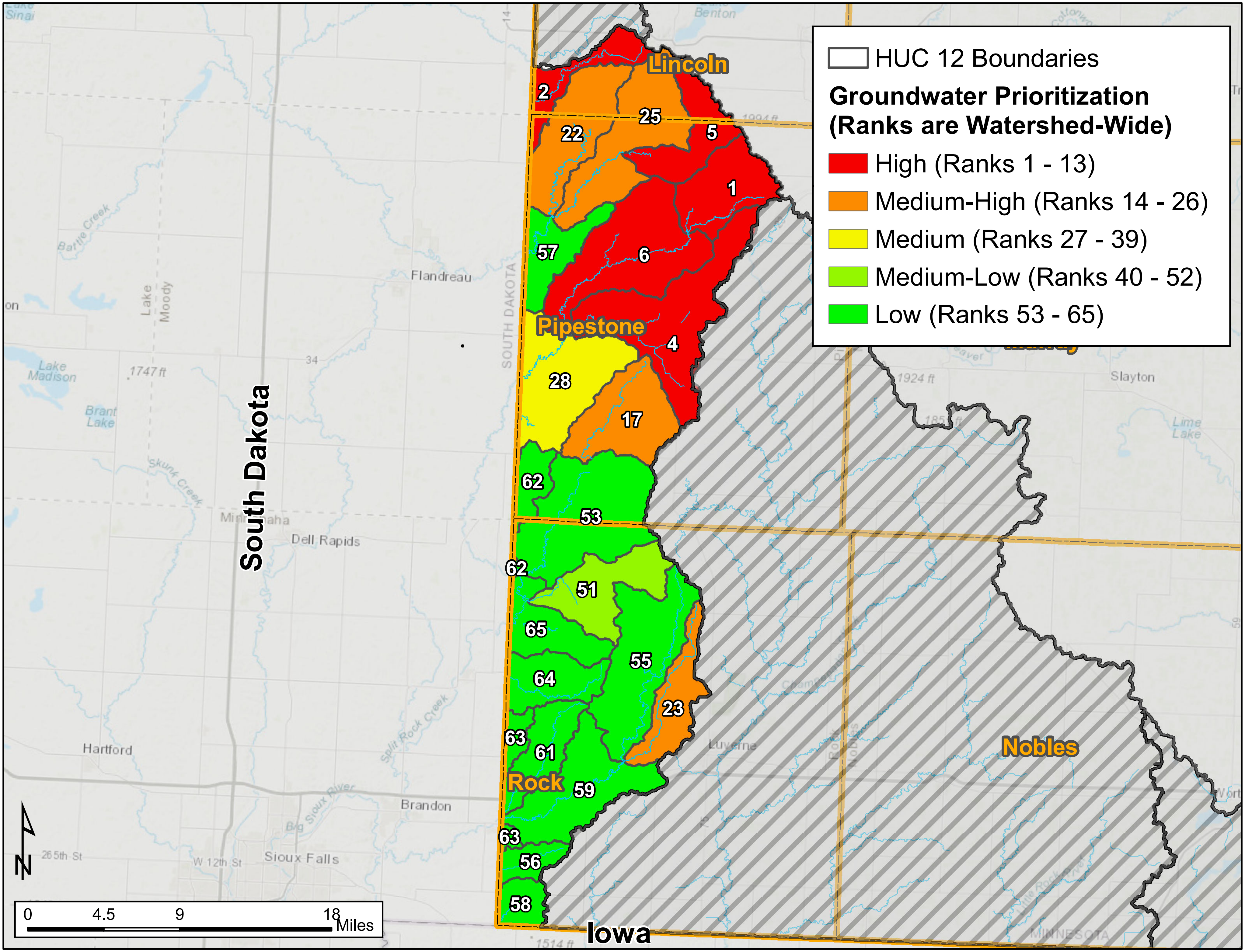
HUC 12 Boundaries
Surface Water Prioritization (Ranks are Watershed-Wide)
High (Ranks 1 - 13)
Medium-High (Ranks 14 - 26)
Medium (Ranks 27 - 39)
Medium-Low (Ranks 40 - 52)
Low (Ranks 53 - 65)
South Dakota
Pipestone
Rock
Nobles
Jackson
60
51
29
53
56
61
13
19
11
44
14
4
6
3
65
31
2
20
27
18
10
1
33
30
21
5
22
15
0 3.5 7 14 Miles


HUC 12 Boundaries
Surface Water Prioritization (Ranks are Watershed-Wide)
High (Ranks 1 - 13)
Medium-High (Ranks 14 - 26)
Medium (Ranks 27 - 39)
Medium-Low (Ranks 40 - 52)
Low (Ranks 53 - 65)
Nobles
Jackson
Iowa
64
32
8
28
12
47
37
52
17
16
35
34
50
N
0
2
4
8
Miles

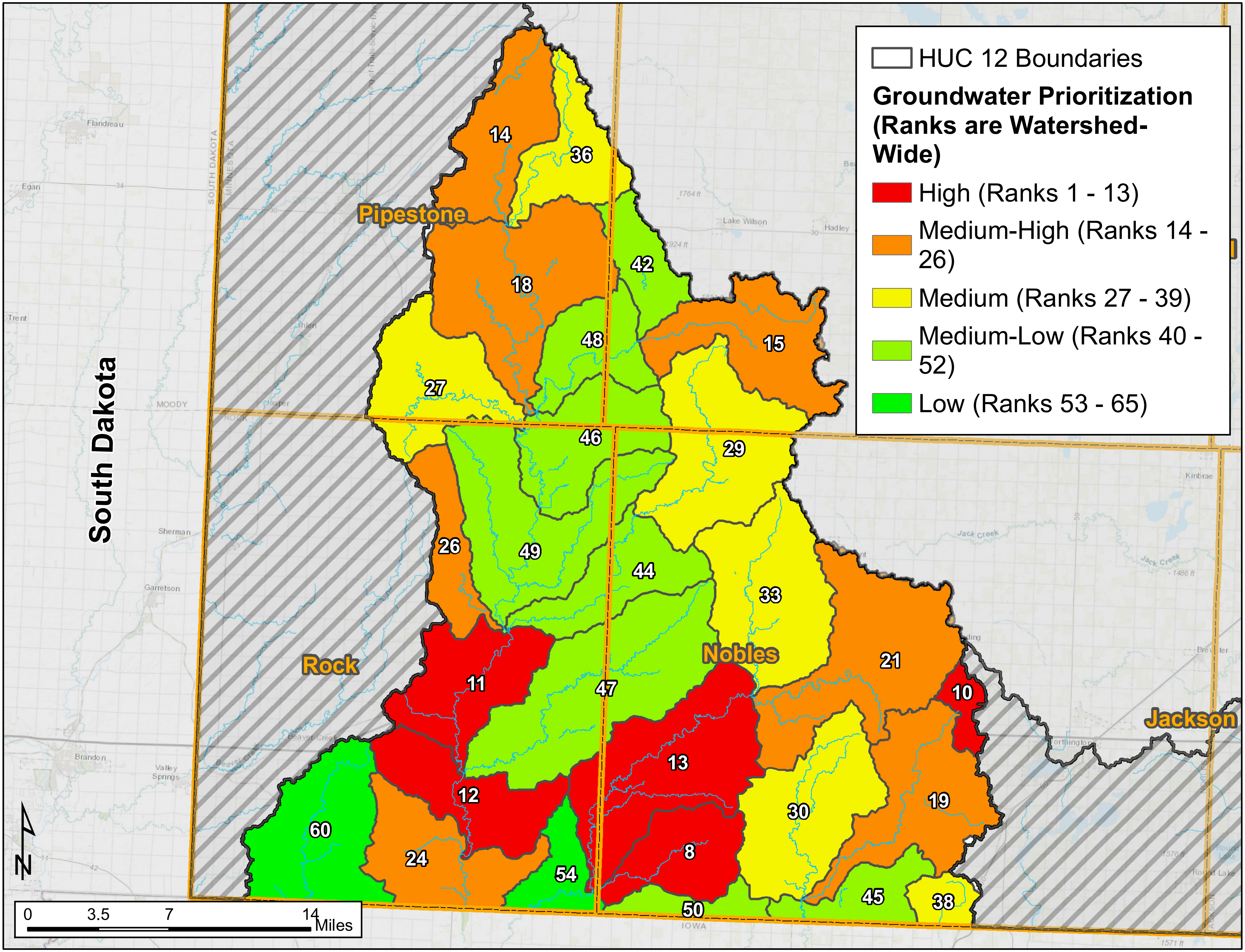

HUC 12 Boundaries
Groundwater Prioritization
(Ranks are Watershed-Wide)
High (Ranks 1 - 13)
Medium-High (Ranks 14 - 26)
Medium (Ranks 27 - 39)
Medium-Low (Ranks 40 - 52)
Low (Ranks 53 - 65)
South Dakota
Lincoln
Lyon
Pipestone
Murray
Cottonwood
Watonwan
Nobles
Rock
Jackson
Martin
Renville
Iowa
0 5 10 20 Miles
N



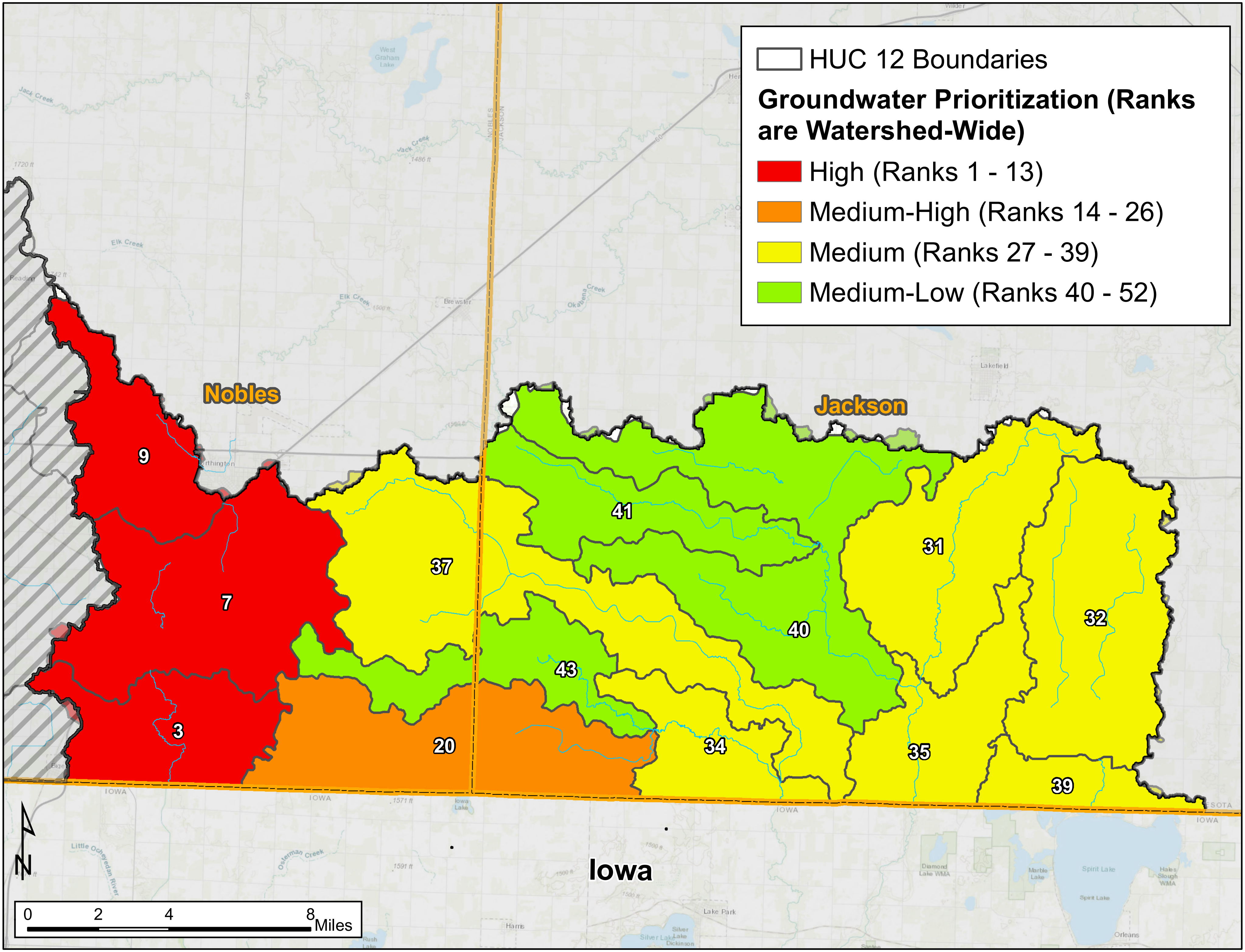
HUC 12 Boundaries
Groundwater Prioritization
(Ranks are Watershed-Wide)
Medium-High (Ranks 14 - 26)
Medium-Low (Ranks 40 - 52)
Lake Shaokatan
52
SOUTH DAKOTA
South Dakota
Lincoln
Norwegian Creek
16
14
Lake Benton
Lake Benton
1862 ft
1973 ft
N
0
1
2
4
Miles

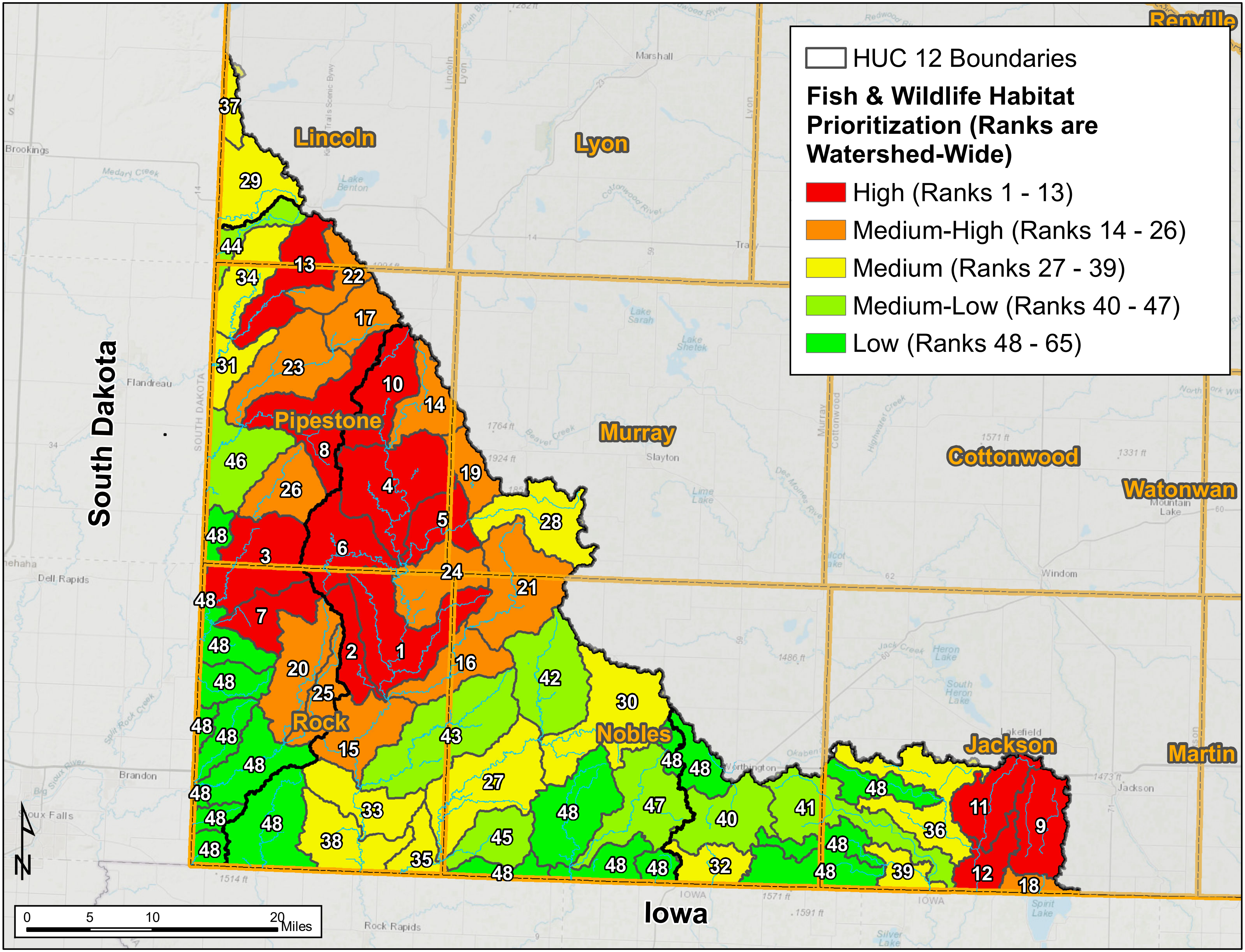


HUC 12 Boundaries
Groundwater Prioritization (Ranks are Watershed-Wide)
High (Ranks 1 - 13)
Medium-High (Ranks 14 - 26)
Medium (Ranks 27 - 39)
Medium-Low (Ranks 40 - 52)
Low (Ranks 53 - 65)
Lincoln
Pipestone
Rock
Nobles
South Dakota
Iowa
2
25
22
5
1
57
6
4
28
17
62
53
62
51
65
55
64
23
63
61
59
63
56
58
Flandreau
Dell Rapids
Hartford
Brandon
Sioux Falls
Luverne
Slayton
0 4.5 9 18 Miles
N



HUC 12 Boundaries
Groundwater Prioritization (Ranks are Watershed-Wide)
High (Ranks 1 - 13)
Medium-High (Ranks 14 - 26)
Medium (Ranks 27 - 39)
Medium-Low (Ranks 40 - 52)
Low (Ranks 53 - 65)
South Dakota
Pipestone
Rock
Nobles
Jackson
14
36
18
42
15
48
27
46
29
26
49
44
33
21
11
47
10
13
12
19
30
60
8
24
54
45
38
50
0
3.5
7
14
Miles


HUC 12 Boundaries
Groundwater Prioritization (Ranks are Watershed-Wide)
High (Ranks 1 - 13)
Medium-High (Ranks 14 - 26)
Medium (Ranks 27 - 39)
Medium-Low (Ranks 40 - 52)
Nobles
Jackson
Iowa
9
7
3
37
20
41
43
40
34
31
32
35
39
N
0 2 4 8 Miles



