Mississippi River – Brainerd Area Watershed

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Mississippi River-Brainerd Area Watershed Restoration and Protection Strategy Report

MINNESOTA POLLUTION CONTROL AGENCY

CLEAN WATER LAND & LEGACY AMENDMENT

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Key terms and abbreviations

Assessment Unit Identifier (AUID): The unique waterbody identifier for each river reach comprised of the US Geological Survey (USGS) eight-digit HUC plus a three-character code unique within each HUC.

Aquatic life impairment: The presence and vitality of aquatic life is indicative of the overall water quality of a stream. A stream is considered impaired for impacts to aquatic life if the fish Index of Biotic Integrity (IBI), macroinvertebrate IBI, dissolved oxygen, turbidity, or certain chemical standards are not met.

Aquatic recreation impairment: Streams are considered impaired for impacts to aquatic recreation if fecal bacteria standards are not met. Lakes are considered impaired for impacts to aquatic recreation if total phosphorus and either chlorophyll-a or Secchi disc depth standards are not met.

Hydrologic Unit Code (HUC): A HUC is assigned by the USGS for each watershed. HUCs are organized in a nested hierarchy by size. For example, the Minnesota River Basin is assigned a HUC-4 of 0702 and the Pomme de Terre River Watershed is assigned a HUC-8 of 07020002.

Impairment: Waterbodies are listed as impaired if water quality standards are not met for designated uses including aquatic life, aquatic recreation, and aquatic consumption.

Index of Biotic Integrity (IBI): A method for describing water quality using characteristics of aquatic communities, such as the types of fish and invertebrates found in the waterbody. It is expressed as a numerical value between 0 (lowest quality) to 100 (highest quality).

Protection: This term is used to characterize actions taken in watersheds of waters not known to be impaired to maintain conditions and beneficial uses of the waterbodies.

Restoration: This term is used to characterize actions taken in watersheds of impaired waters to improve conditions, eventually to meet water quality standards and achieve beneficial uses of the waterbodies.

Source (or pollutant source): This term is distinguished from 'stressor' to mean only those actions, places or entities that deliver/discharge pollutants (e.g., sediment, phosphorus, nitrogen, pathogens).

Stressor (or biological stressor): This is a broad term that includes both pollutant sources and nonpollutant sources or factors (e.g., altered hydrology, dams preventing fish passage) that adversely impact aquatic life.

Total Maximum Daily Load (TMDL): A calculation of the maximum amount of a pollutant that may be introduced into a surface water and still ensure that applicable water quality standards for that water are met. A TMDL is the sum of the wasteload allocation for point sources, a load allocation for nonpoint sources and natural background, an allocation for future growth (i.e., reserve capacity), and a margin of safety as defined in the Code of Federal Regulations.

Executive summary

The Mississippi River-Brainerd Area Watershed (MRBW) is located in central Minnesota as part of the Upper Mississippi River Basin and covers 1,687 square miles. The MRBW spans parts of Aitkin, Crow Wing, Morrison, and Todd Counties and has abundant water resources with approximately 2,149 river miles and containing more than 200 lakes with 66,569 total acres. The water resources located in the MRBW provide recreational and economic benefits to the region.

The MRBW is located in the Northern Lakes and Forests Ecoregion (81%) and the North Central Hardwood Forests Ecoregion (19%) within a relatively rural region of the state. The largest city in the watershed is Brainerd, with a population of 13,428 (2017). Other towns in the watershed include Little Falls and Aitkin. Approximately 77% of the land in this watershed is privately owned, with the remaining portion owned by the state (21%), county (< 1%), federal (2%), or tribal landowners (< 1%). The most prominent land cover type in the watershed is forests (33%), followed by wetlands, hay/pasture, agriculture, open water, and urban land cover.

In 2016, the Minnesota Pollution Control Agency (MPCA) began an intensive watershed monitoring (IWM) effort of rivers, streams, and lakes within the MRBW. Then, in 2018, many of these waterbodies were assessed to determine if they met standards that protect aquatic life, aquatic recreation, and aquatic consumption. Results from these assessments varied, although overall water quality within the watershed is generally good. Water quality monitoring was conducted on 141 lakes; of those lakes, 92 (65%) had sufficient data to assess aquatic recreation (nutrients) and 61 (43%) had sufficient data to assess aquatic life (fish). Seventy-four lakes (80% of assessed) fully supported aquatic recreation and 18 (20% of assessed) did not support aquatic recreation. Fifty-seven lakes (93% of assessed) supported aquatic life and only four lakes (Elm Island, Crow Wing, Green Prairie Fish, and Moose lakes) (7% of assessed) did not meet aquatic life standards. Similar to lakes, the aquatic life in streams, as indicated by the fish and macroinvertebrate communities, was generally good. The Nokasippi River from Hay Creek to the Little Nokasippi River was designated as exceptional based on the composition of the fish and macroinvertebrate communities. This reach should be protected for its diverse biological community. Several streams have impaired aquatic life based on poor fish and/or macroinvertebrate communities. In total, 25 waterbody IDs (WIDs) support aquatic life (61%), 16 WIDs are nonsupportive of aquatic life (39%), 13 WIDs support aquatic recreation (59%), and 9 WIDs are nonsupporting (41%) of aquatic recreation. A more detailed analysis of the assessed lakes and streams is provided in Section 2.1 of this report.

To assess the causes of aquatic life impairments in the assessed streams, a stressor identification (SID) study was completed by the MPCA in 2019. The SID report evaluated possible stressors for 12 separate stream Assessment Unit Identification (AUID) reaches. The results of the analysis concluded that low dissolved oxygen (DO), flow alteration, and ditching were the most common stressors with high nutrients, hydrologic connectivity, lack of habitat, and excessive sediment also contributing to biological impairments across the watershed. A more detailed analysis of the SID results can be found in Section 2.3 of this report.

To target the prioritization efforts for the restoration and protection, the MRBW was divided into three separate management zones: the north, central, and south. The prioritization approach for the MRBW

was designed to allow flexibility for local water quality professionals by providing the necessary information to guide their selection of priority waterbodies. This approach allows local water quality professionals to apply their knowledge of each system in tandem with the information available to select which waterbody to target for protection or restoration efforts. This information will also lay the groundwork for future watershed planning efforts. A detailed summary of this approach is provided in Section 3.1 of this report.

What is the WRAPS report?

Minnesota has adopted a watershed approach to address the state's 80 major watersheds. The Minnesota watershed approach incorporates **water quality monitoring and assessment, watershed analysis, public participation, planning, implementation, and measurement of results** into a 10-year cycle that addresses both restoration and protection.

As part of the watershed approach, the MPCA developed a process to identify and address threats to water quality in each of the major watersheds.

This process is called Watershed Restoration and Protection Strategy (WRAPS) development. The WRAPS reports have two parts: impaired waters have strategies for restoration, and waters that are not impaired have strategies for protection.

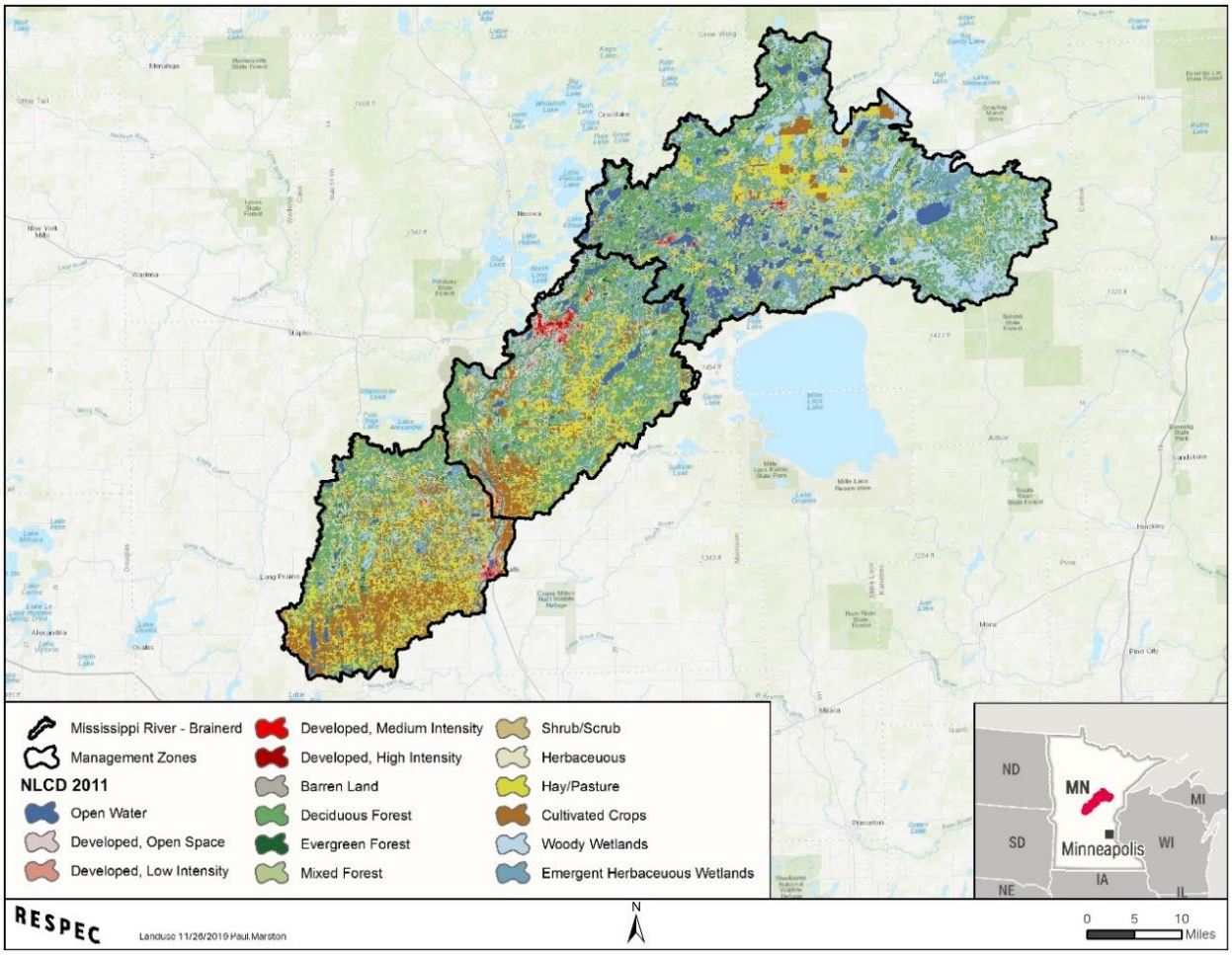
Waters not meeting state standards are listed as impaired and total maximum daily load (TMDL) studies are developed for them. The TMDLs are incorporated into the WRAPS reports. In addition, the watershed approach process facilitates a more cost-effective and comprehensive characterization of multiple waterbodies and overall watershed health, including both protection and restoration efforts. A key aspect of this effort is to develop and use watershed-scale models and other tools to identify strategies for addressing point and nonpoint source pollution that will cumulatively achieve water quality targets. For nonpoint source pollution, the WRAPS report informs local planning efforts, but ultimately, the local partners decide what work will be included in their local plans. The WRAPS report also serves as the basis for addressing the U.S. Environmental Protection Agency's (EPA's) Nine Minimum Elements of watershed plans to help qualify applicants for eligibility for Clean Water Act Section 319 implementation funds.

Purpose	•Support local working groups and jointly develop scientifically-supported restoration and protection strategies to be used for subsequent implementation planning •Summarize watershed approach work done to date, including the following reports: •*Upper Mississippi River-Brainerd Watershed Monitoring and Assessment 2019* •*Upper Mississippi River-Brainerd Watershed Biotic Stressor Identification 2019* •*Upper Mississippi River-Brainerd Watershed Total Maximum Daily Load 2020*
Scope	•Impacts to aquatic recreation and impacts to aquatic life in streams •Impacts to aquatic recreation in lakes
Audience	•Local working groups (local governments, SWCDs, watershed management groups, etc.) •State agencies (MPCA, DNR, BWSR, etc.)

1. Watershed background and description

The MRBW covers 1,687 square miles and is located in central Minnesota as a part of the Upper Mississippi River Basin. The watershed covers parts of Aitkin, Crow Wing, Morrison, and Todd counties. The MRBW has abundant surface water resources with approximately 2,149 river miles and 212 lakes greater than 10 acres in size. The most prominent land cover in the watershed is forest (33%), followed by wetlands (28%), range (18%), and row crops (10%) with urban only accounting for 5% (Figure 1).

Figure 1. MRBW land cover.



Additional Mississippi River-Brainerd Watershed resources

USDA Natural Resources Conservation Service (NRCS) Rapid Watershed Assessment for the Mississippi River-Brainerd Watershed: https://www.nrcs.usda.gov/Internet/FSE_DOCUMENTS/nrcs142p2_022730.pdf

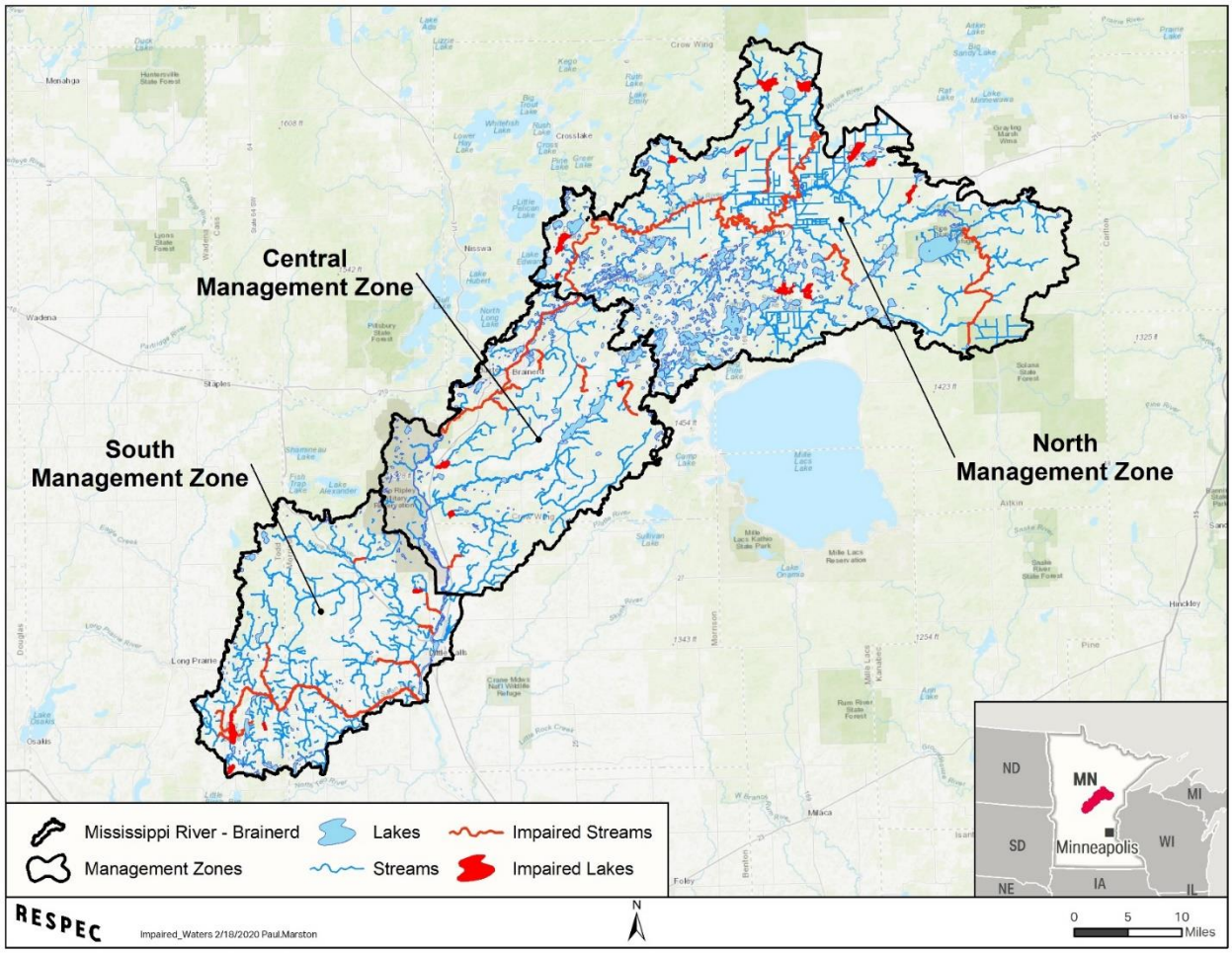
Minnesota Department of Natural Resources (MNDNR) Watershed Health Assessment Framework Watershed Report Card for the Mississippi River-Brainerd Watershed: http://files.dnr.state.mn.us/natural_resources/water/watersheds/tool/watersheds/ReportCard_Major_10.pdf

Minnesota Pollution Control Agency (MPCA) Mississippi River-Brainerd Watershed: https://www.pca.state.mn.us/water/watersheds/mississippi-river-brainerd

2. Watershed conditions

For the purposes of the WRAPS report and targeting protection and restoration efforts, the MRBW was broken into three distinct management zones: north, central, and south (Figure 2). Separating the MRBW into three districts allows for a targeted approach to better assess watershed conditions as they relate to regional land covers and stressors.

Figure 2. MRBW impaired waterbodies.



The north management zone is defined by a landscape dominated by wetlands, forests, and lakes. In this area there are water quality impairments to both streams and lakes, but overall water quality is good. Of the 25 impaired stream reaches and 19 impaired lakes in the watershed, 9 (includes Mississippi River reach -656 that is in both north and central management zone) and 12, respectively, are located in the north management zone. Water quality impairments in the north management zone include excess nutrients, low DO, total suspended solids (TSS), *Escherichia coli* bacteria (*E. coli*), and impaired fish and macroinvertebrate communities. Many of the impairments in this area are caused by natural causes, such as low DO waters flowing from wetlands following heavy rain events. In addition to natural causes, internal loading, lakeshore development, and disturbed/developed land areas in the lakeshed and drainage areas contribute to the excess nutrients.

The central management zone is the transition zone of the MRBW from the northern wetlands and forests to the southern prairies and wetlands and has the largest city in the watershed, Brainerd. Similar to the north management zone, the central management zone has lake and stream water quality impairments but the overall water quality is good. Of the 25 impaired stream reaches and 19 impaired lakes in the watershed, 7 (includes Mississippi River reach -656 that is in both north and central management zone) and 3, respectively, are located in the central management zone. Water quality impairments in the central management zone include excess nutrients, TSS, *E. coli*, and impaired fish and macroinvertebrate communities. Impairments in this area are caused by natural causes, lakeshore development, urban stormwater, and agricultural runoff.

The south management zone is differentiated from the rest of the watershed by its largely agricultural landscape, and it has a majority of the watershed's feedlots. Of the 25 impaired stream reaches and 19 impaired lakes in the watershed, 10 and 4, respectively, are located in the south management zone. Water quality impairments in the south management zone include excess nutrients, low DO, *E. coli*, and impaired fish and macroinvertebrate communities. A list of all of the impaired waterbodies in the MRBW is shown in Table 1.

Table 1. Summary of impaired waterbodies in the MRBW.

Name	Lake/ Stream	ID	Proposed Use Subclass	Management Zone	Impairment	Year Listed
Gun	Lake	01-0099-00	2B, 3C	North	Nutrients, Fish Bioassessments	2010
Fleming	Lake	01-0105-00	2B, 3C	North	Nutrients	2010
Elm Island	Lake	01-0123-00	2B, 3C	North	Nutrients, Fish Bioassessments	2010
Ripple	Lake	01-0146-00	2B, 3C	North	Nutrients	2020
Crow Wing	Lake	18-0155-00	2B, 3C	Central	Nutrients	2010
Sebie	Lake	18-0161-00	2B, 3C	Central	Nutrients	2020
Fawn	Lake	18-0240-00	2B, 3C	North	Nutrients	2020
Lower Mission	Lake	18-0243-00	2B, 3C	North	Nutrients	2020
Trace	Lake	77-0009-00	2B, 3C	South	Nutrients	2008
Big Swan	Lake	77-0023-00	2B, 3C	South	Nutrients	2010
Moose	Lake	77-0026-00	2B, 3C	South	Nutrients, Fish Bioassessments	2020
Portage	Lake	01-0069-00	2B, 3C	North	Nutrients	2020
Waukenabo	Lake	01-0136-00	2B, 3C	North	Nutrients	2010
Esquagamah	Lake	01-0147-00	2B, 3C	North	Nutrients	2010
Blind	Lake	01-0188-00	2B, 3C	North	Nutrients	2010
Casey	Lake	18-0087-00	2B, 3C	North	Nutrients	2020
Grave	Lake	18-0110-00	2B, 3C	Central	Nutrients	2020
Upper Dean	Lake	18-0170-00	2B, 3C	North	Nutrients	2020
Green Prairie Fish	Lake	49-0035-00	2B, 3C	South	Fish Bioassessments	2020
Sisabagamah Creek	Stream	07010104-659	2Bg, 3C	North	Macroinvertebrate Bioassessments	2020
Hay Creek	Stream	07010104-645	2Bg, 3C	Central	*E. coli*	2020
Unnamed creek (Headwaters to Sand Cr)	Stream	07010104-679	2Bg, 3C	Central	Macroinvertebrate Bioassessments	2020
Little Elk River	Stream	07010104-521	2Bg, 3C	South	*E. coli*	2020
Pike Creek	Stream	07010104-522	2Bg, 3C	South	*E. coli*	2020

Name	Lake/ Stream	ID	Proposed Use Subclass	Management Zone	Impairment	Year Listed
Unnamed creek (Headwaters to Big Swan Lk)	Stream	07010104-626	2Bg, 3C	South	*E. coli*	2020
Schwanke Creek	Stream	07010104-627	2Bg, 3C	South	*E. coli*	2020
Unnamed creek (Long Lake to Big Swan Lake)	Stream	07010104-629	2Bg, 3C	South	*E. coli*	2020
Swan River	Stream	07010104-502	2Bg, 3C	South	Dissolved Oxygen, *E. coli*	2010
Rice River	Stream	07010104-505	2Bg, 3C	North	Fish Bioassessments, Dissolved Oxygen	2020
Little Swan River	Stream	07010104-570	2Bg, 3C	South	Fish Bioassessments	2020
Whiteley Creek	Stream	07010104-589	1B, 2Ag, 3B	Central	Macroinvertebrate Bioassessments	2020
Buffalo Creek	Stream	07010104-610	2Bg, 3C	Central	Macroinvertebrate Bioassessments	2020
Unnamed creek (Headwaters to Long Lake)	Stream	07010104-632	2Bg, 3C	South	*E. coli*	2020
Rice River	Stream	07010104-649	2Bg, 3C	North	Fish IBI, Dissolved Oxygen, *E. coli*	2020
Mississippi River	Stream	07010104-655	2Bg, 3C	North	Turbidity	1998
Mississippi River	Stream	07010104-656	2Bg, 3C	North and Central	TSS	2016
Sisabagamah Creek	Stream	07010104-677	2Bg, 3C	North	Fish Bioassessments	2020
Unnamed creek (Unnamed Ditch to Miss. River)	Stream	07010104-681	2Bg, 3C	Central	Fish Bioassessments	2020
Hay Creek	Stream	07010104-682	2Bg, 3C	South	Macroinvertebrate Bioassessments	2020
Unnamed creek (Green Prairie Fish Lake to Miss. River)	Stream	07010104-684	2Bg, 3C	South	Macroinvertebrate Bioassessments, Dissolved Oxygen	2020
Rabbit Creek	Stream	07010104-688	2Bg, 3C	North	Fish Bioassessments	2020
Unnamed ditch (Little Willow River Diversion)	Stream	07010104-691	2Bg, 3C	North	Macroinvertebrate Bioassessments	2020
Buffalo Creek (Little Buffalo Creek)	Stream	07010104-695	2Bg, 3C	Central	Fish Bioassessments, Macroinvertebrate Bioassessments, *E. coli*	2002
Little Willow River Old Channel	Stream	07010104-701	2Bg, 3C	North	Fish Bioassessments	2020

2.1 Condition status

The MPCA conducted its IWM efforts in 2016-2017 for the MRBW's lakes and streams. The results of the IWM efforts were evaluated in 2018 to determine if lakes and streams met the standards for supporting aquatic life and aquatic recreation. Results showed that water quality is good in the watershed, but with several impairments requiring restoration efforts. Waterbodies that are supporting aquatic life and recreation are candidates for protection efforts to ensure future support of designated uses.

The quality of streams was determined through water quality and biological sampling. Biological monitoring resulted in 25 WIDs supporting aquatic life, 16 WIDs nonsupporting aquatic life, and 15 WIDs with insufficient data. Water quality monitoring to determine if WIDs support aquatic recreation resulted in 13 WIDs supporting, 9 nonsupporting, and 9 with insufficient data. Results from monitoring also indicated that there is an exceptional waterbody, the Nokasippi River from Hay Creek to the Little Nokasippi River, because of its diverse biological community. Because of its designation as an exceptional waterbody, the Nokasippi River should be a priority for protection. Streams that were impaired because of the sampled biology are likely a result of low DO, altered hydrology, and loss of stream connectivity.

Similar to streams, water quality and biological sampling were conducted on lakes across the MRBW with 92 lakes having sufficient data to assess aquatic recreation and 61 lakes having sufficient data to assess aquatic life. Biological monitoring results showed that 57 lakes support aquatic life, 4 lakes were nonsupporting of aquatic life, and 29 lakes had insufficient data. Water quality monitoring conducted on lakes showed that 74 lakes support aquatic recreation, 18 lakes were nonsupporting of aquatic recreation, and 46 lakes had insufficient data.

Some of the waterbodies in the MRBW are impaired by mercury; however, this report does not cover toxic pollutants. For more information on mercury impairments, see the statewide mercury TMDL (http://www.pca.state.mn.us/index.php/water/water-types-and-programs/minnesotas-impaired-waters-and-tmdls/tmdl-projects/special-projects/statewide-mercury-tmdl-pollutant-reduction-plan.html).

Streams

Stream water quality monitoring was conducted by the MPCA with the help of the Aitkin Soil and Water Conservation District (SWCD) and Crow Wing SWCD across 11 water chemistry stations in 2016 and 2017. Following IWM, water chemistry stations were placed at the outlet of each aggregated HUC-12 subwatershed. Water chemistry is an important component to evaluating the overall water quality of a stream, but support for aquatic recreation is only dependent on meeting the bacteria standard. Results from stream monitoring show that 13 WIDs support aquatic recreation, 9 WIDs are nonsupporting of aquatic recreation, and 9 WIDs have insufficient data.

The biological monitoring component of the IWM in the MRBW was completed during the summers of 2016 and 2017. To evaluate the health of aquatic life in streams, fish and macroinvertebrates were sampled, as well as the general water chemistry. Fish and macroinvertebrate samples were used to develop the indices of biological integrity for fish (FIBI) and macroinvertebrates (MIBI). The indices scores for a sampled monitored point were compared to their respective thresholds to determine if the

stream supported aquatic life. Water chemistry results help evaluate the causes of a biological impairment, if present (Section 2.3). Results of the biological monitoring in the MRBW show that 25 WIDs support aquatic life, 16 WIDs are nonsupporting of aquatic life, and 15 WIDs have insufficient data. To see the full results of the IWM efforts on streams in the MRBW see Appendix A.

Lakes

The MRBW's lakes were assessed for meeting aquatic recreation and aquatic life uses. To determine if a lake supported aquatic recreation, the MPCA, with the help of the Aitkin SWCD, Crow Wing SWCD, and Todd SWCD, collected water quality samples from lakes across the watershed. To evaluate lakes for supporting aquatic recreation, 8 samples within a 10-year period (June through September) were needed for phosphorus, chlorophyll-a, and Secchi depth. This provided a comprehensive analysis of the pollutant (phosphorus) and response variables (chlorophyll-a and Secchi depth) to fully understand the impacts on water quality. Additional constituents tested include chloride, sulfate, and nitrates, which are important when assessing wild rice lakes, testing if lakes are being impacted by elevated chloride, and for lakes designated for drinking water use. The results of the monitoring show that of the 138 lakes assessed for aquatic recreation, 74 were supporting, 18 were nonsupporting, and 46 had insufficient data.

The Minnesota Department of Natural Resources (DNR) Fisheries Unit conducted fish monitoring on lakes in the MRBW in 2016–2017 and assessed the results in 2018 to determine which lakes met the aquatic life use standards. To determine if a lake was supporting aquatic life, an FIBI score was calculated based on the fish monitoring conducted. The FIBI is a comprehensive score that represents the community composition of fish species, number of fish, and sizes of fish. The FIBI score for a lake is compared to a FIBI threshold to determine if a lake is supporting a healthy fish community. A total of 90 lakes had data to assess aquatic life use; of the 90 lakes, 57 were supporting aquatic life, 4 were nonsupporting, and 29 had insufficient data. To see the full results of the IWM efforts on lakes in the MRBW, see Appendix A.

2.2 Water quality trends

Long-term water quality trends were calculated by the MPCA for major watershed monitoring sites as part of the former Minnesota Milestone Monitoring Program [MPCA 2014(a)]. Long-term data were available for the Mississippi River in the MRBW for the period 1967 through 2010. Table 2 summarizes trends of several pollutants over the entire period of record and over the more recent time period of 1995 through 2010. Long-term data trends show decreases of 35%, 63%, and 59% for TSS, biochemical oxygen demand, and total phosphorus, respectively, and increases of 399% and 216% for nitrate/nitrite and chloride, respectively. The significantly increasing trends for nitrate/nitrite and chloride are noteworthy, but should be attributed to the entire Mississippi River drainage area upstream of the Camp Ripley site and are not directly indicative of what is occurring within the MRBW. No trends were detected for all monitored constituents for the time period of 1995 through 2010 at this site.

There were not enough data to develop statistically significant trends for streams in the MRBW aside from the data evaluated as a part of the Minnesota Milestone Monitoring Program on the Mississippi River.

Table 2. Water quality trends for the Mississippi River at bridge on MN 115 at Camp Ripley (S000-151).

Parameter	Historical Trend (1967–2009)	Recent Trend (1995–2010)	Median Concentration first 10 years (mg/L)	Median Concentration most recent 10 years (mg/L)
TSS	–35%	no trend	8	5
Biochemical Oxygen Demand	–63%	no trend	2	1
Total Phosphorus	–59%	no trend	0.07	0.05
Nitrite/Nitrate	399%	no trend	0.07	0.19
Chloride	216%	no trend	4	9

Lake trends

The MPCA has analyzed 59 lakes in the MRBW for transparency trends using Secchi data from its Citizens Lake Monitoring Program (CLMP), as listed in Table 3. The analysis of the CLMP data was conducted using the *R* program to run a seasonal Kendall test that is applied to all June through September Secchi data for each lake that has a minimum of 8 years of data and 25 pairs of data. The median Secchi depth is calculated and charted along with the minimum and maximum measurements for each year. The summer median and a smoothing technique are used to draw the regression line. The resulting trend is reported for each lake.

Improving water quality trends are highlighted in green, and declining water quality trends are highlighted in red. Sixteen lakes show an improving trend and 11 lakes show decline.

Table 3. Water clarity trends for MRBW lakes from CLMP data.