HUC 12 Boundaries
Fish & Wildlife Habitat Prioritization (Ranks are Watershed-Wide)
High (Ranks 1 - 13)
Medium-High (Ranks 14 - 26)
Medium (Ranks 27 - 39)
Medium-Low (Ranks 40 - 47)
Low (Ranks 48 - 65)
South Dakota
Iowa
Lincoln
Lyon
Pipestone
Murray
Cottonwood
Watonwan
Renville
Rock
Nobles
Jackson
Martin
Brookings
Marshall
Flandreau
Slayton
Windom
Dell Rapids
Brandon
Sioux Falls
Worthington
Lakefield
Jackson
Rock Rapids
0 5 10 20 Miles
N
37
29
44
13
22
34
17
31
23
10
14
8
46
26
4
19
28
48
5
3
6
24
21
48
7
48
2
1
16
42
20
48
30
25
48
48
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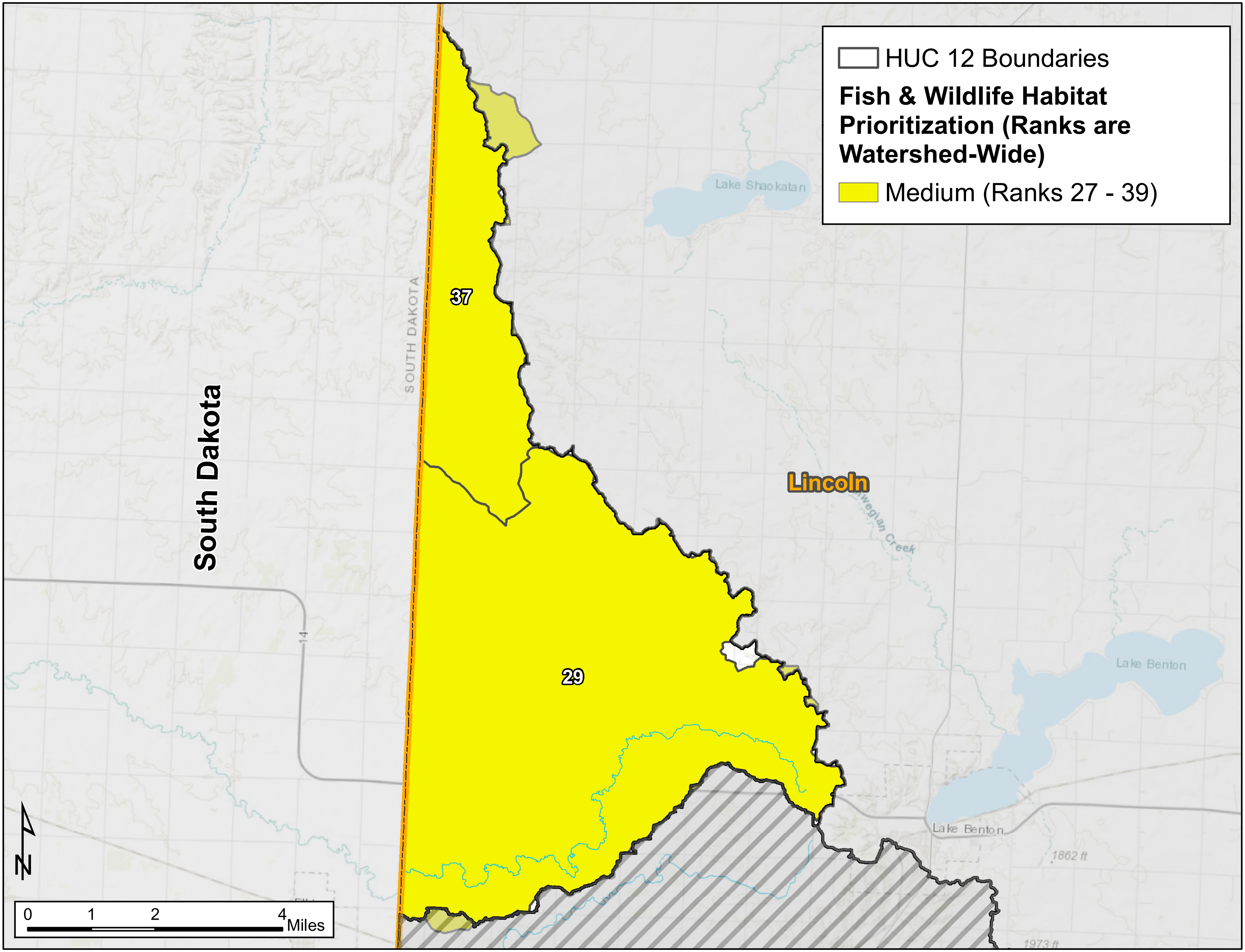
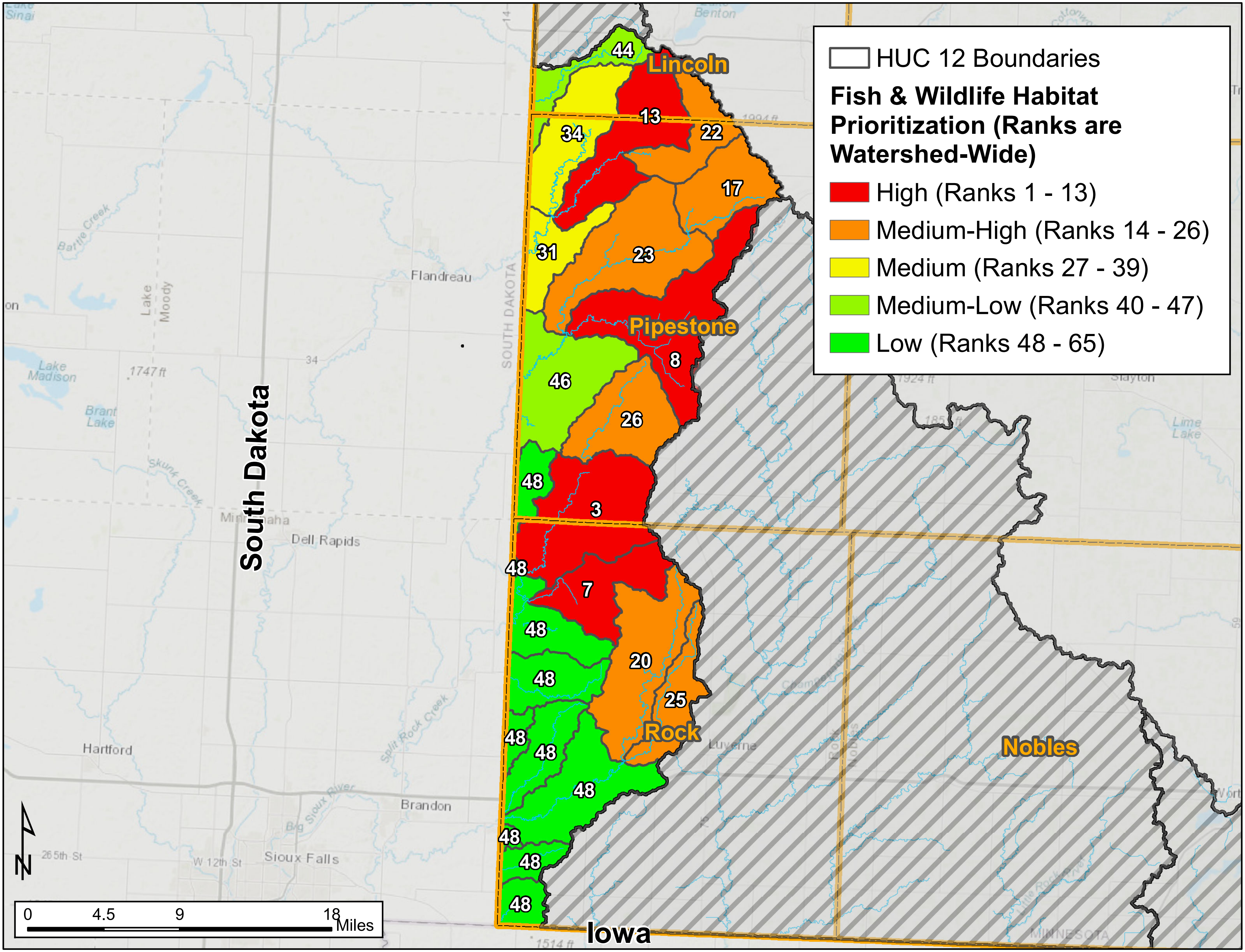
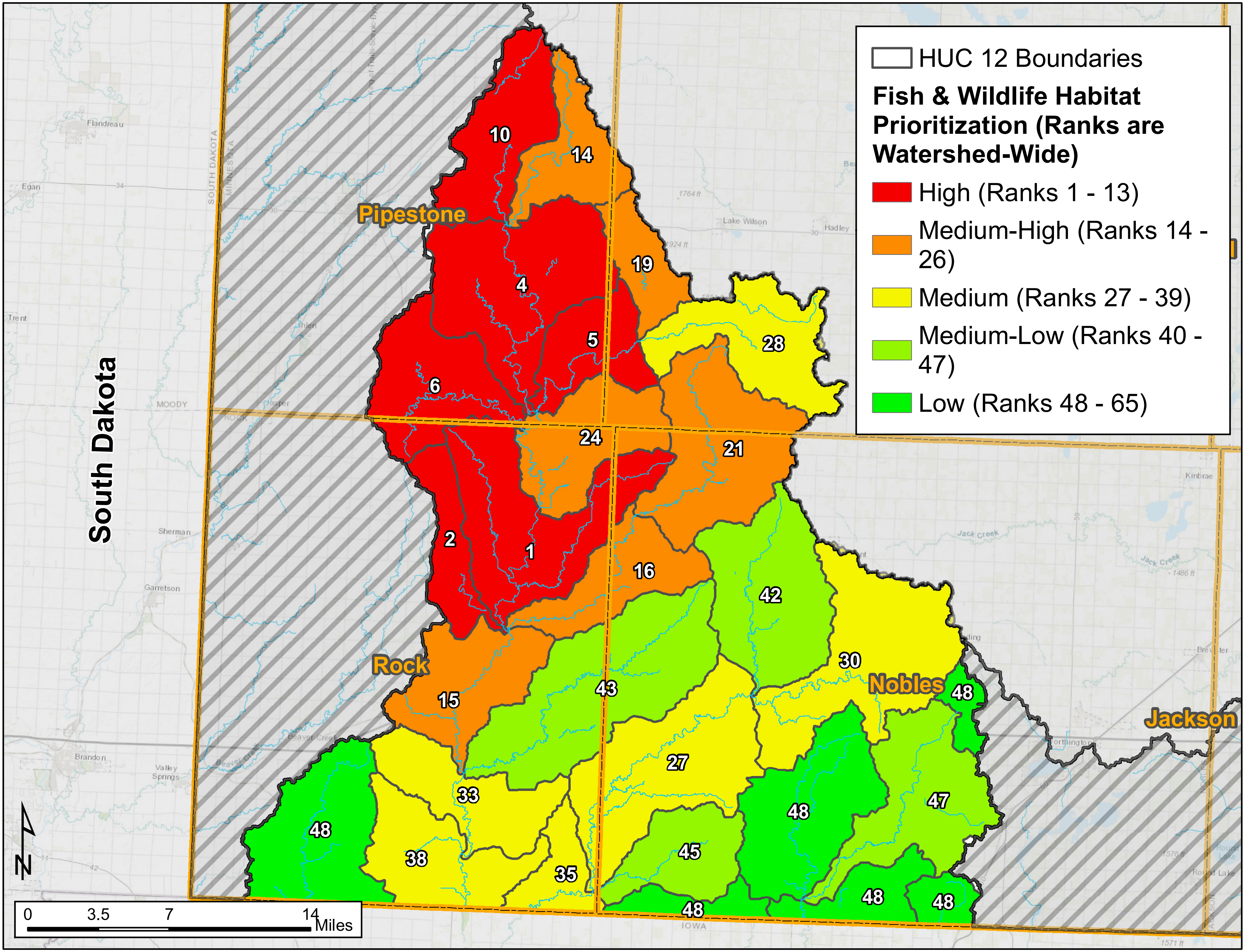
12
18

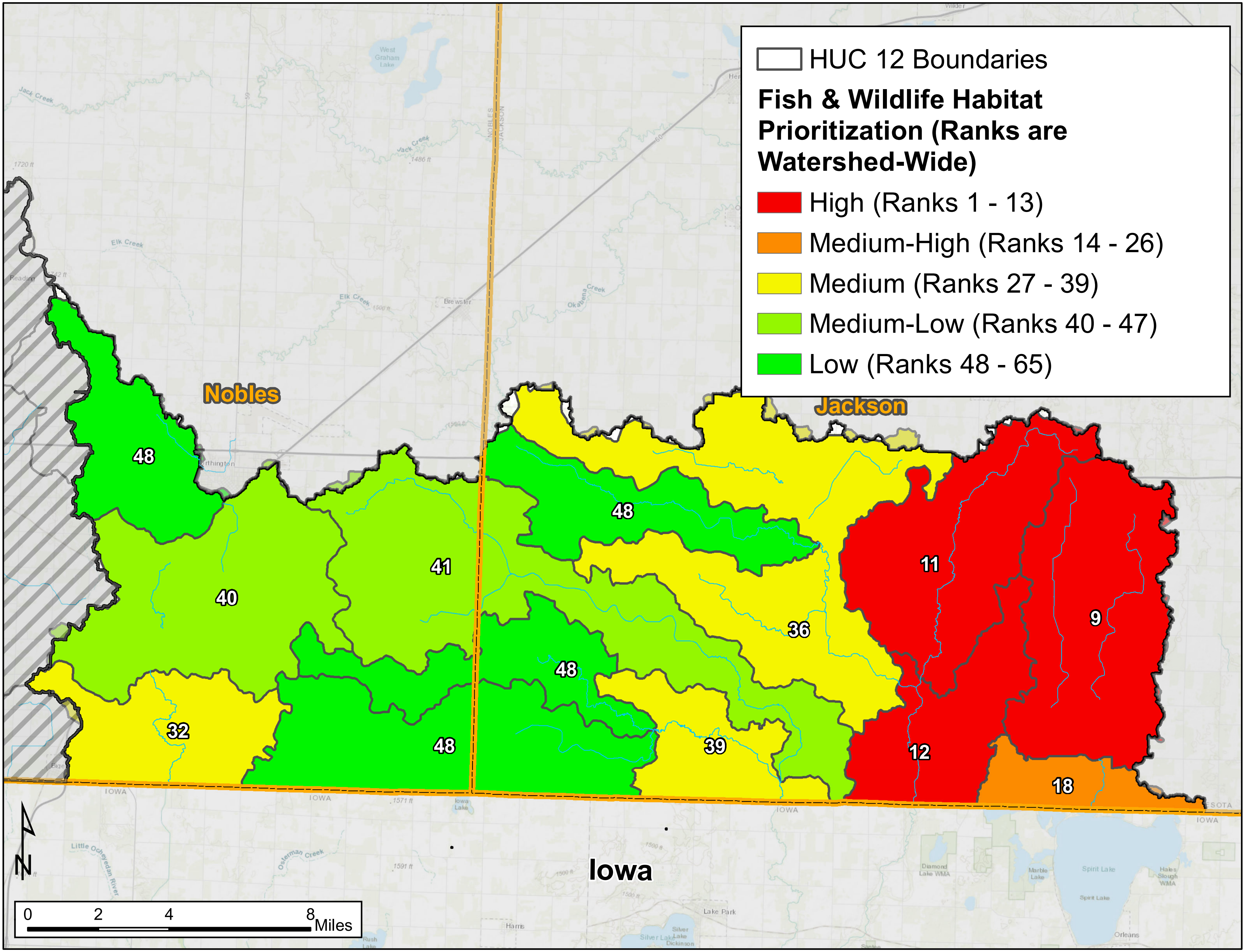


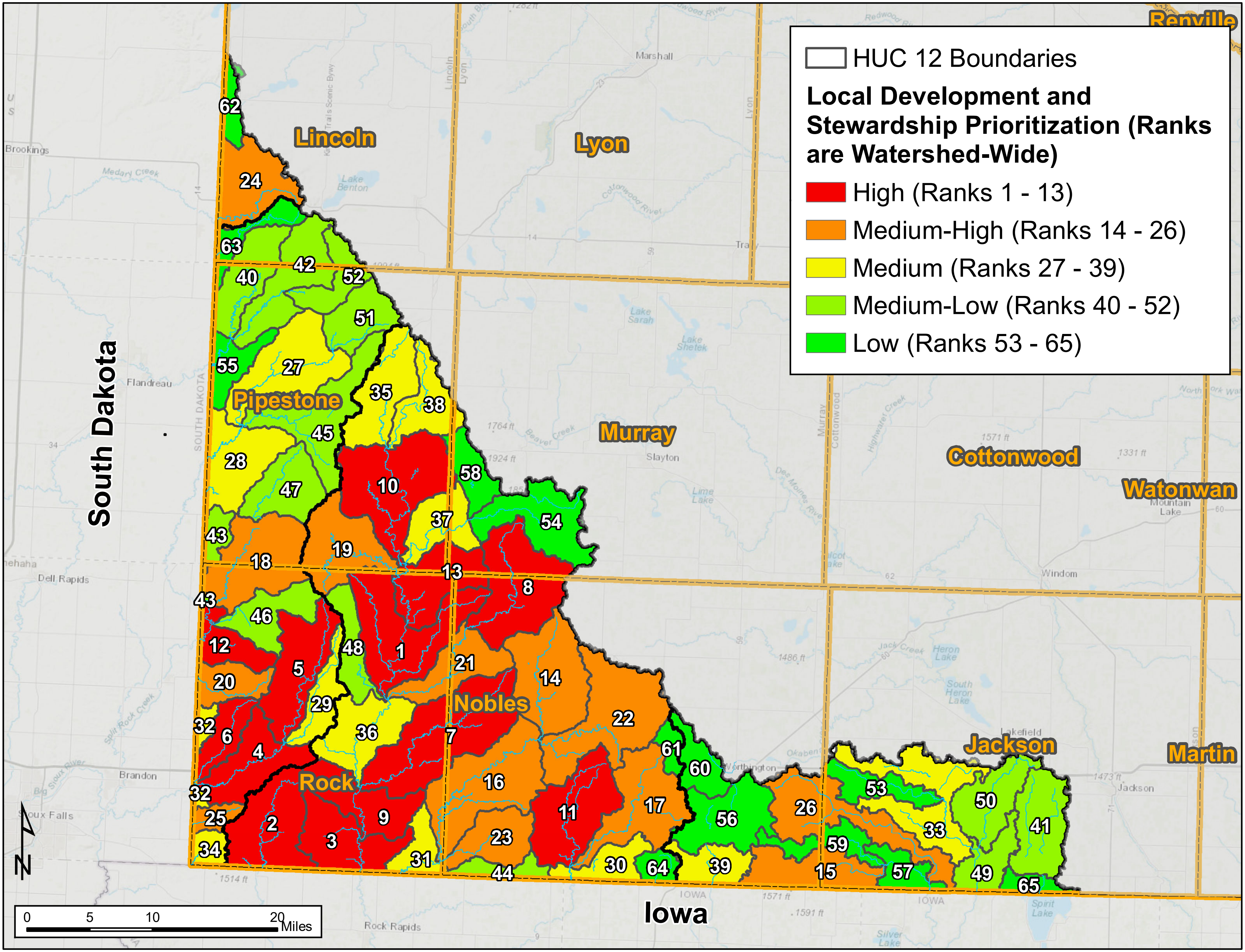
HUC 12 Boundaries
Fish & Wildlife Habitat Prioritization (Ranks are Watershed-Wide)
Medium (Ranks 27 - 39)
37
29
South Dakota
SOUTH DAKOTA
Lincoln
Lake Shaokatan
Lake Benton
Lake Benton
14
1862 ft
1973 ft
0 1 2 4 Miles
N

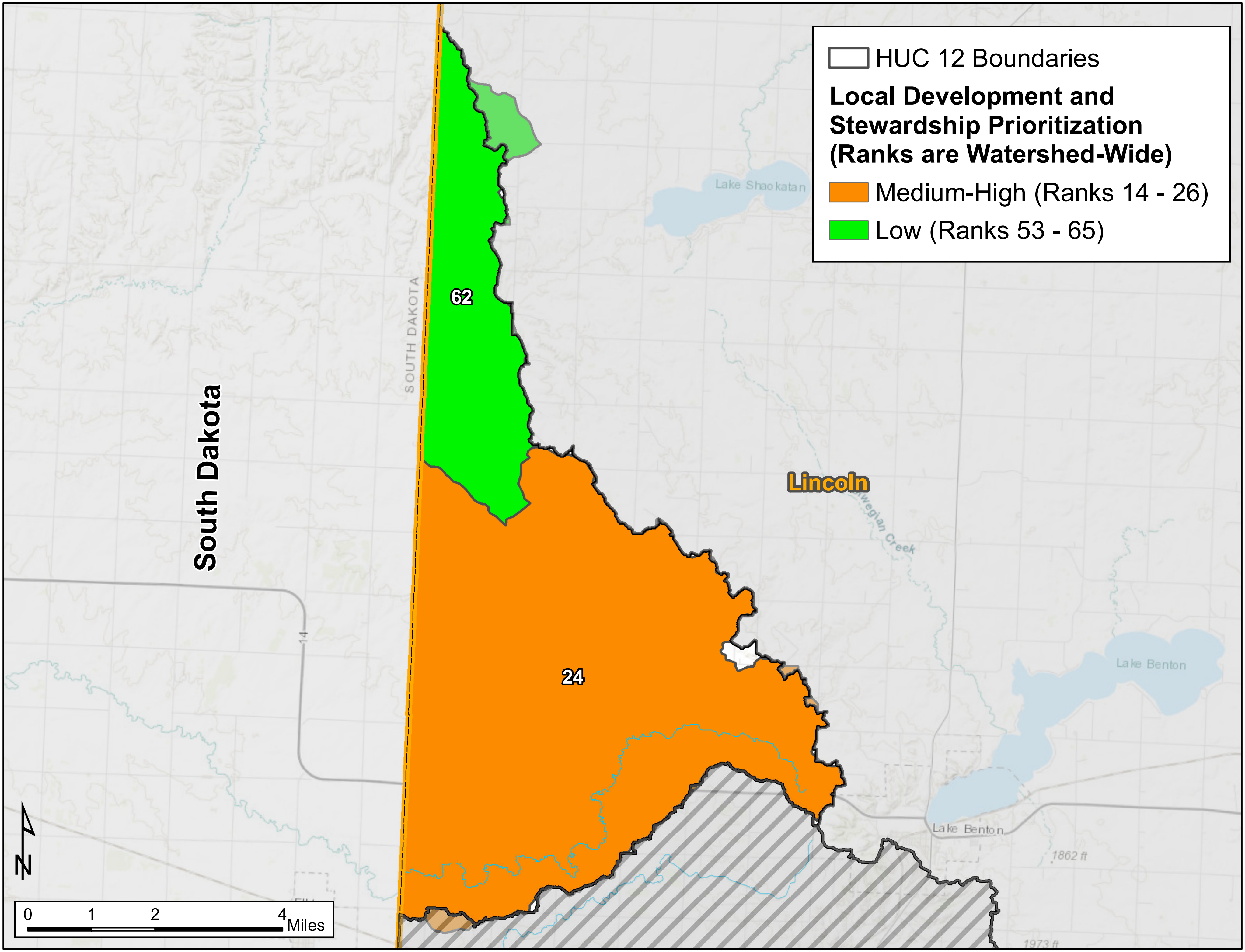

HUC 12 Boundaries
Fish & Wildlife Habitat Prioritization (Ranks are Watershed-Wide)
High (Ranks 1 - 13)
Medium-High (Ranks 14 - 26)
Medium (Ranks 27 - 39)
Medium-Low (Ranks 40 - 47)
Low (Ranks 48 - 65)
Lincoln
Pipestone
Rock
Nobles
South Dakota
Iowa
44
13
22
34
17
31
23
8
46
26
48
3
7
20
25
Flandreau
Dell Rapids
Hartford
Brandon
Sioux Falls
Luverne
0
4.5
9
18
Miles

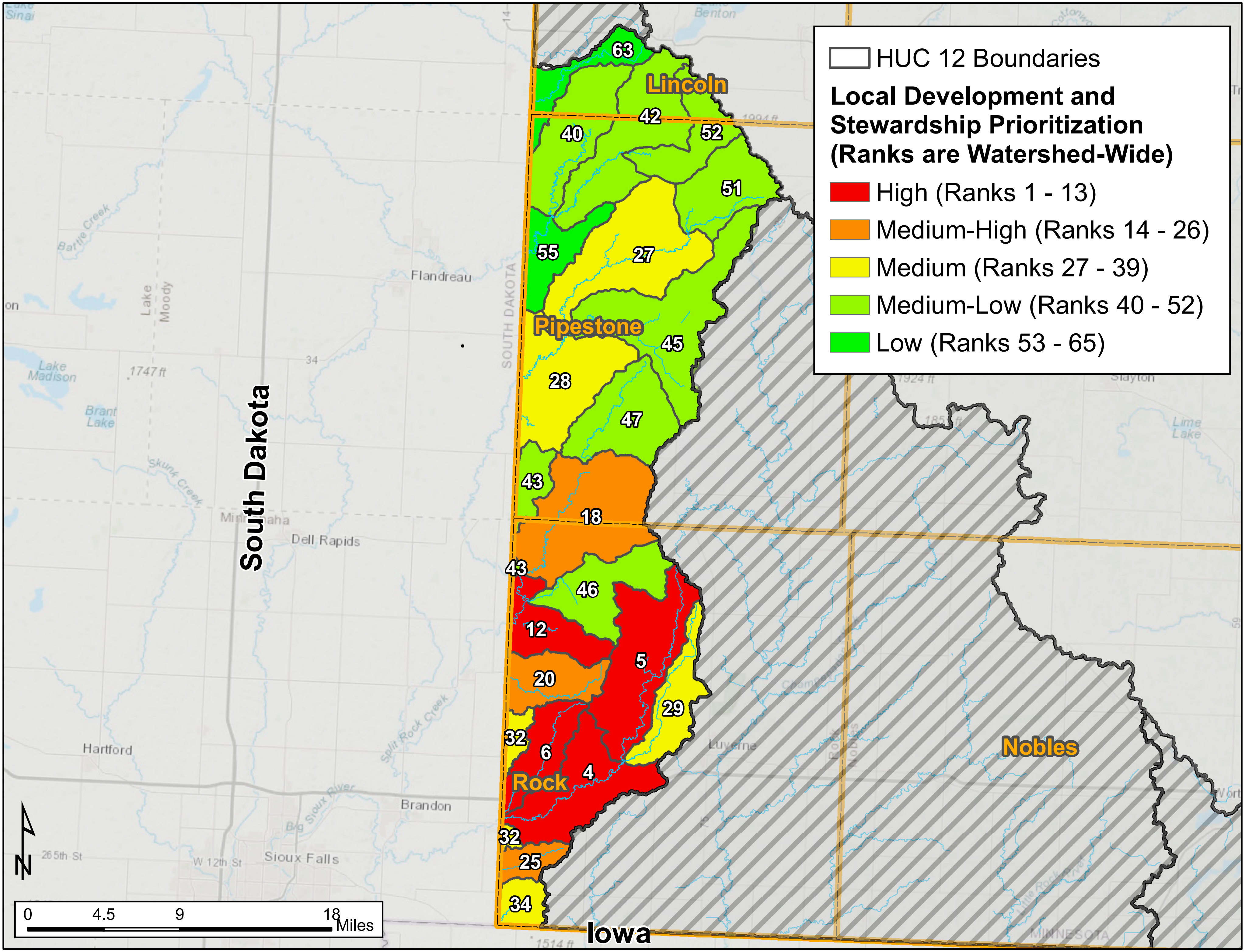


HUC 12 Boundaries
Fish & Wildlife Habitat Prioritization (Ranks are Watershed-Wide)
High (Ranks 1 - 13)
Medium-High (Ranks 14 - 26)
Medium (Ranks 27 - 39)
Medium-Low (Ranks 40 - 47)
Low (Ranks 48 - 65)
South Dakota
Pipestone
Rock
Nobles
Jackson
10
14
4
19
5
6
28
24
21
2
1
16
42
30
15
43
48
27
33
47
38
45
35
0
3.5
7
14
Miles
N

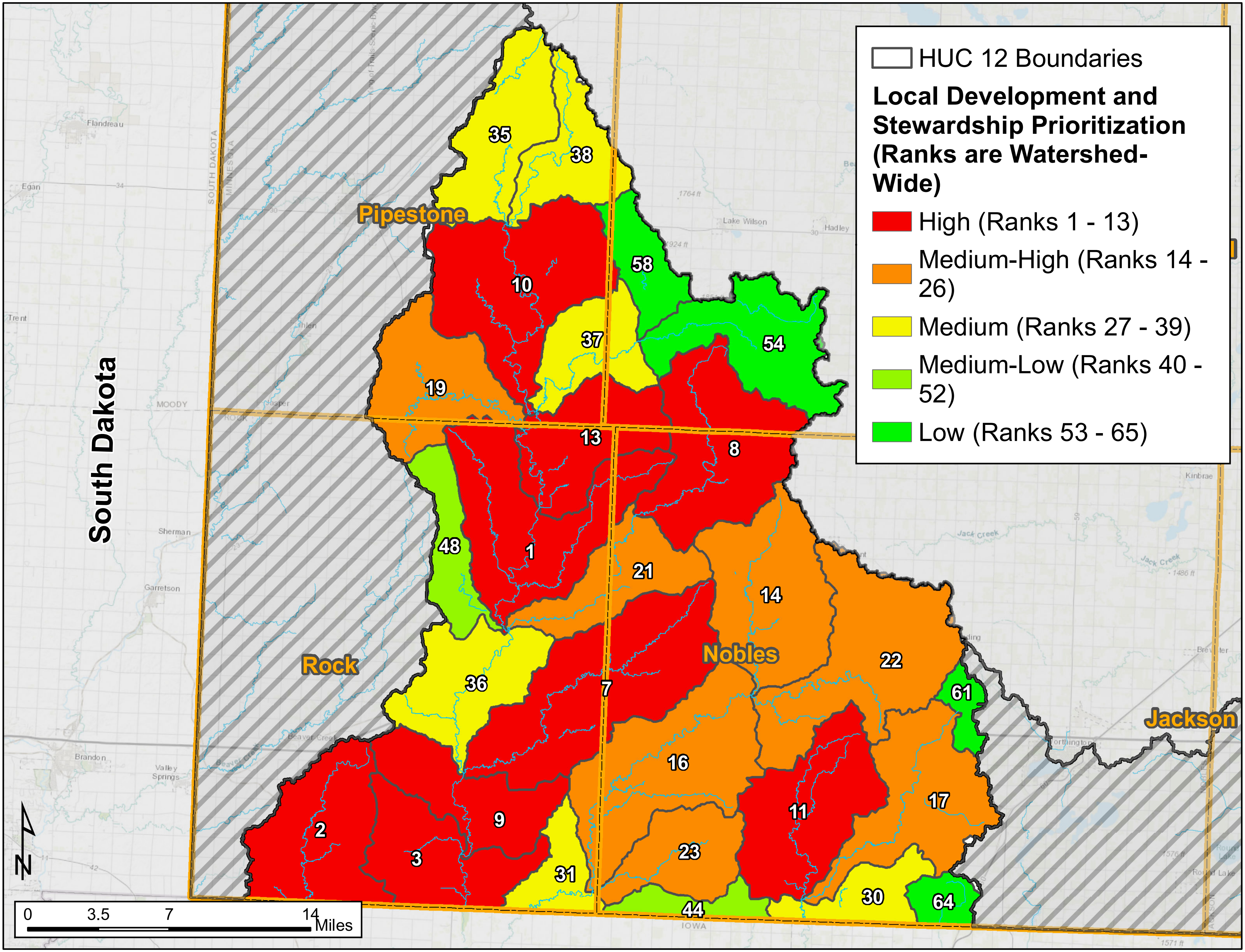

HUC 12 Boundaries
Fish & Wildlife Habitat Prioritization (Ranks are Watershed-Wide)
High (Ranks 1 - 13)
Medium-High (Ranks 14 - 26)
Medium (Ranks 27 - 39)
Medium-Low (Ranks 40 - 47)
Low (Ranks 48 - 65)
Nobles
Jackson
Iowa
48
40
41
48
48
48
48
32
36
39
11
9
12
18
0
2
4
8
Miles
N


HUC 12 Boundaries
Local Development and Stewardship Prioritization (Ranks are Watershed-Wide)
High (Ranks 1 - 13)
Medium-High (Ranks 14 - 26)
Medium (Ranks 27 - 39)
Medium-Low (Ranks 40 - 52)
Low (Ranks 53 - 65)
Lincoln
Lyon
Pipestone
Murray
Cottonwood
Watonwan
Nobles
Rock
Jackson
Martin
Renville
South Dakota
Iowa
0 5 10 20 Miles


HUC 12 Boundaries
Local Development and Stewardship Prioritization (Ranks are Watershed-Wide)
Medium-High (Ranks 14 - 26)
Low (Ranks 53 - 65)
62
24
South Dakota
SOUTH DAKOTA
Lincoln
Lake Shaokatan
Lake Benton
Lake Benton
1862 ft
1973 ft
14
0
1
2
4
Miles
N



HUC 12 Boundaries
Local Development and Stewardship Prioritization (Ranks are Watershed-Wide)
High (Ranks 1 - 13)
Medium-High (Ranks 14 - 26)
Medium (Ranks 27 - 39)
Medium-Low (Ranks 40 - 52)
Low (Ranks 53 - 65)
Lincoln
Pipestone
Rock
Nobles
South Dakota
Iowa
63
42
52
40
51
55
27
45
28
47
43
18
43
46
12
5
20
29
32
6
4
32
25
34
Flandreau
Dell Rapids
Hartford
Brandon
Sioux Falls
Luverne
Slayton
0
4.5
9
18
Miles