Lake Name	Lake ID	Management Zone	Trend
Portage	01-0069-00	North	No Trend
Sugar	01-0087-00	North	No Trend
Long	01-0089-00	North	Declining
Rabbit	01-0091-00	North	No Trend
Clear	01-0093-00	North	Improving
Dam	01-0096-00	North	No Trend
Gun	01-0099-00	North	No Trend
Wilkins	01-0102-00	North	Improving
Fleming	01-0105-00	North	Declining
Nord	01-0117-00	North	Declining
Elm Island	01-0123-00	North	Improving
Lone	01-0125-00	North	Declining
Waukenabo	01-0136-00	North	No Trend
Round	01-0137-00	North	Declining
Ripple	01-0146-00	North	No Trend
Esquagamah	01-0147-00	North	No Trend
Farm Island	01-0159-00	North	No Trend
Hammal	01-0161-00	North	Declining
Hanging Kettle	01-0170-00	North	No Trend
Little Pine	01-0176-00	North	No Trend

Lake Name	Lake ID	Management Zone	Trend
Spirit	01-0178-00	North	No Trend
Blind	01-0188-00	North	No Trend
Cedar	01-0209-01	North	No Trend
Bay	18-0034-00	North	Improving
Clearwater	18-0038-00	North	No Trend
Crooked	18-0041-02	North	Improving
Hanks	18-0044-00	North	Improving
Portage	18-0050-00	North	No Trend
Agate	18-0060-00	North	Improving
Portage	18-0069-00	North	No Trend
Placid	18-0076-00	North	No Trend
Serpent	18-0090-00	North	Declining
Rabbit (East Portion)	18-0093-01	North	Improving
Rabbit (West Portion)	18-0093-02	North	Improving
Upper South Long	18-0096-00	Central	No Trend
Nokay	18-0104-00	Central	No Trend
South Long	18-0136-00	Central	Improving
Crow Wing	18-0155-00	Central	Declining
Sebie	18-0161-00	Central	Declining
Stark	18-0169-00	North	No Trend
Rogers	18-0184-00	North	Declining
Silver	18-0239-00	North	No Trend
Upper Mission	18-0242-00	North	No Trend
Lower Mission	18-0243-00	North	No Trend
Bass	18-0256-00	North	Improving
Bonnie	18-0259-00	North	No Trend
Gilbert	18-0320-01	Central	Declining
Gilbert (West Bay)	18-0320-02	Central	No Trend
Sorenson	18-0323-00	Central	Improving
Perch	18-0371-00	Central	No Trend
Green Prairie Fish	49-0035-00	South	No Trend
Round	49-0056-00	South	Improving
Pine	49-0081-00	South	No Trend
Mound	77-0007-00	South	Improving
Big Swan	77-0023-00	South	Improving
Moose	77-0026-00	South	Improving
Long	77-0027-00	South	No Trend
Beauty	77-0035-00	South	No Trend
Pine Island	77-0067-00	South	No Trend

2.3 Stressors and sources

To develop appropriate strategies for restoring or protecting waterbodies, the stressors and/or sources impacting or threatening them must be identified and evaluated. Biological SID is done for streams with either fish or macroinvertebrate biota impairments, and encompasses evaluation of both pollutants and nonpollutant-related factors as potential stressors (e.g., altered hydrology, fish passage, habitat). Pollutant source assessments are done where a biological SID process identifies a pollutant as a stressor, as well as for the typical pollutant impairment listings. Section 3 provides further detail on stressors and pollutant sources. More detailed information on the SID process can be found on the EPA website: https://www.epa.gov/caddis.

The Mississippi River – Brainerd Watershed SID Report documents the efforts that were taken to identify the causes, and to some degree the source(s), of impairments to aquatic biological communities in the MRBW. Twelve AUID reaches were brought into the SID process because they had one or both of the sampled biological communities scoring below the impairment thresholds per the 2019 Watershed Monitoring and Assessment Report (Table 4).

Table 4. Impairments for stream reaches assessed in SID report.

Stream Name	AUID	Management Zone	Reach Description	Impairments	
				Biological	Water Quality
Rice River	07010104-505	North	Headwaters (Porcupine Lk 01-0066-00) to Section 5 Cr	Fishes Bioassessments	DO
Rice River	07010104-649	North	Section 5 Cr to Wakefield Bk	Benthic macroinvertebrate bioassessments, Fishes bioassessments	DO
Rabbit Creek	07010104-688	North	Rabbit Lk to Sisabagamah Cr	Fishes Bioassessments	
Sisabagamah Creek	07010104-677	North	Sisabagamah Lk to Rabbit Cr	Fishes Bioassessments	DO
Sisabagamah Creek	07010104-659	North	Unnamed cr to Mississippi R	Benthic macroinvertebrate bioassessments	
Little Willow Diversion Channel	07010104-691	North	Unnamed ditch to Flood Diversion Channel (4c)	Benthic macroinvertebrate bioassessments	
Tributary to Sand Creek	07010104-679	Central	Headwaters to Sand Cr (MU)	Benthic macroinvertebrate bioassessments	
Little Buffalo Creek	07010104-695	Central	Wright St to Mississippi R	Benthic macroinvertebrate bioassessments, Fishes bioassessments	
Buffalo Creek	07010104-610	Central	Unnamed cr to Unnamed cr	Benthic macroinvertebrate bioassessments	
Hay Creek	07010104-682	South	Unnamed cr to Little Elk R	Benthic macroinvertebrate bioassessments	

Stream Name	AUID	Management Zone	Reach Description	Impairments	
				Biological	Water Quality
Tributary to Mississippi River	07010104-684	South	Unnamed outlet to Mississippi R (MU)	Benthic macroinvertebrate bioassessments, Fishes bioassessments	DO
Little Swan River	07010104-570	South	Spring Br to Swan R	Fishes Bioassessments	DO

Stressors of biologically impaired stream reaches

The SID process identified a variety of stressors for the biologically impaired reaches (Table 5). Of the stressors, the most common were low DO and flow alteration/ditching. Based on the biological community structure, collected water chemistry samples, and HSPF model outputs, a strength of evidence to support the identification of the specific stressor was developed by the SID analysis. Three distinct regions within the MRBW each have unique sources contributing to the biological community's degradation. In the northeastern portion of the watershed, the SID analysis concludes that low DO is believed to be caused by natural sources, such as discharge of naturally low DO water from wetlands drainage, low gradient stream systems, and contribution of low DO groundwater to the streams. This area of the watershed also has an extensive ditching network that contributes to the flow alteration/ditching stressor. The central portion of the watershed is susceptible to similar drainage and low DO issues to the northeast, but with more urban areas stormwater runoff resulting in warming stream temperatures. This effect is especially prevalent in Little Buffalo Creek, which is a coldwater resource that more closely reflects a warm water system because of urban runoff. The southwestern portion of the watershed is differentiated from the rest of the watershed because of its landscape, which is largely agriculture and forested land. Low DO in this area is attributed to wetlands and ditching.

Table 5. Probable stressors to aquatic life in biologically impaired reaches in the MRBW.

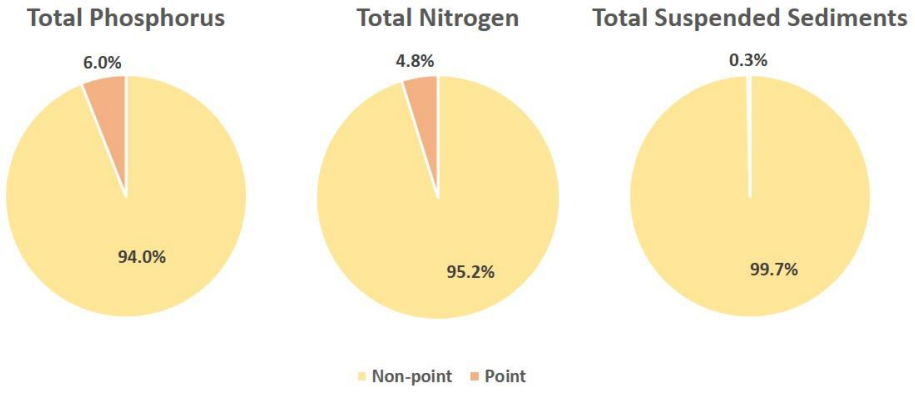
Stream Name	AUID	Management Zone	Biological Impairment	Primary Stressor					
				Low DO	High Nutrients	Longitudinal Connectivity	Flow Alteration/ Ditching	Lack of Habitat	Excess Sediment
Rice River	505	North	Fish	●			●		
Rice River	649	North	Fish and Macroinvertebrates	●			●		
Rabbit Creek	688	North	Fish	●		●			
Sisabagamah Creek	677	North	Fish	●		●			
Sisabagamah Creek	659	North	Macroinvertebrates				●	●	●
Little Willow Diversion Channel	691	North	Macroinvertebrates (modified use)	●			●	●	

Stream Name	AUID	Management Zone	Biological Impairment	Primary Stressor					
				Low DO	High Nutrients	Longitudinal Connectivity	Flow Alteration/ Ditching	Lack of Habitat	Excess Sediment
Tributary to Sand Creek	679	Central	Macroinvertebrates (modified use)	●	●		●	●	
Little Buffalo Creek	695	Central	Fish and Macroinvertebrates				●		●
Buffalo Creek	610	Central	Macroinvertebrates						●
Hay Creek	682	South	Macroinvertebrates	●			●	●	
Tributary to Mississippi River	684	South	Fish and Macroinvertebrates	●		●	●	●	
Little Swan River	570	South	Fish	●			●		

Pollutant sources

This section summarizes the sources of pollutants (e.g., phosphorus, bacteria, or sediment) to lakes and streams in the MRBW, including point sources (such as sewage treatment plants) or nonpoint sources (e.g., runoff from the land). By using the calibrated HSPF model, loading from all of the nonpoint sources was compared to loading from point sources for TP, TN, and TSS, which indicates that nonpoint source pollution is the major concern in the MRBW (Figure 3). Pollutant sources vary across the watershed and should be addressed at a finer scale, but these results indicate that many of the restoration and protection efforts will be addressing nonpoint sources.

Figure 3. Nonpoint versus point source contributions to MRBW loads.



Point sources

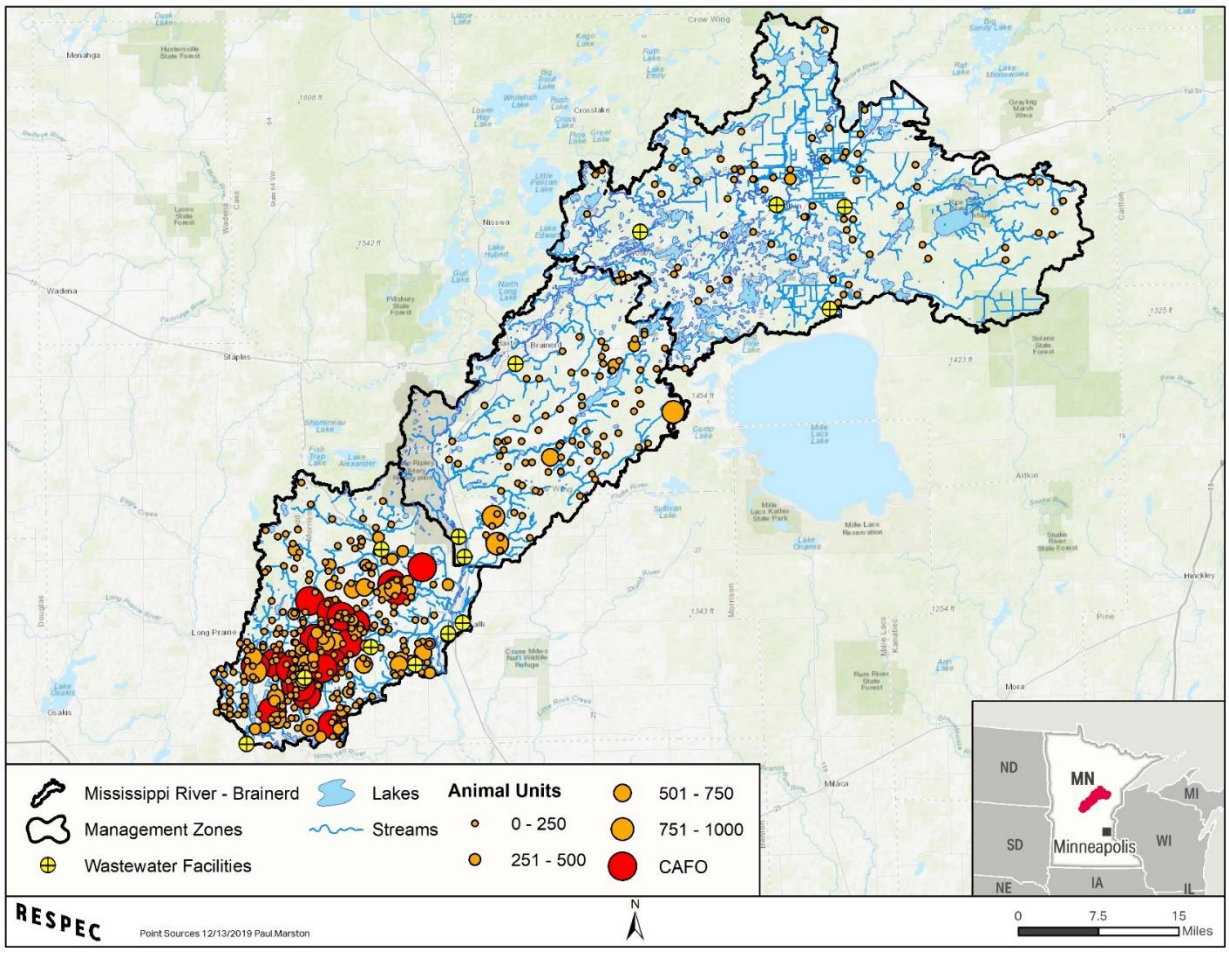
Point sources are defined as facilities that discharge stormwater or wastewater to a lake or stream and have a National Pollutant Discharge Elimination System/State Disposal System (NPDES/SDS) permit. There are 10 municipal wastewater facilities, 4 industrial wastewater facilities, and 24 concentrated

animal feeding operations (CAFOs) located in the MRBW (Table 6). Locations of the point sources and feedlots are shown in Figure 4.

Table 6. Point sources in the MRBW.

HUC-12 Subwatershed	Management District	Point Source			Pollutant Reduction Needed Beyond Current Permit Conditions/Limits?
		Permit #	Permittee Name	Type	
City of Little Falls-Mississippi River	South	MN0003182	Little Falls WTP	Industrial	[No]
Mallard Lake-Ripple River	North	MN0057533	American Peat Technology LLC	Industrial	[No]
Camp Ripley-Mississippi River	Central	MN0063070	Camp Ripley - Area 22 Washrack	Industrial	[No]
City of Little Falls-Mississippi River	South	MNG255005	Anderson Custom Processing Inc	Industrial	[No]
City of Aitkin-Mississippi River	North	MN0020095	Aitkin WWTP	Municipal wastewater	[No]
City of Swanville-Swan River	South	MN0020109	Swanville WWTP	Municipal wastewater	[No]
City of Little Falls-Mississippi River	South	MN0020761	Little Falls WWTP	Municipal wastewater	[No]
Big Swan Lake	South	MN0023566	Grey Eagle WWTP	Municipal wastewater	[No]
Little Elk River	South	MN0024562	Randall WWTP	Municipal wastewater	[No]
Camp Ripley-Mississippi River	Central	MN0025721	USPFO Warehouse Camp Ripley	Municipal wastewater	[No]
City of Brainerd-Mississippi River	Central	MN0049328	Brainerd WWTP	Municipal wastewater	[No]
Pike Creek	South	MNG580016	Flensburg WWTP	Municipal wastewater	[No]
Rabbit River	North	MNG580215	Serpent Lake WWTP	Municipal wastewater	[No]
Swan River	South	MNG580217	Sobieski WWTP	Municipal wastewater	[No]

Figure 4. Point sources and feedlots in the MRBW.



Nonpoint Sources

Nonpoint source pollution, unlike pollution from industrial and sewage treatment plants, comes from many different sources. Nonpoint source pollution is caused by rainfall or snowmelt moving over and through the ground. As the runoff moves, it picks up and carries away natural and anthropogenic pollutants and deposits them into lakes and streams. Common possible nonpoint and natural pollutant sources in the MRBW are listed below. In the MRBW, low DO from natural sources and altered hydrology are identified as the main nonpoint pollutant sources.

- **Fertilizer and/or manure runoff**: Fertilizer and manure contain high concentrations of phosphorus, nitrogen, and bacteria that can run off into lakes and streams when not properly managed.
- **Feedlots**: While only larger feedlot operations are regulated and permitted, Minnesota law requires most feedlot owners to register their feedlots with the MPCA. Feedlots located in shoreland that maintain 10 animal units (AUs) or more and ones located outside of shoreland that maintain 50 AU or more are required to register. AU is a term used to compare the differences in the production of animal manure. Table 20 shows the number of feedlots that are registered in the MRBW and are grouped in different thresholds that contain different requirements. Any feedlot over 1,000 AU is required to obtain an operating permit, an SDS or

NPDES, and is defined as a concentrated animal feeding operation (CAFO). Any operation under 1,000 AU is only required to apply for a permit if constructing or expanding. Table 20 shows that 24 CAFOs are within the watershed. Most of the feedlots within this watershed are under 300 AU, and their operating requirements are to maintain current registration, notify the MPCA of any construction activities taking place, and ensure proper manure management.

- **Urban stormwater runoff**: Stormwater collects and transports pollutants deposited on the impervious surfaces, such as sidewalks and streets, directly to local waterbodies if not properly managed.
- **Failing septic systems**: Septic systems that are not maintained or are failing near a lake or stream can contribute excess phosphorus, nitrogen, and bacteria.
- **Peatlands/wetlands**: Peatlands and wetlands in the MRBW have high levels of phosphorus and low levels of DO that can pollute downstream streams and lakes.
- **Internal loading**: Lake sediments contain large amounts of phosphorus that can be released into the lake water through physical mixing or under certain chemical conditions.
- **Upstream lake loading**: Some lakes receive most of their phosphorus from upstream lakes. For these lakes, restoration and protection efforts should focus on improving the water quality of the upstream lake.
- **Livestock overgrazing in stream**: Livestock grazing/watering in the riparian zone can cause localized damage and erosion of the stream bank and is a source of phosphorus and bacteria pollutants.
- **Wildlife fecal bacteria runoff**: Dense or localized populations of wildlife, such as beavers or geese, can contribute phosphorus and bacteria pollutants to streams or ponds.

2.4 TMDL summary

The TMDL study for the MRBW carried out as part of this WRAPS project quantifies the pollutant reductions needed to meet the state water quality standards for bacteria, biology, and DO for the addressed impaired stream reaches and TP for the lakes. The TMDL study is established in accordance with Section 303(d) of the Clean Water Act (CWA), and defines wasteload allocations (WLAs), load allocations (LAs), and pollutant reductions needed to achieve state water quality standards. Per the EPA, "a TMDL establishes the maximum amount of a pollutant allowed in a waterbody and serves as the starting point or planning tool for restoring water quality." The MRBW TMDL study addresses 8 stream reach *E. coli* impairments, 2 stream reach biology impairments for macroinvertebrates, and 11 lake nutrient (TP) impairments of the MRBW. The impaired waterbodies reside in Aitkin, Crow Wing, Morrison, and Todd counties. Impairments addressed in this TMDL are listed in Table 7. No other TMDLs have previously been developed for waters in the MRBW.

Table 7. Water quality impairments on the 2018 303(d) list that are addressed in the TMDL report completed as part of this project.

Name	Lake/ Stream	ID	Management Zone	Proposed Use Subclass	Pollutant of Concern	Year Listed
Sisabagamah Creek	Stream	07010104-659	North	2Bg, 3C	Inverts	2020
Hay Creek	Stream	07010104-645	Central	2Bg, 3C	*E. coli*	2020
Unnamed creek (Headwaters to Sand Cr)	Stream	07010104-679	Central	2Bg, 3C	Inverts	2020
Buffalo Creek (Little Buffalo Creek)	Stream	07010104-695	Central	2Bg, 3C	*E. coli*	2020
Little Elk River	Stream	07010104-521	South	2Bg, 3C	*E. coli*	2020
Pike Creek	Stream	07010104-522	South	2Bg, 3C	*E. coli*	2020
Swan River	Stream	07010104-502	South	2Bg, 3C	*E. coli*	2020
Unnamed creek (Headwaters to Big Swan Lk)	Stream	07010104-626	South	2Bg, 3C	*E. coli*	2020
Schwanke Creek	Stream	07010104-627	South	2Bg, 3C	*E. coli*	2020
Unnamed creek (Long Lake to Big Swan Lake)	Stream	07010104-629	South	2Bg, 3C	*E. coli*	2020
Gun	Lake	01-0099-00	North	2B, 3C	Nutrients	2020
Fleming	Lake	01-0105-00	North	2B, 3C	Nutrients	2010
Elm Island	Lake	01-0123-00	North	2B, 3C	Nutrients	2010
Ripple	Lake	01-0146-00	North	2B, 3C	Nutrients	2020
Crow Wing	Lake	18-0155-00	Central	2B, 3C	Nutrients	2010
Sebie	Lake	18-0161-00	Central	2B, 3C	Nutrients	2020
Fawn	Lake	18-0240-00	North	2B, 3C	Nutrients	2020
Lower Mission	Lake	18-0243-00	North	2B, 3C	Nutrients	2020
Trace	Lake	77-0009-00	South	2B, 3C	Nutrients	2008
Big Swan	Lake	77-0023-00	South	2B, 3C	Nutrients	2010
Moose	Lake	77-0026-00	South	2B, 3C	Nutrients	2020

Several impairments are not addressed in the MRBW TMDL study. Unaddressed impairments are listed in Table 8. Impaired waterbodies that are not addressed in this TMDL include eight impaired lakes and 13 stream reaches. Waterbodies not addressed in the TMDL either lack sufficient data to adequately develop a TMDL, biological impairments are not tied to pollutant stressors, or impairments are due to natural background causes.

Table 8. Water quality impairments on the 2018 303(d) list that are not addressed in the TMDL report completed as part of this project.

Name	Lake/ Stream	ID	Management Zone	Proposed Use Subclass	Impairment Causes not Addressed
Mississippi River	Stream	07010104-655	North	2Bg, 3C	TSS
Mississippi River	Stream	07010104-656	North/Central	2Bg, 3C	TSS
Mississippi River	Stream	07010104-657	Central	2Bg, 3C	TSS
Mississippi River	Stream	07010104-658	Central/South	2Bg, 3C	TSS
Swan River	Stream	07010104-502	South	2Bg, 3C	Dissolved Oxygen
Pike Creek	Stream	07010104-522	South	2Bg, 3C	Dissolved Oxygen
Rice River	Stream	07010104-505	North	2Bg, 3C	Fish, Dissolved Oxygen
Rice River	Stream	07010104-649	North	2Bg, 3C	Fish, Dissolved Oxygen, *E. coli*
Sisabagamah Creek	Stream	07010104-677	North	4C	Fish, Dissolved Oxygen
Rabbit Creek	Stream	07010104-688	North	4C	Fish
Little Willow River Old Channel	Stream	07010104-701	North	4C	Fish
Unnamed creek (Unnamed Ditch to Miss. River)	Stream	07010104-681	Central	4C	Fish
Little Swan River	Stream	07010104-570	South	2Bg, 3C	Fish
Portage	Lake	01-0069-00	North	2B, 3C	Nutrients
Waukenabo	Lake	01-0136-00	North	2B, 3C	Nutrients, Mercury in Fish Tissue
Esquagamah	Lake	01-0147-00	North	2B, 3C	Nutrients, Mercury in Fish Tissue
Blind	Lake	01-0188-00	North	2B, 3C	Nutrients, Mercury in Fish Tissue
Casey	Lake	18-0087-00	North	2B, 3C	Nutrients
Grave	Lake	18-0110-00	Central	2B, 3C	Nutrients
Upper Dean	Lake	18-0170-00	North	2B, 3C	Nutrients, Mercury in Fish Tissue
Green Prairie Fish	Lake	49-0035-00	South	2B, 3C	Fish
Gun	Lake	01-0099-00	North	2B, 3C	Mercury in Fish Tissue
Elm Island	Lake	01-0123-00	North	2B, 3C	Mercury in Fish Tissue
Ripple	Lake	01-0146-00	North	2B, 3C	Mercury in Fish Tissue
Crow Wing	Lake	18-0155-00	Central	2B, 3C	Mercury in Fish Tissue
Sebie	Lake	18-0161-00	Central	2B, 3C	Mercury in Fish Tissue
Big Swan	Lake	77-0023-00	South	2B, 3C	Mercury in Fish Tissue

Completed *E. coli* TMDLs

Load duration curves (LDCs), or the allowable daily *E. coli* loads under a wide range of flow conditions, were used to represent each impaired reach's *E. coli* loading capacity and allocations. This approach results in a flow-variable target that considers the entire flow regime within the time period of interest. Five flow intervals were developed for each reach, and the loading capacity and allocations were developed for each flow interval. The five resulting flow intervals were very high (0% to 10%), high (10% to 40%), mid (40% to 60%), low (60% to 90%), and very low (90% to 100%) in adherence to guidance

provided by the EPA [2007]. The eight *E. coli* impairments (Reaches 502, 521, 522, 626, 627, 629, 645, and 695) were addressed as part of the TMDL studies. Reductions across the five flow zones for each reach are presented in Table 9. Based on the geometric mean of available data, reductions are needed for Reach 502 in the mid-flow zone; for Reach 521 in the very-high-, low-, and very-low-flow zones; for Reach 522 in the high-, mid-, and low-flow zones; for Reach 626 in the low- and very-low-flow zones; for Reach 627 in the high-, low-, and very-low-flow zones; for Reach 629 in the mid-, low-, and very-low-flow zones; for Reach 645 in the high-flow zone; and for Reach 695 in the very-high-, high-, and mid-flow zones. The percent load reductions needed to meet the loading capacity in each flow interval provide the overall magnitude of the required reductions. Reduction magnitudes also help to focus future management actions; if higher reductions are needed in a certain flow interval, management practices should focus on the sources that most likely influence concentrations in those flow conditions. Exceedances of the *E. coli* target during high flows are typically caused by larger, area-induced, indirect pollutant sources that reach surface waters through watershed runoff. Low-flow exceedances are typically caused by direct pollutant loads or sources near the stream, such as direct defecation by wildlife or livestock in the stream channel or septic system failures [EPA 2007].

Table 9. Required *E. coli* reductions by flow zone as determined from the TMDL studies.

	Flow Zone				
Stream ID	Very High (%)	High (%)	Mid (%)	Low (%)	Very Low (%)
Swan River -502	(a)	0	12	0	(a)
Little Elk River -521	52	0	0	53	15
Pike Creek -522	(a)	87	93	79	(a)
Unnamed Creek (Headwaters to Big Swan Lk) -626	0	0	0	82	30
Schwanke Creek -627	(a)	57	0	66	79
Unnamed Creek (Long Lake to Big Swan Lake) -629	(a)	0	68	57	48
Hay Creek -645	(a)	10	0	(a)	(a)
Little Buffalo Creek -695	6	58	85	0	(a)

(a) No data available to calculate current load

Completed aquatic macroinvertebrate TMDLs

The SID Study [MPCA 2019(a)] found that the main stressors in Sisabagamah Creek (Reach 659) are a lack of habitat caused by flow alteration and the amount of sediment coming into the stream from stream bank instability and nonvegetated ditch banks; the study also found that TSS is a stressor to the creek's macroinvertebrates. TSS contributions generally increase because of flow alteration and stream bank instability, and high concentrations of TSS decrease the likelihood of a good instream macroinvertebrate habitat. Therefore, TSS was used a surrogate to address the MIBI impairment in Sisabagamah Creek (Reach 659). In addition, in the tributary to Sand Creek (Reach 679), the study discovered that the main stressor is elevated nutrients and low levels of DO, along with poor habitat. Because elevated nutrients are listed as a main stressor and they lead to low levels of DO, total phosphorus was used as a surrogate to address the MIBI impairment in the unnamed tributary to Sand

Creek (Reach 679). The two impaired aquatic macroinvertebrate bioassessment streams addressed in this TMDL did not have continuous flow data available. The model-simulated flow is available for the TMDL time period (2006 through 2015), but no observed data are available during this time period. Applicable observed data are available in Reach 659 for 2016 (TSS) and Reach 679 for 2017 (DO).

For the TSS invertebrate TMDL in Sisabagamah Creek the LDC approach was used. LDCs represent the allowable daily load under a wide range of flow conditions and were used to represent the loading capacity and allocations of each impaired reach. This approach results in a flow-variable target that considers the entire flow regime within the time period of interest. Five flow intervals were developed for each reach, and the loading capacity and allocations were developed for each flow interval. The five flow intervals were very high (0% to 10%), high (10% to 40%), mid (40% to 60%), low (60% to 90%), and very low (90% to 100%) in adherence to guidance provided by the EPA [2007]. Current loads for the Sisabagamah TSS TMDL were calculated using the median flow in each flow zone and the simulated 95th percentile TSS concentration in each flow zone, and the percent load reduction needed to meet the loading capacity in each flow interval was calculated to provide the magnitude of the required reductions at different flows. Reduction magnitudes by flow help to focus future management actions; if higher reductions are needed in a certain flow interval, management practices should focus on the sources that most likely influence concentrations in those flow conditions. Exceedances of the TMDL target during higher flows are typically caused by storm-related washoff or high-flow related instream/near-stream erosion and scour (bed and bank loads). Low-flow exceedances are more likely to be caused by direct pollutant loads or sources near the stream [EPA 2007]. In the Sisabagamah Creek TSS TMDL table, reductions are needed during high flows that lead to the impairment of the macroinvertebrates. Overall, observed data collected during 2016 are in agreeance with model results, showing 1 of 11 samples exceeding 15 milligrams per liter (mg/L) TSS. The implementation for the TSS improvements should focus on the high-flow sediment contributions. Reductions across the five flow zones for Reach 659 are presented in Table 10.

Table 10. Required TSS reductions by flow zone as determined from the TMDL studies.

Stream ID	Pollutant	Flow Zone				
		Very High (%)	High (%)	Mid (%)	Low (%)	Very Low (%)
Sisabagamah Creek -659	TSS	10	0	0	0	0

Because the standard for TP is based on the growing season average, the overall loading capacity was calculated using the simulated median growing season flow and the simulated mean growing season concentration, and the overall percent load reduction needed was calculated. The overall phosphorus reduction required in the unnamed tributary to Sand Creek is 40% and is shown in Table 11.

Table 11. Required TP reductions for median flow zone as determined from the TMDL studies.

Stream ID	Pollutant	Reduction Required (%)
Unnamed Creek (Trib to Sand Cr) -679	TP	40

Completed Lake Nutrient TMDLs

The loading capacity for impaired lakes was determined by using calibrated BATHTUB models based on HSPF loads and the growing season monitored mean values for TP, chlorophyll-a, and Secchi disk from 2006 to 2015. The allowable loading capacity (or the TMDL) is defined as the maximum allowable pollutant load that will allow water quality standards to be met. Loading capacities were defined by using the calibrated BATHTUB models and reducing source loads until the appropriate standards for each lake were achieved. The 11 nutrient (TP) impairments (Trace, Big Swan, Crow Wing, Elm Island, Fawn, Fleming, Gun, Lower Mission, Moose, Ripple, and Sebie lakes) were addressed as part of the TMDL studies. The reductions required to achieve lake standards are listed in Table 12 and range from 15% in Gun Lake to 66% in Fawn Lake. Sequential improvement of water quality will be realized for lakes in series (i.e., joined or in close proximity), as noted for Elm Island/Ripple lakes and Trace/Big Swan lakes. Of the three shallow lakes, only Trace Lake is located in an ecoregion (North Central Hardwood Forest) that has a specific shallow lake standard. Although Fleming and Fawn lakes do not have a specific shallow lake standard, they are grouped as shallow lakes in the TMDL tables.

Table 12. Required TP reductions for each impaired lake as determined from the TMDL studies.

Lake/Type Required TMDL Reductions		
Lake Name	**Lake ID**	**(%)**
Shallow Lakes		
Trace	77-0009-00	46
Fleming	01-0105-00	64
Fawn	18-0240-00	66
Deep Lakes		
Big Swan	77-0023-00	31
Crow Wing	18-0155-00	41
Elm Island	01-0123-00	56
Gun	01-0099-00	15
Lower Mission	18-0243-00	53
Moose	77-0026-00	37
Ripple	01-0146-00	27
Sebie	18-0161-00	46

2.5 Protection considerations

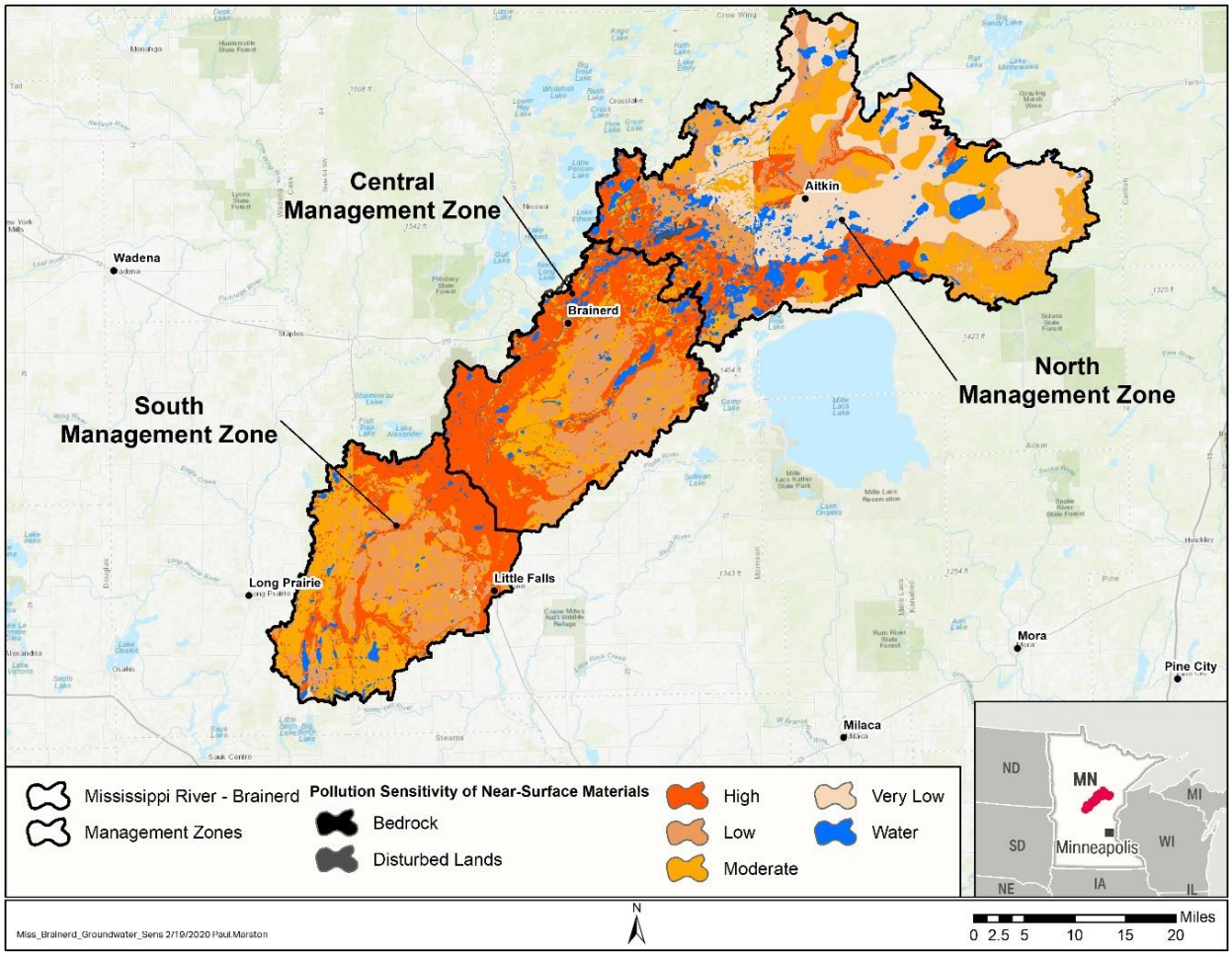
The MRBW has many high-quality water resources; as such, it is important that efforts are taken to protect these resources from future degradation. In addition to protecting high-quality waterbodies from degradation for the recreational and economic benefits they bring to the area, protecting these resources is a more cost-effective approach to maintaining high-quality water resources throughout the watershed compared to restoring impaired waters. Prioritization of specific waterbodies and protection targets are explained in further detail in Section 3.1, but watershed-wide considerations are addressed below.

Hydrogeology/Groundwater

The surficial and bedrock geology of the MRBW is largely associated with the Des Moines and Rainy ice lobe glaciation, and post-glacial alterations including soil formation and peat accumulation. As a result of past glaciations, the depth to bedrock ranges from exposed at the surface to 430 feet buried below glacial lake sediment, lake modified till, moraines, mine workings, peat, outwash, and alluvium. The MRBW is located primarily in the Central Groundwater Province with one minor area with Cretaceous bedrock in the northeast region. The Central Province has sand aquifers in thick sandy and clayey glacial drift [DNR 2001]. The Cretaceous bedrock consists of layers of sandstone that are interbedded with thick layers of shale, located between older bedrock and glacial drift, and often used as local water sources [DNR 2001]. The Central Province has good groundwater availability in the surficial sands, moderate availability in the buried sands, and limited availability within the bedrock [DNR 2001; DNR 2018].

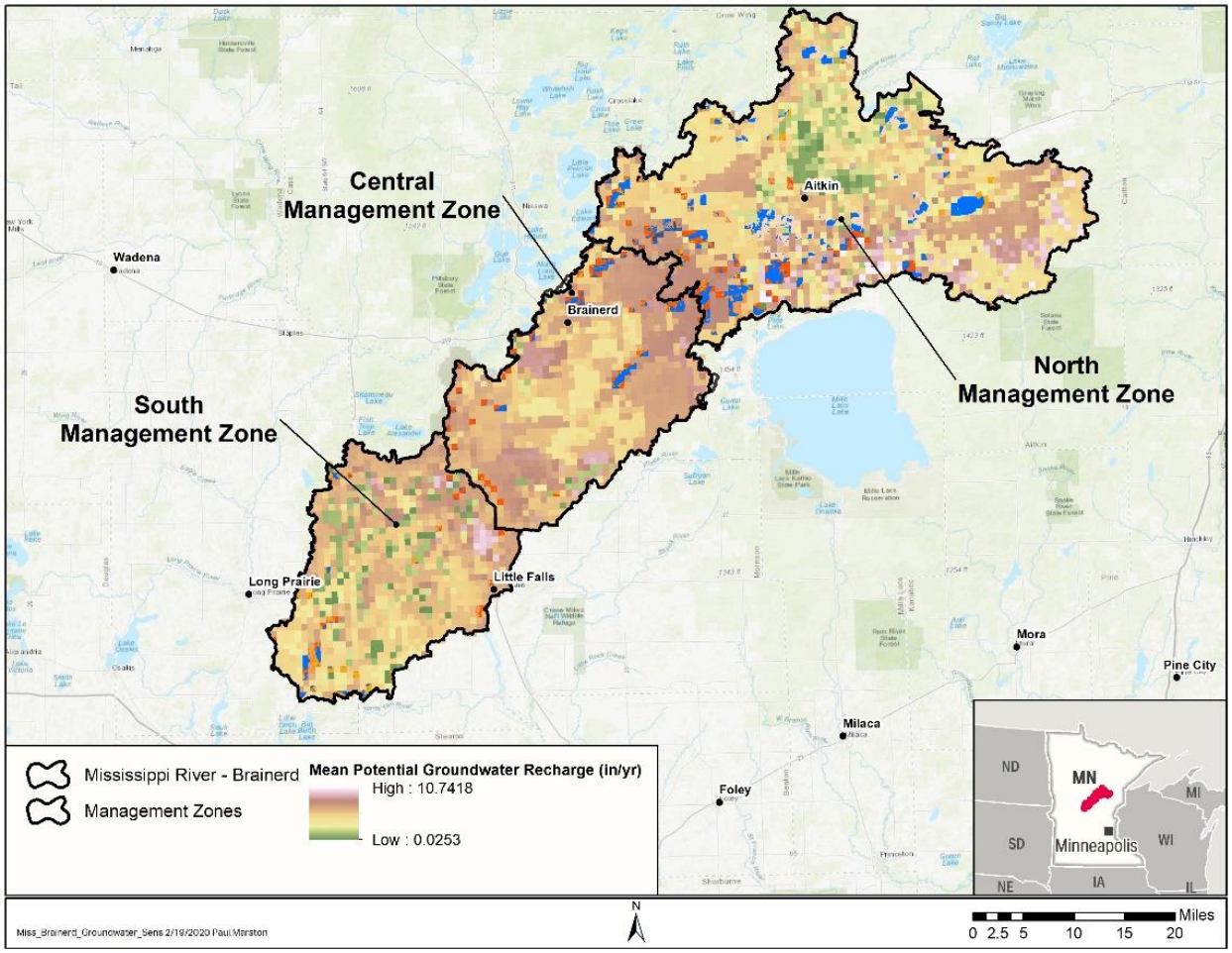
Aquifer sensitivity is dependent on depth of the aquifer and overlay material, among other factors. The DNR conducted a statewide evaluation of pollution sensitivity of near-surface materials to estimate pollution vulnerability up to 10 feet from the land surface. Based on this analysis, the MRBW is estimated to overall have a very low to moderate pollutant sensitivity, with some areas of high pollution sensitivity (Figure 5).

Figure 5. Pollution sensitivity of near-surface materials for the MRBW.



Groundwater recharge is an important component of the overall water budget and the relationship between surface water and groundwater quality and quantity. The MPCA contracted the USGS to develop a statewide estimate of recharge using the Soil-Water-Balance (SWB) code. The result of this analysis was a gridded based recharge estimate. The full report and data can be found at: https://gisdata.mn.gov/dataset/geos-gw-recharge-1996-2010-mean. In the MRBW, the average annual potential recharge rate to surficial minerals ranges from 0.03 to 10.74 inches per year (Figure 6), with an average of 5.08 inches per year. The statewide potential recharge is estimated to be 4 inches per year; therefore, the MRBW receives roughly an inch greater average potential recharge per year.

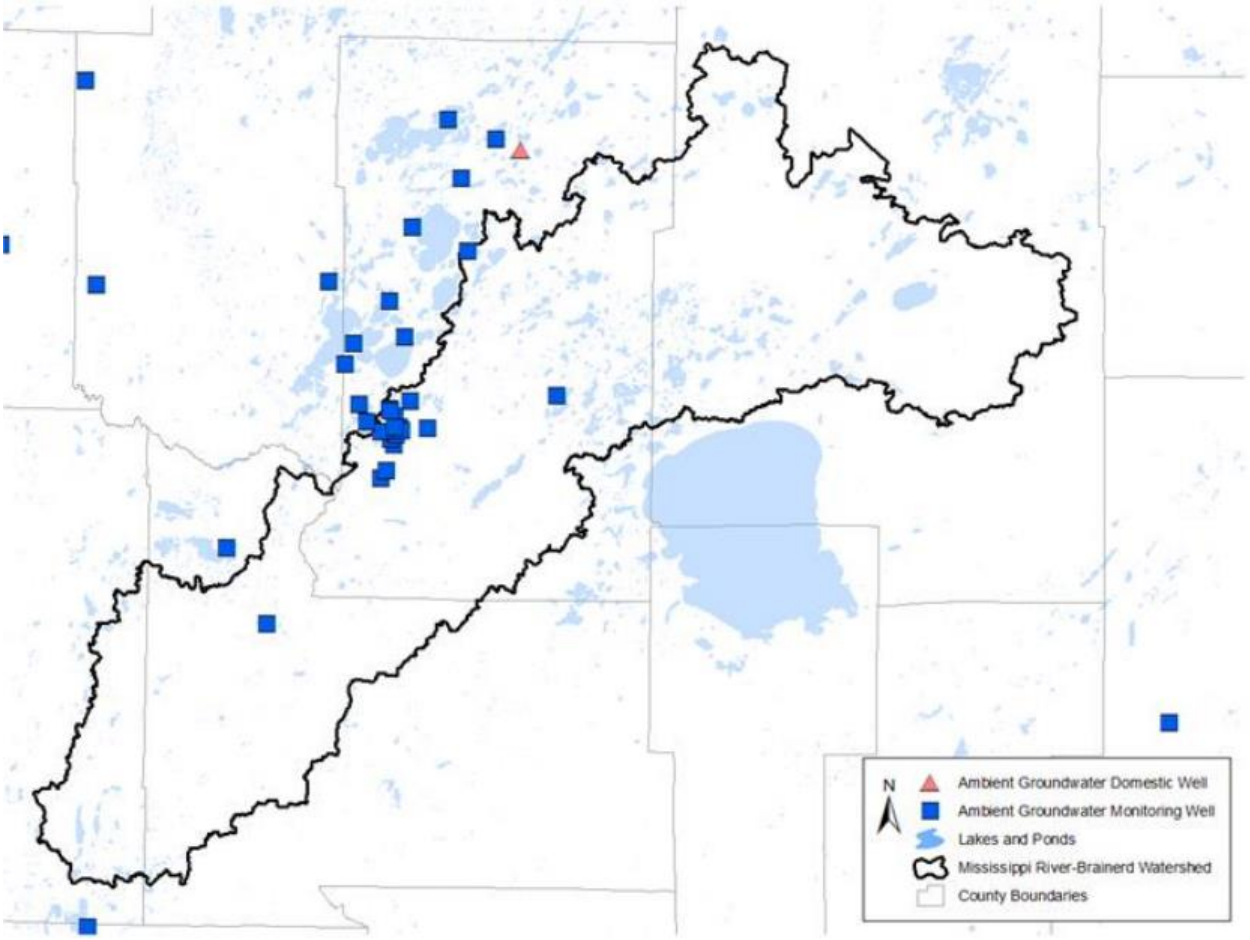
Figure 6. Average annual potential recharge rate to surficial materials in the MRBW.



Groundwater is a vital source of drinking water, providing 75% of Minnesota's population with their drinking water. In the MRBW, all drinking water is from groundwater. The MPCA's Ambient Groundwater Monitoring Program monitors trends in groundwater quality by sampling for a wide range of chemicals, including nutrients, metals, and volatile organic compounds. There are 20 MPCA ambient groundwater monitoring wells within the MRBW with data from 2004 to 2018 (Figure 7). Overall, the monitoring results show that a majority of the analytes detected are naturally occurring and cause no harm. There were 49 exceedances of a water quality standard. These exceedances included manganese (17.7%), perfluorooctane sulfonate (PFOS) (10.0%), iron (8.6%), aluminum (6.6%), perfluorohexane sulfonate (PFHxS) (5.0%), inorganic nitrogen (1.4%), and chloride (0.7%). For a detailed analysis of the

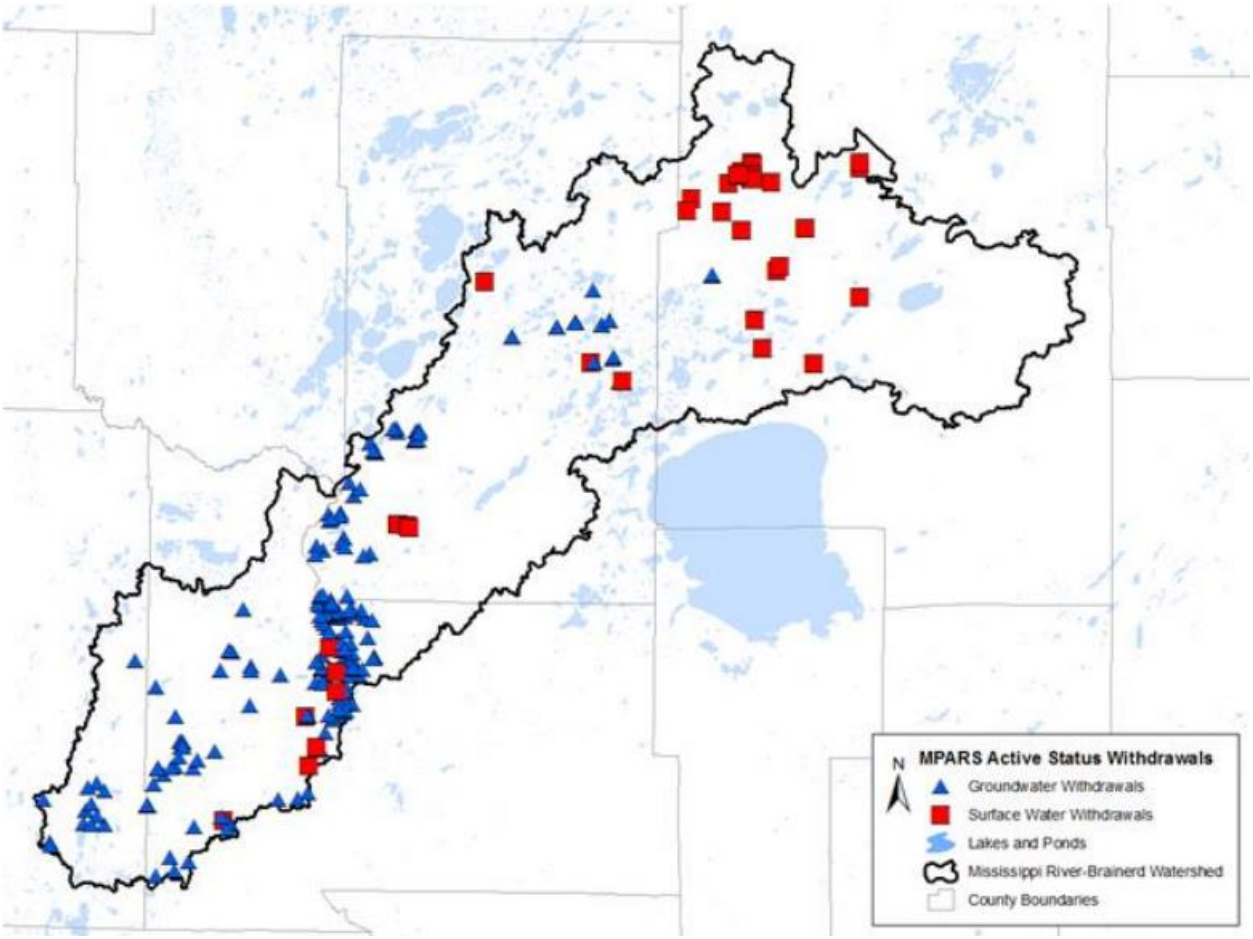
sources of each of these pollutants and their health impacts, see the MRBW Monitoring and Assessment Report: https://www.pca.state.mn.us/sites/default/files/wq-ws3-07010104b.pdf.

Figure 7. MPCA ambient groundwater monitoring well locations in the MRBW.



Groundwater quantity is managed and permitted by the DNR, which tracks water use as reported by permit holders. The three largest permitted consumers of water in the state are (in order) power generation, public water supply (municipals), and irrigation [DNR 2018]. In 2016, the DNR Permitting and Reporting System (MPRAS) showed that in the MRBW, withdrawals were used for agricultural irrigation (53.4%) followed by water supply (39.1%). The remaining withdrawals include noncrop irrigation (3.5%), water level maintenance (2.3%), industrial processing (1.2%), and special categories (0.4%). Locations of the high capacity withdrawals with active permit status as of 2016 which report to MPRAS is shown in Figure 8. During 1997 to 2016, groundwater withdrawals within the MRBW appear to be increasing, but not at a significant rate, while surface water withdrawals exhibit a significant decreasing rate. For a more detailed analysis of the hydrogeology/groundwater in the MRBW, see the MRBW Monitoring and Assessment Report.

Figure 8. Locations of active status permitted high capacity withdrawals in 2016 within the MRBW.



Forest resource protection

The largest single land cover in the MRBW is forests, which make up approximately 33% of the total area. Forests provide a number of water quality benefits; as such, it is important to maintain and manage the forests throughout the MRBW. The Minnesota Forest Resource Council's (MFRC) North Central Landscape Plan provides a watershed framework for sustainable forest use. While the entire MRBW does not fall within the North Central Landscape, all of the north management zone and much of the central management zone do.

The "Lake Based Watershed Approaches" section of Section 9-A of the plan (https://mn.gov/frc/docs/NC_Landscape_Plan.pdf) provides guidance on prioritization based on lakeshed land cover:

"Modeling of over 1300 lakes by the Minnesota DNR Fisheries Research Unit has revealed that phosphorus concentrations in lakes are directly related to land use disturbance in the watershed. Phosphorus concentrations become elevated when land use disturbance reaches 25% of a lake's watershed and are greatly elevated when land use disturbances exceed 60%. These thresholds set the foundation for identifying appropriate water quality management strategies for lakes. Lakes with relatively undisturbed watersheds need protection, while lakes with heavily disturbed watersheds need restoration. Many watersheds in the forested ecoregions of Minnesota are protected by public

ownership (federal, state, and county). Lakes in the northern part of the state benefit from extensive public holdings within the Superior and Chippewa National Forests, state forests, state and national parks, state and federal wildlife areas and county lands. Lands in public ownership are usually maintained with relatively undisturbed land cover, including forests, grasslands, and wetlands. Lakes with undisturbed watersheds, with high levels of protection, should maintain good water quality. Considerably less public land exists in the southern, agricultural areas of the state. Using land use disturbance and protection status allows for the categorization and prioritization of lakes and their watersheds into a protection vs. restoration framework.

Vigilance: Lakes with watershed disturbances less than 25% and protection greater than 75% can be considered sufficiently protected. These lakes have the suggested approach of "vigilance" (keeping public lands protected in a forested land cover).

Protection: Lakes with watershed disturbances less than 25%, but levels of protection less than 75% are excellent candidates for protection efforts.

Full Restoration: Lakes with watersheds that have moderate levels of disturbance (25% to 60%) have realistic chances for full restoration of water quality.

Partial Restoration: Restoration of lakes with intensive urban and agricultural watersheds (greater than 60% disturbance) to natural levels may not be realistic. The suggested approach for these lakes is partial restoration of water quality that restores some degree of ecological integrity (e.g., reducing phosphorus 39 concentrations sufficiently to allow for the establishment of rooted aquatic vegetation in turbid, eutrophic prairie lakes to benefit fish habitat.)" [MFRC 2017]

Land cover change scenarios

Land cover change scenarios were developed to identify areas that are likely susceptible to impacts associated with expected future changes. To assess the impacts of likely future land cover changes in the MRBW, the SAM software and calibrated HSPF model were used. In total, five separate scenarios were developed and results were evaluated to determine the impacts to stream flow, TSS, TP, and TN. The five scenarios are detailed below and were developed based on feedback from project partners.

- Scenario 1: Increase population
  - 15% of forest and agriculture area converted to developed area around population centers (Brainerd, Aitkin, Crosby, Little Falls)
  - Increase septic loading by 15% in subwatersheds with explicitly modeled lakes to simulate increases in population around lakes.
- Scenario 2: Increase population with Minimal Impact Design Standards (MIDS)
  - Land cover changes from Scenario 1, with the adoption of MIDS on subwatersheds with increases in developed land cover.
- Scenario 3: Increased forest harvest
  - Convert 15% of mature forest to young forest, targeting subwatersheds with at least 45% of subwatershed area being mature forest.

- Scenario 4: Increase Agriculture
  - Convert 5% of forestland, grassland, and pasture/hay area to cropland area in subwatersheds with at least 15% of area being cropland.
- Scenario 5: Cumulative impacts of Scenarios 3 and 4 with implementation of best management practices (BMPs)
  - Forestry BMPs
    - Riparian Management Zones
    - Erosion Control Practices
  - Conservation easements
  - Nutrient management/Manure Management
  - Cover crops.

The results of the scenarios show that given the moderate changes to land cover, impacts are largely localized, with the largest impact to the watershed outlet on the Mississippi River being a 0.9% decrease in TP from Scenario 2. The largest increase in pollutants at the outlet of the watershed from the scenarios is a 0.7% increase in TP from Scenario 1. To assess the local impacts, an average was calculated of the percent change for flow, TSS, TP, and TN from the existing conditions. Only subwatersheds that had a land cover change simulated were included in the calculation. The average percent change for each pollutant for subwatersheds included in each scenario is summarized in Figure 9. Base HSPF loads for flow, TSS, TP, and TN are shown in Figure 10. A more detailed analysis of the impacts of each scenario is shown in Appendix C.

Figure 9. Average percent change of subwatersheds with land cover changes for each scenario.

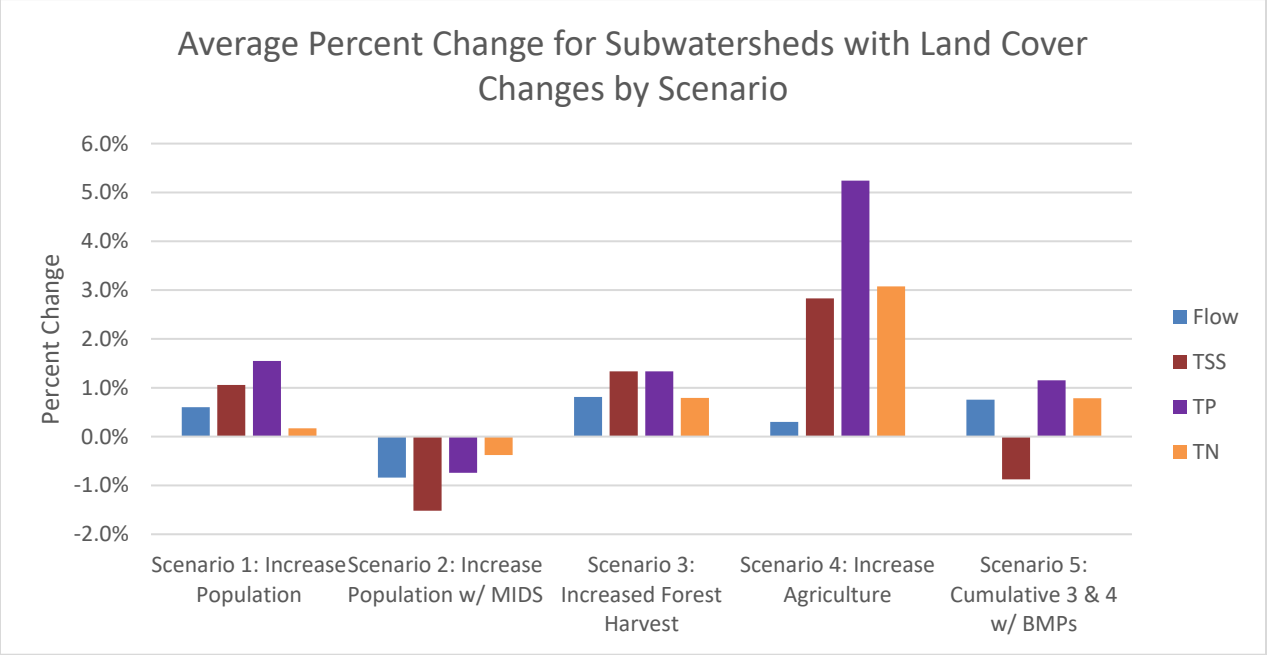
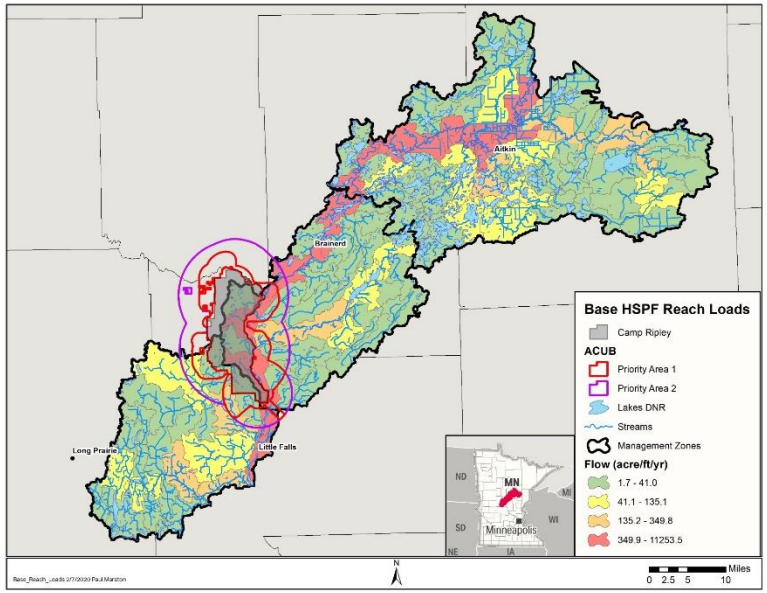
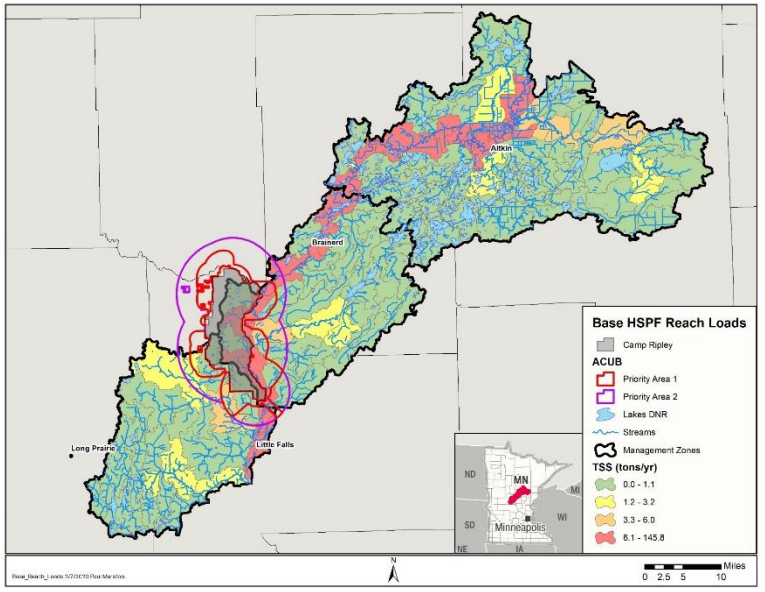
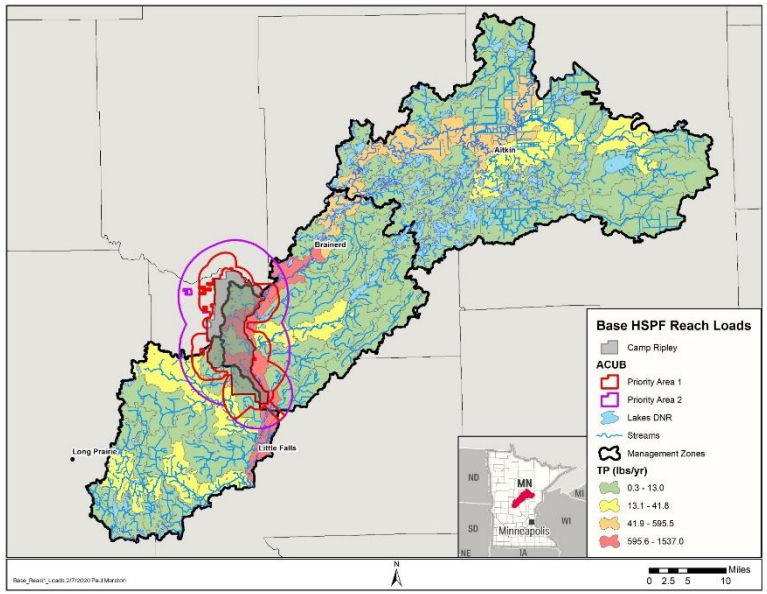
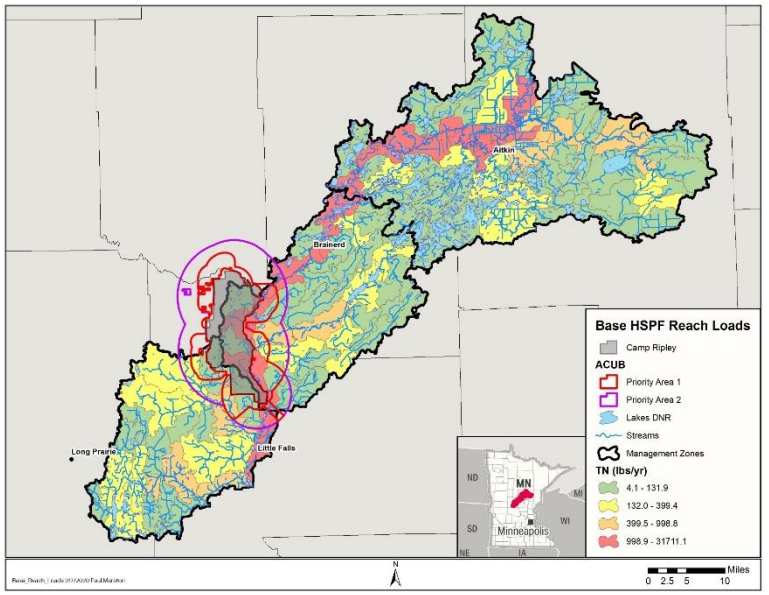


Figure 10. Base HSPF loads for Flow, TSS, TP, and TN.