HUC 12 Boundaries
Local Development and Stewardship Prioritization (Ranks are Watershed-Wide)
High (Ranks 1 - 13)
Medium-High (Ranks 14 - 26)
Medium (Ranks 27 - 39)
Medium-Low (Ranks 40 - 52)
Low (Ranks 53 - 65)
South Dakota
Pipestone
Rock
Nobles
Jackson
35
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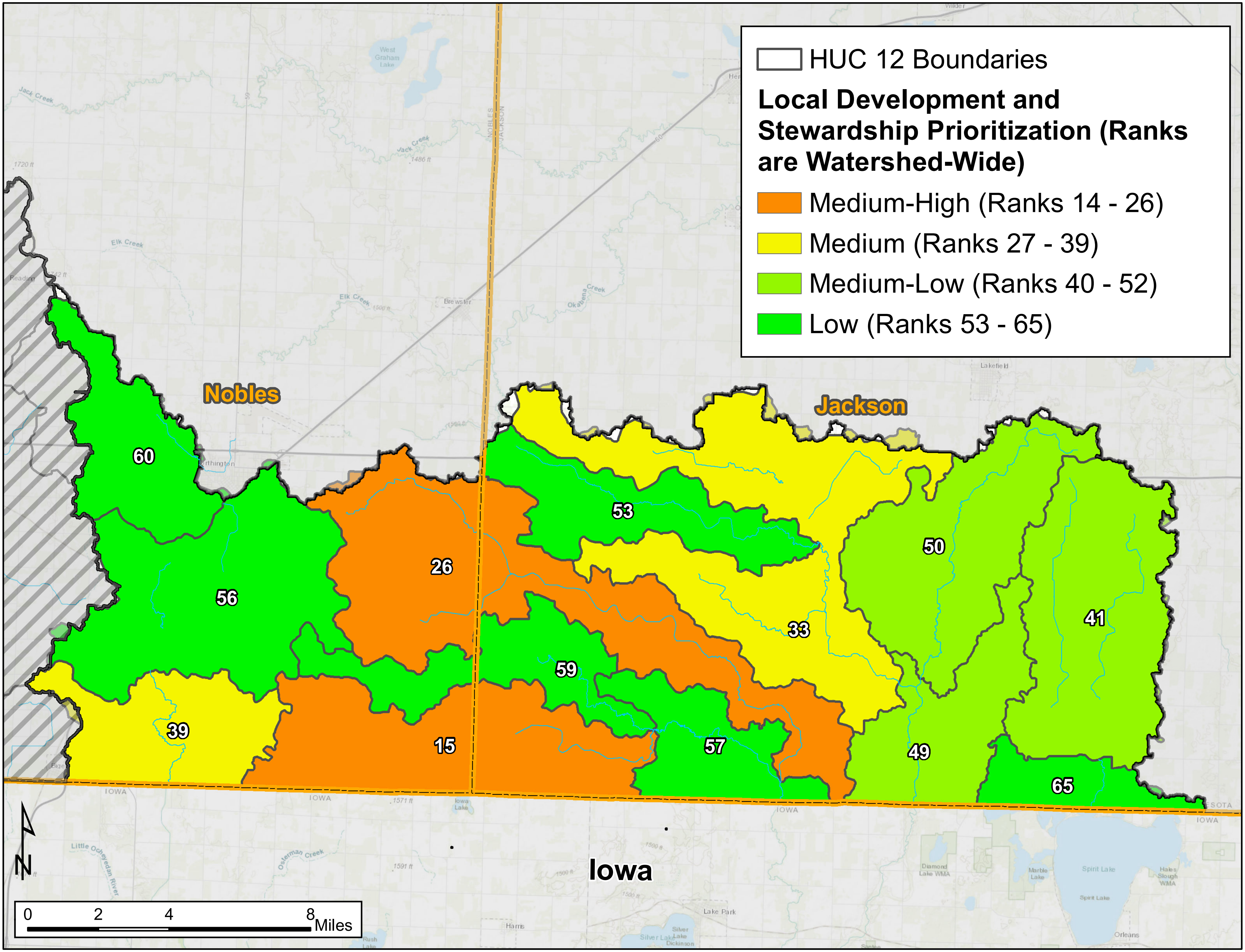
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Medium-Low (Ranks 40 - 52)
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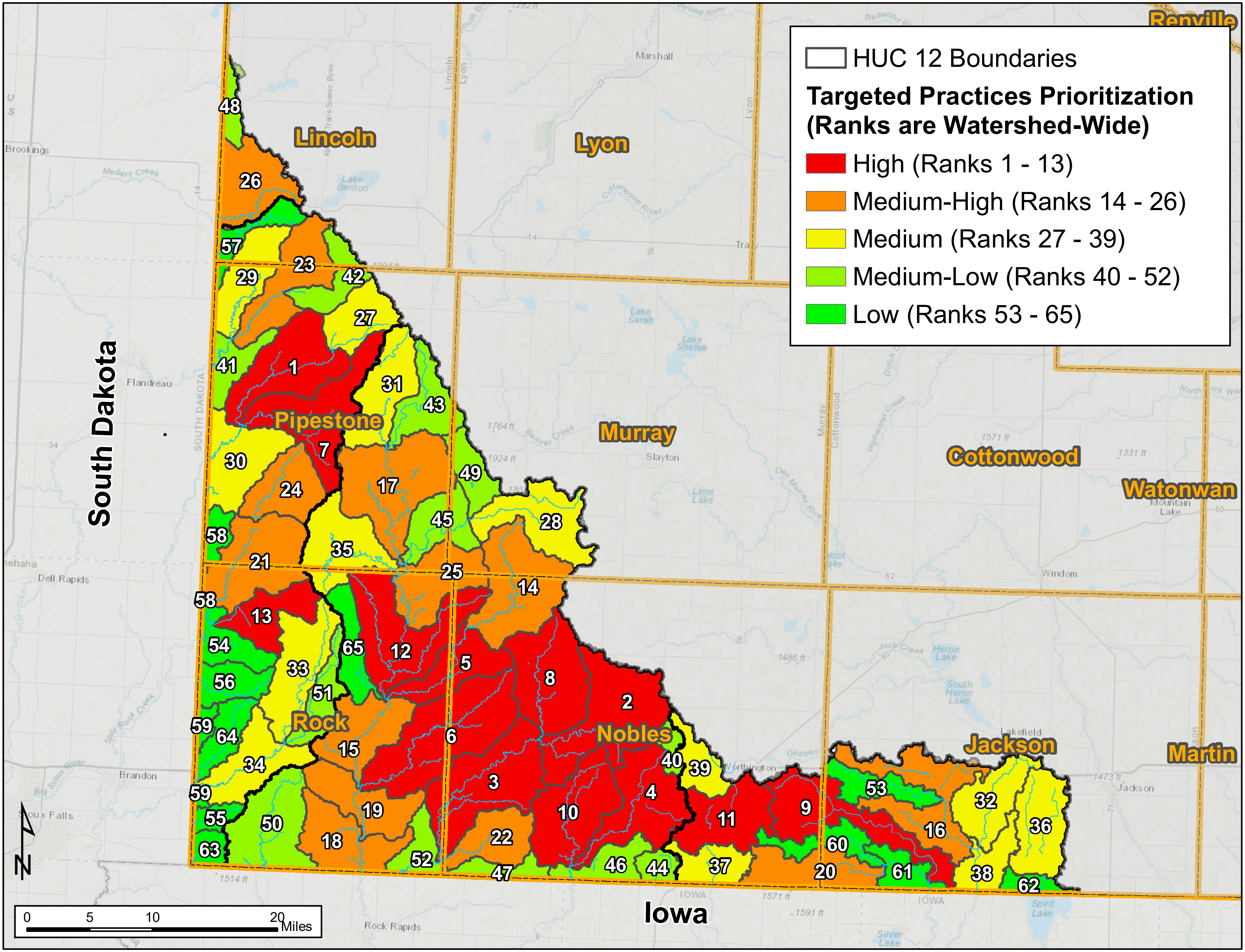
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Targeted Practices Prioritization (Ranks are Watershed-Wide)
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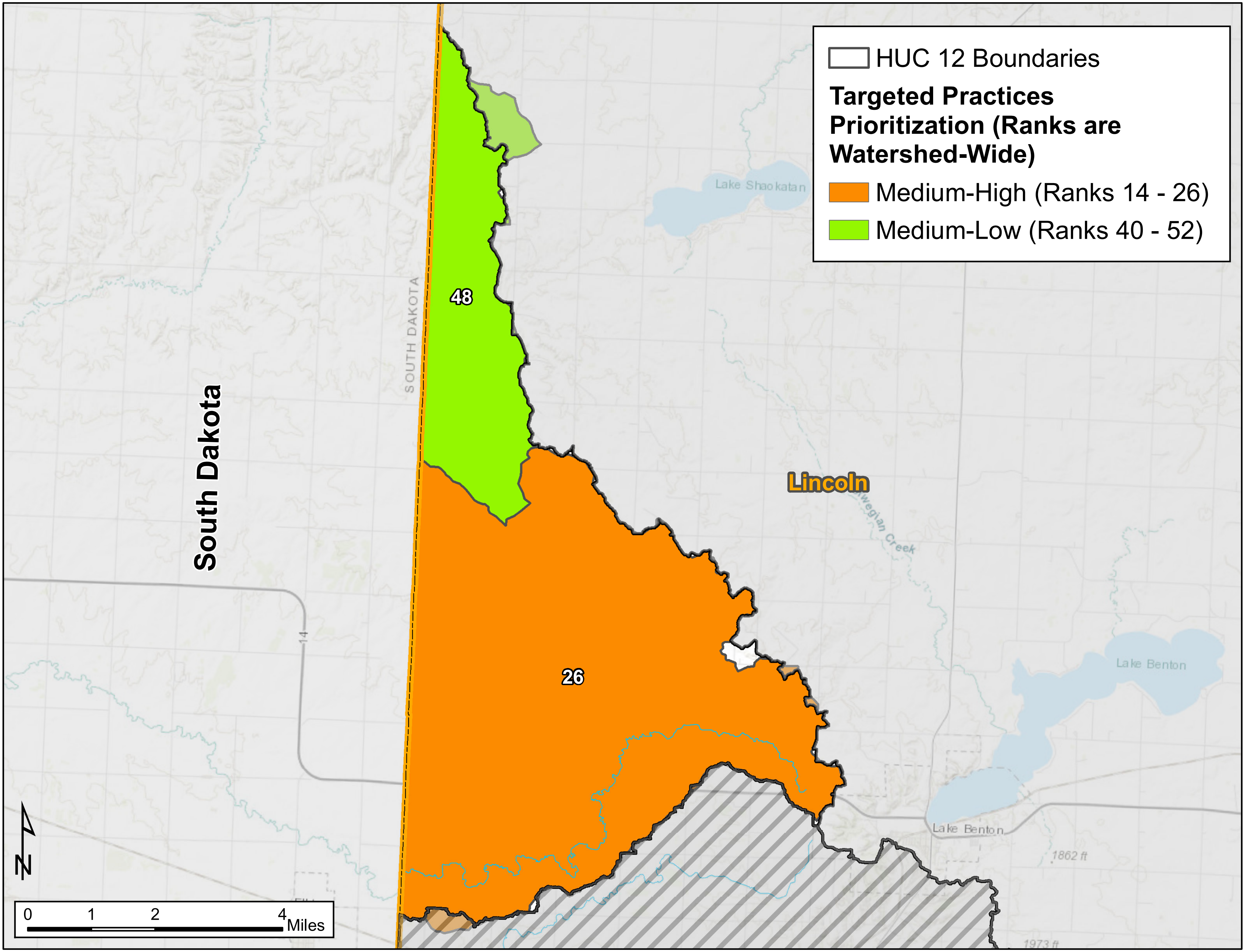

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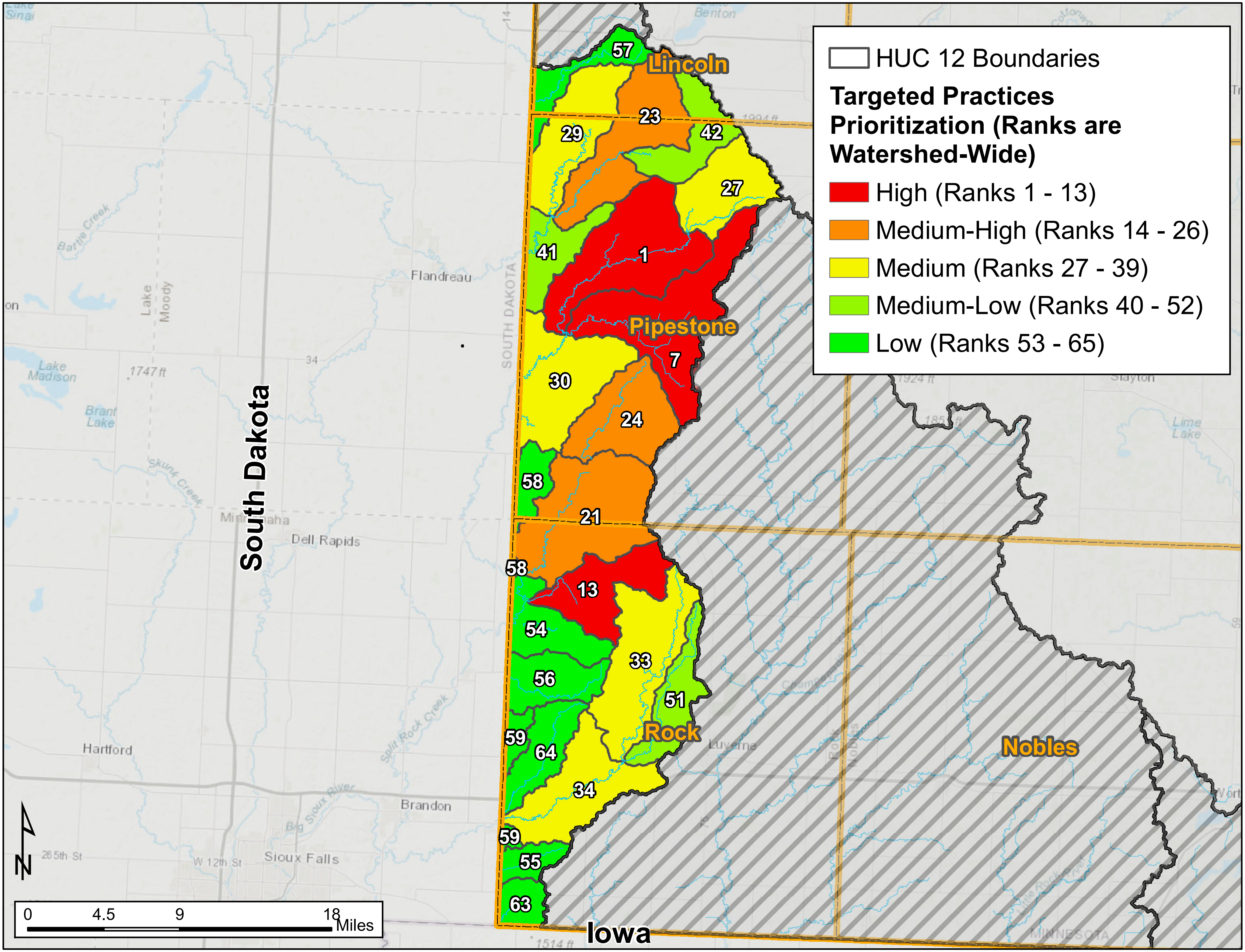

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Targeted Practices Prioritization (Ranks are Watershed-Wide)
High (Ranks 1 - 13)
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Medium (Ranks 27 - 39)
Medium-Low (Ranks 40 - 52)
Low (Ranks 53 - 65)
Lincoln
Pipestone
Rock
Nobles
South Dakota
Iowa
Flandreau
Dell Rapids
Hartford
Brandon
Sioux Falls
Luverne
Slayton
Lake Madison
Brant Lake
Lake Benton
Lime Lake
Split Rock Creek
Battle Creek
Skunk Creek
Big Sioux River
57
23
29
42
27
41
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7
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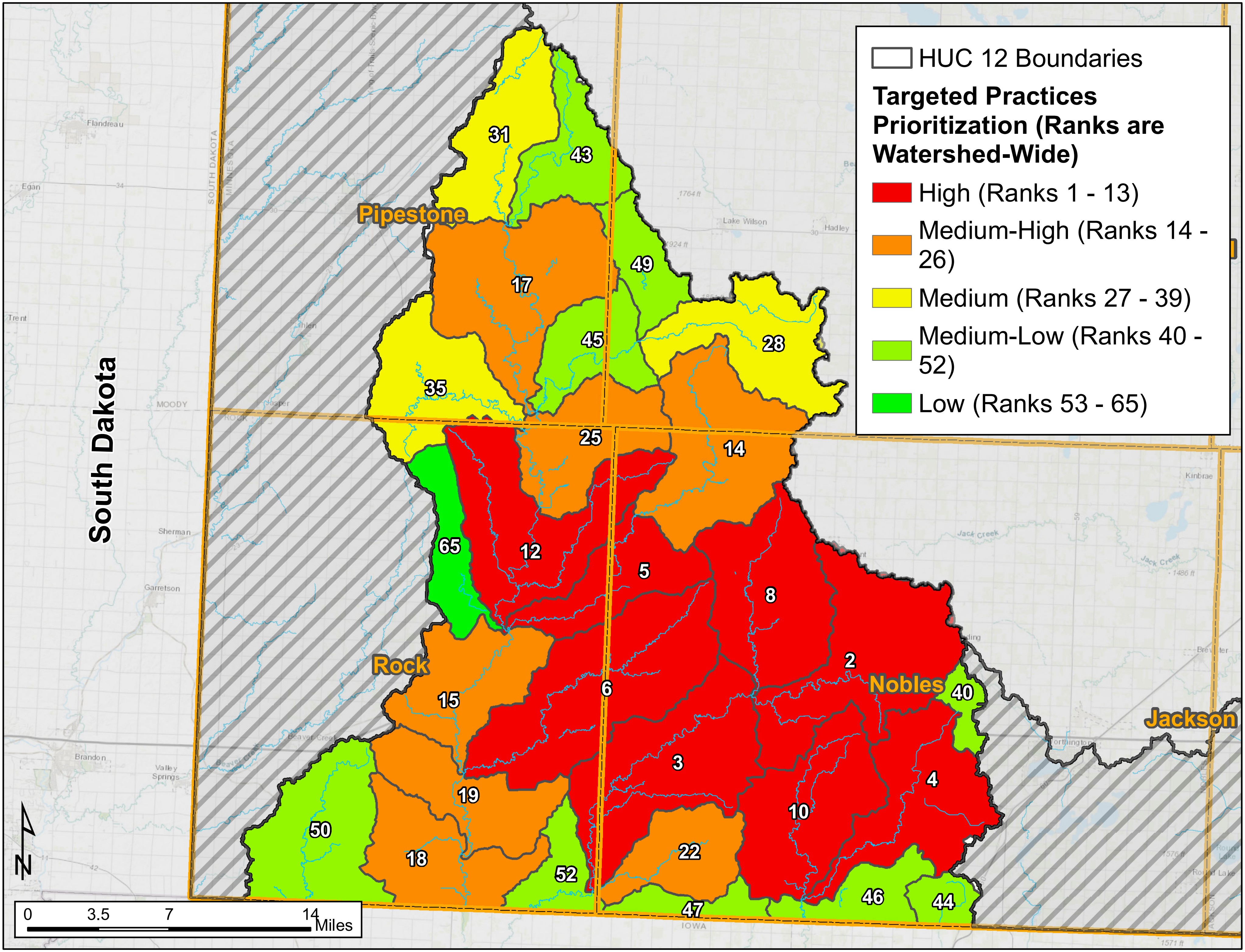
HUC 12 Boundaries
Targeted Practices Prioritization (Ranks are Watershed-Wide)
High (Ranks 1 - 13)
Medium-High (Ranks 14 - 26)
Medium (Ranks 27 - 39)
Medium-Low (Ranks 40 - 52)
Low (Ranks 53 - 65)
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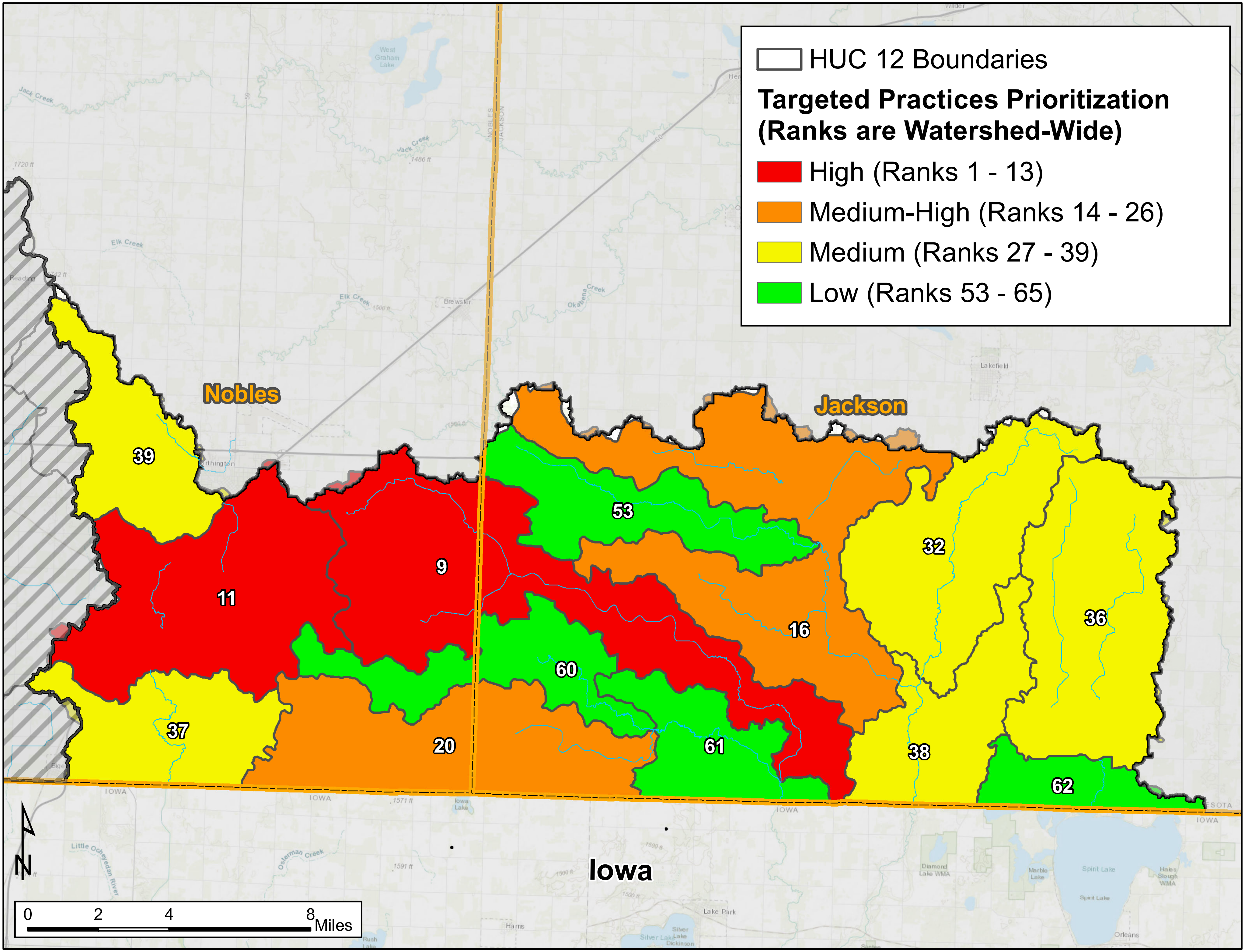