High resource value waterbodies

It is important to protect high-quality resources such as lakes of outstanding biological significance, lakes supporting cisco populations, wild rice lakes, and trout lakes and streams. Further analysis of high resource value waterbodies is conducted in Section 3.1.

3. Prioritizing and implementing restoration and protection

The Clean Water Legacy Act (CWLA) requires that WRAPS reports summarize TMDLs, watershed modeling outputs and resulting pollutant LAs, and identify areas with high pollutant loading rates. In addition, the CWLA requires including strategies that are capable of cumulatively achieving needed pollution load reductions for point and nonpoint sources.

This section of the report provides the results of such prioritization and strategy development. Because many of the nonpoint source strategies outlined in this section rely on voluntary implementation by landowners, land users, and residents of the watershed, it is imperative to create social capital (trust, networks, and positive relationships) with those who will be needed to voluntarily implement BMPs. Thus, effective ongoing public participation and civic engagement is fully a part of the overall plan for moving forward.

Provided in this section are the result of watershed modeling efforts and professional judgment based on what is known at this time and, thus, should be considered approximate. Furthermore, many strategies are predicated on needed funding being secured. As such, the proposed actions outlined are subject to adaptive management—an iterative approach of implementation, evaluation, and course correction.

Certain issues are not addressed in the strategies tables, including the limited local capacity and funding that can greatly affect the outcomes of this report. If resources (e.g., staffing or funding) are limited or nonexistent in the project area, the strategies and goals laid out in this report will likely take longer to achieve. Much of this work relies on reductions from nonregulated actions in the watershed and, to achieve those goals, local relationships and trust need to be built where they may not currently exist. Therefore, as these actions are undertaken, all levels of government and landowners must continue to find ways to support local entities and individuals to ensure that the waterbodies in the MRBW are restored and protected. If this support does not happen, achieving the TMDL reductions and strategies in this report is very unlikely.

3.1 Targeting of geographic areas

The preferred prioritization approach identified by the MRBW project team (Aitkin SWCD, Crow Wing SWCD, Morrison SWCD, Todd SWCD, The Nature Conservancy, Camp Ripley, MPCA, DNR, and Board of Water and Soil Resources [BWSR]) was to summarize the relevant waterbody information and data to guide their selection of protection and restoration strategies. The overall focus of protection or restoration is defined for each of the three management zones, while case by case prioritization is left up to local water quality professionals who best understand resource limitations. To aid the selection of

which waterbodies to focus on, this section highlights the key information to consider when deciding between impaired waterbodies to restore and high-quality waterbodies to protect. The information to guide these decisions is provided in this section, with specific strategies provided by waterbody in the strategies table in Section 3.3.

North management zone

The north management zone is comprised of high-quality waterbodies, with a largely natural landscape of forest and wetlands with minimal stress from anthropogenic disturbances. The impairments in this management zone are mostly caused by natural causes, such as low DO water discharging from large wetland complexes following large rain events and fish connectivity issues. Thus, conservation efforts to protect the high-quality resources that are abundant in this region of the watershed are the focus for this zone.

Protection Priorities

Lakes

There are many high-quality lakes in the north management zone that require protection from future stressors. Through project team meetings a list of priority protection lakes was selected, which are shown in Table 16 and included in the strategies table. Given budget and time constraints, local water quality professionals will have to prioritize their protection efforts. A list of metrics, their descriptions, and values that are used to quantify the quality and susceptibility to degradation of each lake is provided in Table 13. The values for each of these metrics for priority lakes in the north management zone are provided in Table 14. Prioritization metrics for all lakes with data is in Appendix D. Local water quality professionals will use the information in Table 14 to select the priority lakes to focus their protection efforts on.

Streams

Similar to lakes, many high-quality streams are in the north management zone, and prioritization is needed to focus protection efforts. The MPCA and DNR have worked together to prioritize 25 streams in the MRBW that were found to be supportive of designated aquatic life uses. The goal of this prioritization exercise was to identify and prioritize streams that are (1) currently healthy but near the impairment threshold or (2) currently healthy and are indicating good water quality. For those streams that are currently healthy, further prioritization exercises were performed to identify watersheds that are largely protected versus those that are at risk for being developed. The stream protection and prioritization exercise identified two main landscape risks to biological condition, including (1) percent disturbed land and (2) density of roads. Each risk factor was assessed at two different scales, including the riparian scale (200-meter buffer on each side of stream) and the stream's watershed scale. The exercise then identified the amount of land in public ownership or permanent easement at both the riparian and watershed scales. Next, each stream was assessed to determine the number of communities (fish, macroinvertebrates, or both) that were near the impairment threshold. Each risk factor was assessed relative to a statewide database for fully supporting streams. The results of this

analysis are shown for each management zone in Table 15, Table 18, and Table 23. Because the north management zone is targeted for protection, all priority protection streams (Classes A through C) were included in the strategies table. In addition to these streams, the project team indicated they wanted all of the streams listed as impaired to be included for protection for nonimpaired constituents. A full list of the priority streams for protection in the north management zone is shown in Table 16.

Restoration priorities

Restoration efforts should focus on addressing the waterbodies that have had a completed TMDL study, have pollutant sources not attributed to natural causes, or are impaired but close to the water quality standard.

Lakes

Lakes with completed TMDL studies in the north management zone include Elm Island Lake, Fawn Lake, Fleming Lake, Gun Lake, Lower Mission Lake, and Ripple Lake for exceeding the nutrient/eutrophication standard. Restoration priorities for Fleming Lake and Gun Lake should be focused on consulting with the DNR for recommendations on restoring a healthy native vegetation population, and most lakes are candidates for reducing stormwater runoff from the lakeshed, septic system upgrades, shoreline management, and public outreach. Lakes that are impaired and near the water quality standard also provide opportunities to restore and delist. Gun Lake, Portage Lake, and Waukenabo Lake are all near the water quality standard and should be priorities for restoration to enable delisting from the impaired waters list. All priority restoration lakes included in the strategies table are shown in Table 16.

Streams

There is only one stream with a completed TMDL study in the north management zone, Sisabagamah Creek (-659), for the impaired macroinvertebrate community. The main stressors leading to the macroinvertebrate community impairment were identified as lack of habitat caused by flow alteration, bank instability, and TSS. Historical ditching in the area resulted in increases in drainage area and flow, which in conjunction with channel alterations near the airport west of CR54 have led to the channel destabilization, increased TSS during high flows, and streambed embeddedness that is impairing the local macroinvertebrate community. Stream restoration work should be a priority to address the stressors causing the macroinvertebrate community impairment in Sisabagamah Creek. Impaired streams with no TMDL study were also included as a priority for restoration in the north management zone, which are shown in Table 16 along with Sisabagamah Creek.

Priority waterbodies

Using the available information and local knowledge of the surface-water systems, the project team identified the waterbodies listed in Table 16 as priority waterbodies for protection and restoration in the north management zone.

Table 13. Metrics used to quantify the quality of each lake.

Metric	Metric Description	Value
Water Clarity Trend	Trends were calculated based on the Seasonal Kendall-Mann statistical analysis, completed on lakes with a minimum of 8 years of Secchi transparency, "Decreasing Trend" indicates water clarity trend shows a decrease in water clarity, "Increasing Tend" indicates water clarity is improving, "No evidence of trend" indicates there was not a statistically significant trend. A blank cell indicates there were not sufficient data to complete a trend analysis.	Decreasing Trend/Increasing Trend/No Evidence of Trend
Percent Disturbed Land Cover in Lakeshed	Proportion of land cover in the lake's immediate catchment composed of urban and row crop cultivated (based on the 2011 National Land Cover Dataset).	Percent of lakeshed area that is disturbed
LPSS Priority Class	Grouping of waterbodies was based on the lake phosphorus sensitivity significance priority score, which is a function of phosphorus sensitivity, lake size, lake total phosphorus concentration, proximity to PCA's phosphorus impairment thresholds, and watershed disturbance. Classes relate to the State's priority of focusing on "high quality, unimpaired lakes at greatest risk of becoming impaired."	High/Higher/Highest
LBCA Priority Class	Grouping of waterbodies was based on the lake benefit:cost assessment priority score, which is a function of phosphorus sensitivity, lake size, and catchment disturbance. Classes relate to the State's priority of focusing on "high quality, high value lakes that likely provide the greatest return on investment."	High/Higher/Highest
Lake of Biological Significance	Lakes were assigned one of three biological significance classes based on the presence of unique aquatic plants, fish, birds, and amphibians. Lakes with no values were not assessed.	Moderate/High/Outstanding
Cisco Refuge Lake	Deep, clear lakes identified by U of M and DNR that will be still be suitable for cisco after climate warming.	Yes/No (blank)
Near WQ Standard	The average TP is within 5 micrograms per liter (ug/L) of standard. Water quality data used to calculate average are from 2006 to 2018.	Yes/No (blank)
Protection Candidates Based on FIBI Score	Lakes that scored exceptionally high by the DNR FIBI analysis.	Yes/No (blank)
Lake Protection and Prioritization Rating	Lake protection and restoration priority as identified by the MPCA, DNR, and BWSR methods based on a lake's sensitivity to an increase in phosphorus, decline in water clarity, high percentage of developed land cover in area, and monitored phosphorus concentrations close to water quality standard.	A (highest), B, C (Lowest), Blank (not enough evidence)

Table 14. North management zone lake prioritization metrics.

Lake Name	Lake ID	Management Zone	Lake Acres	Watershed Acres	Mean TP (ug/L)	Mean Secchi (m)	Water Clarity Trend	Disturbed Land cover in Lakeshed (%)	LPSS Priority Class	LBCA Priority Class	Lake of Biological Significance	Cisco Refuge Lake	Near Water Quality Standard	Protection Candidates Based on FIBI Score	Lake Protection and Prioritization Rating
Bay	18-0034-00	North	2329.9	16970.4	12.8	4.0	Increasing trend	10	Highest	Highest				Yes	A
Cedar	01-0209-00	North	1725.8	26052.8	13.4	3.2	Decreasing trend	8	Highest	Highest	Outstanding	Yes		Yes	
Clearwater	18-0038-00	North	905.5	2504.1	18.5	4.0	Decreasing trend	8	Highest	Highest					A
Crooked	18-0041-00	North	462.7	1483.0	13.7	4.6	Increasing trend	13	Highest	Highest		Yes			
Farm Island	01-0159-00	North	2005.2	26566.6	20.1	3.3	No evidence of trend	10	Higher	Higher	Moderate				B
Lone	01-0125-00	North	433.5	1000.4	8.6	6.8	Decreasing trend	14	Highest	Highest					A
Nord	01-0117-00	North	418.2	1516.4	18.3	2.9	Decreasing trend	8	Highest	Higher					A
Portage	18-0050-00	North	286.8	3115.2	16.6	3.6	Increasing trend	6	Highest	Higher					A
Rabbit (East Portion)	18-0093-01	North	669.6	4826.0	13.4	3.8	Increasing trend	10	Highest	Highest				Yes	A
Rabbit (West Portion)	18-0093-02	North	535.9	4826.0	13.9	4.1	Increasing trend	10	Highest	Higher				Yes	A
Round	01-0137-00	North	634.0	1439.0	9.9	4.8	Decreasing trend	9	Highest	Highest					A
Serpent	18-0090-00	North	1116.3	6382.6	16.6	5.0	Decreasing trend	22	Highest	Highest					A
Sissabagamah	01-0129-00	North	405.8	5178.0	17.6	2.6		6	Higher	High					B
Spirit	01-0178-00	North	523.4	30315.8	13.2	3.8	Increasing trend	10	Higher	High	Outstanding				B
Wilkins	01-0102-00	North	348.9	1572.8	19.9	4.4	Increasing trend	7	Highest	Higher					A

Table 15. North management zone stream prioritization metrics.

AUID or Waterbody ID (WID)	Stream Name	Reach Length (mi)	Drainage Area (mi2)	TALU	AQL Vulnerable Designation ? (Y/N)	Cold/ Warm	Community Nearly Impaired	Riparian Risk	Watershed Risk	Current Protection Level	Protection Priority Rank	Protection Priority Class
07010104-536	Wakefield Brook	10.76	21.43206	general	N	warm	both	medium	medium	medium	6	A
07010104-660	Ripple River	5.9	124.6611	general	Y	warm	one	high	med/high	med/low	8	A
07010104-543	Unnamed ditch (French Lake to Rice River)	2.22	20.01246	general	N	warm	one	high	med/high	medium	9	A
07010104-697	Unnamed ditch (Blind Lake to Miss. River flood diversion channel)	5.52	18.85191	modified	N	warm	one	high	medium	medium	10	A
07010104-678	Dean Brook	2.91	28.55981	general	N	warm	one	med/high	med/low	medium	12	B
07010104-641	Cedar Creek	3.13	48.29848	general	N	warm	neither	high	med/high	medium	13.5	B
07010104-661	Ripple River	5.27	114.0484	general	N	warm	neither	med/high	med/high	med/low	13.5	B
07010104-666	Ripple River	2.26	77.47745	modified	N	warm	neither	medium	med/high	med/low	15	B
07010104-692	Rice River	10.65	190.7505	general	N	warm	one	low	med/low	med/high	16	B
07010104-693	Rice River	24.58	290.0003	general	N	warm	neither	medium	medium	medium	18	B
07010104-689	Little Willow River	11.96	47.76493	general	N	warm	neither	low	medium	med/high	22.5	C

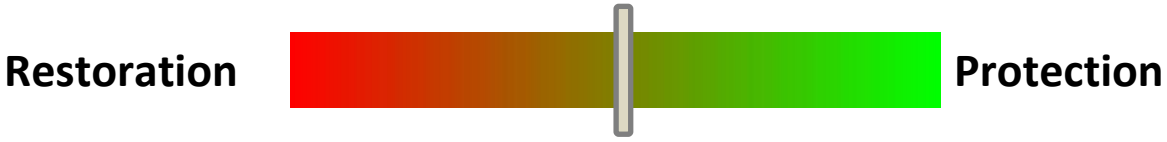
Table 16. Priority waterbodies for the north management zone.

Priority Focus	Lake/Stream	Name	ID
Protection	Lakes	Wilkins Lake	01-0102-00
		Lone Lake	01-0125-00
		Farm Island Lake	01-0159-00
		Spirit Lake	01-0178-00
		Bay Lake	18-0034-00
		Crooked Lake	18-0041-00
		Portage Lake	18-0050-00
		Nord Lake	01-0117-00
		Round Lake	01-0137-00
		Cedar Lake	01-0209-00
		Sissabagamah Lake	01-0129-00
		Serpent Lake	18-0090-00
		East and West Rabbit Lake	18-0093-00
		Clearwater Lake	18-0038-00
	Streams	Rice River	07010104-505
		Rice River	07010104-649
		Wakefield Brook	07010104-536
		Unnamed Ditch (French Lake to Rice River)	07010104-543
		Ripple River	07010104-660
		Little Willow River Old Channel	07010104-701
		Unnamed Ditch (Little Willow River Diversion)	07010104-691
		Unnamed Ditch (Blind Lake to Miss. River flood diversion channel)	07010104-697
		Sisabagamah Creek	07010104-659
		Sisabagamah Creek	07010104-677
		Rabbit Creek	07010104-688
		Rice River	07010104-692
		Rice River	07010104-693
		Ripple River	07010104-661
		Ripple River	07010104-666
		Little Willow River Old Channel	07010104-689
		Cedar Creek	07010104-641
		Dean Brook	07010104-678
Restoration	Lakes	Gun Lake	01-0099-00
		Fleming Lake	01-0105-00
		Portage Lake	01-0069-00
		Elm Island Lake	01-0123-00
		Ripple Lake	01-0146-00
		Waukenabo Lake	01-0136-00
		Esquagamah Lake	01-0147-00

Priority Focus	Lake/Stream	Name	ID
		Blind Lake	01-0188-00
		Casey Lake	18-0087-00
		Lower Mission Lake	18-0243-00
		Fawn Lake	18-0240-00
	Streams	Mississippi River	07010104-655 and -656
		Rice River	07010104-505
		Rice River	07010104-649
		Unnamed Ditch (Little Willow River Diversion)	07010104-691
		Sisabagamah Creek	07010104-659
		Sisabagamah Creek	07010104-677

Central management zone

The central management zone is unique as it is not dominated by any one distinct landscape, and is the transition zone from the heavily forested northeast region of the watershed to the agricultural southwest. The central management zone is also where the largest population center is located within the watershed. As such, the priority in this management zone is to balance protection of the high-quality water resources from future stresses and restore impaired resources.



Restoration priorities

There are three impaired lakes located in the central management zone (Crow Wing Lake, Sebie Lake, Grave Lake), two of which have had TMDL studies completed (Crow Wing Lake and Sebie Lake). In addition to the three lakes, there are a total of six impaired stream reaches with eight unique impairments in the central management zone. Of the eight impairments, three TMDL studies were completed, two for *E. coli* (Hay Creek -645 and Little Buffalo Creek -695) and one for macroinvertebrates (Unnamed Creek (Trib to Sand Cr) -679).

Lakes

Water quality information and likely pollutant sources for each impaired lake should be used when selecting which lake to focus restoration efforts on. Crow Wing Lake shows a decreasing water clarity trend and has an average TP of 38 ug/L, which is 8 ug/L above the water quality standard. Crow Wing Lake's shoreline is very developed and has a drainage area with more potential for restoration than other impaired lakes in this management zone. Sebie Lake also shows a decreasing water clarity trend and has an average TP of 43 ug/L, which is 13 ug/L above the water quality standard. The lakeshed area is primarily forest and wetland with some agriculture. Grave Lake shows an improving water clarity trend indicating improving water quality, but the average TP is 49.6 ug/L, which is 19.6 ug/L above the water quality standard. Restoring Grave Lake may be difficult as Grave Lake is shallow and is located in the Northern Lakes and Forests ecoregion, which does not have a separate standard for shallow lakes.

The tributary to Grave Lake, Hay Creek, is impaired and restoration efforts can be targeted to address both of the impairments. Additional challenges include low potential for improving runoff from the lakeshed, as the area around Grave Lake is primarily forest and wetland.

All of the priority restoration lakes included in the strategies table for the central management zone are shown in Table 19.

Streams

The TMDL study results, as well as pollutant source assessments, can inform stream restoration efforts in the central management zone.

Unnamed Creek (Trib to Sand Cr -679) has impaired macroinvertebrates, with the SID report identifying elevated nutrients, low DO, and channel instability resulting from a feedlot upstream of the biological monitoring site as causes of the impairment. Past discussions with this landowner should be leveraged to implement strategies to remove the cattle from the stream and manage pasture runoff and manure applications.

Hay Creek (-645) is impaired by *E. coli* and flows into the impaired Grave Lake. The TMDL study completed for Hay Creek indicates it is close to achieving the water quality standard, with a 10% reduction needed in the high-flow zone. This indicates the pollutant source is likely larger-scale, indirect sources rather than cattle access issues and direct runoff from feedlots adjacent to the stream. Three feedlots are located within the drainage area of Hay Creek that should be the focus of restoration efforts, which include pasture management and manure application/disposal improvements. Residences along Hay Creek can also be targeted for septic system improvements.

Little Buffalo Creek (-695) is impaired by *E. coli* and requires a more significant reduction with the TMDL study indicating up to an 85% reduction in the mid-flow zone.

Buffalo Creek flows directly through the east side of Brainerd and outlets into the Mississippi River. An extensive storm sewer system feeds the stream. Based on the TMDL study, reductions are called for the mid (85%), high (58%), and very high (6%) flow zones. This correlates with storm events contributing flows from the storm sewer system into the stream. Restoration efforts should be focused on addressing bacteria sources located in the drainage area feeding the storm sewer system. Strategies include BMPs that infiltrate stormwater and street sweeping, as well as domestic animal waste cleanup. There were no TMDL studies completed on the fish and macroinvertebrate impairments on Buffalo Creek, but the impairments are attributed to the flashy flows because of the storm sewers' contribution during rain events. Therefore, strategies that address the bacteria contributions from the urban areas draining to the storm sewer network should also include detention/retention to address the flashy flows.

Whiteley Creek (-589) has impaired invertebrates but was re-sampled late, which did not allow for it to be assessed as a part of the SID report. Whiteley Creek is a priority for protection/restoration, as it is home to a trout fishery and provides important recreational opportunities in this area.

NonTMDL study streams that have impairments include Unnamed Creek (Unnamed Ditch to Mississippi River -681) for fish and Buffalo Creek (-610) for macroinvertebrates. Strategies to address the fish impairment in Unnamed Creek (Unnamed Ditch to Mississippi River) should be focused on restoring connectivity by removing any fish barriers. Strategies to address the macroinvertebrate impairment in

Buffalo Creek (-610) should include improving floodplain access for high-flow events to address the identified stressors of flow alteration and bank instability.

All of the priority restoration streams included in the strategies table for the central management zone are shown in Table 19.

Protection priorities

There are a number of high-quality resources located in the central management zone that require protection efforts to avoid future degradation. Population growth and conversion of forest land to agriculture are the likely future stressors.

Streams

The Nokasippi River is a very high-quality resource that flows roughly 46.5 miles from its headwaters at Clearwater Lake to its outlet at the Mississippi River just north of Fort Ripley. Water quality data indicate TP values are nearing the limit for the eutrophication standards, particularly in the most downstream reach (-511), while DO and TSS values are still well above and below, respectively, their standards. It is important to focus on reducing nutrient loading to the Nokasippi by implementing BMPs throughout the drainage area. In addition to the Nokasippi, priority streams that have a protection priority class score of "A" identified by the DNR analysis described in the north management zone's priority protection streams section were included (Table 18). A complete list of the priority protection streams in the central management zone is shown in Table 19.

Lakes

The strategies table includes lakes identified as priority waterbodies for protection, which are shown in Table 19. These lakes were selected by project partners along with their associated strategies as priority lakes. Table 17 lists metrics that should be used by local professionals to prioritize protection efforts in the central management zone. These efforts will be based on their knowledge of these local systems and what is a priority based on available resources, past work, and local values.

Table 17. Central management zone lake prioritization metrics.

Lake Name	Lake ID	Management Zone	Lake Acres	Watershed Acres	Mean TP (ug/L)	Mean Secchi (m)	Water Clarity Trend	Disturbed Land cover > 40%	LPSS Priority Class	LBCA Priority Class	Lake of Biological Significance	Cisco Refuge Lake	Near Water Quality Standard	Protection Candidates Based on FIBI Score	Lake Protection and Prioritization Rating
Gilbert	18-0320-01	Central	356.6	5091.5	11.7	5.1	Decreasing trend	13%	Highest	Higher					A
Gilbert (West Bay)	18-0320-02	Central	57.2	5091.5	16.3	3.2	No evidence of trend	13%	Higher	High					B
Nokay	18-0104-00	Central	703.6	15792.9	20.9	2.8	No evidence of trend	7%	Higher	High				Yes	B
Rice	18-0145-00	Central	418.4	4485719.6	35.7	1.8		5%	High	High			Yes		C
Round	18-0147-00	Central	139.0	100332.6	52.3	1.3		12%	High	High			Yes		C
Sorenson	18-0323-00	Central	92.0	135.1	10.1	4.6	Increasing trend	13%	Highest	Higher					A
South Long	18-0136-00	Central	1309.1	49194.2	33.5	2.2	Increasing trend	11%	Higher	High			Yes		B
Upper South Long	18-0096-00	Central	804.3	39723.5	23.9	2.1	No evidence of trend	11%	Higher	High	Outstanding			Yes	B

Table 18. Central management zone stream prioritization metrics.

AUID or Waterbody ID (WID)	Stream Name	Reach Length (mi)	Drainage Area (mi2)	TALU	AQL Vulnerable Designation? (Y/N)	cold/ warm	Community Nearly Impaired	Riparian Risk	Watershed Risk	Current Protection Level	Protection Priority Rank	Protection Priority Class
07010104-589	Whiteley Creek	3.05	9.520561	General	N	cold	both	med/low	med/high	med/low	5.5	A
07010104-510	Nokasippi River	15.42	159.2669	General	N	warm	one	medium	med/high	low	9	A
07010104-511	Nokasippi River	9.28	193.3497	Exceptional	N	warm	one	medium	med/high	med/low	10	A
07010104-532	Little Nokasippi River	13.8	30.3882	General	N	warm	one	medium	med/high	med/low	10	A
07010104-580	Sand Creek	5.8	33.87825	General	N	warm	one	medium	medium	med/low	11	A
07010104-509	Nokasippi River	20.77	79.41589	General	N	warm	one	medium	medium	medium	12	B
07010104-534	Daggett Brook	22.48	51.74825	General	Y	warm	neither	med/high	med/high	low	12	B
07010104-699	Hay Creek	3.7	24.30545	General	N	warm	neither	med/low	med/high	low	15	B

Table 19. Priority waterbodies for the central management zone.

Priority Focus	Lake/Stream	Name	ID
Protection	Lakes	Sorenson Lake	18-0323-00
		Gilbert Lake	18-0320-00
		Rice Lake	18-0145-00
		Upper South Long Lake	18-0096-00
		Nokay Lake	18-0104-00
		Round Lake	18-0147-00
		South Long Lake	18-0136-00
	Streams	Whiteley Creek	07010104-589
		Nokasippi	07010104-510
		Nokasippi	07010104-511
		Little Nokasippi	07010104-532
		Sand Creek	07010104-580
Restoration	Lakes	Sebie Lake	18-0161-00
		Grave Lake	18-0110-00
		Crow Wing Lake	18-0155-00
	Streams	Mississippi River	07010104-656, -657, and -658
		Unnamed Creek (Trib to Sand Cr)	07010104-679
		Buffalo Creek	07010104-610
		Buffalo Creek (Little Buffalo Creek)	07010104-695
		Hay Creek	07010104-645
		Unnamed Creek (Unnamed Ditch to Miss. River)	07010104-681

Priority waterbodies

Using the available information and local knowledge of the surface water systems, the project team identified the waterbodies listed in Table 19 as priority waterbodies for protection and restoration.

South management zone

The south management zone is differentiated from the other two management zones because of the landscape largely consisting of agriculture, and the presence of a majority of the watershed's feedlots. As such, the overarching priority for this management zone is focusing efforts on restoration of the degraded waterbodies.

Restoration priorities

There is a total of 12 impairments on 10 stream reaches in the south management zone. Of the 12 impairments, 7 are caused by elevated levels of bacteria. TMDL studies were completed on six of the reaches impaired by *E. coli (*-502, -521, -522, -626, -627, -629). There are four impaired lakes located in the south management zone: three are exceeding the nutrient/eutrophication standard for total

phosphorus (Trace Lake, Big Swan Lake, and Moose Lake) and one is not supporting local fish communities (Green Prairie Fish Lake). TMDL studies were completed on the three lakes with nutrient impairments.

Streams

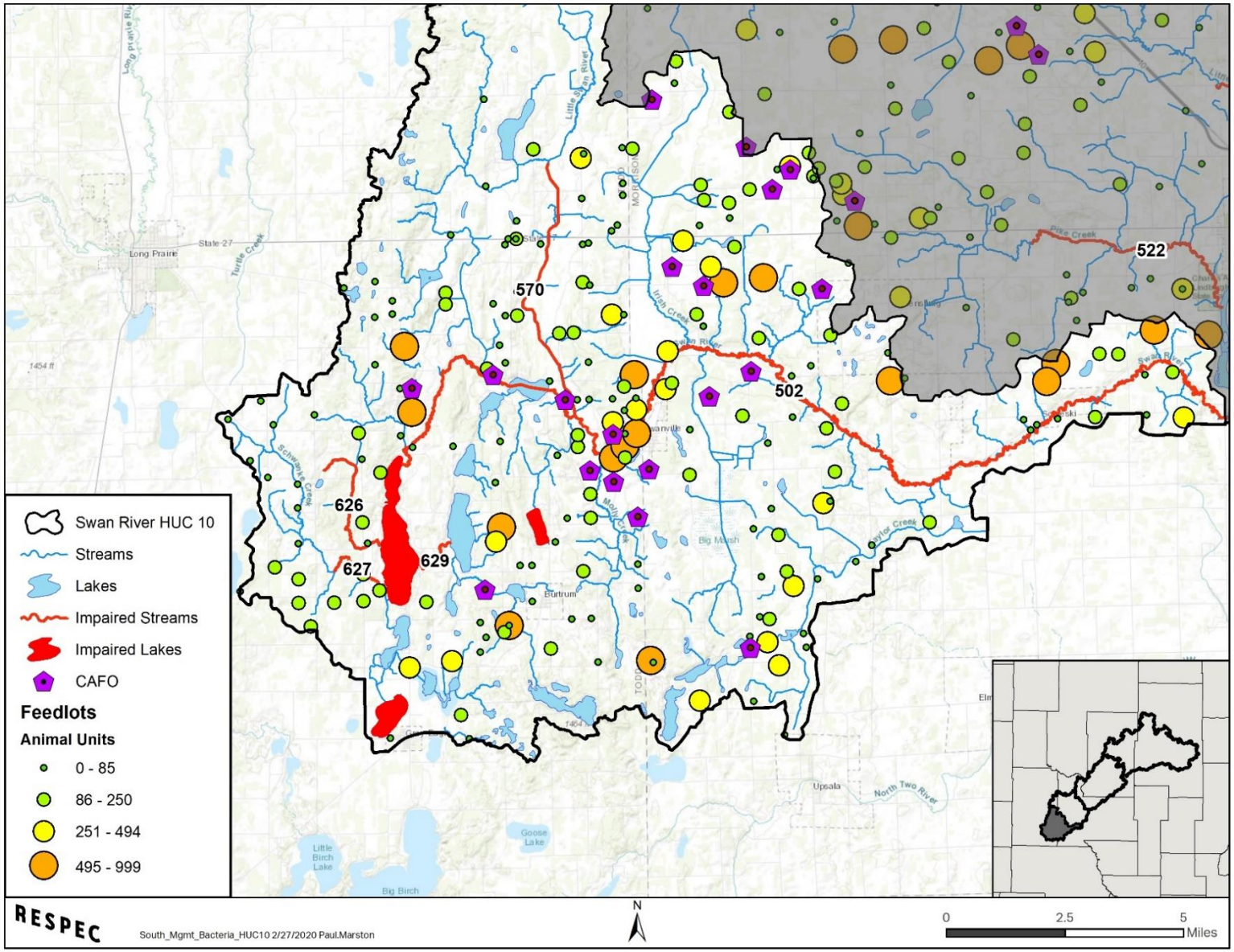
Elevated *E.coli* is the main source of impairments for streams in the south management zone. Bacteria sources include livestock, wildlife, humans, and pets. Because of the prevalence of feedlots in the south management zone, restoration efforts to address elevated bacteria levels should be focused around feedlots. Livestock contribute bacteria loads directly to streams by defecating in the stream and indirectly by defecating on cropland or pastures where bacteria can be washed off during precipitation events, snowmelt, or irrigation. Spreading livestock manure on cropland or pasture can also contribute bacteria to waterbodies. Therefore, limiting livestock access to streams and properly managing manure application rates and runoff is vital to addressing the bacteria impairments.

Restoration efforts to address bacteria impairments should be targeted based on AU count and proximity to streams. Table 20 provides the number of CAFOs, feedlots, and associated AUs that can be used to target specific HUC-10 subwatersheds. To highlight how to prioritize which feedlots to focus on, Figure 11 depicts the Swan River HUC-10 that has four reaches impaired by bacteria. This HUC-10 has several large feedlot operations and several CAFOs, but efforts to address the bacteria impairments in the upstream reaches (-626, -627, -629) should start with the smaller feedlots located right along the impaired reaches. While smaller, these feedlots are the most likely to be contributing bacteria directly via defecation in the stream, and indirectly from field runoff that livestock grazes and defecates on. For the impairment on Swan River (-502), larger feedlots and CAFOs should be the focus.

Table 20. HUC-10 feedlot and CAFO count.