HUC 12 Boundaries
Targeted Practices Prioritization
(Ranks are Watershed-Wide)
High (Ranks 1 - 13)
Medium-High (Ranks 14 - 26)
Medium (Ranks 27 - 39)
Low (Ranks 53 - 65)
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Appendix P
Watershed District Rules

MISSOURI RIVER WATERSHED
Comprehensive Watershed Management Plan

OKABENA-OCHEDA WATERSHED DISTRICT
RULES AND REGULATIONS
May 4, 2010

Section 1: Introduction.

1.1 *Authority*. The Okabena-Ocheda Watershed District was established by Order of the Minnesota Water Resources Board on February 28, 1961.

1.2 *Statutory Policy and Rulemaking Authority*. Under Chapter 103D of Minnesota Statutes, it is the policy of the State of Minnesota to authorize the establishment of watershed districts ". . . *to conserve the natural resources of the State by land use planning, flood control, and other conservation projects by using sound scientific principles for the protection of the public health and general welfare and the provident use of the natural resources*". The legislature has granted express statutory authority to watershed districts to adopt rules to accomplish the purposes of Minnesota Statutes, Chapter 103D, and to implement the powers of the managers.

1.3 *Watershed Regulatory Policy Statement.* The goal of regulation is to provide for the initiation, implementation and enforcement of a comprehensive and uniform system of rules and regulations protecting water quality and managing, conserving and controlling the use of water within the watershed district. In order to continue to develop and implement the watershed district's overall plan, it is desirable and beneficial to manage landuse, construction activities, and control private and public drainage activities affecting water flow between private landowners and/or impacting public drainage systems within the district. Regulation of private and public drainage activities is also desirable and beneficial as a means of data acquisition and record-keeping of all drainage systems within the district as such records assist, aid and facilitate the determination of impact, influence and effect that such private activities have upon public drainage systems and the watershed as a whole. For purposes of these rules, the term *"regulate"* shall be defined as imposing such restraints upon the private rights of landowners to improve their property through drainage activities as are necessary for the general welfare.

1.4 *Jurisdiction and Applicability of Rules.* These rules shall apply to and include all of the area, incorporated and unincorporated, including both land and water, within the territory of the Okabena-Ocheda Watershed District. These rules shall have the force and effect of law.

1.5 *Inconsistent Provisions*. If any rule or regulation herein contained is inconsistent with the provisions of the water law of the State of Minnesota, or other applicable state or federal law, then such state or federal law shall govern and the rule or regulation shall be deemed null and void. Any inconsistency of a rule or regulation with a state or federal law will not and shall not be deemed to affect the validity of any other rule or regulation.

1.6 *Scope*. It is not intended that these rules shall repeal, abrogate, annul, or in any way impair or otherwise interfere with the existing provisions of other laws.

1.7 *Severability***.** These rules and regulations are intended to be severable and in the event that any rule or regulation herein contained is held to be invalid, the remaining rules and regulations shall be deemed to be in full force and effect as if there had been an expungement of the invalid provisions.

1.8 *Due Process*. These rules and regulations are intended to provide all affected persons and entities with due process of law.

Section 2: Adoption of Existing Laws, Rules, and Regulations.

2.1 *Adoption of Water Law*. The Board of Managers expressly adopts by reference all of the water law of the State of Minnesota. The Board of Managers reserves the right to impose rules and regulations that are more restrictive than the laws contained within the water law of the State of Minnesota.

2.2 *Other Rules, Regulations, or Provisions.* The Board of Managers expressly adopts by reference the rules, regulations, and provisions of the following agencies and statutes to the extent that such rules, regulations, and provisions apply to activities regulated by these rules: Minnesota Board of Water and Soil Resources (BWSR); Minnesota Department of Health (MDH); Minnesota Pollution Control Agency (MPCA); Minnesota Department of Natural Resources (MDNR); Minnesota Environmental Quality Board (EQB); U.S. Department of Agriculture (USDA); U.S. Environmental Protection Agency (EPA); U.S. Army Corps of Engineers (ACOE); Nobles Soil and Water Conservation District (SWCD); Nobles County; Local governmental units, including municipalities and townships; Minnesota Environmental Rights Law, MS Chapter 116B, as amended; State Environmental Policy, MS Chapter 116D, as amended; Minnesota Wetland Conservation Act of 1991, as amended. Where more than one rule, regulation, or provision applies, the most restrictive rule, regulation, or provision shall pertain.

Section 3: Definitions. For purposes of these rules, certain words and terms are defined herein. In absence of a definition for a word or term in these rules, the definition established by statute or case law of the State of Minnesota shall apply unless clearly in conflict, inapplicable, or absurd.

3.1 *Agricultural Land:* means land used for horticultural, row, close grown, pasture, and hay land crops; growing nursery stocks; animal feedlots; farm yards; associated building sites; and public and private drainage systems and field roads located on any of the foregoing. (MS 103G.005, Subd. 2a)

3.2 *Best Management Practices (BMPs):* means practices, techniques, and measures that prevent or reduce water pollution from nonpoint sources and which will minimize erosion of soil and deposition of sediment in private or public drainage systems or waters by using the most effective and practicable means of achieving water quality and runoff goals. BMPs include, but are not limited to, structural controls, nonstructural controls, operational procedures, and maintenance procedures. The BMPs approved by MPCA in its handbook "Protecting Water Quality in Urban Areas" satisfy the requirement for BMPs under these rules.

3.3 *Board of Managers, Board, or District:* means the Board of Managers of the Okabena-Ocheda Watershed District.

3.4 *General Welfare:* means any act or anything tending to improve or benefit or contribute to the safety or well being of the general public or benefit the inhabitants of the watershed district. General welfare shall be synonymous with “public welfare” or “public benefit”.

3.5 *Impervious Surface:* means a constructed hard surface that either prevents or retards the entry of water into the soil and causes water to run off the surface in greater quantities or at an increased rate of flow than prior to development. Examples include, but are not limited to, rooftops, sidewalks, patios, storage areas, roads, streets, driveways, parking lots, or other structural improvements utilizing concrete, asphalt, or compacted soils.

3.6 *Shore Impact Zone:* means land located between the ordinary high water level of a public water and a line parallel to and one half (½) the distance of the required setback for structures from the ordinary high water mark of the public water; except that on property used for agricultural purposes, the shore impact zone means that land located between the ordinary high water level of a public water and a line parallel to and fifty feet (50’) from the ordinary high water mark of the public water.

3.7 *Stormwater Management:* means the regulation of the quantity (rate control) and quality of stormwater entering lakes, rivers, streams, or public drainage systems in order to ensure that all nonpoint source pollution, erosion, and sedimentation is minimized.

3.8 *Terrace:* means an earthen embankment, a channel, or a combination ridge and channel constructed across the existing slope of the land.

3.9 *Water Quality Management:* means the monitoring and control of the quality of the water directly affected by a drainage activity, as well as the receiving waters of a drainage activity, to ensure that minimal degradation in surface or ground water quality occurs.

3.10 *Waterway:* means a natural or constructed channel, with a permanent grass or vegetative cover, that is shaped or graded to engineered dimensions, and is established for the stable conveyance of runoff.

3.11 *Project:* means any construction activity that includes clearing, grading, or excavation. Projects cannot be phased to avoid the permit requirements.

Section 4: Regulation of Activities.

The following activities shall require a permit from the Board of Managers of the Okabena-Ocheda Watershed District prior to initiation of the activity.

4.1 Work in any watercourse or water basin, whether or not water is present at the time of work; including but not limited to excavation, filling, dredging and the placement of structures of any type.

4.2 Work in the right of way of any public drainage system.

4.3 Withdrawal of ground or surface water at a rate greater than 50 gallons per minute or installation of an irrigation project serving an area over 1 acre.

4.4 Installation of new surface tile intakes and catch basins, including those draining new or existing impervious surfaces.

4.5 Construction or improvement of any agricultural drainage tile system that includes a surface intake or other device that may allow unfiltered surface water to enter the subsurface drainage system.

4.6 Construction of an open ditch drainage system or dike.

4.7 Construction activities that may drain or fill wetlands as defined by the 1987 Corps of Engineers Wetland Delineation Manual

4.8 Operation or alteration of any water control structure in any watercourse or water basin.

4.9 Diversion of water into a different sub-watershed or into a public drainage system from land not assessed for the system.

4.10 Installation of riprap on lake shore or stream banks.

4.11 Installation of new storm sewers, culverts or bridges, or replacement of existing storm sewers culverts or bridges with structures having a greater flow capacity.

4.12 Installation of agricultural best management practices that require land alteration including surface tile intakes, terraces, waterways, and diversions that have not been designed by the Natural Resources Conservation Service or Soil and Water Conservation District.

4.13 Grading or fill placement within the shore impact zone.

4.14 Disposal of snow within the shore impact zone or on impervious surfaces that drain directly or indirectly through storm water disposal systems to lakes, streams, ditches or wetlands.

4.15 Construction activity including clearing, grading and excavation that disturbs one or more acres of land. These projects require the owner to obtain a National Pollutant Discharge Elimination System/State Disposal System permit. District rules regulating these projects and the permit process therefore are located in **Appendix A** to these rules.

4.16 Earth moving projects involving more than 200 cubic yards of excavation or fill; or which disturbs more than 10,000 square feet of soil, and which project, or any part thereof, is located:

- within 300 feet of a stream, storm sewer catch basin, drainage tile intake or a wetland, or
- within 1,000 feet of a lake.

District rules regulating earth moving projects and the permit process therefore are located in **Appendix B** to these rules.

4.17 Any other act that, as judged by the Managers, may have a significant impact on the Districts water resources.

The following activities shall be prohibited in the Okabena-Ocheda Watershed District.

4.18 Disposal of anything other than water in a public or private drainage systems and road right-of ways.

4.19 Planting, cultivating or harvesting agricultural crops, other than grass hay, closer than 16.5 feet from a tile intake, the top of a public or private ditch bank, or the top of a stream course bank.

4.20 Planting, cultivating or harvesting agricultural crops, other than grass hay, closer than 50 feet from a lakeshore or the shoreline of a municipal reservoir.

4.21 Planting, cultivating or harvesting agricultural crops, other than grass hay, in public road right-of-ways.

4.22 Constructing drainage systems, or installing tile or ditch outlets, in public road right-of ways without written permission from the road authority.

4.23 Replacement of culverts under public roads or private driveways, with culverts or bridges with greater or lesser flow capacity, unless required for a conservation practice project meeting Natural Resources Conservation Services standards and specifications, or required for a project designed by a licensed engineer for flood water storage, or required for a project designed by a licensed engineer to comply with state standards and specifications for protection of existing structures or public safety.

Section 5: Permit Application Process: A request for permit or other approval of an activity under these rules shall be commenced by delivering, either in person or by U.S. Mail, a signed application on the form required by the Board of Managers to the office of the Okabena-Ocheda Watershed District, 960 Diagonal Road, P.O. 114, Worthington, MN 56187.

5.1 *Permit Fees:* A $10.00 application fee and a $40.00 inspection fee shall be charged for each storm water permit. A $10 application fee and a $15.00 inspection fee shall be charged for each erosion control plan permit. Application fees are waived for public entities. Design information must be submitted with the application. After-the-fact permits will be subject to the application fee and all other costs incurred by the District. If, in the opinion of the Board of Managers, it is necessary for the watershed district engineer or other consultant to review the application and all exhibits, view the site, and make a report to the watershed district as to the technical implications of the work, costs incurred by the watershed district during this review shall be borne by the applicant.

5.2 *Project Plan:* A plan, design, or map of the proposed activity shall be attached to the application form. Such plan, design, or map shall be drawn and shall clearly and accurately show all work to be performed, and shall include, either within the plan, design, or map, or by attachment, the following information at a minimum.

5.2.1 *Construction Plan*. At the request of the Board of Managers, the plan, design, or map must show the materials to be used, the proposed duration of the activity and/or construction involving the activity, and the proposed initiation and completion dates.

5.2.2 *Stormwater and Water Quality Management.* The plan, design, or map must separately address the issues of, and make provisions for, stormwater management and water quality management both during construction and post-construction activities.

5.2.2.1 Stormwater management and water quality management may include structural water management measures (retention areas, swales, infiltration trenches, filter strips, detention basins, vegetative buffer zones, etc.) or nonstructural water management measures (temporary erosion and sedimentation controls, fertilizer and pesticide application controls, solid waste collection, phosphorous abatement and control, etc.) or a combination of both types of management measures.

5.2.2.2 Stormwater management and water quality management plans shall include a maintenance plan for all structural and nonstructural controls included within the plan, to include: the party responsible for maintenance, a maintenance schedule, and procedures to be followed if maintenance is not performed or is inadequately performed.

5.2.3 *Sewage or Waste*. The plan, design, or map must be accompanied by or contain a statement as to whether the drainage activity involves the installation, abandonment, or removal of a sewage or waste disposal system.

5.2.4 *Livestock.* The plan, design, or map must be accompanied by or contain a statement as to whether livestock will be watered, fed, pastured, or held upon or around the proposed drainage activity. If livestock are involved with the proposed drainage activity, the Board of Managers may require the requestor to devise a livestock management plan that minimizes the adverse impact upon the proposed drainage activity.

5.2.5 *Design, Material Standards*. The plan, design, or map must be accompanied by or contain a statement that all culvert and tile emplacement, construction, design, and materials shall conform, at a minimum, to the standards of the NRCS.

5.3 *SWCD and NRCS Checkoff*. All applications must be reviewed by the Nobles Soil and Water Conservation District (SWCD) and/or the Natural Resources Conservation Service (NRCS) to advise the District about whether the proposed activity is in compliance with Wetland Conservation Act rules or Swampbuster provisions of the federal farm program.

5.4 *Easement/Access*. All permits and other approvals will contain a grant of easement and/or right of access to the watershed district, its Board of Managers, employees, agents, and assigns, for purposes of inspection and monitoring of the drainage or construction activity.

5.5 *Completion Time*. Unless otherwise stated on the permit or other approval, the drainage or construction activity involved shall be completed within two years or an extension must be requested and approved by the Board of Managers. The Board of Managers shall be notified upon completion of the activity by the permittee or holder of other approval of the Board.

5.6 *Additional Information*. After initial review of the request, the Board of Managers may require that the applicant provide such additional information as deemed necessary to evaluate the proposed drainage or construction activity in accordance with the required considerations.

5.7 *Best Management Practices*. All permitted activities shall incorporate best management practices (BMPs). It is the goal of these rules to ensure that the degree of water quality improvement and runoff protection is maximized relative to the cost of implementing the BMPs.

5.8 *Restoration*. Exposed and/or disturbed soil shall be restored to a condition equivalent to or better than that which existed prior to the construction or drainage activity.

5.9 *Spoils*. All spoils will be leveled and shall be seeded to prevent erosion.

5.10 *Discharge*. Wherever feasible, water from drainage activities will be discharged through retention basins, or other diffusing structures.

5.12 *Upstream Storage*. Wherever feasible, drainage or construction activities will include use of temporary storage areas, retention basins, or other similar structures to maximize upstream storage and reduce peak flows, erosion damage, and sedimentation.

5.13 *Filter Strips*. Unless otherwise noted in the permit or other approval of a drainage activity, all tile intake and catch basin permits include a requirement for a grass filter strip possessing a radius of 16.5 feet surrounding such device.

5.14 *Shoulder and Bank Protection*. All water inlets, culvert openings, and bridge approaches shall have adequate shoulder and bank protection in order to minimize land and soil erosion. Adequate shoulder and bank protection shall include by way of example and not by way of limitation: permanent grass or other ground cover, mulch, sod, riprap, retaining walls, and terraces.

5.15 *Slopes.* Each landowner shall be required to apply BMPs to minimize soil erosion and sedimentation from all construction or drainage activities. At a minimum, the following rules shall apply:

5.15.1 All ditch, watercourse, shore land, and water basin slopes shall be constructed with a side slope as determined by customary engineering practices so as to reasonably minimize land and soil erosion.

5.15.2 All determinations as to whether a side slope reasonably minimizes land and soil erosion shall include the intended capacity of the watercourse or other water body; the depth, width, and elevation; and the character of the soils involved.

5.15.3 Exposed or disturbed soil on slopes or topographic contours of any drainage activity, above the low water mark, shall be mulched, sodded, and/or seeded to hinder erosion and maintained until stabilized by establishment of permanent grass or other approved ground cover.

5.16 *Riprap*. Riprap may not be installed more than five feet waterward of the ordinary high water mark and must conform to the natural alignment of the shore or waterway and not obstruct the flow of water.

5.17 *No Estoppel*. The issuance of a permit or other approval for drainage activity under these rules shall not constitute an estoppel or limitation of any claim or right of action of the watershed district against the applicant, its contractors, agents, or employees for violation of or failure to comply with the provisions, conditions, or limitations of the permit or other approval granted by the Board of Managers or other applicable provisions of the law.

5.18 *Changes to Activity, Plan, or Design*. Any new development, redevelopment, addition, change, or modification of an existing drainage activity, or a proposed drainage activity previously approved by the Board of Managers shall require review and re-approval by the Board of Managers under these rules. The Board of Managers may waive the application fee if the requestor has previously paid an application fee within the last two years.

5.19 *Termination, Cancellation, and Revocation*. A permit or other approval of a drainage or construction activity may be terminated, canceled, or revoked as provided by this section. Such termination, cancellation, or revocation shall be with or without notice, provided that where no notice is given, the applicant shall possess the right to appeal said action to the Board of Managers by written request delivered within 30 days of the action to the office of the Okabena-Ocheda Watershed District.

5.19.1 Termination shall mean the permit or other approval expired by its own terms or that the drainage activity involved has been completed and approved by the Board of Managers, thereby terminating the permit.

5.19.2 Cancellation shall mean the permit or other approval was suspended, either temporarily or permanently, in whole or in part, upon a determination that such cancellation is deemed necessary to protect the public welfare.

5.19.3 Revocation shall mean the permit or other approval was withdrawn after issuance by the Board of Managers based upon an alleged violation of any of the provisions, conditions, or limitations contained in the permit, license, or other approval granted by the Board of Managers, or for failure to obtain other necessary approvals from, or comply with the requirements of an authority other than the Board of Managers.

5.20 *Limited Approval Only*. Obtaining a permit or other approval for drainage or construction activities under these rules shall not constitute absolute authority to perform the drainage activity. The applicant remains responsible for obtaining any other required authorization. The permit or other authority is permissive only and shall not release the applicant from any liability nor obligation imposed by Minnesota law, Federal law, or local ordinances and shall be subject to all conditions and limitations imposed by the Board of Managers or hereafter imposed by applicable law. The Board of Managers, by approving a request for permit or other approval of a drainage activity, makes no representations to the applicant that the proposed drainage activity complies or does not comply with existing law. No liability shall be imposed upon or incurred by the watershed district, its Board of Managers, or its officers, agents, and employees, officially or personally, on account of the granting of the permit or other approval, or on account of any damage to any person or property resulting from any act or omission of the applicant or any of its contractors, agents, or employees relating to the drainage activity.

Section 6: Project Notification for Subsurface Tile Drainage Activities: Before initiation of an agricultural drainage project, the landowner must obtain a permit, or file a completed *Subsurface Tile Drainage Project Notification Form.* Permits are required for tile drainage projects that include the installation of new surface intakes, catch basins or other devices that may allow unfiltered surface water to enter the subsurface drainage system. Permits are also required for any project that may drain or fill wetlands as defined by the 1987 Corps of Engineers Wetland Delineation Manual. Other agricultural tiling projects may be initiated by the landowner after a completed *Subsurface Tile Drainage Project Notification Form* is filed with the District. Landowners must mail or deliver the completed notification form to the Okabena-Ocheda Watershed District, 960 Diagonal Road, P.O. Box 114, Worthington, MN 56187 at least 10 days before construction begins.

Section 7: Variances: The Watershed District Board of Managers may hear requests for variances from the literal provisions of these rules in instances where their strict enforcement would cause undue hardship because of circumstances unique to the property under consideration. The Board of Managers may grant variances where it is demonstrated that such action will be in keeping with the spirit and intent of these rules.

7.1 The Board of Managers may grant variances only where it is demonstrated that such action will be consistent with the district's watershed management plan and Minnesota water law generally.

7.2 In order to grant a variance, the Board of Managers shall determine that the special conditions that apply to the structure or land in question do not apply generally to other land or structures in the District, that the granting of the variance will not merely serve as a convenience to the applicant, and that the variance will not impair or be contrary to the intent of these rules. A hardship cannot be created by the landowner, the landowner's agent or representative, or a contractor, and must be unique to the property. Economic hardship alone is not grounds for issuing a variance. Land platted within a municipality that has storm water infrastructure installed before the adoption date of these rules, shall be eligible for a variance. The term *"undue hardship"* as used in connection with the granting of a variance shall mean that the property under consideration cannot be put into a reasonable use if these rules were strictly applied and enforced

7.3 A variance shall become void after one year after it is granted if not used.

7.4 A violation of any condition set forth in a variance shall be a violation of the District rules and shall automatically terminate the variance.

Section 8: Restrictions and Limitations upon Board Action.

8.1 *Time deadline for action*. The Board of Managers will approve or deny within 60 days a written request for a permit or other governmental approval of drainage activity under these rules. Failure of the Board of Managers to deny a request within 60 days is approval of the request. If the Board of Managers denies the request, it must state in writing the reasons for the denial at the time that the request is denied. If the watershed district receives a written request that does not contain all required or necessary information, the 60-day limit starts over only if the watershed sends written notice to the requestor within ten business days of the initial consideration of the request by the Board of Managers telling the requestor what information is missing.

8.1.1 The watershed district's response meets the 60-day limit if the watershed district can document that its written approval or denial action was sent within 60 days of receipt of the written request as defined above.

8.1.2. The time limit in subdivision 8.1 is extended if a state statute, federal law, or court order requires a process to occur before the Board of Managers acts on the request, and the time periods prescribed in the state statute, federal law, or court order make it impossible to act on the request within 60 days. In cases described in this paragraph, the deadline is extended to 60 days after completion of the last process required in the applicable statute, law, or order.

8.1.3. The time limit in subdivision 8.1 is extended if a request submitted to the watershed district requires prior approval of another local, state, or federal agency or board. For purposes of this provision, another local, state, or federal agency or board includes the following: a city, county, town, school district, metropolitan, or regional entity, or other political subdivision. In cases described in this paragraph, the deadline for watershed district action is extended to 60 days after the required prior approval is granted.

8.1.4 The Board of Managers may extend the time limit in subdivision 8.1 before the end of the initial 60-day period to protect against serious or significant harm to the public health, safety, or welfare by providing written notice of the extension to the applicant. The notification must state the reasons for the extension and its anticipated length. A decision by the Board of Managers to require an engineering report, environmental impact assessment, or similar preliminary evaluation of a request submitted to the watershed district shall be deemed an act to protect against serious or significant harm to the public health, safety, or welfare.

8.2 *Required Considerations*. The following criteria shall be considered by the Board of Managers in approving or denying a written request for a permit or other approval of a proposed activity under these rules.

8.2.1 The private or public benefits and costs of the proposed activity.

8.2.2 The present and anticipated agricultural land acreage availability and use affected by the proposed activity.

8.2.3 The present and anticipated land use affected by the proposed activity.

8.2.4 The flooding characteristics of property affected by the proposed activity and the anticipated impact or effect upon said flooding characteristics of the proposed activity.

8.2.5 The waters to be drained and availability of alternative measures to conserve, allocate, and use the waters – including the potential for storage and retention of such waters.

8.2.6 The anticipated effect of the proposed activity upon water quality.

8.2.7 The anticipated effect of the proposed activity upon fish and wildlife resources.

8.2.8 The anticipated effect of the proposed activity upon shallow ground water availability, distribution, and use.

8.2.9 The overall environmental impact of the proposed activity.

8.2.10 The adequacy and non-erodability of the outlet for the proposed activity.

8.2.11 The need and reasonableness of the proposed activity.

8.2.12 The anticipated injury or damage to adjoining or downstream property from the proposed activity and potential alternatives avoiding/reducing such injury and damage.

8.2.13 Whether the benefits of the proposed activity outweigh the anticipated harm.

8.2.14 Whether the proposed activity is consistent with the *"general welfare"*. In determining the general welfare, the Board of Managers will consider both agricultural best management practices and water quality best management practices.

8.2.15 Whether the proposed activity is consistent with city, county and state shoreland and floodplain ordinances.

8.2.16 Whether, under all the circumstances, the proposed activity constitutes a reasonable use of the land and resources involved. For purposes of these rules, the term *"reasonable use"* shall be interpreted to incorporate the doctrine of reasonable use; i.e., in affecting a reasonable use for a legitimate purpose a landowner, acting in good faith, may drain his land of surface waters and cast them as a burden upon the land of another, although such drainage carries with it some waters which would otherwise have never gone that way, if there is a reasonable necessity for such drainage; and if reasonable care be taken to avoid unnecessary injury to the land receiving the burden; and if the utility or benefit accruing to the land drained reasonably outweighs the gravity of the harm resulting to the land receiving the burden; and if, where practicable it is accomplished by reasonably improving and aiding the normal and natural system of drainage according to its reasonable carrying capacity, or if, in the absence of a practicable natural drain, a reasonable and feasible artificial drainage system is adopted.

8.3 *Reservation of Right to Require Preliminary Analysis*. The Board of Managers reserves the right, when in the Board's considered opinion, such action is deemed to be in the public's welfare, to require that any person or entity requesting a permit or other approval of a drainage activity under these rules, procure and pay for an engineering study, environmental impact assessment, or other preliminary analysis determined by the Board of Managers to be beneficial and reasonably necessary to the Board's consideration, evaluation, and determination of the request.

Section 9: Other Regulation of Activities Affecting Drainage. The Board of Managers may enter into or issue letters of understanding, consent agreements, stipulations, orders, or other forms of approval for activities affecting drainage which do not require a permit under these rules. In all such cases, approvals will be entered into or issued upon majority approval by the Board of Managers after notice and hearing at a regular, special, or emergency meeting.

Section 10: Effect on Other Drainage Law.

10.1 *No Effect*. These rules and regulations shall not be deemed to have any impact, influence, nor effect upon the requirements for drainage projects regulated and controlled by Minnesota Statutes Chapter 103E and 103D involving public drainage systems.

10.2 *Responsibilit***y**. It remains the responsibility of the person or entity engaging in an activity which requires a drainage project petition prior to initiation pursuant to Minnesota Statutes Chapter 103E or 103D to make appropriate application to the drainage authority possessing jurisdiction.

Section 11: Enforcement Powers. The Board of Managers may enforce any violation of a watershed district's rules and regulations, or the terms, conditions, and/or limitations of a permit or other approval of a drainage activity issued thereunder, through injunction, action to compel performance, restoration, abatement, or other appropriate relief in the district court and/or by referral of criminal misdemeanor charges to the appropriate county attorney office.

11.1 A violation of a rule, regulation, order, stipulation, agreement, or permit issued by the Board of Managers under these rules and regulations shall be a misdemeanor as that term is defined by Minn.Stat. § 609.02, Subd. 3, as amended.

11.2 *Concurrent Authority to Enforce Water Law*. The enforcement powers described herein are not exclusive to the watershed district, but are concurrent with all county, state, and federal agencies possessing authority to regulate the activities embraced herein.

Section 12: Appeal of Decision by Board of Managers.

12.1 *Reconsideration*. Any person aggrieved by a decision on a permit or other action of the Board of Managers shall possess the right to appeal for reconsideration to the Board of Managers by making a written demand for a hearing within 30 days of the person receiving written notice of the decision.

12.2 *Appeal to District Court or BWSR*. Any person may appeal a rule, permit decision, or order made by the Board of Managers by appropriate action in accordance with appellate procedures and review provided in Minnesota Statutes.

Section 13: Adoption or Amendment of Rules.

13.1. *Procedure*. Rules of the Okabena-Ocheda Watershed District shall be adopted or amended by a majority vote of the Board of Managers after public notice and hearing. Rules must be signed by the secretary of the Board of Managers and recorded in the Board of Managers' official minute book in accordance with MS 103D.341, Subd. 2, as amended.

13.2 *Repeal of Rules*. All rules and regulations bearing an earlier date of adoption or amendment than these rules shall be of no further force or effect and shall be repealed on the date that these rules become effective. Hereafter, any adoption or amendment to these rules by the Board of Managers shall act as a repeal of these rules to the extent that such adoption or amendment is inconsistent herewith.

Section 14: Effective Date of Rules.

14.1 *Effective Date of Rules*. These rules shall be effective upon the date of the occurrence of the last of the following actions:

14.1.1 Approval of the rules by the Board of Managers after notice and hearing and publication as required by law.

14.1.2 Filing of the rules with the Board of Water and Soil Resources, the Nobles County Recorder and with the governing body of each municipality located, in whole or in part, within the watershed district.

These rules are hereby adopted pursuant to Minnesota Statute Chapter 103D on this 4th day of May, 2010.

____

Jeff Rogers
Secretary
Okabena-Ocheda Watershed District

Appendix A

OKABENA-OCHEDA WATERSHED DISTRICT
WATER MANAGEMENT PERMITTING RULES

EROSION CONTROL AND STORMWATER MANAGEMENT

Purposes and Policy. The purpose of this section is to afford reasonable protection to the water quality and habitat of the Okabena-Ocheda Watershed District's lakes and streams. Erosion control measures provide for the prevention of nutrient, sediment and other pollutant loading from soils exposed during construction. Runoff storage and treatment systems provide for the filtration of nutrients, sediments, and other pollutants from storm flows; protection of stream beds and banks and mitigation of downstream flooding through moderation of peak flows both into and within the resource; preservation of aquatic and terrestrial habitat; protection of scenic resources; and maintenance of property values.

To accomplish these purposes, the Okabena-Ocheda Watershed District hereby adopts, by reference, the standards put forth in the Minnesota Pollution Control Agency's (MPCA) *General Permit Authorization to Discharge Stormwater Associated with Construction Activity Under The National Pollutant Discharge Elimination System/State Disposal System Permit Program*, along with any future amendments.

1. *Permit Coverage and Limitations*

   1.1 A watershed district and National Pollutant Discharge Elimination System (NPDES)/State Disposal System (SDS) permit shall be required, and all construction site erosion control provisions of this permit shall apply, to land disturbing activities associated with construction activity and small construction activity as defined below.

      1.1.1 Construction activity includes clearing, grading and excavation, that disturbs land of equal or greater than five (5) acres and includes the disturbance of less than five (5) acres of total land area that is part of a larger common plan of development or sale if the larger common plan will ultimately disturb five (5) acres or more.

      1.1.2 Small construction activity includes clearing, grading and excavation, that disturbs land of equal to or greater than one (1) acre, and includes the disturbance of less than one (1) acre of total land area that is part of a larger common plan of development or sale if the larger common plan will ultimately disturb equal to or greater than one and less than five (5) acres.

      1.1.3 For drainage ditches, small construction activity does not include routine maintenance that is performed to maintain the original line and grade, hydraulic capacity, or original purpose of the facility.

2 *Stormwater Pollution Prevention Plan: Permits and Administration*

2.1 No activity meeting the requirements for an NPDES/SDS Permit shall occur before a permit is issued from the Okabena-Ocheda Watershed District.

2.2 The applicant must provide the following when requesting a watershed district permit:

2.2.1 A completed watershed district application;

2.2.2 A copy of the Stormwater Pollution Prevention Plan (SWPPP) prepared for the MPCA NPDES/SDS Permit program;

2.2.3 A proposed timetable and schedule for completion and installation of all elements of approved erosion control and stormwater management plans and a proposed schedule for completion of construction; and

2.2.4 A $10.00 application fee and $40.00 site inspection fee.

3 *Permit Conditions*

3.1 The SWPPP shall be implemented prior to the start of any land disturbing activity and shall be maintained over the duration of the project. Permanent stormwater components of the plan shall be maintained in perpetuity.

3.2 The permittee is responsible for the successful completion of the SWPPP. The permittee shall be liable for all costs incurred, including environmental restoration costs resulting from noncompliance with an approved plan.

3.3 Application for a permit shall constitute express permission by the permittee and landowner for the watershed district Board of Managers, employees, agents and assigns to enter the property for purposes of inspection, monitoring a project for compliance with the SWPPP, and if necessary, requiring curative action.

4 *Permit Transfer*

When the owner or operator changes (e.g. an original developer sells portions of the property to various homebuilders), the new owner or operator must submit to the watershed district a copy of the change of ownership/subdivision short form application that was sent to the MPCA as a requirement of the NPDES/SDS Permit Program.

5 *Plan or Permit Amendments*

Any major modification to an approved SWPPP, construction schedules or alterations to accepted sequencing of land disturbing site activities shall be approved by the watershed district.

6 *Fees*

A $10.00 application fee and a $40.00 inspection fee shall be submitted with the erosion control and stormwater management permit application. Application fees are waived for public entities. After-the-fact permits will be subject to the application fee and all other costs incurred by the District. If, in the opinion of the Board of Managers, it is necessary for the watershed district engineer or other consultant to review the application and all exhibits, including the SWPPP, view the site and make a report to the watershed district as to the technical implications of the work, costs incurred by the watershed district during this review shall be borne by the applicant. Public entities are not exempt from these costs.

7 Termination of Coverage

A permittee wishing to terminate an erosion control and stormwater management permit must submit to the watershed district a copy of the Notice of Termination (NOT) form sent to the MPCA. Compliance with the erosion control and stormwater management permit is required until the NOT is received by the watershed district.

When residential lots are transferred to the home owner, the permittee must distribute the MPCA's "homeowner factsheet" to the homeowner to inform the homeowner of the need for, and benefits of, practices to achieve final stabilization of the lot.

8 Compliance and Enforcement

8.1 The watershed district will perform field inspections on all construction sites that disturb one or more acres to determine if:

8.1.1 The MPCA NPDES/SDS Permit application and a watershed district permit have been acquired.

8.1.2 There is a Stormwater Pollution Prevention Plan (SWPPP) for the site and it is being followed.

8.1.3 The Best Management Practices called for in the SWPPP are working properly.

8.2 The watershed district, during inspections, will record deficiencies and violations of permitting rules and SWPPP's. Recommendations for correcting deficiencies and violations will be distributed to landowners, contractors and permittees.