HUC-10	HUC-10 Name	Management Zone	Impaired Reach Located in HUC-10	Number of CAFOs	Number of Feedlots	Total AUs
701010401	Rice River	North	07010104-649	1	26	1,512
701010402	Ripple River	North		0	14	673
701010403	Little Willow River	North		0	3	230
701010404	City of Aitkin-Mississippi River	North		0	31	1,877
701010405	City of Brainerd-Mississippi River	North/Central	07010104-695	0	18	612
701010406	Nokasippi River	North/Central	07010104-645	0	69	5,331
701010407	Little Elk River	South	07010104-682, 07010104-521	4	71	16,640
701010408	Swan River	South	07010104-626, 07010104-627, 07010104-629, 07010104-502, 07010104-570, 07010104-632	18	212	53,739
701010409	City of Little Falls-Mississippi River	South/Central	07010104-522, 07010104-684	1	56	10,698

Figure 11. Swan River HUC-10 feedlot locations.



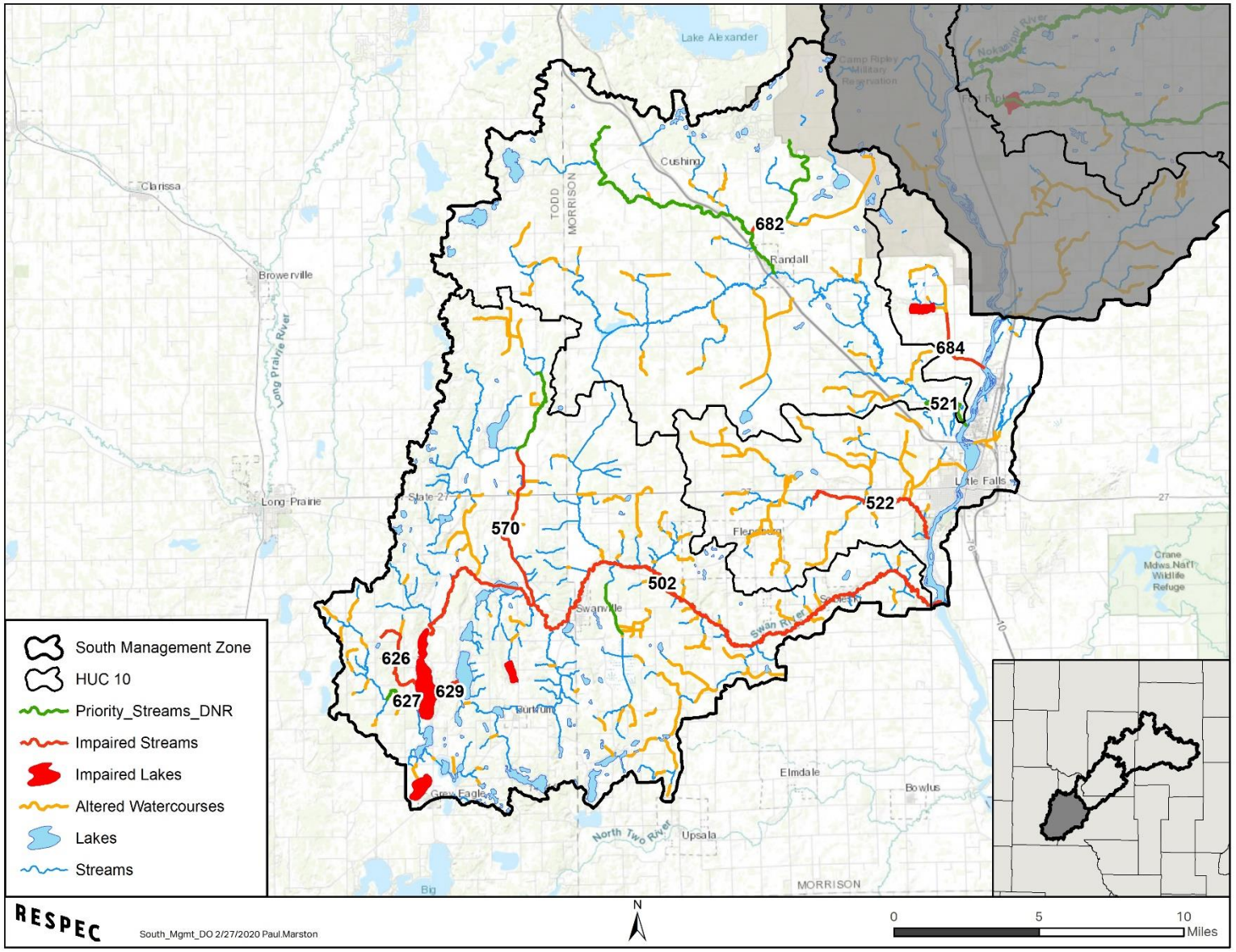
Existing work should also be leveraged to continue working toward achieving the water quality targets. The Swan River has had work done in the past by Morrison County; so have Unnamed Creek (Headwaters to Big Swan Lake -626), Schwanke Creek (-627), and Unnamed Creek (Long Lake to Big Swan Lake -629), where efforts by Todd County have been directed to better quantify the AUs present.

The remaining stream impairments are because of low DO and impaired biological communities. Per the SID report, low DO in this region of the watershed is largely caused by wetlands and ditching that has increased the amount of partially drained wetland acres that contribute low DO water during high-flow periods. Restoration efforts should be focused on addressing the ditching that contributes to the increase in wetland drainage. A summary of the amount of altered stream miles by HUC-10 is shown in Table 21 and Figure 12.

Table 21. South management zone altered watercourse summary by HUC-10.

HUC-10	HUC-10 Name	Impaired Reach	Miles of Altered Streams	Wetland Acres
701010407	Little Elk River	07010104-682, 07010104-521	29.8	26,326
701010408	Swan River	07010104-626, 07010104-627, 07010104-629, 07010104-502, 07010104-570, 07010104-632	67	28,503
701010409	City of Little Falls-Mississippi River	07010104-522, 07010104-684	40.8	10,470

Figure 12. South management zone altered watercourses.



Lakes

Trace Lake is a shallow lake northwest of the town of Grey Eagle. Strategies should focus on reducing stormwater runoff from the town, as well as nutrient contributions from agriculture located in the lakeshed. To meet the water quality standard, total phosphorus loads need to be reduced by 46%. Big Swan Lake is located downstream of Trace Lake. The drainage area of Big Swan Lake is largely agriculture; the lakeshore has areas of development, and curly-leaf pondweed is present. Strategies should focus on reducing nutrient loads from cropland in the drainage area, managing the aquatic vegetation to establish all native vegetation, reduce runoff from shoreland properties, and stabilize the shoreland with buffers. Moose Lake is a headwaters lake with a small lakeshed. Within the lakeshed there are areas of agriculture, wetlands, forests, and lakeshore residences. Moose Lake also has an infestation of curly-leaf pondweed. Similar to other lakes in this management zone, strategies should be targeted to reduce nutrient loading from cropland areas, manage lake vegetation to establish native plant species, and establish shoreland buffers and stabilization.

Protection priorities

Protection efforts in the south management zone should focus on waterbodies that are not yet impaired, but close to or trending toward the water quality standard.

Streams

Priority streams that have a protection priority class score of “A” identified by the DNR analysis described in the north management zone’s priority protection streams section were included in the priority protection streams in the south management zone (Table 23). A complete list of the priority protection streams in the south management zone is shown in Table 24.

Lakes

To guide the selection of lakes to prioritize for protection efforts, Table 22 lists metrics that can be considered by local water quality professionals. The strategies table includes lakes identified as priority waterbodies for protection, which are shown in Table 24. These lakes were selected by project partners along with their associated strategies. The information provided in Table 22 can be used to guide implementation efforts within this group of priority lakes.

Table 22. South management zone lake prioritization metrics.

Lake Name	Lake ID	Management Zone	Lake Acres	Watershed Acres	Mean TP (ug/L)	Mean Secchi (m)	Water Clarity Trend	Disturbed Land cover > 40%	LPSS Priority Class	LBCA Priority Class	Lake of Biological Significance	Cisco Refuge Lake	Near Water Quality Standard	Protection Candidates Based on FIBI Score	Lake Protection and Prioritization Rating
Bass	77-0024-00	South	122.6	640.4	17.6	4.0		59%	Highest	Higher	Outstanding	Yes			A
Beauty	77-0035-00	South	240.1	1792.3	21.8	2.7	No evidence of trend	9%	Higher	High	Moderate				B
Big	77-0063-00	South	297.1	1629.2	22.1	2.3		11%	Higher	Higher					A
Lady	77-0032-00	South	176.5	4880.1	22.8	3.8		56%	Highest	Higher	Outstanding			Yes	A
Little Swan	77-0034-00	South	164.4	35603.9	21.4	3.1		43%	High	High	Outstanding				C
Long	77-0027-00	South	398.7	6822.2	24.1	3.6	Increasing trend	49%	Highest	Higher	High			Yes	A
Mound	77-0007-00	South	270.3	991.8	15.5	4.9	No evidence of trend	13%	Highest	Higher	Outstanding			Yes	A
Pine	49-0081-00	South	177.7	908.7	11.8	5.2	No evidence of trend	21%	Highest	Highest	High				A
Pine Island	77-0067-00	South	238.2	805.8	13.8	3.3	Increasing trend	20%	Highest	Highest	Outstanding			Yes	A

Table 23. South management zone stream prioritization metrics.

AUID or Waterbody ID (WID)	Stream Name	Reach Length (mi)	Drainage Area (mi^2)	TALU	AQL Vulnerable Designation? (Y/N)	cold/ warm	Community Nearly Impaired	Riparian Risk	Watershed Risk	Current Protection Level	Protection Priority Rank	Protection Priority Class
07010104-521	Little Elk River	2.55	148.5467	General	N	warm	neither	high	high	med/low	10.5	A
07010104-687	Little Swan River	3.89	10.88169	General	N	warm	one	med/low	medium	low	11	A
07010104-529	Little Elk River	13.48	63.80345	General	N	warm	neither	med/high	med/high	low	12	B
07010104-685	Unnamed creek (Trib to Swan River)	1.88	8.885539	Modified	N	warm	neither	medium	high	low	12	B

Table 24. Priority waterbodies for the south management zone.

Priority Focus	Lake/Stream	Name	ID
Protection	Lakes	Pine Island Lake	77-0067-00
		Big Lake	77-0063-00
		Little Swan Lake	77-0034-00
		Beauty Lake	77-0035-00
		Lady Lake	77-0032-00
		Long Lake	77-0027-00
		Mound Lake	77-0007-00
		Bass Lake	77-0024-00
		Pine Lake	49-0081-00
	Streams	Little Elk River	07010104-521
		Little Swan River	07010104-687
Restoration	Lakes	Trace Lake	77-0009-00
		Big Swan Lake	77-0023-00
		Moose Lake	77-0026-00
		Green Prairie Fish Lake	49-0035-00
	Streams	Little Elk River	07010104-521
		Hay Creek	07010104-682
		Schwanke Creek	07010104-627
		Unnamed Creek (Headwaters to Big Swan Lk)	07010104-626
		Unnamed Creek (Long Lake to Big Swan Lake)	07010104-629
		Swan River	07010104-502
		Little Swan River	07010104-570
		Unnamed Creek (Headwaters to Long Lake)	07010104-632
		Pike Creek	07010104-522
		Unnamed Creek (Green Prairie Fish Lake to Miss. River)	07010104-684

Priority waterbodies

Using the available information and local knowledge of the surface-water systems, the project team identified the waterbodies listed in Table 24 above as priority waterbodies for protection and restoration.

3.2 Public Participation

Accomplishments and future plans

Efforts to facilitate public education, review, and comment when developing the MRBW WRAPS/TMDL included meetings with local groups in the watershed on the assessment findings and a 30-day public notice period for public review of and comment on the draft TMDL and WRAPS documents. All input,

comments, responses, and suggestions from public meetings and the public notice period were addressed or were taken into consideration in developing the TMDL and WRAPS. The draft TMDL report was made available via public notice in the State Register from June 1, 2020, through July 1, 2020. Regular updates regarding the TMDL process with the MRBW WRAPS team included meetings to discuss TMDL processes and results. Public and team meetings are listed below:

- A project kickoff meeting was held with the project team on May 19, 2016.
- Project team meetings were held on June 24, 2015, March 20, 2016, October 19, 2016, March 29, 2017, January 31, 2018, June 20, 2018, and March 7, 2019 to discuss the project timeline, methods, and TMDL segments to be addressed.
- Project team meetings were held on July 17, 2019, and December 19, 2019 to discuss the prioritization approach and priority waterbody protection and restoration strategies.
- Public meetings to discuss assessment results were held in the Center Township on July 26, 2018, in Todd and Morrison Counties on September 13, 2018, and in Aitkin on September 19, 2018.
- A virtual public presentation was available for interested citizens in May 2020, to present the draft TMDL report and allocations and receive public comments and concerns during the public notice.

Public notice for comments

An opportunity for public comment on the draft WRAPS report was provided via a public notice in the *State Register* from June 1, 2020, through July 1, 2020. There was one comment letter received and responded to as a result.

3.3 Restoration and protection strategies

The strategies tables include all of the priority waterbodies as identified in Section 3.1 and are divided into three separate tables for the north, central, and south management zones (Tables 26 to 28). Figures 13 to 15 provide the locations of each priority waterbody and land cover classification in each management zone. A description of each category in the strategies tables is provided in Table 25. A comprehensive list of BMPs that were considered for the strategies tables is included in Appendix B. The strategies tables organize priority waterbodies by HUC-10, with restoration strategies highlighted in red and protection strategies in white. The goal of the strategies tables is to identify all strategies and BMPs that can be implemented to achieve the water quality targets. Future watershed planning efforts will use the strategies identified to develop waterbody specific goals and timelines.

Table 25. Strategies table category descriptions.

Strategy Table Category	Category Description
HUC-10 Subwatershed	The HUC-10 where the priority waterbody is located.
Waterbody (ID)	The name and ID of the priority waterbody.
Location Description	A general description of the stream reach segment (this is only applicable to streams).
Pollutant/ Stressor	The pollutant/stressor that strategies and BMPs address.
Current WQ Conditions	The current observed water quality conditions for the pollutant/stressor. Water quality data are from the MPCA. For streams it is the average from 2006 through 2018 and for lakes it is the average TP concentration provided from the phosphorus sensitivity analysis. For lakes with a BATHTUB model completed as a part of the TMDL study, both TP concentration (parts per billion [ppb]) and load (kilograms [kg]) are included. Waterbodies with no observed data for these time periods are denoted with a "-".
10-year WQ milestone Year:	The 10-year milestone goal is based on a general target of reducing the pollutant by 1% each year, or 10% total. This is applied to both restoration and protection waterbodies. For protection waterbodies with no observed data the 10-year milestone is labeled as "Maintain or Improve."
Final WQ Goal Year:	For lakes with a TMDL study completed, the final water quality goal is equal to the water quality standard plus the reductions necessary to achieve the MOS. For nonTMDL lakes, the final water quality goal is based on the estimate of the 25th percentile of the summer mean TP concentration or the 10-yr water quality goal, whichever is lower. For streams that still exceed the water quality standard for the 10-year milestone, the final WQ goal is equal to the water quality standard. For streams with 10-year milestones that meet the water quality standard, the final water quality goal is "Maintain or Improve" from the 10-year milestone.
Strategy Type	General strategy classification (see Appendix B for further description of strategies).
BMP Scenario	Specific sample BMP associated with the strategy to address pollutant/stressor and achieve the water quality goals (see Appendix B for further description of strategies).

Figure 13. North management zone priority waterbodies.

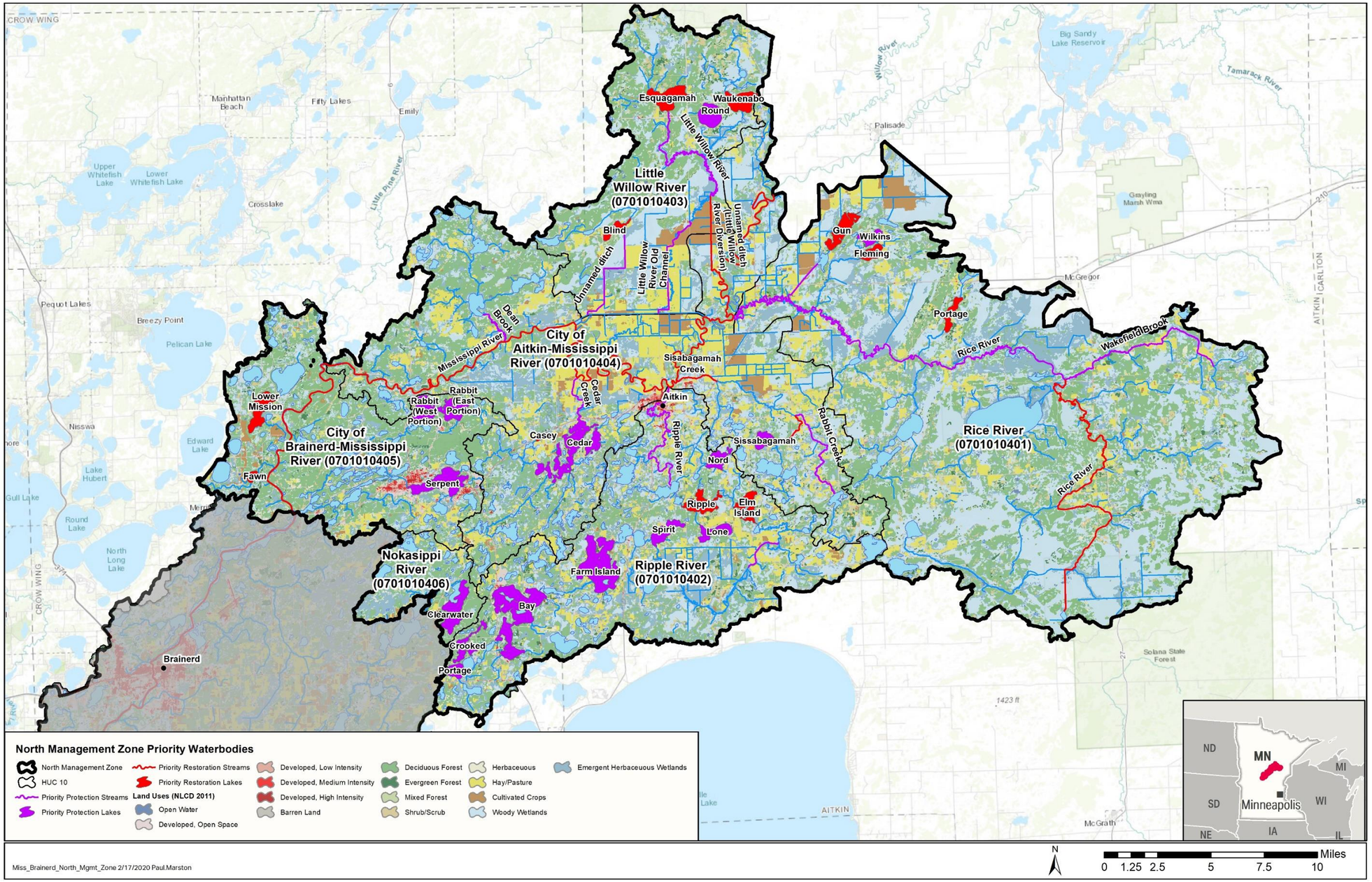


Table 26. Strategies and actions proposed for the north management zone of the MRBW.

North Management Zone								
Waterbody and Location			**Water Quality**				**Strategies to Achieve Final Water Quality Goal**	
HUC-10 Subwatershed	**Waterbody (ID)**	**Location Description**	**Pollutant/ Stressor**	**Current WQ Conditions**	**10-year WQ Milestone Year:**	**Final WQ Goal Years**	**Strategy Type**	**BMP Scenario**
NA	Mississippi River (07010104-655 and -656)	NA	Sediment/TSS	30–39 mg/L	27–35 mg/L	Not to Exceed 15 mg/L	Stream banks, bluffs and ravines protected/restored	Stream Channel Stabilization [584]
							Stream banks, bluffs and ravines protected/restored	Riparian herbaceous cover [390]
							Urban Stormwater runoff control	Stormwater practices to meet TMDL & permit conditions
Rice River (0701010401)	Rice River (07010104-505)	Headwaters (Porcupine Lk 01-0066-00) to Section 5 Cr	Dissolved Oxygen	4.1 mg/L	4.5 mg/L	> 5 mg/L	Ditch Management	Consider ditch abandonment and plugging
							Ditch Management	Re-meander channel and connect to floodplain
			Fish IBI	FIBI Score: 31	FIBI Score: 34	FIBI Score: 40	Ditch Management	Consider ditch abandonment and plugging
							Ditch Management	Re-meander channel and connect to floodplain
	Rice River (07010104-649)	Section 5 Cr to Wakefield Bk	Dissolved Oxygen	5.8 mg/L, Low DO of 2.7 mg/L	6.4 mg/L, Low DO of 3 mg/L	> 5 mg/L	Habitat and stream connectivity management	Stream restoration (go to strategy "Stream banks, bluffs & ravines protected/restored")
			Fish IBI	FIBI Score: 39	FIBI Score: 43	FIBI Score: 50	Habitat and stream connectivity management	Stream restoration (go to strategy "Stream banks, bluffs & ravines protected/restored")
			Bacteria /*E. coli*	Seasonal geomean 232.3 org/ 100mL	Seasonal geomean 209.1 org/ 100mL	Seasonal geomean < 126 org/ 100mL	Habitat and stream connectivity management	Stream restoration (go to strategy "Stream banks, bluffs & ravines protected/restored")
							Riparian Habitat	Evaluate bacteria sources at stations with high *E. coli* located near wildlife management areas
	Gun Lake (01-0099-00)		Phosphorus	Lake Concentration: 34 ppb Lake Load: 3,633.9 lbs/yr	Lake Concentration: 30.6 ppb Lake Load: 3,270.51 lbs/yr	Lake Concentration: 27 ppb Lake Load: 3,102.5 lbs/yr	Nutrient management (cropland)	Fertilizer rates match University of Minnesota (U of MN) recommendations (without government funding)
							Nutrient management (cropland)	Precision nutrient timing and Management (beyond 590 standard)
							Septic system improvements	Septic system improvement (126M)
							Lakeshore	Shoreline stabilization and buffer
							In-lake management	Consulting with the DNR for recommendations on managing and restoring a healthy native vegetation population.
							Stormwater runoff control	Decrease runoff from impervious surfaces in lakeshed area
							Public Outreach	Provide education opportunities to lakeshore property owners on importance of shoreline protection
	Fleming Lake (01-0105-00)		Phosphorus	Lake Concentration: 62 ppb Lake Load: 1,211.0 lbs/yr	Lake Concentration: 56 ppb Lake Load: 1,090 lbs/yr	Lake Concentration: 27 ppb Lake Load: 436.6 lbs/yr	Nutrient management (cropland)	Fertilizer rates match University of Minnesota (U of MN) recommendations (without government funding)
							Nutrient management (cropland)	Precision nutrient timing and management (beyond 590 standard)
							Septic system improvements	Septic system improvement (126M)
							Lakeshore	Shoreline stabilization and buffer

Waterbody and Location			Water Quality				Strategies to Achieve Final Water Quality Goal	
HUC-10 Subwatershed	Waterbody (ID)	Location Description	Pollutant/ Stressor	Current WQ Conditions	10-year WQ Milestone Year:	Final WQ Goal Years	Strategy Type	BMP Scenario
Rice River (0701010401) (cont.)	Fleming Lake (01-0105-00) (cont.)		Phosphorus (cont.)	Lake Concentration: 62 ppb Lake Load: 1,211.0 lbs/yr (cont.)	Lake Concentration: 56 ppb Lake Load: 1,090 lbs/yr (cont.)	Lake Concentration: 27 ppb Lake Load: 436.6 lbs/yr (cont.)	In-lake management	Consulting with the DNR for recommendations on managing and restoring a healthy native vegetation population.
							Pasture management	Pasture improvement [101]
							Stormwater runoff control	Decrease runoff from impervious surfaces in lakeshed area
							Public outreach	Provide education opportunities to lakeshore property owners on importance of shoreline protection
	Portage Lake (01-0069-00)		Phosphorus	31.3 ppb	28.1 ppb	27.0 ppb	Septic system improvements	Septic system improvement (126M)
							Lakeshore	Shoreline stabilization and buffer
							Stormwater runoff control	Decrease runoff from impervious surfaces in lakeshed area
							Public outreach	Provide education opportunities to lakeshore property owners on importance of shoreline protection
	Wilkins Lake (01-0102-00)		Phosphorus	19.9 ppb	17.9 ppb	14.0 ppb	Septic system improvements	Septic system improvement (126M)
							Stormwater runoff control	Raingardens, rain barrels, vegetated swales
							Stormwater runoff control	Decrease runoff from impervious surfaces in lakeshed area
							Stormwater runoff control	Decrease runoff at lake public access
							Shoreline protection	Maintain vegetated buffer along shoreline
							Shoreline protection	Increase native vegetation along shoreline
							Shoreline protection	Enforce existing shoreland zoning requirements
							Forestry management	Forestry management - comprehensive (147M)
							Converting land to perennials	Conservation easements
							Public outreach	Provide education opportunities to lakeshore property owners on importance of shoreline protection
							Public outreach	Implement DNR's "Score Your Shore"
	Rice River (07010104-505)	Headwaters (Porcupine Lk 01-0066-00) to Section 5 Cr	Phosphorus	85 ppb	77 ppb	Not to Exceed 50 ppb	These protection strategies apply to all pollutants	
							Stream banks, bluffs and ravines protected/restored	Stream channel stabilization (584)
							Ditch management	Consider ditch abandonment/restoration
							Buffers and filters, field edge	Increase buffer width using native vegetation and trees
							Pasture management	Livestock access control (472)
			Dissolved Oxygen	4.1 mg/L	4.4 mg/L	> 5 mg/L	Habitat and stream connectivity management	Culvert inventory
							Habitat and stream connectivity management	Conduct desktop recon of stream crossings

Waterbody and Location			Water Quality				Strategies to Achieve Final Water Quality Goal	
HUC-10 Subwatershed	Waterbody (ID)	Location Description	Pollutant/ Stressor	Current WQ Conditions	10-year WQ Milestone Year:	Final WQ Goal Years	Strategy Type	BMP Scenario
Rice River (0701010401) (cont.)	Rice River (07010104-505) (cont.)	Headwaters (Porcupine Lk 01-0066-00) to Section 5 Cr (cont.)	Dissolved Oxygen (cont.)	4.1 mg/L (cont.)	4.4 mg/L (cont.)	> 5 mg/L (cont.)	Habitat and stream connectivity management	Manage beaver dams
							Forestry management	Forestry management - comprehensive (147M)
							Forestry management	Actively seek landowners willing to participate in the Sustainable Forest Incentive Act (SFIA)
			Sediment /TSS	5.9 mg/L	5.3 mg/L	Maintain or Improve	Public outreach	Provide education opportunities to local landowners
	Rice River (07010104-649)	Section 5 Cr to Wakefield Bk	Phosphorus	87 ppb	78 ppb	Not to Exceed 50 ppb	These protection strategies apply to all pollutants	
							Stream banks, bluffs and ravines protected/restored	Stream Channel Stabilization (584)
							Buffers and filters, field edge	Increase buffer width using native vegetation and trees
							Pasture management	Livestock access control (472)
							Source assessment	Conduct a source assessment to determine anthropogenic sources of *E. coli*
			Dissolved Oxygen	5.8 mg/L, Low DO of 2.7 mg/L	6.4 mg/L, Low DO of 3.0 mg/L	> 5 mg/L	Habitat and stream connectivity management	Culvert inventory
							Habitat and stream connectivity management	Conduct desktop recon of stream crossings
							Habitat and stream connectivity management	Manage beaver dams
							Forestry management	Forestry management - comprehensive (147M)
							Forestry management	Actively seek landowners willing to participate in the Sustainable Forest Incentive Act (SFIA)
			Sediment/TSS	4.9 mg/L	4.4 mg/L	Maintain or Improve	Public outreach	Provide education opportunities to local landowners
	Rice River (07010104-692)	Wakefield Bk to Dam Bk	Phosphorus	–	Maintain or Improve	Not to Exceed 50 ppb	These protection strategies apply to all pollutants	
							Stream banks, bluffs and ravines protected/restored	Stream channel stabilization (584)
							Buffers and filters, field edge	Increase buffer width using native vegetation and trees
							Pasture management	Livestock access control (472)
							Habitat and stream connectivity management	Culvert Inventory
			Dissolved Oxygen	-–	Maintain or Improve	> 5.0 mg/L	Habitat and stream connectivity management	Conduct desktop recon of stream crossings
							Habitat and stream connectivity management	Manage beaver dams
							Forestry management	Forestry management - comprehensive (147M)
							Forestry management	Actively seek landowners willing to participate in the Sustainable Forest Incentive Act (SFIA)
			Sediment/TSS	–	Maintain or Improve	Not to Exceed 15 mg/L	Public outreach	Provide education opportunities to local landowners

Waterbody and Location			Water Quality				Strategies to Achieve Final Water Quality Goal	
HUC-10 Subwatershed	Waterbody (ID)	Location Description	Pollutant/ Stressor	Current WQ Conditions	10-year WQ Milestone Year:	Final WQ Goal Years	Strategy Type	BMP Scenario
Rice River (0701010401) (cont.)	Rice River (07010104-693)	Wakefield Bk to Mississippi R	Phosphorus		Maintain or Improve	Not to Exceed 50 ppb	These protection strategies apply to all pollutants	
							Stream banks, bluffs and ravines protected/restored	Stream channel stabilization (584)
							Buffers and filters, field edge	Increase buffer width using native vegetation and trees
							Pasture management	Livestock access control (472)
							Habitat and stream connectivity management	Culvert inventory
			Dissolved Oxygen	–	Maintain or Improve	> 5.0 mg/L	Habitat and stream connectivity management	Conduct desktop recon of stream crossings
							Habitat and stream connectivity management	Manage beaver dams
							Forestry management	Forestry management - comprehensive (147M)
							Forestry management	Actively seek landowners willing to participate in the Sustainable Forest Incentive Act (SFIA)
			Sediment /TSS	–	Maintain or Improve	Not to Exceed 15 mg/L	Public outreach	Provide education opportunities to local landowners
	Wakefield Brook (07010104-536)	Headwaters to Rice R	Phosphorus	64.5 ppb	58.1 ppb	Not to Exceed 50 ppb	These Protection Strategies apply to all Pollutants	
							Nutrient management (cropland)	Fertilizer rates match U of MN recommendations (without government funding)
							Stream banks, bluffs and ravines protected/restored	Stream channel stabilization (584)
							Buffers and filters, field edge	Increase buffer width using native vegetation and trees
							Pasture management	Livestock access control (472)
			Dissolved Oxygen	5.3 mg/L	5.8 mg/L	Maintain or Improve	Habitat and stream connectivity management	Culvert Inventory
							Habitat and stream connectivity management	Conduct Desktop recon of stream crossings
							Habitat and stream connectivity management	Manage beaver dams
							Forestry management	Forestry management – comprehensive (147M)
							Forestry management	Actively seek landowners willing to participate in the Sustainable Forest Incentive Act (SFIA)
			Sediment /TSS	–	Maintain or Improve	Not to Exceed 15 mg/L	Public outreach	Provide education opportunities to local landowners
	Unnamed Ditch (07010104-543)	French Lk to Rice R	Phosphorus	–	Maintain or Improve	Not to Exceed 50 ppb	These protection strategies apply to all pollutants	
							Nutrient management (cropland)	Fertilizer rates match U of MN recommendations (without gov't funding)
							Stream banks, bluffs and ravines protected/restored	Stream channel stabilization (584)