8.3 The watershed district, when necessary, will exercise enforcement actions up to and including issuing "stop work orders" for sites that do not comply with MPCA NPDES/SDS and watershed district permit requirements.

8.4 The watershed district will make non-compliance determinations and referrals to MPCA to take enforcement action in the following situations.

8.4.1 All non-permitted sites that disturb one or more acres.

8.4.2 Permitted and non-permitted sites where serious environmental damage has occurred to surface waters.

Appendix B

OKABENA-OCHEDA WATERSHED DISTRICT
WATER MANAGEMENT PERMITTING RULES

EROSION CONTROL ON CONSTRUCTION SITES SMALLER THAN ONE ACRE

Purposes and Policy. The purpose of this section is to afford reasonable protection to the water quality and habitat of the Okabena-Ocheda Watershed District's lakes and streams. Erosion control measures provide for the prevention of nutrient, sediment and other pollutant loading from soils exposed during construction.

1. *Earth Moving Projects*: A district permit will be required for any earth moving project which will result in:

- grading involving more than 200 cubic yards of cut or fill and which project, or any part thereof, is within 300 feet of a water of the state or is within 1000 feet of a lake; or
- disturbance of more than 10,000 square feet of soil and which project, or any part thereof, is within 300 feet of a water of the state or is within 1000 feet of a lake.

Waters of the state include: street gutters, stormsewer catch basins, natural streams, drainage ditches, drainage tile intakes and wetlands. The purpose of the permit is to insure that adequate erosion control measures are taken before, during and after the earth moving project.

2. *Permit Requirements*: Permit applicants must submit one set of the following documents to the Board for its review:

2.1 A Completed Permit Application Form. A request for permit under these rules shall be commenced by delivering, either in person or by U.S. Mail, a signed application on the form required by the Board of Managers to the office of the Okabena-Ocheda Watershed District, 960 Diagonal Road, P.O. Box 114, Worthington, MN 56187.

A $10.00 application fee and a $15.00 inspection fee shall be charged for each erosion control plan permit. Application fees are waived for public entities. Erosion control plan information must be submitted with the application. After-the-fact permits will be subject to the application fee and all other costs incurred by the District.

If, in the opinion of the Board of Managers, it is necessary for the watershed district engineer or other consultant to review the application and all exhibits, view the site, and make a report to the watershed district as to the technical implications of the work, costs incurred by the watershed district during this review shall be borne by the applicant.

2.2 A set of Project Plans, including at least:

- A scale drawing of the site showing property lines and delineation of lands under ownership of the applicant and the proposed earth moving project.
- An Erosion Control Plan showing proposed methods of retaining waterborne-sediments onsite during the period of construction, and shall specify methods and schedules to determine how the site will be restored, covered, or revegetated after construction. *[Note: an erosion control plan does not require the signature of a registered professional engineer.]*

2.3 In addition, the permit applicant shall provide specific measures to control erosion based upon recognized engineering standards and the grade and length of the slopes on the site, to include--at a minimum--the following:

2.3.1 Silt fences or other approved devices shall be placed near the toe of the slopes to prevent soil from moving offsite. All devices shall be installed in accordance with the adopted standards. All silt fences and other devices must be replaced, supplemented or repaired when they become non-functional or sediment reaches the height defined in the adopted standards. These repairs must be made within 24 hours of discovery or as soon as field conditions allow.

2.3.2 Diversion channels or dikes and pipes shall be provided to intercept all drainage at the top of slopes that have grades of more than 10:1. Also, diversion channels or diked terraces and pipes shall be provided across said slopes if needed to ensure that the maximum flow length does not exceed 100 feet. No unbroken slopes longer than 75 feet on grades steeper than 3:1 shall be allowed.

2.3.3 Require that a device meeting the approved standards be installed, around each catch basin inlet on the site. The device shall remain in place until final stabilization of the site occurs.

2.3.4 Ensure that flows from diversion channels or pipes are routed to sedimentation basins or appropriate energy dissipaters in order to prevent transport of sediment to outflow conveyors and to prevent erosion and sedimentation when runoff flows into the conveyors. Any temporary of permanent drainage ditch that drains water from a construction site, or diverts water around a site, must be stabilized within 200 linear feet of the property boundary. Stabilization and energy dissipation practices, where needed, must be installed within 24 hours of the connection to surface water.

2.3.5 Provide that site-access roads be graded or otherwise protected with a device or devices meeting the approved standards to prevent sediment from leaving the site via the access roads.

2.3.6 Require that soils tracked from the site by motor vehicles be cleaned daily (or more frequently, as necessary) from paved roadway surfaces throughout the duration of construction.

2.3.7 Assure that all erosion and sediment control measures be deployed, inspected and maintained for the duration of site construction. If construction operations interfere with these control measures, the devices may be removed or altered as needed but shall be restored to serve their intended function at the end of each day.

2.3.8 Describe temporary erosion protection or permanent cover used to prevent erosion of exposed soil. All exposed soil areas must be stabilized within 14 days after the construction activity in that portion of the site has temporarily or permanently ceased. A schedule of significant grading work will be required as part of the erosion and sedimentation control plan.

2.3.9 Require that temporary erosion protection and permanent cover be provided in accordance with the adopted standards.

2.3.10 Maintain an undisturbed grassed area, or install and maintain silt fence or other approved device, or provide a 4-foot wide sodded area along the curb line of all streets adjacent to the site and along all property boundaries where runoff could leave the site.

2.3.11 Erosion control practices must be maintained until final stabilization of the site occurs. (70 percent vegetative cover is achieved.)

Appendix C

OKABENA-OCHEDA WATERSHED DISTRICT

960 Diagonal Road, P.O. Box 114
Worthington, MN 56187

SUBSURFACE TILE DRAINAGE PROJECT NOTIFICATION FORM

Applicant____Phone___________________________________

Address____ City________________________ State________ Zip___________

LEGAL DESCRIPTION OF PROJECT SITE

______ ¼ _______ ¼ Section________ Township____

______ ¼ _______ ¼ Section________ Township____

Project Street Address (if applicable)____

Landowners Name ______________________________________ Phone____

PROJECT DESCRIPTION

_________New Tile Diameter_______________ Length ___________

_________Tile Repair Diameter_______________ Length ___________

_________Other Project ____

____

Attach an aerial photo, site map or engineer's design for your project. Include proposed tile, existing drainage systems, erosion control plans and other relevant information.

Landowners are strongly encouraged to communicate and cooperate with neighboring landowners to convey water with the least possible damage to existing drainage systems and the receiving waters.

CONDITIONS FOR INSTALLATION OF TILE WITHOUT A PERMIT

Landowners are required to report proposed drainage projects to the Nobles County Farm Services Agency, Nobles Soil and Water Conservation District and Worthington Natural Resources Conservation Service office before installing tile.

Projects may not drain or alter wetlands regulated by the Minnesota Wetland Conservation Act or federal farm bill programs.

Projects may not install new intake devices, inspection pipes, or vents that potentially allow unfiltered surface water to enter the subsurface drainage system.

Projects may not convey sewage, manure or other pollutants.

Landowners must receive written permission from the appropriate road authority before outletting or installing tile in a road right-of-way.

Projects must have a non-erosive outlet.

Landowners must obtain permission from the ditch authority, shoreland ordinance administrator or Department of Natural Resources, as needed, before installing outlets in public drainage systems or waters of the state.

Projects must be completed within two years of filing a subsurface drainage tile notification form.

The information submitted in this notification form is true and accurate to the best of my knowledge. I have read and understand the conditions stated above. I grant Okabena-Ocheda Watershed District Managers and staff permission enter the land described above to inspect the site for compliance with watershed district rules.

____________________________________ ___________________
Landowner Signature Date

KANARANZI-L1TTLE ROCK WATERSHED DISTRICT (KLR)

RULES & REGULATIONS

2014 Review and Proposed Amendments

After

BWSR and Staff Review w/ Changes

Proposed Amendments

TABLE OF CONTENTS

1. Introduction

The Kanaranzi-Little Rock Watershed District (KLR) was established by order of the Minnesota Board of Water and Soil Resources under the authority of Minn. Stat. Chapter 112, the Watershed Law on October 8, 1981. The District's primary purpose is conservation of the natural resources within the watershed. The District's boundary is shown on the last page of these Rules & Regulations

1.1 Purpose

These rules are intended to effectuate the purposes of the District and the powers of the Managers under the Minnesota Watershed Law. The Managers adopt by reference all of the water law of the State of Minnesota; but, reserve the right to impose rules and regulation which are more restrictive than said water law.

1.2 Procedures for Adopting Rules and Amendments

The Kanaranzi-Little Rock Watershed District adopts the procedures illustrated in Minn.Stat. 103D.341, as amended, by reference as means of adopting and amending its rules.

1.3 Consistence with State Law

A. If any rule herein contained is inconsistent with the provisions of the water law of the State of Minnesota, or other applicable state or federal law in a particular instance, then such state or federal law shall govern and the rule or regulation shall be deemed inapplicable.
B. The Board of Managers expressly adopts by reference all of the water law of the State of Minnesota. The Board of Managers reserves the right to impose rules and regulations that are more restrictive than the laws contained within the water law of the State of Minnesota.
C. The Board of Managers expressly adopts by reference the rules, regulations, and provisions of the following agencies and statutes to the extent that such rules, regulations, and provisions apply to activities regulated by these rules: Minnesota Board of Water and Soil Resources (BWSR); Minnesota Department of Health (MDH); Minnesota Pollution Control Agency (MPCA); Minnesota Department of Natural Resources (MDNR); Minnesota Environmental Quality Board (EQB); U.S. Department of Agriculture (USDA); U.S. Environmental Protection Agency (EPA); U.S. Army Corps of Engineers (ACOE); Nobles Soil and Water Conservation District (SWCD); Nobles County; Local governmental units, including municipalities and townships; Minnesota Environmental Rights Law, MS Chapter 116B, as amended; State Environmental Policy, MS Chapter 116D, as amended; Minnesota Wetland Conservation Act of 1991, as amended. Where more than one rule, regulation, or provision applies, the most restrictive rule, regulation, or provision shall pertain.
D. These rules and regulations shall not be deemed to have any impact, influence, nor effect upon the requirements for drainage projects regulated and controlled by Minnesota Statutes Chapter 103D and 103E involving public drainage systems.

1.4 Severability

If any part of these rules is declared invalid by a court of competent jurisdiction, such declaration shall not affect the validity of these rules as a whole, but only the part declared invalid.

1.5 Appeal

Any person aggrieved by the adoption or enforcement of these rules, a permit decision, or an order made by the managers may appeal under the appellate procedures provided in Minnesota Statutes Chapter 103D: In addition to the statutory appeal rights, reconsideration of a decision or order of the Board of Managers may be reconsidered in accordance with the following procedures.

A. Reconsideration. Any person aggrieved by a decision on a permit or other order of the Board of Managers may request reconsideration to the Board of Managers by making a written demand for a hearing within 30 days of the person receiving written notice of the decision.
B. Appeal to County Board. Any person aggrieved by a decision of the Board of Managers upon a request for reconsideration shall possess the right to appeal the Board's decision to the appropriate Board of County Commissioners by making a written demand to the County Commissioners to be placed upon the County Board's agenda. Said demand shall be made within 30 days of the Board of Managers' final decision.

2. General Policy

Pursuant to Minn.Stat. 103D.341, Subd. 1., the Managers must adopt rules to accomplish the purposes of Minnesota Statutes, Chapter 103D, and to implement the powers of the managers.

2.1 Coordination with Other Governmental Units

In order to enable the Managers to coordinate the administration of the District's rules with all interested federal, state, regional and local governmental units and agencies having jurisdiction in the District, each county and city having territory in the District shall forward to the District a copy of all preliminary plats and accompanying drainage and grading plans, whenever all or part of such plans affect land within the District. The District may provide recommendations to the county and cities on the site's suitability for the proposed land use, based on soil and water conditions. The District will require permits for land disturbing activities to ensure that erosion and storm water discharges are properly controlled.

2.2 Review of Local Ordinances

The district adopts, by reference, all existing ordinances of these entities relating to floodplains, shoreland or other water-related topics, and the district shall maintain copies of these ordinances in the district office.

3. Definitions

3.1 An Impairment of Public Welfare: Means any act or thing that tends to degrade, damage or reduce the safety or well-being of the general public or cause any detriment to the inhabitants of the watershed district, wildlife habitat, or any degradation of the District's water resources.
3.2 Complete Application Form: Means applications that contain all information required by these rules and applicable statutes relating to the project; including landowner signatures and dates.
3.3 District: The KLR Board, land, and/or boundary of the Kanaranzi-Little Rock Watershed District.
3.4 Erosion: Means the wearing away of the land surface by water, wind, ice, or other geological agents and by such processes as gravitational creep.
3.5 Excessive Erosion: This exists when either or both of the following conditions exist:

a) Estimated average annual rate of soil erosion for a particular parcel of land under agricultural use resulting from sheet and rill erosion or wind erosion is greater than the soil loss tolerance of any of the soil series comprising that particular parcel of land as stated in the Handbook of Standards (Section 3); or
b) Evidence of active gully erosion on land under agricultural use

3.6 Excessive Sedimentation: Means the rate of an amount of sedimentation from agricultural land that results in any observable detrimental effect, damage, or result to adjacent lands, water, or the atmosphere.
3.7 General Subsurface Tile(ing): Means tiling projects that do not drain or alter wetlands; tiling that does not include the installation of: new intake devices, inspection pipes, or vents that potentially allow in unfiltered water; tiling that doesn't convey sewage, manure, or pollutants; and/or tiling that includes non-erosive outlets.
3.8 General Welfare: Means any act or anything tending to improve or benefit or contribute to the safety or well being of the general public or benefit the inhabitants of the watershed district. General welfare shall be synonymous with "public welfare" or "public benefit".

3.9 Gully Erosion: Means displacement of a large, single channel (gully) of soil by water due to the combination of concentrated flows from numerous rills. It is characterized by its typical persistent and ever-enlarging nature and steep, unstable side slopes. It cannot be obliterated by ordinary tillage operations.
3.10 Handbook of Standards (handbook): means a handbook, adopted by the District (pursuant to section 3.0), containing a compilation of the agricultural erosion control practices, design specifications, and planning procedures used in the control of soil erosion resulting from the agricultural use of land.
3.11 Land Disturbing Activity: Means any activity that exposes one acre of incorporated soil or five acres of unincorporated soil for any length of time, leaving it susceptible to soil erosion; excluding cultivated land with an average soil loss of less than four tons per acre per year.
3.12 Legal Drainage System: Means a county, judicial or district ditch, tile or combination thereof.
3.13 Managers: The Board of Managers of the Kanaranzi-Little Rock Watershed District.
3.14 Non-Polluting Materials: Means which materials or their residues are not classified as a pollutant under any existing federal or state law or agency.
3.15 Normal High Water Mark: Means the ordinary High Water Level as defined by the Department of Natural Resources (DNR) regulatory boundary.
3.16 Proper Disposal of Trees and Brush: Means that trees or brush which is buried or disposed of at least 150 feet from a water basin or watercourse.
3.17 Public Welfare: Means the aggregate enjoyment of, financial needs of, and/or aesthetic benefit to the surrounding public entities.
3.18 Reasonable Use: Means *"reasonable use"* shall be interpreted to incorporate the doctrine of reasonable use; i.e., in affecting a reasonable use for a legitimate purpose a landowner, acting in good faith, may drain his land of surface waters and cast them as a burden upon the land of another, although such drainage carries with it some waters which would otherwise have never gone that way, if there is a reasonable necessity for such drainage; and if reasonable care be taken to avoid unnecessary injury to the land receiving the burden; and if the utility or benefit accruing to the land drained reasonably outweighs the gravity of the harm resulting to the land receiving the burden; and if, where practicable it is accomplished by reasonably improving and aiding the normal and natural system of drainage according to its reasonable carrying capacity, or if, in the absence of a practicable natural drain, a reasonable and feasible artificial drainage system is adopted.
3.19 Required Permit Data: Means the applicants: name, address, phone number, project location (legal description, ¼, section, and township), type of project (ex. ditch, waterway, etc), contractor name; as well as the SWCD signature, corresponding landowner signature, and application date.
3.20 Rill Erosion: Means displacement of tiny or small channels of soil by water due to initial concentration of surface flows from "sheet erosion". "Rill erosion" is characterized by its temporary nature and the fact that it is easily obliterated by ordinary tillage operations.
3.21 Sheet Erosion: Means displacement of thin layers of soil by the action of rainfall and surface runoff acting over the whole soil surface. "Sheet erosion" is the sum of these processes: (a) raindrop splash, which provides the detachment energy, and (b) surface flow, which provides the transporting capacity.
3.22 Soil Loss Tolerance: Means the maximum average annual rate of soil loss from sheet and rill erosion or wind erosion, expressed in tons per acre per year that is allowed; yet still sustains the productive capacity of soil to produce food and fiber over the long term.
3.23 Undue Hardship: Means the property under consideration cannot be put into a reasonable use if these rules were strictly applied and enforced.
3.24 Water basin: Means a contiguous land area greater than five (5) acres that is capable of supporting aquatic vegetation or holding standing open water; excluding artificial basins privately owned.
3.25 Water Control Structure: Means a permanent structure placed in a canal, ditch, or subsurface drainage conduit (drain tile or tube), which provides control of the stage or discharge of surface and/or subsurface drainage. The management mechanism on the structure may be flashboards, gates, valves, risers, or pipes.
3.26 Watercourse: Means any natural or constructed channel which drains an area greater than one square mile.
3.27 Waterway: Means a natural or constructed channel, with a permanent grass or vegetative cover, that is shaped or graded to engineered dimensions, and is established for the stable conveyance of runoff.

4. Adoption of The Handbook of Standards:

In conjunction with the adoption of these Rules and Regulations, the District hereby adopts the Natural Resource Conservation Service technical Guide dated December 1975, and as amended thereafter, specified as the minimum acceptable set of practice specifications and planning procedures for implementing the provisions of this Ordinance.

5. Notification Requirements:

In order to expedite landowner projects, assist landowners with proper project consultation, and appropriately notify the Managers of projects or activities which may affect the Districts water resources, the following notification requirements are established.

5.1 Actions Requiring District Notification

General subsurface tiling project(s) are those that meet the requirements of the Natural Resource Conservation Service and the Nobles Soil and Water Conservation District.

5.2 Notification Procedures

A. Applicant requests project input from the Nobles Soil and Water Conservation District.

B. If the project is considered a general subsurface tile project, the producer will be given a Kanaranzi-Little Rock Watershed District Subsurface Tile and Project Notification form to fill out. If the project is not considered a general subsurface tile project, a KLR Application for Permit will be given to the producer/landowner.

C. The Subsurface Tile and Project Notification Form will be forwarded to the Managers for their review.

D. The Managers have the authority to require further technical analysis of any notified project.

E. The Managers has the authority to request that any project be submitted to the Managers under the permitting process as set forth in Rule 6.2 of these Rules.

6. Permit Requirements

In order to help ensure wise deve1opment and conservation of the District's water resources in accordance with the Watershed Management Plan, the following permit procedure is adopted:

Obtaining a permit or other approval for drainage or construction activities under these rules shall not constitute absolute authority to perform the drainage activity. The applicant remains responsible for obtaining any other required authorization. The permit or other authority is permissive only and shall not release the applicant from any liability nor obligation imposed by Minnesota law, Federal law, or local ordinances and shall be subject to all conditions and limitations imposed by the Board of Managers or hereafter imposed by applicable law. The Board of Managers, by approving a request for permit or other approval of a drainage activity, makes no representations to the applicant that the proposed drainage activity complies or does not comply with existing law. No liability shall be imposed upon or incurred by the watershed district, its Board of Managers, or its officers, agents, and employees, officially or personally, on account of the granting of the permit or other approval, or on account of any damage to any person or property resulting from any act or omission of the applicant or any of its contractors, agents, or employees relating to the drainage activity.

6.1 Actions Requiring a District Permit

A. Land disturbing activity in any watercourse or water basin, whether or not open water is present at the time of the work; including to excavation, filling, dredging and the placement of structures; except general subsurface tile.

B. Land disturbing activity in the Right of Way of any legal drainage system.

C. Withdrawal of ground or surface water at a rate greater than 50 gallons per minute, or installation of an irrigation project serving an area over five acres.

D. Operation or alteration of any water control structure in any watercourse or water basin.

E. Diversion of water into a different sub—watershed or into a legal drainage system from land not assessed for the system.

F. Construction or improvement of any open ditch system or dike.

G. Cultivating any area that is closer than one rod from the top edge of a watercourse bank or the normal high water mark of a water basin.

H. Any other act that, as judged by the Managers, may have a significant impact on the District's water resources within the District's regulatory authority.

I. Earth moving projects involving more than 200 cubic yards of excavation or fill; or which disturbs more than 10,000 square feet of soil, and which project, or any part thereof, is located within 300 feet of a stream, storm sewer catch basin, drainage tile intake or a wetland.

J. Construction of new waterways, and alteration or work in/clean out of existing waterways requires a Permit.

K. Work in existing ditches, which does not constitute a repair or improvement under Minnesota Statutes, Chapter 103E, requires a Permit.

6.2 General Permit Procedures

A. Applicant obtains and completes a permit application form, which are located at the Nobles Soil and Water Conservation District offices at 1567 McMillan Street, Suite 3, Worthington, MN 56187.

B. The complete application form is sent or delivered to The Kanaranzi-Little Rock Watershed District Office; for Manager review. In accordance with and subject to the exceptions and requirements of Minn.Stat. 15.99, which is hereby adopted by reference and Rule 7 set forth below, the Managers shall act on all permit applications within 60 days of receiving the application and required permit data.

C. Managers review the permit application and assess the impact the proposal would have on the District's water resources. Managers may approve the work, disapprove the work, approve the work with conditions, or, based on their preliminary assessment, may require the applicant to appear at a Board meeting to explain the proposal, may decide to view the site, or may require that a technical analysis of the proposed work be done to better understand its potential impacts.

D. If the Managers determine that further technical analysis is required, the District may assess the reasonable costs of such analysis to the applicant. If a permit is denied, the Managers shall state the reasons for such denial to the applicant.

E. If a permit is issued, the applicant shall abide by all of the terms and conditions of the permit, or the permit may be revoked and withdrawn by the Managers. Each permit issued must be signed by a Manager.

F. If the Managers determine that it is necessary to monitor any work authorized by permit, such monitoring costs may be assessed to the applicant in accordance of Minn.Stat. 103D.345, which sets forth a districts authority to charge for permits, field inspections and bonds.

G. No work requiring a permit shall commence until a permit is issued. If required by the Managers, the applicant shall file a bond or approved escrow deposit with the District, before issuance or re—issuance of a permit, in an amount set by the Managers and conditioned on performance by the applicant of authorized activities in conformance with the terms and conditions of the permits. If the work is not performed satisfactorily, the Managers may complete the work using the forfeited funds from the bond or escrow account. Unused funds shall be returned to the applicant.

H. Unless otherwise specified in the permit, work for which the permit is given must be completed within two years or else a permit extension will be required.

I. Obtaining a District permit does not relieve the applicant from responsibility of obtaining any other needed permits from other governmental units or agencies. The District will endeavor to inform the applicant of other permits which may be required. It is unlawful for any agent, servant or employee of another to do any work within the District for which a permit is required under these Rules and Regulations unless the agent, servant or employee has obtained from the landowner a signed written statement stating either that all permits required for work have been obtained or that no permits are required. Prior to the commencement of any such work, the agent, servant or employee shall mail a copy of such statement to the District at its office. Violation of this section constitutes a separate and independent offense from any other provided by these Rules and Regulations.

J. There will be no charge for permits issued except for violators after the fact. The fee to landowners for an after the fact permit shall be $10.00 plus all other costs incurred by the District. The fee to contractors will be $10.00 plus all other costs incurred by the District. All after the fact permits shall be issued at the discretion of the Board.

7. Criteria for Reviewing Permit Applications

The Managers will review and apply, as deemed applicable; the criteria set forth in Rule 6.2 herein to all permits applications.

7.1 Work in Watercourses and Water Basins

A. No reservoir, dam, dike or crossing shall be constructed that would damage other people's rights to use waters of the State or which would cause serious erosion or additional flooding on other people's property without their consent.

B. Waterway openings in a new or reconstructed crossing shall have a capacity that is compatible with the nearest crossings upstream and downstream in the watercourse or their planned replacements.

C. Side inlets shall be constructed so as to protect watercourses from serious erosion and increased flooding.

7.2 Floodplain, Shoreland and General Land Development

A. All plats and plans which are within any designated floodplain or shoreland area shall be submitted to the Managers. The Managers intent is to review these plans and provide comments and recommendations to all cities and counties within the District. The Managers do not intend to require a separate District permit for such work unless the cities or counties do not require that minimum State standards be met.

B. The Managers encourage all landowners to retain non—agricultural land for wildlife habitat purposes. The Managers will cooperate with private and public efforts to develop improved fish and wildlife habitat in the District.

C. The Managers will review all shore land development proposals as to their impact on District water resources, including site suitability and the drainage plan. Proposals having a potential flooding impact will be required to detain a portion of storm water runoff for a time period sufficient to prevent increased downstream flooding.

7.3 Erosion

A. New or reconstructed ditches shall have side slopes, grades, grassed berms, and waterways that prevent excessive erosion. The Managers will consult with the Nobles and/or Rock County Soil and Water Conservation Districts on matters pertaining to the control of soil erosion.

B. Water inlets, culverts, texas crossings, bridges and all other structures affecting runoff water in watercourses shall be adequately protected against erosion.

C. All construction sites shall apply effective erosion control measures until vegetation has been re-established.

D. If the Managers are made aware of an excessive erosion problem caused by a certain cultivated tract, they may request a report from the Nobles and/or Rock Soil and Water Conservation Districts to determine the soil losses taking place. In cases where excessive erosion is resulting in an impairment of the public welfare, the Managers may require the responsible land owner to repair, install, and/or replace infrastructure to stop soil loss.

7.4 Water Withdrawal

A. Artificial recharge of ground water is discouraged unless the water quality effects of such action are clearly known.

B. Water conservation practices are encouraged for all water users.

C. District permits for water withdrawals may be suspended if the permitee fails to reasonably satisfy owners of neighboring wells or the neighboring well owners start to experience well interference problems as a result of the permitee's withdrawals.

7.5 Water Quality

A. No refuse, garbage, untreated wastes, or other pollutants shall be dumped or discharged directly into any watercourse or water basin, or placed in a location where runoff waters would carry them into any watercourse or water basin.

B. All trees and brush cut from watercourses and the rights of way of legal drainage systems shall be removed and properly disposed of.

C. Material used as fill or riprap in watercourses or water basins shall be nonpolluting.

7.6 Tiling

A. No tiling without a subsurface tile notification for or an approved permit, including all Local, State and Federal Governmental bodies within the Watershed District.

B. The applicant bears the responsibility of contacting adjacent landowners to inform them of the proposed project.

C. No tiling shall outlet into a county or township ditch without the permission of those bodies except for a bridge or culvert crossing. Tile outlets shall stay a minimum of one foot inside of the property line.

D. New tile crossing the road must connect to existing tile; as directed by the Managers.

E. Surface inlets must be installed where Managers deem necessary.

7.7 Waterway

A. Construction of new waterways, and alteration or work in/clean out of existing waterways requires a Permit.

B. The applicant bears the responsibility of contacting adjacent landowners to inform them of the proposed-project.

C. Clean Out of a waterway includes:

1) Removal of silt.

2) Removal of brush or trees.

All silt, brush, and/or trees removed from a waterway shall be buried or disposed of 150' from the waterway; and other watercourses or water basins. Sediment and silt cannot be placed in wetlands adjacent to a watercourse. Sediment and silt may be placed adjacent to a watercourse (in non-wetland areas) as long as it is leveled and seeded with appropriate grass cover within 48 hours of completion of project unless otherwise directed by the Board of Directors.

D. All applicants must adhere to the recommended directives of the watershed managers including adhering to the recommended standards and specifications put in place by the Kanaranzi-Little Rock Watershed District, Nobles Soil and Water Conservation District and the Natural Resource Conservation Service that are approved by the Managers.

7.8 Wetlands

A. The Nobles Soil and Water Conservation District and the Natural Resource Conservation Service must be consulted for review and determination as to the applicability and compliance with rules and regulations concerning wetlands.

B. The applicant must complete the necessary corresponding notification or permit process; as explained previously in Section 5 and Section 6.

7.9 Watercourses

A. Work in streams, creeks and rivers, requires a Permit from the Watershed. If public waters are involved, a separate permit from the Department of Natural Resources and or the Army Corps of Engineers may also be required.

B. No channel straightening (unless the project is approved through a permit from the DNR Hydrologist of Public Waters)

C. KLR supports the Counties' efforts to require grass sod within 16.5 feet from the outer edge of all water courses. This sod is required on both sides and shall not be plowed up at any time. The Watershed Board of Managers reserves the right to require landowners to extend the width of the vegetation buffer strip beyond 16.5 feet; where deemed necessary.

D. The applicant will not be allowed to change the established grade-line of the channel bed.

7.10 Dams, Dikes and Crossings

A. Permit needed for all construction.

B. The applicant bears the responsibility of contacting adjacent landowners to inform them of the proposed project.

C. A DNR permit shall be required for all dam, dike or crossing construction done in a public water course.

7.11 Ditches

A. Work in existing ditches, which does not constitute a repair or improvement under Minnesota Statutes, Chapter 103E, requires a Permit.

B. The applicant bears the responsibility of contacting adjacent landowners to inform them of the proposed project.

C. Clean outs

1) Removal of silt only to the original grade line.
2) Brush and tree removal; as defined.

D. Construction of new or repair of an existing ditch requires a Petition under Minnesota Chapter 103E, and not a permit.

<u>8. Limitations with District Action</u>

8.1 <u>Time deadline for action</u>. The Board of Managers will approve or deny within 60 days a written request for a permit or other governmental approval of drainage activity under these rules. Failure of the Board of Managers to deny a request within 60 days is approval of the request. If the Board of Managers denies the request, it must state in writing the reasons for the denial at the time that the request is denied. The time deadline for permit action begins when the application is submitted. If the watershed district receives a written request that does not contain all required or necessary information, the 60-day limit starts over only if the watershed sends written notice to the requestor within ten business days of the initial consideration of the request by the Board of Managers telling the requestor what information is missing.

8.1.1 The watershed district's response meets the 60-day limit if the watershed district can document that its written approval or denial action was sent within 60 days of receipt of the written request as defined above.

8.1.2. The time limit in subdivision 6.1 is extended if a state statute, federal law, or court order requires a process to occur before the Board of Managers acts on the request, and the time periods prescribed in the state statute, federal law, or court order make it impossible to act on the request within 60 days. In cases described in this paragraph, the deadline is extended to 60 days after completion of the last process required in the applicable statute, law, or order.

8.1.3. The time limit in subdivision 6.2 is extended if a request submitted to the watershed district requires prior approval of another local, state, or federal agency or board. For purposes of this provision, another local, state, or federal agency or board includes the following: a city, county, town, school district, metropolitan, or regional entity, or other political subdivision. In cases described in this paragraph, the deadline for watershed district action is extended to 60 days after the required prior approval is granted. The watershed district will forward copies of the application to such other state or federal agencies whose approval is required.

8.1.4 The Board of Managers may extend the time limit in subdivision 6.2 before the end of the initial 60-day period to protect against serious or significant harm to the public health, safety, or welfare by providing written notice of the extension to the applicant. The notification must state the reasons for the extension and its anticipated length which may not exceed an additional 60 days unless approved by the applicant. A decision by the Board of Managers to require an engineering report, environmental impact assessment, or similar preliminary evaluation of a request submitted to the watershed district shall be deemed an act to protect against serious or significant harm to the public health, safety, or welfare.

8.2 <u>Required Considerations</u>. In addition to the Criteria for Reviewing Permit Applications contained in Section 7, the following criteria shall be considered by the Board of Managers in approving or denying a written request for a permit or other approval of a proposed activity under these rules.

A. The private or public benefits and costs of the proposed activity.

B. The present and anticipated agricultural land acreage availability and use affected by the proposed activity.

C. The present and anticipated land use affected by the proposed activity.

D. The flooding characteristics of property affected by the proposed activity and downstream for 10 and 100-year flood events and the anticipated impact or effect upon said flooding characteristics of the proposed activity.

E. The waters to be drained and availability of alternative measures to conserve, allocate, and use the waters – including the potential for storage and retention of such waters.

F. The anticipated effect of the proposed activity upon water quality – to include construction.

G. The anticipated effect of the proposed activity upon fish and wildlife resources – to include construction.

H. The anticipated effect of the proposed activity upon shallow ground water availability, distribution, and use.

I. The overall environmental impact of the proposed activity.

J. The adequacy and non-erodability of the outlet for the proposed activity.

K. The need and reasonableness of the proposed activity.

L. The anticipated injury or damage to adjoining or downstream property from the proposed activity and potential alternatives avoiding/reducing such injury and damage.

M. Whether the benefits of the proposed activity outweigh the anticipated harm.

N. Whether the proposed activity is consistent with the *"general welfare"*. In determining the general welfare, the Board of Managers will consider both agricultural best management practices and water quality best management practices.

Whether, under all the circumstances, the proposed activity constitutes a reasonable use of the land and resources involved. For purposes of these rules, the term *"reasonable use"* shall be interpreted to incorporate the doctrine of reasonable use; i.e., in affecting a reasonable use for a legitimate purpose a landowner, acting in good faith, may drain his land of surface waters and cast them as a burden upon the land of another, although such drainage carries with it some waters which would otherwise have never gone that way, if there is a reasonable necessity for such drainage; and if reasonable care be taken to avoid unnecessary injury to the land receiving the burden; and if the utility or benefit accruing to the land drained reasonably outweighs the gravity of the harm resulting to the land receiving the burden; and if, where practicable it is accomplished by reasonably improving and aiding the normal and natural system of drainage according to its reasonable carrying capacity, or if, in the absence of a practicable natural drain, a reasonable and feasible artificial drainage system is adopted.

8.3 Reservation of Right to Require Preliminary Analysis. The Board of Managers reserves the right, when in the Board's considered opinion, such action is deemed to be in the public's welfare, to require that any person or entity requesting a permit or other approval of a drainage activity under these rules, procure and pay for an engineering study, environmental impact assessment, or other preliminary analysis determined by the Board of Managers to be beneficial and reasonably necessary to the Board's consideration, evaluation, and determination of the request.

9. Enforcement: As authorized by Minn.Stat. 103D.545 and 103D.551, the Board of Managers may enforce any violation of a watershed district's rules and regulations, or the terms, conditions, and/or limitations of a permit or other approval of a drainage activity issued thereunder, through injunction, action to compel performance, restoration, abatement, or other appropriate relief in the district court and/or by referral of criminal misdemeanor charges to the appropriate county attorney office.

9.1 Penalty: A violation of a District rule or permit provision is a misdemeanor under Minnesota Statute Section 103D.545, Subd.l.

9.2 Concurrent Authority to Enforce Water Law. The enforcement powers described herein are not exclusive to the watershed district, but are concurrent with all county, state, and federal agencies possessing authority to regulate the activities embraced herein.

10. Variances: The Watershed District Board of Managers may hear requests for variances from the literal provisions of these rules in instances where their strict enforcement would cause undue hardship because of circumstances unique to the property under consideration.

A. A request for variance shall be made in writing to the Managers and shall set forth the basis for the request.

B. In order to grant a variance, the Board of Managers shall determine that the special conditions that apply to the structure or land in question do not apply generally to other land or structures in the District, that the granting of the variance will not merely serve as a convenience to the applicant, and that the variance will not impair or be contrary to the intent of these rules and will be consistent with the district's watershed management plan and Minnesota water law generally..

C. The term *"undue hardship"* as used in connection with the granting of a variance shall mean that the property under consideration cannot be put into a reasonable use if these rules were strictly applied and enforced. A hardship cannot be created by the landowner, the landowner's agent or representative, or a contractor, and must be unique to the property. Economic hardship alone is not grounds for issuing a variance.

D. A variance shall become void after one year after it is granted if not used.

E. A violation of any condition set forth in a variance shall be a violation of the District rules and shall automatically terminate the variance.

11. Adoption

These rules were hereby adopted pursuant to Minn. Stat. Chapter 103D, on the 17th day of March 1983, amended on the 16th day of October 1997, and again amended pursuant to Minnesota Statutes Section 103D.341, Subd. 2, item b on the ____ day of _____________ 2014

FOR THE BOARD OF MANAGERS
KANARANZI-LITTLE ROCK WATERSHED DISTRICT

____

Tim Taylor
Chairman

____

Jerry Brake
Secretary

12. Kanaranzi-Little Rock Watershed District Boundary