Waterbody and Location			Water Quality				Strategies to Achieve Final Water Quality Goal	
HUC-10 Subwatershed	Waterbody (ID)	Location Description	Pollutant/ Stressor	Current WQ Conditions	10-year WQ Milestone Year:	Final WQ Goal Years	Strategy Type	BMP Scenario
Rice River (0701010401) (cont.)	Unnamed Ditch (07010104-543) (cont.)	French Lk to Rice R (cont.)	Phosphorus (cont.)	–	Maintain or Improve (cont.)	Not to Exceed 50 ppb (cont.)	Buffers and filters, field edge	Increase buffer width using native vegetation and trees
							Pasture management	Livestock access control (472)
			Dissolved Oxygen	–	Maintain or Improve	> 5.0 mg/L	Habitat and stream connectivity management	Culvert inventory
							Habitat and stream connectivity management	Conduct desktop recon of stream crossings
							Habitat and stream connectivity management	Manage beaver dams
							Forestry management	Forestry management - comprehensive (147M)
							Forestry management	Actively seek landowners willing to participate in the Sustainable Forest Incentive Act (SFIA)
			Sediment /TSS	–	Maintain or Improve	Not to Exceed 15 mg/L	Public outreach	Provide education opportunities to local landowners
Ripple River (0701010402)	Elm Island Lake (01-0123-00)		Phosphorus	Lake Concentration: 59 ppb Lake Load: 5,801.4 lbs/yr	Lake Concentration: 53.1 ppb Lake Load: 5,221.3 lbs/yr	Lake Concentration: 26 ppb Lake Load: 2,561.7 lbs/yr	Septic system improvements	Septic system improvement (126M)
							Lakeshore	Shoreline stabilization and buffer
							Nutrient management (cropland)	Fertilizer rates match U of MN recommendations (without government funding)
							Nutrient management (cropland)	Precision nutrient timing and management (beyond 590 standard)
							Stormwater runoff control	Decrease runoff from impervious surfaces in lakeshed area
							Public outreach	Provide education opportunities to lakeshore property owners on importance of shoreline protection
							Ditch management	Consider ditch abandonment/restoration
							Converting land to perennials	Conservation easements
			Fish IBI	FIBI Score: 31/33	FIBI Score: 35	FIBI Score: 38	Septic system improvements	Septic system improvement (126M)
							Lakeshore	Shoreline stabilization and buffer
	Ripple Lake (01-0146-00)		Phosphorus	Lake Concentration: 34 ppb Lake Load: 5,769.5 lbs/yr	Lake Concentration: 31 ppb Lake Load: 5,192.6 lbs/yr	Lake Concentration: 27 ppb Lake Load: 4,197.9 lbs/yr	Septic system improvements	Septic system improvement (126M)
							Lakeshore	Shoreline stabilization and buffer
							Nutrient management (cropland)	Fertilizer rates match U of MN recommendations (without government funding)
							Nutrient management (cropland)	Precision nutrient timing and management (beyond 590 standard)
							Stormwater runoff control	Decrease runoff from impervious surfaces in lakeshed area
							Public outreach	Provide education opportunities to lakeshore property owners on importance of shoreline protection

Waterbody and Location			Water Quality				Strategies to Achieve Final Water Quality Goal	
HUC-10 Subwatershed	Waterbody (ID)	Location Description	Pollutant/ Stressor	Current WQ Conditions	10-year WQ Milestone Year:	Final WQ Goal Years	Strategy Type	BMP Scenario
Ripple River (0701010402) (cont.)	Ripple Lake (01-0146-00) (cont.)		Phosphorus (cont.)	Lake Concentration: 34 ppb Lake Load: 5,769.5 lbs/yr (cont.)	Lake Concentration: 31 ppb Lake Load: 5,192.6 lbs/yr (cont.)	Lake Concentration: 27 ppb Lake Load: 4,197.9 lbs/yr (cont.)	Converting land to perennials	Conservation easements
	Lone Lake (01-0125-00)		Phosphorus	8.6 ppb	7.7 ppb	7.0 ppb	Septic system improvements	Septic system improvement (126M)
							Stormwater runoff control	Raingardens, rain barrels, vegetated swales
							Stormwater runoff control	Decrease runoff from impervious surfaces in lakeshed area
							Stormwater runoff control	Decrease runoff at lake public access
							Shoreline protection	Maintain vegetated buffer along shoreline
							Shoreline protection	Increase native vegetation along shoreline
							Shoreline protection	Enforce existing shoreland zoning requirements
							Feedlot runoff controls	Feedlot runoff reduction/treatment (635, 784)
							Forestry management	Forestry management - comprehensive (147M)
							Converting land to perennials	Conservation easements
							Public outreach	Provide education opportunities to lakeshore property owners on importance of shoreline protection
							Public outreach	Implement DNR's "Score Your Shore"
	Farm Island Lake (01-0159-00)		Phosphorus	20.1 ppb	18.1 ppb	18.1 ppb	Septic system improvements	Septic system improvement (126M)
							Stormwater runoff control	Raingardens, rain barrels, vegetated swales
							Stormwater runoff control	Decrease runoff from impervious surfaces in lakeshed area
							Stormwater runoff control	Decrease runoff at lake public accesses
							Shoreline protection	Maintain vegetated buffer along shoreline
							Shoreline protection	Increase native vegetation along shoreline
							Shoreline protection	Enforce existing shoreland zoning requirements
							Forestry management	Forestry management - comprehensive (147M)
							Converting land to perennials	Conservation easements
							Public outreach	Provide education opportunities to lakeshore property owners on importance of shoreline protection
							Public outreach	Implement DNR's "Score Your Shore"
	Spirit Lake (01-0178-00)		Phosphorus	13.2 ppb	11.9 ppb	11.9 ppb	Septic system improvements	Septic system improvement (126M)
							Stormwater runoff control	Raingardens, rain barrels, vegetated swales
							Stormwater runoff control	Decrease runoff from impervious surfaces in lakeshed area
							Stormwater runoff control	Decrease runoff at lake public access

Waterbody and Location			Water Quality				Strategies to Achieve Final Water Quality Goal	
HUC-10 Subwatershed	Waterbody (ID)	Location Description	Pollutant/ Stressor	Current WQ Conditions	10-year WQ Milestone Year:	Final WQ Goal Years	Strategy Type	BMP Scenario
Ripple River (0701010402) (cont.)	Spirit Lake (01-0178-00) (cont.)		Phosphorus (cont.)	13.2 ppb (cont.)	11.9 ppb (cont.)	11.9 ppb (cont.)	Shoreline protection	Maintain vegetated buffer along shoreline
							Shoreline protection	Increase native vegetation along shoreline
							Shoreline protection	Enforce existing shoreland zoning requirements
							Forestry management	Forestry management - comprehensive (147M)
							Converting land to perennials	Conservation Easements
							Public outreach	Provide education opportunities to lakeshore property owners on importance of shoreline protection
							Public outreach	Implement DNR's "Score Your Shore"
	Bay Lake (18-0034-00)		Phosphorus	13.0 ppb	11.7 ppb	11.0 ppb	Septic system improvements	Septic system improvement (126M)
							Stormwater runoff control	Raingardens, rain barrels, vegetated swales
							Stormwater runoff control	Decrease runoff from impervious surfaces in lakeshed area
							Stormwater runoff control	Decrease runoff at lake public accesses
							Shoreline protection	Maintain vegetated buffer along shoreline
							Shoreline protection	Increase native vegetation along shoreline
							Shoreline protection	Enforce existing shoreland zoning requirements
							Forestry management	Forestry management - comprehensive (147M)
							Converting land to perennials	Conservation easements
							Public outreach	Provide education opportunities to lakeshore property owners on importance of shoreline protection
							Public outreach	Implement DNR's "Score Your Shore"
	Crooked Lake (18-0041-00)		Phosphorus	13.9 ppb	12.5 ppb	10.0 ppb	Septic system improvements	Septic system improvement (126M)
							Stormwater runoff control	Raingardens, rain barrels, vegetated swales
							Stormwater runoff control	Decrease runoff from impervious surfaces in lakeshed area
							Stormwater runoff control	Decrease runoff at lake public access
							Shoreline protection	Maintain vegetated buffer along shoreline
							Shoreline protection	Increase native vegetation along shoreline
							Shoreline protection	Enforce existing shoreland zoning requirements
							Forestry management	Forestry management - comprehensive (147M)
							Converting land to perennials	Conservation easements
							Public outreach	Provide education opportunities to lakeshore property owners on importance of shoreline protection
							Public outreach	Implement DNR's "Score Your Shore"
			Phosphorus	17.2 ppb	15.5 ppb	13.0 ppb	Septic system improvements	Septic system improvement (126M)

Waterbody and Location			Water Quality				Strategies to Achieve Final Water Quality Goal	
HUC-10 Subwatershed	Waterbody (ID)	Location Description	Pollutant/ Stressor	Current WQ Conditions	10-year WQ Milestone Year:	Final WQ Goal Years	Strategy Type	BMP Scenario
Ripple River (0701010402) (cont.)	Portage Lake (18-0050-00)						Stormwater runoff control	Raingardens, rain barrels, vegetated swales
							Stormwater runoff control	Decrease runoff from impervious surfaces in lakeshed area
							Stormwater runoff control	Decrease runoff at lake public access
							Shoreline protection	Maintain vegetated buffer along shoreline
							Shoreline protection	Increase native vegetation along shoreline
							Shoreline protection	Enforce existing shoreland zoning requirements
							Feedlot runoff controls	Feedlot runoff reduction/treatment (635, 784)
							Forestry management	Forestry management - comprehensive (147M)
							Converting land to perennials	Conservation easements
							Public outreach	Provide education opportunities to lakeshore property owners on importance of shoreline protection
							Public outreach	Implement DNR's "Score Your Shore"
	Nord Lake (01-0117-00)		Phosphorus	18.3 ppb	16.4 ppb	16.0 ppb	Septic system improvements	Septic system improvement (126M)
							Stormwater runoff control	Raingardens, rain barrels, vegetated swales
							Stormwater runoff control	Decrease runoff from impervious surfaces in lakeshed area
							Stormwater runoff control	Decrease runoff at lake public access
							Shoreline protection	Maintain vegetated buffer along shoreline
							Shoreline protection	Increase native vegetation along shoreline
							Shoreline protection	Enforce existing shoreland zoning requirements
							Feedlot runoff controls	Feedlot runoff reduction/treatment [635, 784]
							Forestry management	Forestry management - comprehensive (147M)
							Converting land to perennials	Conservation easements
							Public outreach	Provide education opportunities to lakeshore property owners on importance of shoreline protection
							Public outreach	Implement DNR's "Score Your Shore"
	Ripple River (07010104-660)	Raspberry Cr to Mississippi R	Phosphorus	–	Maintain or improve	Not to exceed 50 ppb	These protection strategies apply to all pollutants	
							Urban stormwater runoff control	Permeable surfaces and pavements (800M, 804M)
							Urban stormwater runoff control	Supplemental street sweeping
							Urban stormwater runoff control	Bioretention/biofiltration (urban) (712M)
							Urban stormwater runoff control	Constructed stormwater pond (urban) (155M)
		Raspberry Cr to Mississippi R (cont.)	Phosphorus (cont.)		Maintain or improve (cont.)	Not to exceed 50 ppb (cont.)	Urban stormwater runoff control	Dry swales

Waterbody and Location			Water Quality				Strategies to Achieve Final Water Quality Goal	
HUC-10 Subwatershed	Waterbody (ID)	Location Description	Pollutant/ Stressor	Current WQ Conditions	10-year WQ Milestone Year:	Final WQ Goal Years	Strategy Type	BMP Scenario
Ripple River (0701010402) (cont.)	Ripple River (07010104-660) (cont.)		Dissolved Oxygen	–	Maintain or Improve	> 5.0 mg/L	Urban stormwater runoff control	Improved lawn/turf vegetation and soil practices
							Urban stormwater runoff control	Tree trenches and boxes
							Urban zoning	Enforce existing zoning rules
							Stream banks, bluffs and ravines protected/restored	Stream channel stabilization (584)
							Buffers and filters, field edge	Increase buffer width using native vegetation and trees
							Habitat and stream connectivity management	Culvert inventory
			Sediment /TSS	–	Maintain or Improve	Not to Exceed 15 mg/L	Habitat and stream connectivity management	Conduct desktop recon of stream crossings
							Habitat and stream connectivity management	Manage beaver dams
							Forestry management	Forestry management - comprehensive (147M)
							Forestry management	Actively seek landowners willing to participate in the Sustainable Forest Incentive Act (SFIA)
							Forestry management	Invasive species control
							Public outreach	Provide education opportunities to local landowners
	Ripple River (07010104-661)	Hanging Kettle Lk to Raspberry Cr	Phosphorus	–	Maintain or Improve	Not to Exceed 50 ppb	These Protection Strategies apply to all Pollutants	
							Stream banks, bluffs and ravines protected/restored	Stream channel stabilization (584)
							Buffers and filters, field edge	Increase buffer width using native vegetation and trees
							Habitat and stream connectivity management	Culvert inventory
							Habitat and stream connectivity management	Conduct desktop recon of stream crossings
							Habitat and stream connectivity management	Manage beaver dams
			Dissolved Oxygen	–	Maintain or Improve	> 5.0 mg/L	Forestry management	Forestry management - comprehensive (147M)
							Forestry management	Actively seek landowners willing to participate in the Sustainable Forest Incentive Act (SFIA)
							Forestry management	Invasive species control
							Public outreach	Provide education opportunities to local landowners
			Sediment /TSS	–	Maintain or Improve	Not to Exceed 15 mg/L		
			Phosphorus	–	Maintain or Improve	Not to Exceed 50 ppb	These Protection Strategies apply to all Pollutants	

Waterbody and Location			Water Quality				Strategies to Achieve Final Water Quality Goal	
HUC-10 Subwatershed	Waterbody (ID)	Location Description	Pollutant/ Stressor	Current WQ Conditions	10-year WQ Milestone Year:	Final WQ Goal Years	Strategy Type	BMP Scenario
Ripple River (0701010402) (cont.)	Ripple River (07010104-666)	Unnamed wetland (01-0394-00) to Lingroth Lk outlet					Stream banks, bluffs and ravines protected/restored	Stream channel stabilization (584)
							Buffers and filters, field edge	Increase buffer width using native vegetation and trees
							Habitat and stream connectivity management	Culvert Inventory
							Habitat and stream connectivity management	Conduct Desktop recon of stream crossings
							Habitat and stream connectivity management	Manage beaver dams
			Dissolved Oxygen	–	Maintain or Improve	> 5.0 mg/L	Forestry management	Forestry management - comprehensive (147M)
							Forestry management	Actively seek landowners willing to participate in the Sustainable Forest Incentive Act (SFIA)
							Public outreach	Provide education opportunities to local landowners
			Sediment /TSS	–	Maintain or Improve	Not to Exceed 15 mg/L		
Little Willow River (0701010403)	Unnamed Ditch (Little Willow River Diversion) (07010104-691)	Little Willow Ditch old channel to Mississippi R	Macroinvertebrate IBI	MIBI Score: 33.4	MIBI Score: 36.7	MIBI Score: 37	Drainage ditch modifications	Two-stage ditch - open channel [582]
	Waukenabo Lake (01-0136-00)		Phosphorus	27.1 ppb	24.4 ppb	23.0 ppb	Septic system improvements	Septic system improvement (126M)
							Lakeshore	Shoreline stabilization and buffer
							Converting land to perennials	Conservation easements
							Public outreach	Provide education opportunities to local landowners
	Esquagamah Lake (01-0147-00)		Phosphorus	43.5 ppb	39.2 ppb	36 ppb	Septic system improvements	Septic system improvement (126M)
							Lakeshore	Shoreline stabilization and buffer
							Converting land to perennials	Conservation easements
							Public outreach	Provide education opportunities to local landowners
	Blind Lake (01-0188-00)		Phosphorus	37.3 ppb	33.6 ppb	33.6 ppb	Septic system improvements	Septic system improvement (126M)
							Lakeshore	Shoreline stabilization and buffer
							Converting land to perennials	Conservation easements
							Public outreach	Provide education opportunities to local landowners
	Round Lake (01-0137-00)		Phosphorus	9.9 ppb	8.9 ppb	8.9 ppb	Septic system improvements	Septic system improvement (126M)
							Stormwater runoff control	Raingardens, rain barrels, vegetated swales
Little Willow River (0701010403) (cont.)	Round Lake (01-0137-00) (cont.)		Phosphorus (cont.)	9.9 ppb (cont.)	8.9 ppb (cont.)	8.9 ppb (cont.)	Stormwater runoff control	Decrease runoff from impervious surfaces in lakeshed area
							Stormwater runoff control	Decrease runoff at lake public access
							Shoreline protection	Maintain vegetated buffer along shoreline
							Shoreline protection	Increase native vegetation along shoreline

Waterbody and Location			Water Quality				Strategies to Achieve Final Water Quality Goal	
HUC-10 Subwatershed	Waterbody (ID)	Location Description	Pollutant/ Stressor	Current WQ Conditions	10-year WQ Milestone Year:	Final WQ Goal Years	Strategy Type	BMP Scenario
							Shoreline protection	Enforce existing shoreland zoning requirements
							Forestry management	Forestry management - comprehensive (147M)
							Converting land to perennials	Conservation Easements
							Public Outreach	Provide education opportunities to lakeshore property owners on importance of shoreline protection
							Public Outreach	Implement DNR's "Score Your Shore"
	Little Willow River Old Channel (07010104-689)	Headwaters (Esquagamah Lk 01-0147-00) to Little Willow Diversion ditch	Phosphorus	–	Maintain or Improve	Not to Exceed 50 ppb	These Protection Strategies apply to all Pollutants	
							Nutrient management (cropland)	Fertilizer rates match U of MN recommendations (without government funding)
							Stream banks, bluffs and ravines protected/restored	Stream channel stabilization (584)
							Buffers and filters, field edge	Increase buffer width using native vegetation and trees
							Habitat and stream connectivity management	Culvert Inventory
			Dissolved Oxygen	–	Maintain or Improve	> 5.0 mg/L	Habitat and stream connectivity management	Conduct Desktop recon of stream crossings
							Habitat and stream connectivity management	Manage beaver dams
							Forestry management	Forestry management - comprehensive (147M)
							Forestry management	Actively seek landowners willing to participate in the Sustainable Forest Incentive Act (SFIA)
							Public Outreach	Provide education opportunities to local landowners
			Sediment /TSS	–	Maintain or Improve	Not to Exceed 15 mg/L	Nutrient management (cropland)	Nutrient Management (fertilizer, soil, manure) (590)
							Pasture management	Conventional pasture to prescribed rotational grazing (528)
							Feedlot runoff controls	Feedlot runoff reduction/treatment (635, 784)
	Little Willow River Old Channel (07010104-701)	Unnamed ditch to Flood Diversion Channel	Phosphorus	–	Maintain or Improve	Not to Exceed 50 ppb	These Protection Strategies apply to all Pollutants	
							Drainage ditch modifications	Two-stage ditch - open channel (582)
							Nutrient management (cropland)	Fertilizer rates match U of MN recommendations (without gov't funding)
							Stream banks, bluffs and ravines protected/restored	Stream Channel Stabilization (584)
Little Willow River (0701010403) (cont.)	Little Willow River (0701010403) (cont.)	Round Lake (01-0137-00) (cont.)	Dissolved Oxygen	–	Maintain or Improve	> 5.0 mg/L	Buffers and filters, field edge	Increase buffer width using native vegetation and trees
							Habitat and stream connectivity management	Culvert Inventory

Waterbody and Location			Water Quality				Strategies to Achieve Final Water Quality Goal	
HUC-10 Subwatershed	Waterbody (ID)	Location Description	Pollutant/ Stressor	Current WQ Conditions	10-year WQ Milestone Year:	Final WQ Goal Years	Strategy Type	BMP Scenario
							Habitat and stream connectivity management	Conduct Desktop recon of stream crossings
							Habitat and stream connectivity management	Manage beaver dams
							Forestry management	Forestry management - comprehensive (147M)
							Forestry management	Actively seek landowners willing to participate in the Sustainable Forest Incentive Act (SFIA)
			Sediment /TSS	–	Maintain or Improve	Not to Exceed 15 mg/L	Public Outreach	Provide education opportunities to local landowners
							Nutrient management (cropland)	Nutrient Management (fertilizer, soil, manure) (590)
							Pasture management	Conventional pasture to prescribed rotational grazing (528)
		Little Willow River Old Channel (07010104-689)					Feedlot runoff controls	Feedlot runoff reduction/treatment (635, 784)
	Unnamed Ditch (Little Willow River Diversion) (07010104-691)	Little Willow Ditch old channel to Mississippi R	Phosphorus	–	Maintain or Improve	Not to Exceed 50 ppb	These Protection Strategies apply to all Pollutants	
							Stream banks, bluffs and ravines protected/restored	Stream Channel Stabilization (584)
							Buffers and filters, field edge	Increase buffer width using native vegetation and trees
							Pasture management	Livestock access control (472)
							Habitat and stream connectivity management	Culvert Inventory
			Dissolved Oxygen	–	Maintain or Improve	> 5.0 mg/L	Habitat and stream connectivity management	Conduct Desktop recon of stream crossings
							Habitat and stream connectivity management	Manage beaver dams
							Forestry management	Forestry management - comprehensive (147M)
							Forestry management	Actively seek landowners willing to participate in the Sustainable Forest Incentive Act (SFIA)
							Public outreach	Provide education opportunities to local landowners
			Sediment /TSS	–	Maintain or Improve	Not to Exceed 15 mg/L		
	Unnamed Ditch (07010104-697)	Blind Lk to Mississippi R flood diversion channel Little Willow River Old Channel (07010104-701)	Phosphorus	–	Maintain or Improve	Not to Exceed 50 ppb	These Protection Strategies apply to all Pollutants	
							Nutrient management (cropland)	Nutrient Management (fertilizer, soil, manure) (590)
							Nutrient management (cropland)	Fertilizer rates match U of MN recommendations (without gov't funding)
							Stream banks, bluffs and ravines protected/restored	Stream Channel Stabilization (584)
Little Willow River (0701010403) (cont.)	Unnamed Ditch (07010104-697) (cont.)	Blind Lk to Mississippi R flood diversion channel	Phosphorus (cont.)	–	Maintain or Improve (cont.)	Not to Exceed 50 ppb (cont.)	Buffers and filters, field edge	Increase buffer width using native vegetation and trees
			Dissolved Oxygen	–	Maintain or Improve	> 5.0 mg/L	Pasture management	Livestock access control (472)

Waterbody and Location			Water Quality				Strategies to Achieve Final Water Quality Goal	
HUC-10 Subwatershed	Waterbody (ID)	Location Description	Pollutant/ Stressor	Current WQ Conditions	10-year WQ Milestone Year:	Final WQ Goal Years	Strategy Type	BMP Scenario
		Little Willow River Old Channel (07010104-701) (cont.)					Habitat and stream connectivity management	Culvert Inventory
							Habitat and stream connectivity management	Conduct Desktop recon of stream crossings
							Habitat and stream connectivity management	Manage beaver dams
							Forestry management	Forestry management - comprehensive (147M)
			Sediment /TSS	–	Maintain or Improve	Not to Exceed 15 mg/L	Forestry management	Actively seek landowners willing to participate in the Sustainable Forest Incentive Act (SFIA)
							Public outreach	Provide education opportunities to local landowners
City of Aitkin-Mississippi River (0701010404)	Sisabagamah Creek (07010104-659)	Unnamed cr to Mississippi R	Macroinvertebrate IBI / Lack of Habitat	MIBI Score: 37.9, 42	MIBI Score:44	MIBI Score: 52.4	Stream banks, bluffs and ravines protected/restored	Stream restoration using principles such as Natural Channel Design
							Stream banks, bluffs and ravines protected/restored	Stream banks/shoreline - stabilized or restored (580)
							Pasture management	Livestock access control (472)
	Sisabagamah Creek (07010104-677)	Sisabagamah Lk to Rabbit Cr	Dissolved Oxygen	5.1 mg/L, low DO of 4.4	5.6 mg/L, low DO of 4.8	> 5 mg/L	Habitat and stream connectivity management	Modify/replace dams, culverts & fish passage barriers
							Pasture management	Livestock access control (472)
			Fish IBI	FIBI Score: 31	FIBI Score: 34	FIBI Score: 40	Habitat and stream connectivity management	Modify/replace dams, culverts & fish passage barriers
	Casey Lake (18-0087-00)		Phosphorus	136.8 ppb	123.1 ppb	114.0 ppb	Nutrient management (cropland)	Fertilizer rates match U of MN recommendations (without gov't funding)
							Nutrient management (cropland)	Precision Nutrient Timing & Management (beyond 590 standard)
							Lakeshore	Shoreline stabilization and buffer
	Cedar Lake (01-0209-00)		Phosphorus	13.4 ppb	12.1 ppb	11.0 ppb	Septic system improvements	Septic System Improvement (126M)
							Stormwater runoff control	Raingardens, rain barrels, vegetated swales
							Stormwater runoff control	Decrease runoff from impervious surfaces in lakeshed area
							Stormwater runoff control	Decrease runoff at lake public access
							Shoreline protection	Maintain vegetated buffer along shoreline
							Shoreline protection	Increase native vegetation along shoreline
							Shoreline protection	Enforce existing shoreland zoning requirements
							Feedlot runoff controls	Feedlot runoff reduction/treatment (635, 784)
							Forestry management	Forestry management - comprehensive (147M)
							Converting land to perennials	Conservation Easements
City of Aitkin-Mississippi River (0701010404) (cont.)	Cedar Lake (01-0209-00) (cont.)		Phosphorus (cont.)	13.4 ppb (cont.)	12.1 ppb (cont.)	11.0 ppb (cont.)	Public outreach	Provide education opportunities to lakeshore property owners on importance of shoreline protection
							Public outreach	Implement DNR's "Score Your Shore"
			Phosphorus	17.6 ppb	15.8 ppb	15.8 ppb	Septic system improvements	Septic System Improvement (126M)

Waterbody and Location			Water Quality				Strategies to Achieve Final Water Quality Goal	
HUC-10 Subwatershed	Waterbody (ID)	Location Description	Pollutant/ Stressor	Current WQ Conditions	10-year WQ Milestone Year:	Final WQ Goal Years	Strategy Type	BMP Scenario
	Sissabagamah Lake (01-0129-00)						Stormwater runoff control	Raingardens, rain barrels, vegetated swales
							Stormwater runoff control	Decrease runoff from impervious surfaces in lakeshed area
							Stormwater runoff control	Decrease runoff at lake public access
							Shoreline protection	Maintain vegetated buffer along shoreline
							Shoreline protection	Increase native vegetation along shoreline
							Shoreline protection	Enforce existing shoreland zoning requirements
							Feedlot runoff controls	Feedlot runoff reduction/treatment (635, 784)
							Forestry management	Forestry management - comprehensive (147M)
							Converting land to perennials	Conservation Easements
							Public outreach	Provide education opportunities to lakeshore property owners on importance of shoreline protection
							Public outreach	Implement DNR's "Score Your Shore"
	Sisabagamah Creek (07010104-659)	Unnamed cr to Mississippi R	Phosphorus	79 ppb	71 ppb	Not to Exceed 50 ppb	These Protection Strategies apply to all Pollutants	
							Stream banks, bluffs and ravines protected/restored	Stream Channel Stabilization (584)
							Buffers and filters, field edge	Increase buffer width using native vegetation and trees
							Habitat and stream connectivity management	Culvert Inventory
							Habitat and stream connectivity management	Conduct Desktop recon of stream crossings
			Dissolved Oxygen	6.6 mg/L	5.9 mg/L	Maintain or Improve	Habitat and stream connectivity management	Manage beaver dams
							Forestry management	Forestry management - comprehensive (147M)
							Forestry management	Actively seek landowners willing to participate in the Sustainable Forest Incentive Act (SFIA)
							Public outreach	Provide education opportunities to local landowners
			Sediment /TSS	6.7 mg/L	6.0 mg/L	Maintain or Improve		
	Cedar Creek (07010104-641)	Cedar Lk to Mississippi R	Phosphorus	–	Maintain or Improve	Not to Exceed 50 ppb	These Protection Strategies apply to all Pollutants	
							Stream banks, bluffs and ravines protected/restored	Stream Channel Stabilization (584)
							Buffers and filters, field edge	Increase buffer width using native vegetation and trees
							Pasture management	Livestock access control (472)
City of Aitkin-Mississippi River (0701010404) (cont.)	Cedar Creek (07010104-641) (cont.)	Cedar Lk to Mississippi R (cont.)	Phosphorus (cont.)	–	Maintain or Improve (cont.)	Not to Exceed 50 ppb (cont.)	Habitat and stream connectivity management	Culvert Inventory
			Dissolved Oxygen	–	Maintain or Improve	> 5.0 mg/L	Habitat and stream connectivity management	Conduct Desktop recon of stream crossings

Waterbody and Location			Water Quality				Strategies to Achieve Final Water Quality Goal	
HUC-10 Subwatershed	Waterbody (ID)	Location Description	Pollutant/ Stressor	Current WQ Conditions	10-year WQ Milestone Year:	Final WQ Goal Years	Strategy Type	BMP Scenario
							Habitat and stream connectivity management	Manage beaver dams
							Forestry management	Forestry management - comprehensive (147M)
							Forestry management	Actively seek landowners willing to participate in the Sustainable Forest Incentive Act (SFIA)
							Public outreach	Provide education opportunities to local landowners
			Sediment /TSS	–	Maintain or Improve	Not to Exceed 15 mg/L		
	Dean Brook (07010104-678)	Dean Lk to Mississippi R	Phosphorus	–	Maintain or Improve	Not to Exceed 50 ppb	These Protection Strategies apply to all Pollutants	
							Stream banks, bluffs and ravines protected/restored	Stream Channel Stabilization (584)
							Buffers and filters, field edge	Increase buffer width using native vegetation and trees
							Pasture management	Livestock access control (472)
							Habitat and stream connectivity management	Culvert Inventory
			Dissolved Oxygen	–	Maintain or Improve	> 5.0 mg/L	Habitat and stream connectivity management	Conduct Desktop recon of stream crossings
							Habitat and stream connectivity management	Manage beaver dams
							Forestry management	Forestry management - comprehensive (147M)
							Forestry management	Actively seek landowners willing to participate in the Sustainable Forest Incentive Act (SFIA)
							Public outreach	Provide education opportunities to local landowners
			Sediment /TSS	–	Maintain or Improve	Not to Exceed 15 mg/L		
	Sisabagamah Creek (07010104-677)	Sisabagamah Lk to Rabbit Cr	Phosphorus	43 ppb	39 ppb	Maintain or Improve	These Protection Strategies apply to all Pollutants	
							Stream banks, bluffs and ravines protected/restored	Stream Channel Stabilization (584)
							Buffers and filters, field edge	Increase buffer width using native vegetation and trees
							Pasture management	Livestock access control (472)
							Habitat and stream connectivity management	Culvert Inventory
			Dissolved Oxygen	5.1 mg/L, low DO of 4.4	5.6 mg/L, low DO of 4.8	> 5 mg/L	Habitat and stream connectivity management	Conduct Desktop recon of stream crossings
							Habitat and stream connectivity management	Manage beaver dams
City of Aitkin-Mississippi River (0701010404) (cont.)	Sisabagamah Creek (07010104-677) (cont.)	Sisabagamah Lk to Rabbit Cr (cont.)	Dissolved Oxygen (cont.)	5.1 mg/L, low DO of 4.4 (cont.)	5.6 mg/L, low DO of 4.8 (cont.)	> 5 mg/L (cont.)	Forestry management	Forestry management - comprehensive (147M)
							Forestry management	Actively seek landowners willing to participate in the Sustainable Forest Incentive Act (SFIA)
							Public outreach	Provide education opportunities to local landowners

Waterbody and Location			Water Quality				Strategies to Achieve Final Water Quality Goal	
HUC-10 Subwatershed	Waterbody (ID)	Location Description	Pollutant/ Stressor	Current WQ Conditions	10-year WQ Milestone Year:	Final WQ Goal Years	Strategy Type	BMP Scenario
			Sediment /TSS	3.6 mg/L	3.2 mg/L	Maintain or Improve		
	Rabbit Creek (07010104-688)	Rabbit Lk to Sisabagamah Cr	Phosphorus	–	Maintain or Improve	Not to Exceed 50 ppb	These Protection Strategies apply to all Pollutants	
							Stream banks, bluffs and ravines protected/restored	Stream Channel Stabilization (584)
							Buffers and filters, field edge	Increase buffer width using native vegetation and trees
							Pasture management	Livestock access control (472)
							Habitat and stream connectivity management	Culvert Inventory
			Dissolved Oxygen	–	Maintain or Improve	> 5.0 mg/L	Habitat and stream connectivity management	Conduct Desktop recon of stream crossings
							Habitat and stream connectivity management	Manage beaver dams
							Forestry management	Forestry management - comprehensive (147M)
							Forestry management	Actively seek landowners willing to participate in the Sustainable Forest Incentive Act (SFIA)
							Public outreach	Provide education opportunities to local landowners
			Sediment /TSS	–	Maintain or Improve	Not to Exceed 15 mg/L	Habitat and stream connectivity management	Modify/replace dams, culverts & fish passage barriers
			Fish IBI	FIBI Score: 34 (moved to 4D natural background)	FIBI Score: 37	FIBI Score: 40		
City of Brainerd-Mississippi River (0701010405)	Lower Mission Lake (18-0243-00)		Phosphorus	Lake Concentration: 46 ppb Lake Load: 2,078.1 lbs/yr	Lake Concentration: 41 ppb Lake Load: 1,870.3 lbs/yr	Lake Concentration: 27 ppb Lake Load: 967.7 lbs/yr	Septic system improvements	Septic System Improvement (126M)
							Lakeshore	Shoreline stabilization and buffer
	Fawn Lake (18-0240-00)		Phosphorus	Lake Concentration: 55 ppb Lake Load: 832.3 lbs/yr	Lake Concentration: 50 ppb Lake Load: 749.1 lbs/yr	Lake Concentration: 27 ppb Lake Load: 285.9 lbs/yr	Nutrient management (cropland)	Fertilizer rates match U of MN recommendations (without gov't funding)
							Nutrient management (cropland)	Precision Nutrient Timing & Management (beyond 590 standard)
							Water Level Management	Add upstream practices to address fluctuations in water level
	Serpent Lake (18-0090-00)		Phosphorus	17.0 ppb	15.3 ppb	11.0 ppb	Septic system improvements	Septic System Improvement (126M)
							Stormwater runoff control	Raingardens, rain barrels, vegetated swales
							Stormwater runoff control	Decrease runoff from impervious surfaces in lakeshed area
							Stormwater runoff control	Decrease runoff at lake public access
City of Brainerd-Mississippi River (0701010405) (cont.)	Serpent Lake (18-0090-00) (cont.)		Phosphorus (cont.)	17.0 ppb (cont.)	15.3 ppb (cont.)	11.0 ppb (cont.)	Shoreline protection	Maintain vegetated buffer along shoreline
							Shoreline protection	Increase native vegetation along shoreline
							Shoreline protection	Enforce existing shoreland zoning requirements
							Forestry management	Forestry management - comprehensive (147M)

Waterbody and Location			Water Quality				Strategies to Achieve Final Water Quality Goal	
HUC-10 Subwatershed	Waterbody (ID)	Location Description	Pollutant/ Stressor	Current WQ Conditions	10-year WQ Milestone Year:	Final WQ Goal Years	Strategy Type	BMP Scenario
							Converting land to perennials	Conservation Easements
							Public outreach	Provide education opportunities to lakeshore property owners on importance of shoreline protection
							Public outreach	Implement DNR's "Score Your Shore"
	East and West Rabbit Lake (18-0093-00)		Phosphorus	East Rabbit: 13.4 ppb West Rabbit: 13.9 ppb	East Rabbit: 12.1 ppb West Rabbit: 12.5 ppb	East Rabbit: 11.0 ppb West Rabbit: 12.0 ppb	Septic system improvements	Septic System Improvement (126M)
							Stormwater runoff control	Raingardens, rain barrels, vegetated swales
							Stormwater runoff control	Decrease runoff from impervious surfaces in lakeshed area
							Stormwater runoff control	Decrease runoff at lake public access
							Shoreline protection	Maintain vegetated buffer along shoreline
							Shoreline protection	Increase native vegetation along shoreline
							Shoreline protection	Enforce existing shoreland zoning requirements
							Forestry management	Forestry management - comprehensive (147M)
							Converting land to perennials	Conservation Easements
							Public Outreach	Provide education opportunities to lakeshore property owners on importance of shoreline protection
							Public Outreach	Implement DNR's "Score Your Shore"
Nokasippi River (0701010406)	Clearwater Lake (18-0038-00)		Phosphorus	18.5 ppb	16.6 ppb	14.0 ppb	Septic system improvements	Septic System Improvement (126M)
							Stormwater runoff control	Raingardens, rain barrels, vegetated swales
							Stormwater runoff control	Decrease runoff from impervious surfaces in lakeshed area
							Stormwater runoff control	Decrease runoff at lake public access
							Shoreline protection	Maintain vegetated buffer along shoreline
							Shoreline protection	Increase native vegetation along shoreline
							Shoreline protection	Enforce existing shoreland zoning requirements
							Forestry management	Forestry management - comprehensive (147M)
							Converting land to perennials	Conservation Easements
							Public outreach	Provide education opportunities to lakeshore property owners on importance of shoreline protection
							Public outreach	Implement DNR's "Score Your Shore"

Figure 14. Central management zone priority waterbodies.

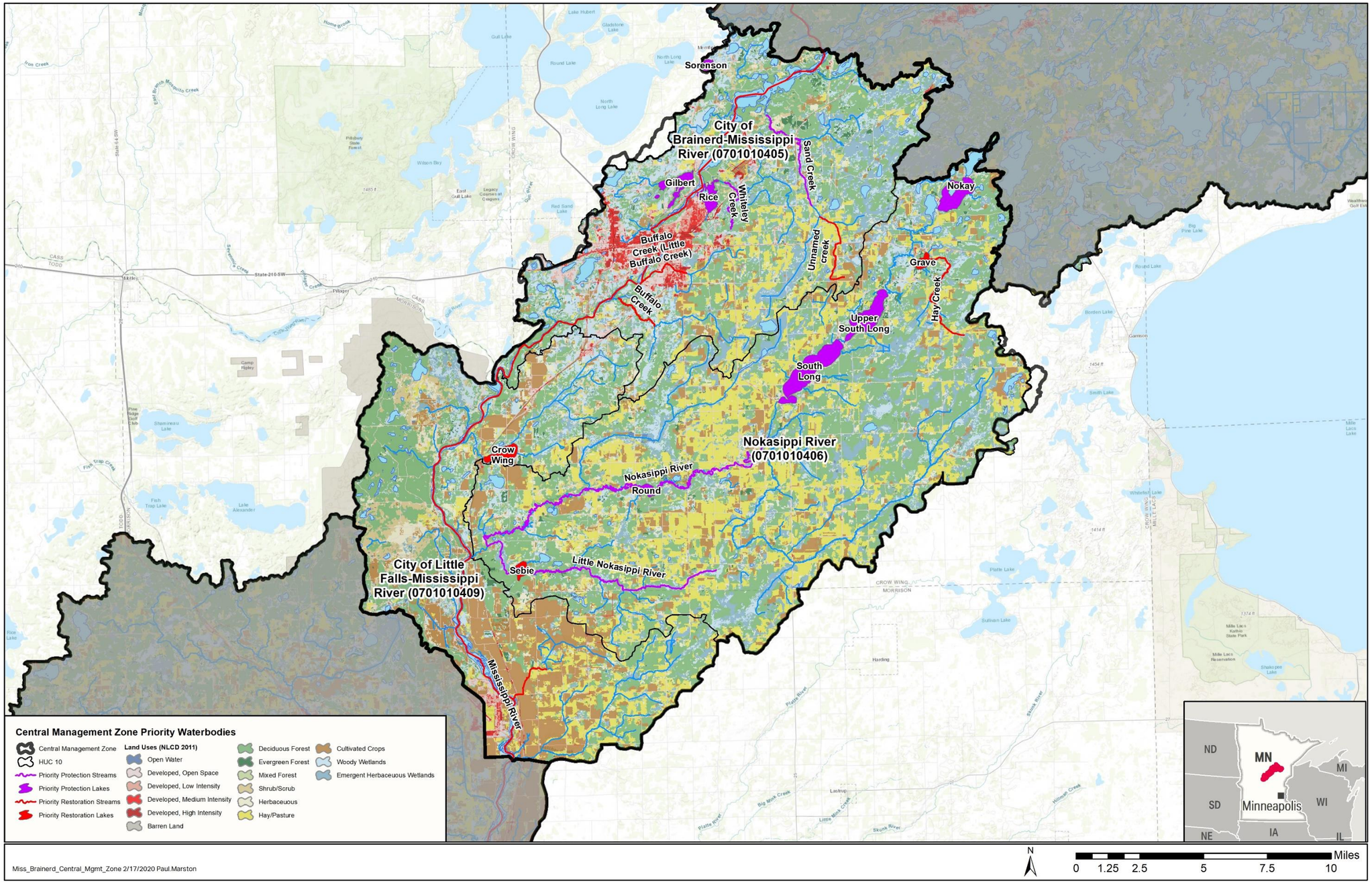


Table 27. Strategies and actions proposed for the central management zone of the MRBW.

Central Management Zone

Waterbody and Location			Water Quality				Strategies to Achieve Final Water Quality Goal	
HUC-10 Subwatershed	**Waterbody (ID)**	**Location and Upstream Influence Counties**	**Pollutant/ Stressor**	**Current WQ Conditions**	**10-year WQ Milestone**	**Final WQ Goal**	**Strategy Type**	**BMP Scenario**
NA	Mississippi River (07010104-656, -657, and -658)	NA	Sediment /TSS	30 - 39 mg/L	27 - 35 mg/L	Not to Exceed 15 mg/L	Stream banks, bluffs and ravines protected/restored	Stream Channel Stabilization [584]
							Stream banks, bluffs and ravines protected/restored	Riparian herbaceous cover [390]
							Urban Stormwater runoff control	Stormwater practices to meet TMDL and permit conditions
							Buffers and filters, field edge	Riparian Buffers, 16+ feet (perennials replace tilled) [390, 391, 327]
							Converting land to perennials	Conservation Easements
City of Brainerd-Mississippi River (0701010405)	Unnamed Creek (07010104-679)	Headwaters to Sand Cr	Macroinvertebrate IBI	MIBI Score: 17.3/19.9	MIBI Score: 20.5	MIBI Score: 52.4	Feedlot runoff controls	Feedlot runoff reduction/treatment (635, 784)
							Habitat and stream connectivity management	Stream restoration (go to strategy "Stream banks, bluffs and ravines protected/restored")
	Buffalo Creek (07010104-610)	Unnamed cr to Unnamed Cr	Macroinvertebrate IBI	MIBI Score: 38.7, 40.7	MIBI Score: 43.7	MIBI Score: 50.3	Stream banks, bluffs and ravines protected/restored	Stream Channel Stabilization (584)
							Stream banks, bluffs and ravines protected/restored	Stream habitat improvement and management [395]
							Stream banks, bluffs and ravines protected/restored	Stream restoration using principles such as Natural Channel Design
							Stream banks, bluffs and ravines protected/restored	Floodplain restoration; connecting channel to floodplain
							Habitat and stream connectivity management	Modify/replace dams, culverts and fish passage barriers
	Buffalo Creek (Little Buffalo Creek) (07010104-695)	Wright St to Mississippi R	Macroinvertebrate IBI	MIBI Score: 24.2	MIBI Score: 26.6	MIBI Score: 50.3	Urban Stormwater runoff control	Bioretention/Biofiltration (urban) [712M]
							Urban Stormwater runoff control	Permeable surfaces and pavements (800M, 804M)
							Urban Stormwater Runoff Control	Supplemental Street Sweeping
							Urban Stormwater Runoff Control	Constructed Stormwater Pond (urban) (155M)
							Stream banks, bluffs and ravines protected/restored	Stream habitat improvement and management [395]
			Fish IBI	FIBI Score: 16	FIBI Score: 17.6	FIBI Score: 40	Urban Stormwater Runoff Control	Infiltration Basin (urban) (803M)
							Urban Stormwater Runoff Control	Permeable surfaces and pavements (800M, 804M)
							Urban Stormwater Runoff Control	Supplemental Street Sweeping
							Urban Stormwater Runoff Control	Constructed Stormwater Pond (urban) (155M)

Waterbody and Location			Water Quality				Strategies to Achieve Final Water Quality Goal	
HUC-10 Subwatershed	**Waterbody (ID)**	**Location and Upstream Influence Counties**	**Pollutant/ Stressor**	**Current WQ Conditions**	**10-year WQ Milestone**	**Final WQ Goal**	**Strategy Type**	**BMP Scenario**
City of Brainerd-Mississippi River (0701010405) (cont.)	Buffalo Creek (Little Buffalo Creek) (07010104-695) (cont.)	Wright St to Mississippi R (cont.)	Bacteria/*E. coli*	Seasonal geomean 215 org/ 100mL	Seasonal geomean 193.5 org/ 100mL	Seasonal geomean < 126 org/ 100mL	Urban Stormwater Runoff Control	Infiltration Basin (urban) (803M)
							Urban Stormwater Runoff Control	Permeable surfaces and pavements (800M, 804M)
							Urban Stormwater Runoff Control	Supplemental Street Sweeping
							Urban Stormwater Runoff Control	Constructed Stormwater Pond (urban) (155M)
							Urban Stormwater runoff control	Improved lawn/turf vegetation and soil practices
							Monitoring	Conduct source assessment
							Public Outreach	Provide information to local landowners on impacts of pet waster on local waterbodies
	Whiteley Creek (07010104-589)	Headwaters to Rice Lk (18-0145-00)	Macroinvertebrate IBI	MIBI Score: 19.5 / 14.4	MIBI Score: 18.7	MIBI Score: 32	Monitoring	Conduct continuous DO analysis at multiple locations and collect sonde and secchi-tube data in 2020 field season
			Phosphorus	-	Maintain or Improve	Not to Exceed 50 ppb	These Protection Strategies apply to all Pollutants	
							Nutrient management (cropland)	Nutrient Management (fertilizer, soil, manure) [590]
							Monitoring	Conduct continuous DO analysis at multiple locations and collect sonde and secchi-tube data in 2020 field season
							Stream banks, bluffs and ravines protected/restored	Riparian herbaceous cover [390]
							Habitat and stream connectivity management	Manage beaver dams
			Dissolved Oxygen	-	Maintain or Improve	> 7.0 mg/L		
			Sediment /TSS	-	Maintain or Improve	Not to Exceed 15 mg/L		
			Water Temp	-	Maintain or Improve	> 20° C avg. summer temp	Stream banks, bluffs and ravines protected/restored	Riparian herbaceous cover [390]
	Sand Creek (07010104-580)	T45 R30W S13, south line to Mississippi R	Phosphorus	-	Maintain or Improve	Not to Exceed 50 ppb	These Protection Strategies apply to all Pollutants	
							Monitoring	Conduct water quality monitoring in 2020 field season
			Dissolved Oxygen	-	Maintain or Improve	> 5.0 mg/L		
			Sediment /TSS	-	Maintain or Improve	Not to Exceed 15 mg/L		

Waterbody and Location			Water Quality				Strategies to Achieve Final Water Quality Goal	
HUC-10 Subwatershed	**Waterbody (ID)**	**Location and Upstream Influence Counties**	**Pollutant/ Stressor**	**Current WQ Conditions**	**10-year WQ Milestone**	**Final WQ Goal**	**Strategy Type**	**BMP Scenario**
Nokasippi River (0701010406)	Hay Creek (07010104-645)	Headwaters to Grave Lk	Bacteria /*E. coli*	Seasonal geomean 134.8 org/100mL	Seasonal geomean 121.32 org/100mL	Seasonal geomean < 126 org/100mL	Pasture management	Pasture improvement (101)
							Feedlot runoff controls	Feedlot runoff reduction/treatment [635, 784]
							Feedlot runoff controls	Feedlot manure/runoff storage addition (313, 784)
							Septic system improvements	Septic System Improvement [126M]
	Sebie Lake (18-0161-00)		Phosphorus	Lake Concentration: 43 ppb Lake Load: 4,001.4 lbs/yr	Lake Concentration: 39 ppb Lake Load: 3,601.3 lbs/yr	Lake Concentration: 27 ppb Lake Load: 2,150.0 lbs/yr	Nutrient management (cropland)	Fertilizer rates match U of MN recommendations (without gov't funding)
							Nutrient management (cropland)	Precision Nutrient Timing and Management (beyond 590 standard)
							Septic system improvements	Septic System Improvement [126M]
							Lakeshore	Shoreline stabilization and buffer
							In-lake management	Consulting with the DNR for recommendations on managing and restoring a healthy native vegetation population.
	Grave Lake (18-0110-00)		Phosphorus	53.0 ppb	47.7 ppb	47.0 ppb	Nutrient management (cropland)	Fertilizer rates match U of MN recommendations (without gov't funding)
							Nutrient management (cropland)	Precision Nutrient Timing and Management (beyond 590 standard)
							Septic system improvements	Septic System Improvement [126M]
							Lakeshore	Shoreline stabilization and buffer
	Nokasippi (07010104-510)	Daggett Bk to Hay Cr	Phosphorus	58.8 ppb	52.9 ppb	Not to Exceed 50 ppb	These Protection Strategies apply to all Pollutants	
							Nutrient management (cropland)	Nutrient Management (fertilizer, soil, manure) [590]
							Add cover crops for living cover in fall/spring	Cover Crops with Corn and Soybeans [340]
							Converting land to perennials	Conservation Easements
							Forestry management	Forestry management - comprehensive [147M]
			Dissolved Oxygen	-	Maintain or Improve	> 5.0 mg/L	Buffers and filters, field edge	Establish perennial riparian buffer

Waterbody and Location			Water Quality				Strategies to Achieve Final Water Quality Goal	
HUC-10 Subwatershed	**Waterbody (ID)**	**Location and Upstream Influence Counties**	**Pollutant/ Stressor**	**Current WQ Conditions**	**10-year WQ Milestone**	**Final WQ Goal**	**Strategy Type**	**BMP Scenario**
Nokasippi River (0701010406) (cont.)			Dissolved Oxygen (cont.)	-	Maintain or Improve (cont.)	> 5.0 mg/L (cont.)	Pasture management	Livestock access control [472]
							Stream banks, bluffs and ravines protected/restored	Maintain current channel morphology
			Sediment /TSS	2.7 mg/L	2.3 mg/L	Maintain or Improve		
	Nokasippi (07010104-511)	Hay Cr to Little Nokasippi R	Phosphorus	57.2 ppb	51.5 ppb	Not to Exceed 50 ppb	These Protection Strategies apply to all Pollutants	
							Nutrient management (cropland)	Nutrient Management (fertilizer, soil, manure) [590]
							Add cover crops for living cover in fall/spring	Cover Crops with Corn and Soybeans [340]
							Converting land to perennials	Conservation Cover Perennials [327, 327M, 342, 612]
							Forestry management	Forestry management - comprehensive [147M]
			Dissolved Oxygen	8.9 mg/L	9.8 mg/L	Maintain or Improve	Buffers and filters, field edge	Establish perennial riparian buffer
							Pasture management	Livestock access control [472]
							Stream banks, bluffs and ravines protected/restored	Maintain current channel morphology
			Sediment /TSS	6.4 mg/L	5.8 mg/L	Maintain or Improve		
	Little Nokasippi (07010104-532)	Headwaters to Nokasippi R	Phosphorus	203.5 ppb	183.2 ppb	Not to Exceed 50 ppb	These Protection Strategies apply to all Pollutants	
							Nutrient management (cropland)	Nutrient Management (fertilizer, soil, manure) [590]
							Add cover crops for living cover in fall/spring	Cover Crops with Corn and Soybeans [340]
							Converting land to perennials	Conservation Cover Perennials [327, 327M, 342, 612]
							Forestry management	Forestry management - comprehensive [147M]
			Dissolved Oxygen	-	Maintain or Improve	> 5.0 mg/L	Buffers and filters, field edge	Establish perennial riparian buffer
							Pasture management	Livestock access control [472]
							Stream banks, bluffs and ravines protected/restored	Maintain current channel morphology
			Sediment /TSS	75.1 mg/L	67.6 mg/L	Not to Exceed 15 mg/L		
City of Little Falls-Mississippi River (0701010409)	Crow Wing Lake (18-0155-00)		Phosphorus	38 ppb 2,434.5 lbs/yr	Lake Concentration: 34 ppb Lake Load: 2,191.1 lbs/yr	Lake Concentration: 27 ppb Lake Load: 1,432.6 lbs/yr	Nutrient management (cropland)	Fertilizer rates match U of MN recommendations (without government funding)

Waterbody and Location			Water Quality				Strategies to Achieve Final Water Quality Goal	
HUC-10 Subwatershed	**Waterbody (ID)**	**Location and Upstream Influence Counties**	**Pollutant/ Stressor**	**Current WQ Conditions**	**10-year WQ Milestone**	**Final WQ Goal**	**Strategy Type**	**BMP Scenario**
City of Little Falls-Mississippi River (0701010409) (cont.)	Crow Wing Lake (18-0155-00) (cont.)		Phosphorus (cont.)	38 ppb 2,434.5 lbs/yr (cont.)	Lake Concentration: 34 ppb Lake Load: 2,191.1 lbs/yr (cont.)	Lake Concentration: 27 ppb Lake Load: 1,432.6 lbs/yr (cont.)	Nutrient management (cropland)	Precision Nutrient Timing and Management (beyond 590 standard)
							Septic system improvements	Septic System Improvement [126M]
							Lakeshore	Shoreline stabilization and buffer
							In-Lake Management	Consulting with the DNR for recommendations on managing and restoring a healthy native vegetation population.
							Public Outreach	Implement DNR's "Score Your Shore"
			Fish IBI	FIBI Score: 21/38/33	FIBI Score: 33.7	FIBI Score: 38	Nutrient management (cropland)	Fertilizer rates match U of MN recommendations (without government funding)
							Nutrient management (cropland)	Precision Nutrient Timing and Management (beyond 590 standard)
							Septic system improvements	Septic System Improvement [126M]
							Lakeshore	Shoreline stabilization and buffer
							In-Lake Management	Consulting with the DNR for recommendations on managing and restoring a healthy native vegetation population.

Figure 15. South management zone priority waterbodies.

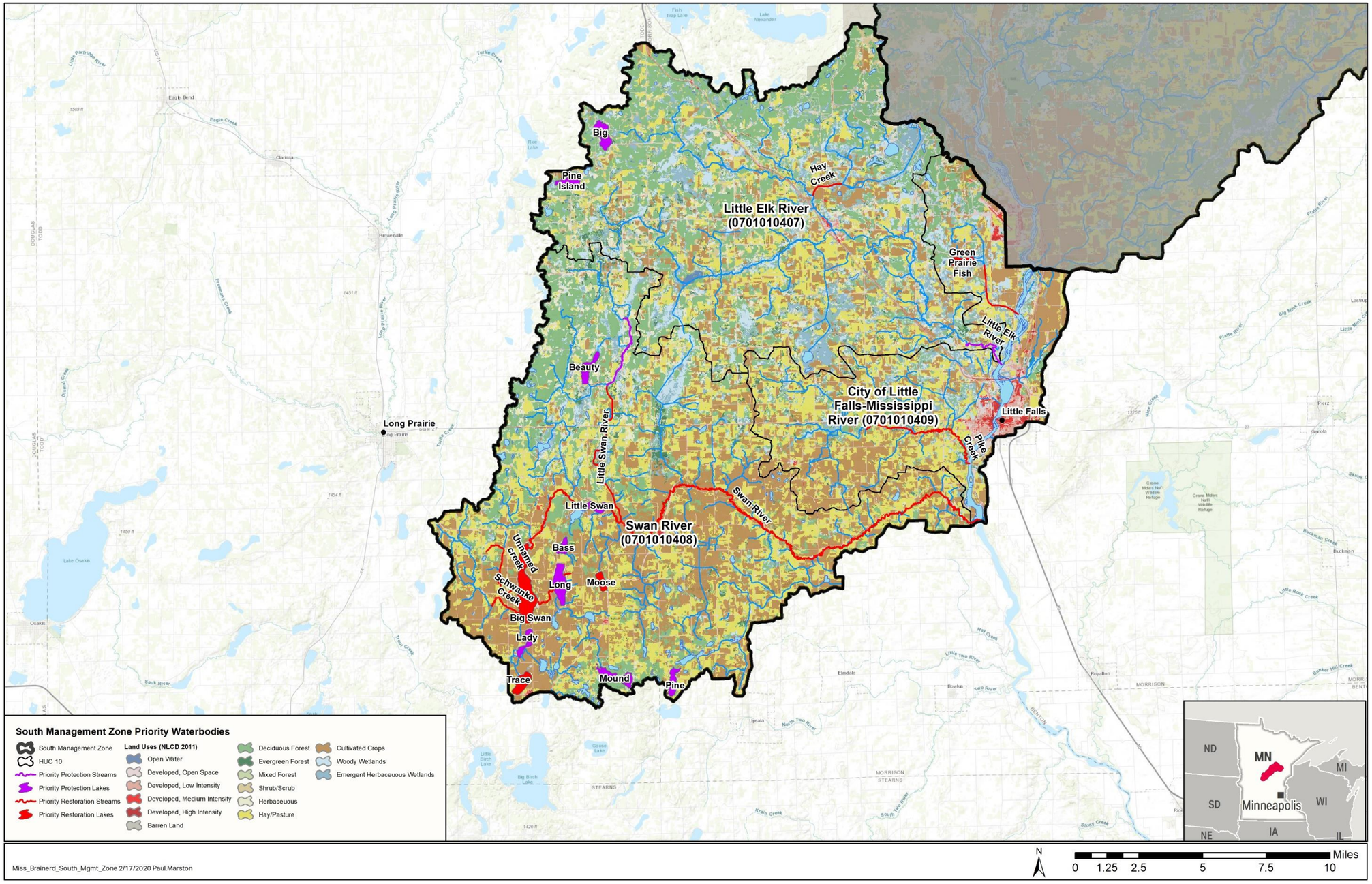


Table 28. Strategies and actions proposed for the south management zone of the MRBW Watershed.

South Management Zone								
Waterbody and Location			**Water Quality**				**Strategies to Achieve Final Water Quality Goal**	
HUC-10 Subwatershed	**Waterbody (ID)**	**Location and Upstream Influence Counties**	**Pollutant/ Stressor**	**Current WQ Conditions**	**10-year WQ Milestone**	**Final WQ Goal**	**Strategy Type**	**BMP Scenario**
Little Elk River (0701010407)	Little Elk River (07010104-521)	T129 R30W S1, north line to Mississippi R	Bacteria /*E. coli*	Seasonal geomean 152.6 org/100mL	Seasonal geomean 137.3 org/100mL	Seasonal geomean < 126 org/100mL	Pasture management	Livestock access control [472]
							Buffers and filters, field edge	Field Border [393, 327]
							Feedlot runoff controls	Feedlot runoff reduction/treatment [635, 784]
							Pasture management	Conventional pasture to prescribed rotational grazing [528]
							Manure management	Manage manure stockpiles to minimize impacts and meet 7020 rules
							Public outreach	Provide education opportunities for landowners to learn how what they do on their land impacts local waterbodies
	Hay Creek (07010104-682)	Unnamed cr to Little Elk R	Macroinvertebrate IBI	MIBI Score: 29.3	MIBI Score: 32.2	MIBI Score: 46.3	Habitat and stream connectivity management	Riparian tree planting to improve shading [390, 612]
							Drainage ditch modifications	Investigate ditch abandonment and blockage for ditch that drains large wetland complex
							Public outreach	Provide education opportunities for landowners to learn how what they do on their land impacts local waterbodies
							Ditch management	Re-meander channel and connect to floodplain
	Little Elk River (07010104-521)	Unnamed cr to Little Elk R	Phosphorus	80.8 ppb	72.7 ppb	Maintain or Improve	These Protection Strategies apply to all Pollutants	
							Nutrient management (cropland)	Nutrient Management (fertilizer, soil, manure) [590]
							Pasture management	Livestock access control [472]
							Pasture management	Pasture improvement [101]
							Agricultural tile drainage water treatment/storage	Wetland Restoration or Creation for treatment [657, 658]
			Dissolved Oxygen	8.6 mg/L	9.5 mg/L	Maintain or Improve		
			Sediment /TSS	2.9 mg/L	2.6 mg/L	Maintain or Improve		
			Bacteria /*E. coli*	—	Maintain or Improve	Seasonal geomean < 126 org/100mL	Pasture management	Livestock access control [472]
							Pasture management	Pasture improvement [101]
	Pine Island Lake (77-0067-00)		Phosphorus	13 ppb	12 ppb	Maintain or Improve	Lakeshore	Shoreline stabilization and buffer
							Forestry management	Forestry management–comprehensive [147M]
							Agricultural tile drainage water treatment/storage	Wetland Restoration or Creation for treatment [657, 658]
							Public outreach	Provide education opportunities for landowners to learn how what they do on their land impacts local waterbodies
			Phosphorus	22.1 ppb	19.9 ppb	19.9 ppb	Forestry management	Forestry management–comprehensive [147M]

Waterbody and Location			Water Quality				Strategies to Achieve Final Water Quality Goal	
HUC-10 Subwatershed	**Waterbody (ID)**	**Location and Upstream Influence Counties**	**Pollutant/ Stressor**	**Current WQ Conditions**	**10-year WQ Milestone**	**Final WQ Goal**	**Strategy Type**	**BMP Scenario**
Little Elk River (0701010407) (cont.)	Big Lake (77-0063-00)						Public outreach	Provide education opportunities for landowners to learn how what they do on their land impacts local waterbodies
Swan River (0701010408)	Schwanke Creek (07010104-627)	Unnamed cr to Big Swan Lk	Bacteria/*E. coli*	Seasonal geomean 204 org/100 mL	Seasonal geomean 184.1 org/100mL	Seasonal geomean < 126 org/100mL	Pasture management	Livestock access control [472]
							Buffers and filters, field edge	Field Border [393, 327]
							Feedlot runoff controls	Feedlot runoff reduction/treatment [635, 784]
							Add cover crops for living cover in fall/spring	Cover Crops with Corn and Soybeans [340]
							Public Outreach	Provide education opportunities for landowners to learn how what they do on their land impacts local waterbodies
	Unnamed Creek (07010104-626)	Headwaters to Big Swan Lk	Bacteria/*E. coli*	Seasonal geomean 214.1 org/100mL	Seasonal geomean 192.7 org/100mL	Seasonal geomean < 126 org/100mL	Pasture management	Livestock access control [472]
							Buffers and filters, field edge	Field Border [393, 327]
							Feedlot runoff controls	Feedlot runoff reduction/treatment [635, 784]
							Public Outreach	Provide education opportunities for landowners to learn how what they do on their land impacts local waterbodies
	Unnamed Creek (07010104-629)	Long Lk (77-0027-00) to Big Swan Lk	Bacteria/*E. coli*	Seasonal geomean 170.4 org/100mL	Seasonal geomean 153.4 org/100mL	Seasonal geomean < 126 org/100mL	Pasture management	Livestock access control [472]
							Buffers and filters, field edge	Field Border [393, 327]
							Feedlot runoff controls	Feedlot runoff reduction/treatment [635, 784]
							Public Outreach	Provide education opportunities for landowners to learn how what they do on their land impacts local waterbodies
	Swan River (07010104-502)	Headwaters (Big Swan Lk 77-0023-00) to Mississippi R	Bacteria/*E. coli*	Seasonal geomean 69.1 org/100mL	Seasonal geomean 62.2 org/100mL	Seasonal geomean < 126 org/100mL	Pasture management	Livestock access control [472]
							Buffers and filters, field edge	Field Border [393, 327]
							Feedlot runoff controls	Feedlot runoff reduction/treatment [635, 784]
							Public Outreach	Provide education opportunities for landowners to learn how what they do on their land impacts local waterbodies
	Little Swan River (07010104-570)	Spring Br to Swan R	Fish IBI	FIBI Score: 33/35	FIBI Score: 37.4	FIBI Score: 40	Habitat and stream connectivity management	Stream restoration (go to strategy "Stream banks, bluffs and ravines protected/restored")
							Public Outreach	Provide education opportunities for landowners to learn how what they do on their land impacts local waterbodies
							Monitoring and pollutant source assessment	Investigate drained wetlands along corridor and consider restoration to address low DO issues at high flows
Swan River (0701010408) (cont.)	Unnamed Creek (07010104-632)	Headwaters to Long Lk	Bacteria/*E. coli*	Seasonal geomean 196.0 org/100mL	Seasonal geomean 176.4 org/100mL	Seasonal geomean < 126 org/100mL	Pasture management	Livestock access control [472]
							Buffers and filters, field edge	Field Border [393, 327]
							Feedlot runoff controls	Feedlot runoff reduction/treatment [635, 784]
							Public Outreach	Provide education opportunities for landowners to learn how what they do on their land impacts local waterbodies

Waterbody and Location			Water Quality				Strategies to Achieve Final Water Quality Goal	
HUC-10 Subwatershed	Waterbody (ID)	Location and Upstream Influence Counties	Pollutant/ Stressor	Current WQ Conditions	10-year WQ Milestone	Final WQ Goal	Strategy Type	BMP Scenario
	Trace Lake (77-0009-00)		Phosphorus	Lake Concentration: 84 ppb Lake Load: 653.6 lbs/yr	Lake Concentration: 76 ppb Lake Load: 588.2 lbs/yr	Lake Concentration: 55 ppb Lake Load: 350.6 lbs/yr	Nutrient management (cropland)	Fertilizer rates match U of MN recommendations (without gov't funding)
							Urban Stormwater runoff control	Bioretention/Biofiltration (urban) [712M]
							Urban Stormwater runoff control	Permeable surfaces and pavements [800M, 804M]
Swan River (0701010408) (cont.)	Trace Lake (77-0009-00) (cont.)		Phosphorus (cont.)	Lake Concentration: 84 ppb Lake Load: 653.6 lbs/yr (cont.)	Lake Concentration: 76 ppb Lake Load: 588.2 lbs/yr (cont.)	Lake Concentration: 55 ppb Lake Load: 350.6 lbs/yr (cont.)	Lakeshore	Shoreline stabilization and buffer
							Public Outreach	Provide education opportunities for landowners to learn how what they do on their land impacts local waterbodies
	Big Swan Lake (77-0023-00)		Phosphorus	Lake Concentration: 45 ppb Lake Load: 10,134.8 lbs/yr	Lake Concentration: 41 ppb Lake Load: 9,121.3 lbs/yr	Lake Concentration: 37 ppb Lake Load: 6,946.9 lbs/yr	Nutrient management (cropland)	Fertilizer rates match U of MN recommendations (without gov't funding)
							Nutrient management (cropland)	Precision Nutrient Timing and Management (beyond 590 standard)
							Septic system improvements	Septic System Improvement [126M]
							Lakeshore	Shoreline stabilization and buffer
							Lakeshore	Field buffers and cover crops on east end of lake near forest cutdown
							Urban Stormwater runoff control	Improved lawn/turf vegetation and soil practices
							In-lake management	Consulting with the DNR for recommendations on managing and restoring a healthy native vegetation population.
							Public Outreach	Provide education opportunities for landowners to learn how what they do on their land impacts local waterbodies
	Moose Lake (77-0026-00)		Phosphorus	Lake Concentration: 49 ppb Lake Load: 414.0 lbs/yr	Lake Concentration: 44 ppb Lake Load: 372.6 lbs/yr	Lake Concentration: 36 ppb Lake Load: 261.0 lbs/yr	Nutrient management (cropland)	Fertilizer rates match U of MN recommendations (without gov't funding)
							Nutrient management (cropland)	Precision Nutrient Timing and Management (beyond 590 standard)
							Septic system improvements	Septic System Improvement [126M]
							Lakeshore	Shoreline stabilization and buffer
Swan River (0701010408) (cont.)	Moose Lake (77-0026-00)		Phosphorus (cont.)	Lake Concentration: 49 ppb Lake Load: 414.0 lbs/y (cont.)r	Lake Concentration: 44 ppb Lake Load: 372.6 lbs/yr (cont.)	Lake Concentration: 36 ppb Lake Load: 261.0 lbs/yr (cont.)	In-lake management	Consulting with the DNR for recommendations on managing and restoring a healthy native vegetation population.
							Public Outreach	Provide education opportunities for landowners to learn how what they do on their land impacts local waterbodies
			Fish IBI	FIBI Score: 30/38	FIBI Score: 37.4	FIBI Score: 38	Nutrient management (cropland)	Fertilizer rates match U of MN recommendations (without gov't funding)
							Nutrient management (cropland)	Precision Nutrient Timing and Management (beyond 590 standard)

Waterbody and Location			Water Quality				Strategies to Achieve Final Water Quality Goal	
HUC-10 Subwatershed	Waterbody (ID)	Location and Upstream Influence Counties	Pollutant/ Stressor	Current WQ Conditions	10-year WQ Milestone	Final WQ Goal	Strategy Type	BMP Scenario
							Septic system improvements	Septic System Improvement [126M]
							Lakeshore	Shoreline stabilization and buffer
							In-lake management	Consulting with the DNR for recommendations on managing and restoring a healthy native vegetation population.
							Public Outreach	Provide education opportunities for landowners to learn how what they do on their land impacts local waterbodies
Swan River (0701010408) (cont.)	Little Swan River (07010104-687)	T129 R30W S1, north line to Mississippi R	Phosphorus	-	Maintain or Improve	Not to Exceed 100 ppb	These Protection Strategies apply to all Pollutants	
							Nutrient management (cropland)	Nutrient Management (fertilizer, soil, manure) [590]
							Pasture management	Livestock access control [472]
							Pasture management	Pasture improvement [101]
							Agricultural tile drainage water treatment/storage	Wetland Restoration or Creation for treatment [657, 658]
			Dissolved Oxygen	-	Maintain or Improve	> 5.0 mg/L		
			Sediment /TSS	-	Maintain or Improve	Not to Exceed 30 mg/L		
			Bacteria /*E. coli*	-	Maintain or Improve	Seasonal geomean < 126 org/100mL	Pasture management	Livestock access control [472]
							Pasture management	Pasture improvement [101]
	Little Swan Lake (77-0034-00)		Phosphorus	21.4 ppb	19.3 ppb	19.0 ppb	Lakeshore	Shoreline stabilization and buffer
							Public Outreach	Provide education opportunities for landowners to learn how what they do on their land impacts local waterbodies
	Beauty Lake (77-0035-00)		Phosphorus	21.8 ppb	19.6 ppb	19.6 ppb	Lakeshore	Shoreline stabilization and buffer
							Forestry management	Forestry management–comprehensive [147M]
							Public Outreach	Provide education opportunities for landowners to learn how what they do on their land impacts local waterbodies
	Lady Lake (77-0032-00)		Phosphorus	22.8 ppb	20.5 ppb	19.0 ppb	Urban Stormwater runoff control	Manage stormwater runoff
							Septic system improvements	Campground/resort
Swan River (0701010408) (cont.)	Lady Lake (77-0032-00) (cont.)		Phosphorus (cont.)	22.8 ppb (cont.)	20.5 ppb (cont.)	19.0 ppb (cont.)	Septic system improvements	Septic System Improvement [126M]
							Converting land to perennials	Conservation Cover Perennials [327, 327M, 342, 612]
							Public Outreach	Provide education opportunities for landowners to learn how what they do on their land impacts local waterbodies
	Long Lake (77-0027-00)		Phosphorus	25.3 ppb	22.8 ppb	21.0 ppb	Nutrient management (cropland)	Nutrient Management (fertilizer, soil, manure) [590]

Waterbody and Location			Water Quality				Strategies to Achieve Final Water Quality Goal	
HUC-10 Subwatershed	Waterbody (ID)	Location and Upstream Influence Counties	Pollutant/ Stressor	Current WQ Conditions	10-year WQ Milestone	Final WQ Goal	Strategy Type	BMP Scenario
							Agricultural tile drainage water treatment/storage	Wetland Restoration or Creation for treatment [657, 658]
							Lakeshore	Shoreline restoration and stabilization
							Stormwater management	Reduce erosion from roads surrounding lake
							Public Outreach	Provide education opportunities for landowners to learn how what they do on their land impacts local waterbodies
	Mound Lake (77-0007-00)		Phosphorus	15.5 ppb	14.0 ppb	11.0 ppb	Urban Stormwater runoff control	Manage stormwater runoff
							Lakeshore	Shoreline stabilization and buffer
							Public Outreach	Provide education opportunities for landowners to learn how what they do on their land impacts local waterbodies
Swan River (0701010408) (cont.)	Bass Lake (77-0024-00)		Phosphorus	17.6 ppb	15.8 ppb	15.8 ppb	Pasture management	Livestock access control [472]
							Lakeshore	Shoreline restoration and stabilization
							Urban Stormwater runoff control	Manage stormwater runoff
							Lake Access	Improve lake public access
							Public Outreach	Provide education opportunities for landowners to learn how what they do on their land impacts local waterbodies
	Pine Lake (49-0081-00)		Phosphorus	11.8 ppb	10.6 ppb	10.6 ppb	Lakeshore	Shoreline stabilization and buffer
							Public Outreach	Provide education opportunities for landowners to learn how what they do on their land impacts local waterbodies
City of Little Falls-Mississippi River (0701010409)	Pike Creek (07010104-522)	T129 R30W S21, west line to Mississippi R	Bacteria /*E. coli*	Seasonal geomean 1,163.6 org/100mL		Seasonal geomean < 126 org/100mL	Pasture management	Livestock access control [472]
							Pasture management	Pasture improvement [101]
							Buffers and filters, field edge	Field Border [393, 327]
							Feedlot runoff controls	Feedlot runoff reduction/treatment [635, 784]
							Public Outreach	Provide education opportunities for landowners to learn how what they do on their land impacts local waterbodies
City of Little Falls-Mississippi River (0701010409) (cont.)	Unnamed Creek (07010104-684)	Unnamed outlet to Mississippi R	Dissolved Oxygen	7.75 mg/L, low DO near 0 mg/L from continuous monitoring		> 5 mg/L	Habitat and stream connectivity management	Modify/replace dams, culverts and fish passage barriers
							Drainage ditch modifications	Two-stage ditch–open channel [582]
							Public Outreach	Provide education opportunities for landowners to learn how what they do on their land impacts local waterbodies
			Fish IBI	FIBI Score: 24		FIBI Score: 40	Habitat and stream connectivity management	Modify/replace dams, culverts and fish passage barriers
							Drainage ditch modifications	Two-stage ditch–open channel [582]
							Public Outreach	Provide education opportunities for landowners to learn how what they do on their land impacts local waterbodies

South Management Zone

Waterbody and Location			Water Quality				Strategies to Achieve Final Water Quality Goal	
HUC-10 Subwatershed	**Waterbody (ID)**	**Location and Upstream Influence Counties**	**Pollutant/ Stressor**	**Current WQ Conditions**	**10-year WQ Milestone**	**Final WQ Goal**	**Strategy Type**	**BMP Scenario**
			Macroinvertebrate IBI	MIBI Score: 14.4		MIBI Score: 46.3	Habitat and stream connectivity management	Modify/replace dams, culverts and fish passage barriers
							Drainage ditch modifications	Two-stage ditch–open channel [582]
							Public Outreach	Provide education opportunities for landowners to learn how what they do on their land impacts local waterbodies
	Green Prairie Fish Lake (49-0035-00)		Fish IBI	FIBI Score: 31/33		FIBI Score: 38	Septic system improvements	Septic System Improvement [126M]
							Lakeshore	Shoreline stabilization and buffer
							In-lake management	Consulting with the DNR for recommendations on managing and restoring a healthy native vegetation population.
							Add cover crops for living cover in fall/spring	Cover Crops with Corn and Soybeans [340]
							Water Level	Irrigation management
							Public Outreach	Provide education opportunities for landowners to learn how what they do on their land impacts local waterbodies

4. Monitoring plan

The intent of the implementing organizations in this watershed is to make steady progress in terms of pollutant reduction. Accordingly, as a very general guideline, progress benchmarks are established for this watershed that assume that improvements will occur, resulting in a water quality pollutant concentration decline each year equivalent to approximately 1% of the starting (i.e., long-term) pollutant concentration. For example, for a lake with a long-term growing season total phosphorus concentration of 90 µg/L, by year 10 the concentration would be 90–(10 × 0.9) = 81 µg/L.

Again, this is a general guideline. Factors that may mean slower progress include limits in funding or landowner acceptance, challenging fixes (e.g., unstable bluffs and ravines, invasive species), and unfavorable climatic factors. Conversely, there may be faster progress for some impaired waters, especially where high-impact fixes are slated to occur.

Data from current monitoring programs will continue to be collected and analyzed for the MRBW as part of Minnesota's Water Quality Monitoring Strategy - 2011-2021 [MPCA 2011]. These monitoring programs are summarized below: Through the IWM approach, chemistry and biological data are collected throughout each major watershed once every 10 years. (See Watershed Approach to Restoring and Protecting Water Quality). This work is scheduled to begin its second iteration in the MRBW in 2026. These data provide a periodic but intensive "snapshot" of water quality throughout the watershed. In addition to the monitoring conducted in association with this process, other watershed partner organizations (e.g., local, state, federal, tribal) within the watershed may have their own monitoring activities. All of the data collected locally should be submitted regularly to the MPCA for entry into the EQuIS database system for ultimate use in water quality assessments. The Watershed Pollutant Load Monitoring Network intensively collects pollutant samples and flow data to calculate sediment and nutrient loads on either an annual or seasonal (no-ice) basis. In the MRBW, there are two subwatershed and one basin pollutant load monitoring sites. The two subwatershed sites include: the Swan River on Minnesota State Highway 238 (MN 238), southwest of Little Falls S001-996; and the Nokassippi River on CSAH-2, 3 miles northeast of Fort Ripley S002-956. The basin site is located on the Mississippi River on CSAH-1 at Aitkin S002-010. This site characterizes not only the influence of the MRBW on the Mississippi River, but of all the land that drains to the river upstream of this site.

The Citizen Surface Water Monitoring Program is a network of volunteers who make monthly lake and river transparency readings (Figure 16). Several dozen data collection locations exist within the MRBW. These data provide a continuous record of one water quality parameter (transparency/turbidity) throughout much of the watershed.

In addition to the monitoring conducted in association with the processes noted above, there are other monitoring programs where data have been and will continue to be collected on surface-water resources within or associated with this watershed. The programs include the following:

Minnesota's Fish Contaminant Monitoring Program (MPCA 2008) - This program helps to support human health and environmental protection programs within Minnesota by providing information on fish consumption, mercury cycling/trends, and analysis of potential newly identified bioaccumulative pollutants.

Wetland monitoring and assessment - Wetlands are an integral part of Minnesota's water resources, and wetland monitoring information will be an essential component in the implementation of efforts to protect and restore lakes and streams.

Figure 16. Citizen Lake monitor volunteers using Secchi disk to measure lake clarity.

5. References and further information

Barr Engineering, Inc., 2011. *Assessment of MIDS Performance Goal Alternatives: Runoff Volumes, Runoff Rates, and Pollutant Removal Efficiencies*, prepared by Barr Engineering, Inc., Minneapolis, MN, prepared for the Minnesota Pollution Control Agency, St. Paul, MN.

Minnesota Department of Natural Resources, **2001.** "Figure1. Minnesota Ground Water Provinces," *state.mn.us*, accessed September, 18, 2019, from *http://files.dnr.state.mn.us/natural_resources/water/groundwater/provinces/gwprov.pdf*

Minnesota Department of Natural Resources, 2016. *Pollution Sensitivity of Near-Surface Materials*, prepared by the Minnesota Department of Natural Resources, St. Paul, MN.

Minnesota Department of Natural Resources, 2018. "Groundwater Provinces," *state.mn.us*, accessed September, 18, 2019, from *https://www.dnr.state.mn.us/groundwater/provinces/index.html*

Minnesota Forest Resource Council, 2017. *North Central Landscape Forest Resources Plan*, prepared by the Minnesota Forest Resource Council, St. Paul, MN. Available online at http://mn.gov/frc.

Minnesota Pollution Control Agency, 2007. *Minnesota Statewide Mercury Total Maximum Daily Load*, prepared by the Minnesota Pollution Control Agency, St. Paul, MN.

Minnesota Pollution Control Agency, 2011. *Minnesota's Water Quality Monitoring Strategy 2011 to 2021*, prepared by the Minnesota Pollution Control Agency, St. Paul, MN.

Minnesota Pollution Control Agency, 2014(a). *Water Quality Trends for Minnesota Rivers and Streams at Milestone Sites*, prepared by the Minnesota Pollution Control Agency, St. Paul, MN.

Minnesota Pollution Control Agency, 2014(b). "Minimal Impact Design Standards (MIDS) Performance Goals," *pca.state.mn.us*, accessed May 9, 2019, from *https://www.pca.state.mn.us/water/enhancing-stormwater-management-minnesota*

Minnesota Pollution Control Agency, 2019(a). *Mississippi Brainerd Watershed Stressor Identification Report: A Study of the Stressors Limiting the Biotic Communities in the Mississippi River Brainerd Watershed*, prepared by the Minnesota Pollution Control Agency, Brainerd, MN.

Minnesota Pollution Control Agency, 2019(b). *Upper Mississippi River-Brainerd Watershed Monitoring and Assessment Report*, prepared by the Minnesota Pollution Control Agency, Brainerd, MN.

US Environmental Protection Agency, 2007. *An Approach for Using Load Duration Curves in the Development of TMDLs*, prepared by the US Environmental Protection Agency Office of Water, Washington, DC.

Mississippi River-Brainerd Watershed Reports

All Mississippi River-Brainerd Watershed reports referenced in this watershed report are available at the Mississippi River-Brainerd Watershed webpage:
https://www.pca.state.mn.us/water/watersheds/mississippi-river-brainerd

6. Appendix A

Table 29. Assessment status of stream reaches in the MRBW.

HUC-12	Management Zone	WID *Reach name,* *Reach description*	Biological Station ID	Reach length (miles)	Use class*	Aquatic life indicators:									Aquatic life	Aquatic rec. (Bacteria)
						Fish IBI	Invert IBI	Dissolved oxygen	TSS	Secchi Tube	Chloride	pH	Ammonia -NH_3	Eutrophication		
NA	North/Central	07010104-655 *Mississippi River* *Willow River to Pine River*	13UM017 13UM016	54.4	WWg	MTS	--	--	IMP	--	--	--	--	--	SUP	--
		07010104-656 *Mississippi River* *Pine River to Crow Wing River*	13UM013 13UM014 13UM015 13UM033	32.2	WWg	MTS	--	--	IMP	--	--	--	--	--	SUP	--
Lower Rice River (0701010401-01)	North	07010104-543 *Unnamed ditch* *French Lk to Rice R*	16UM058	2.22	WWg	MTS	MTS	IF	IF	IF	--	IF	IF	IF	SUP	--
		07010104-693 *Rice River* *Wakefield Bk to Mississippi R*	16UM037	24.58	WWg	MTS	MTS	MTS	IF	IF	MTS	MTS	MTS	IF	SUP	SUP
Upper Rice River (0701010401-02)	North	07010104-505 *Rice River* *Headwaters (Porcupine Lk*	16UM036, 98NF143	13.27	WWg	EXS	--	EXS	MTS	NA	--	IF	IF	IF	IMP	SUP

HUC-12	Management Zone	WID *Reach name,* *Reach description*	Biological Station ID	Reach length (miles)	Use class*	Aquatic life indicators:									Aquatic life	Aquatic rec. (Bacteria)
						Fish IBI	Invert IBI	Dissolved oxygen	TSS	Secchi Tube	Chloride	pH	Ammonia -NH_3	Eutrophication		
		01-0066-00) to Section 5 Cr														
		07010104-536 *Wakefield Brook* *Headwaters to Rice R*	16UM061	10.76	WWg	MTS	MTS	IF	IF	IF	--	IF	IF	IF	SUP	--
		07010104-649 *Rice River* *Section 5 Cr to Wakefield Bk*	10EM088	7.8	WWg	EXP	MTS	EXS	MTS	NA	--	MTS		IF	IMP	IMP
		07010104-692 *Rice River* *Wakefield Bk to Dam Bk*	00UM019	10.65	WWg	MTS	MTS	NA	MTS	NA	MTS	MTS	MTS	IF	SUP	SUP
Ripple River (0701010402-01)	North	07010104-660 *Ripple River* *Raspberry Cr to Mississippi R*	16UM041	5.9	WWg	MTS	MTS	NA	IF	MTS	MTS	MTS	MTS	IF	SUP	SUP
		07010104-661 *Ripple River* *Hanging Kettle Lk to Raspberry Cr*	16UM038	5.27	WWg	MTS	MTS	IF	IF	IF	--	IF	IF	IF	SUP	--
		07010104-666 *Ripple River*	16UM040	2.26	WWm	MTS	MTS	NA	IF	IF	--	IF	IF	IF	SUP	--

HUC-12	Management Zone	WID *Reach name,* *Reach description*	Biological Station ID	Reach length (miles)	Use class*	Aquatic life indicators:									Aquatic life	Aquatic rec. (Bacteria)
						Fish IBI	Invert IBI	Dissolved oxygen	TSS	Secchi Tube	Chloride	pH	Ammonia -NH_3	Eutrophication		
		Unnamed wetland (01-0394-00) to Lingroth Lk outlet														
Little Willow River (0701010403-01)	North	07010104-624 *Unnamed creek* *Rice Lk to Little Willow R*	--	3.36	--	--	--	--	--	MTS	--	--	--	--	IF	--
		07010104-689 *Little Willow River* *Headwaters (Esquagamah Lk 01-0147-00) to Little Willow Diversion ditch*	16UM022	11.96	WWg	MTS	--	NA	IF	IF	MTS	MTS	MTS	IF	SUP	IF
		07010104-697 *Unnamed ditch* *Blind Lk to Mississippi R flood diversion channel*	16UM063	5.52	WWm	MTS	MTS	IF	IF	IF	--	IF	IF	IF	SUP	--
		07010104-701 *Little Willow River Old Channel*	16UM020	5.66	WWm	EXS	MTS	IF	IF	IF	MTS	MTS	MTS	IF	IMP	IF
		Unnamed ditch to Flood Diversion Channel														
		07010104-691	17UM200	3.96	WWm	MTS	EXS	--	--	--	--	--	--	--	IMP	--

HUC-12	Management Zone	WID *Reach name,* *Reach description*	Biological Station ID	Reach length (miles)	Use class*	Aquatic life indicators:									Aquatic life	Aquatic rec. (Bacteria)
						Fish IBI	Invert IBI	Dissolved oxygen	TSS	Secchi Tube	Chloride	pH	Ammonia -NH_3	Eutrophication		
		Unnamed ditch (Little Willow River Diversion) Little Willow Ditch old channel to Mississippi R														
City of Aitkin-Mississippi River (0701010404-01)	North	07010104-678 *Dean Brook* *Dean Lk to Mississippi R*	16UM006	2.91	WWg	MTS	IF	IF	IF	IF	--	IF	IF	IF	SUP	--
Cedar Creek (0701010404-02)	North	07010104-639 *Unnamed creek* *Ringhand Lk to Cedar Lk*	--	0.11	--	--	--	NA	NA	NA	--	NA	--	NA	NA	SUP
		07010104-641 *Cedar Creek* *Cedar Lk to Mississippi R*	16UM002	3.13	WWg	MTS	MTS	IF	IF	IF	--	IF	IF	IF	SUP	--
		07010104-642 *Cedar Brook* *Anderson Lk to Unnamed lk*	--	1.26	--	--	--	NA	NA	NA	--	NA	--	NA	NA	SUP
Sisabagamah Creek	North	07010104-659 *Sisabagamah Creek*	16UM047, 16UM171	2.12	WWg	MTS	EXS	NA	IF	IF	MTS	MTS	MTS	IF	IMP	SUP

HUC-12	Management Zone	WID *Reach name,* *Reach description*	Biological Station ID	Reach length (miles)	Use class*	Aquatic life indicators:									Aquatic life	Aquatic rec. (Bacteria)
						Fish IBI	Invert IBI	Dissolved oxygen	TSS	Secchi Tube	Chloride	pH	Ammonia -NH_3	Eutrophication		
(0701010404-03)		*Unnamed cr to Mississippi R*														
		07010104-677 *Sisabagamah Creek* *Sisabagamah Lk to Rabbit Cr*	16UM046	2.13	WWg	EXS	MTS	EXS	IF	IF	--	IF	IF	IF	IMP	--
		07010104-688 *Rabbit Creek* *Rabbit Lk to Sisabagamah Cr*	16UM032	6.04	WWg	EXP	MTS	--	--	--	--	--	--	--	IMP	--
City of Brainerd-Mississippi River (0701010405-01)	North and Central	07010104-580 *Sand Creek* *T45 R30W S13, south line to Mississippi R*	16UM043	5.8	WWg*	MTS	MTS	IF	IF	IF	--	IF	IF	IF	SUP	--
		07010104-589 *Whiteley Creek* *Headwaters to Rice Lk (18-0145-00)*	10UM146	3.05	CWg	MTS	IF	IF	IF	IF	--	IF	IF	IF	SUP	--
		07010104-610 *Buffalo Creek* *Unnamed cr to Unnamed cr*	16UM001	2.83	WWg	MTS	EXS	IF	IF	IF	--	IF	IF	IF	IMP	--
		07010104-653 *Unnamed creek*	--	1.66	--	--	--	IF	IF	IF	MTS	IF	--	IF	IF	--

HUC-12	Management Zone	WID *Reach name,* *Reach description*	Biological Station ID	Reach length (miles)	Use class*	Aquatic life indicators:									Aquatic life	Aquatic rec. (Bacteria)
						Fish IBI	Invert IBI	Dissolved oxygen	TSS	Secchi Tube	Chloride	pH	Ammonia -NH_3	Eutrophication		
		(Whiskey Creek) Headwaters to Mississippi R														
		07010104-679, *Unnamed creek Headwaters to Sand Cr*	16UM042	3.78	WWm	MTS	EXS	IF	IF	IF	--	IF	IF	IF	IMP	--
		07010104-695 *Buffalo Creek (Little Buffalo Creek) Wright St to Mississippi R*	00UM015	2.43	WWg	EXS	EXS	IF	IF	IF	MTS	MTS	IF	IF	IMP	IMP
Nokasippi River (0701010406-01)	Central	07010104-509 *Nokasippi River Headwaters (Clearwater Lk 18-0038-00) to Daggett Bk*	16UM026, 16UM029	20.77	WWg	MTS	MTS	NA	NA	NA	--	NA	NA	NA	SUP	SUP
		07010104-510 *Nokasippi River Daggett Bk to Hay Cr*	16UM027	15.42	WWg	MTS	--	IF	IF	MTS	--	IF	--	IF	SUP	SUP
		07010104-511 *Nokasippi River*	16UM028	9.28	WWe	MTS	MTS	NA	MTS	MTS	MTS	MTS	MTS	IF	SUP	SUP

HUC-12	Management Zone	WID *Reach name,* *Reach description*	Biological Station ID	Reach length (miles)	Use class*	Aquatic life indicators:									Aquatic life	Aquatic rec. (Bacteria)
						Fish IBI	Invert IBI	Dissolved oxygen	TSS	Secchi Tube	Chloride	pH	Ammonia -NH_3	Eutrophication		
		Hay Cr to Little Nokasippi R														
		07010104-532 *Little Nokasippi River Headwaters to Nokasippi R*	16UM017	13.8	WWg	MTS	MTS	IF	IF	IF	--	IF	IF	IF	SUP	IF
		07010104-612 *Unnamed creek Headwaters (Graves Lk 18-0110-00) to Nokasippi R*	--	0.45	--	--	--	NA	NA	NA	--	NA	--	NA	NA	SUP
		07010104-645 *Hay Creek Headwaters to Grave Lk*	--	5.58	--	--	--	IF	MTS	IF	--	MTS	--	--	IF	IMP
		07010104-699 *Hay Creek -94.253 46.244 to Nokasippi R*	16UM010	3.7	WWg	MTS	--	IF	IF	IF	--	IF	IF	IF	SUP	IF
Daggett Brook	Central	07010104-534 *Daggett Brook*	16UM003, 16UM004	22.48	WWg	MTS	MTS	IF	IF	MTS	MTS	MTS	MTS	IF	SUP	SUP

HUC-12	Management Zone	WID *Reach name,* *Reach description*	Biological Station ID	Reach length (miles)	Use class*	Aquatic life indicators:									Aquatic life	Aquatic rec. (Bacteria)
						Fish IBI	Invert IBI	Dissolved oxygen	TSS	Secchi Tube	Chloride	pH	Ammonia -NH_3	Eutrophication		
(0701010406-02)		*Headwaters to Nokasippi R*														
Little Elk River (0701010407-01)	South	07010104-521 *Little Elk River* *T129 R30W S1, north line to Mississippi R*	16UM014	2.55	WWg	MTS	MTS	IF	IF	MTS	MTS	MTS	MTS	IF	SUP	IMP
		07010104-529 *Little Elk River* *Headwaters to S Br Little Elk R*	16UM013	13.48	WWg	MTS	MTS	IF	IF	IF	--	IF	IF	IF	SUP	--
		07010104-530 *Little Elk River* *S Br Little Elk R to T130 R30W S36, south line*	--	13.32	WWg	--	--	--	--	MTS	--	--	--	--	IF	--
		07010104-682 *Hay Creek* *Unnamed cr to Little Elk R*	16UM011	1.36	WWg	MTS	EXS	IF	IF	IF	--	IF	IF	IF	IMP	--
		07010104-683 *Unnamed creek*	16UM060	4.56	WWe	MTS	MTS	IF	IF	IF	--	IF	IF	IF	SUP	--

HUC-12	Management Zone	WID *Reach name,* *Reach description*	Biological Station ID	Reach length (miles)	Use class*	Aquatic life indicators:									Aquatic life	Aquatic rec. (Bacteria)
						Fish IBI	Invert IBI	Dissolved oxygen	TSS	Secchi Tube	Chloride	pH	Ammonia -NH_3	Eutrophication		
		Headwaters to Hay Cr														
Swan River (0701010408-01)	South	07010104-502 *Swan River Headwaters (Big Swan Lk 77-0023-00) to Mississippi R*	16UM049, 16UM050, 16UM051	36.68	WWg	MTS	MTS	EXS	IF	MTS	MTS	MTS	MTS	IF	IMP	IMP
		07010104-570 *Little Swan River Spring Br to Swan R*	10EM118, 16UM018	6.21	WWg	EXP	MTS	IF	IF	IF	--	IF	IF	IF	IMP	--
		07010104-626 *Unnamed creek Headwaters to Big Swan Lk*	--	3.45	--	--	--	IF	MTS	--	MTS	MTS	MTS	IF	IF	IMP
		07010104-627 *Schwanke Creek Unnamed cr to Big Swan Lk*	16UM044	1.77	WWg	MTS	MTS	IF	MTS	IF	MTS	MTS	MTS	IF	SUP	IMP
		07010104-628 *Unnamed creek Lady Lk to Big Swan Lk*	--	0.79	--	--	--	IF	NA	--	NA	NA	NA	NA	NA	SUP

HUC-12	Management Zone	WID *Reach name,* *Reach description*	Biological Station ID	Reach length (miles)	Use class*	Aquatic life indicators:									Aquatic life	Aquatic rec. (Bacteria)
						Fish IBI	Invert IBI	Dissolved oxygen	TSS	Secchi Tube	Chloride	pH	Ammonia -NH_3	Eutrophication		
		07010104-629 *Unnamed creek* *Long Lk (77-0027-00)* *to Big Swan Lk*	--	1.32	--	--	--	NA	NA	--	NA	NA	NA	NA	NA	IMP
		07010104-685 *Unnamed creek* *Big Marsh (49-0160-00) to -94.621, 45.915*	16UM007	1.88	WWm	MTS	MTS	NA	IF	IF	--	IF	IF	IF	SUP	--
		07010104-687 *Little Swan River* *335th Ave to Spring Branch*	16UM019	3.89	WWg	MTS	MTS	NA	IF	IF	--	IF	IF	IF	SUP	--
City of Little Falls-Mississippi River (0701010409-01)	Central and South	07010104-681 *Unnamed creek* *Unnamed ditch to Mississippi R*	16UM055	2.45	WWg	EXS	MTS	IF	IF	IF	--	IF	IF	IF	IMP	--
		07010104-684 *Unnamed creek* *Unnamed outlet to Mississippi R*	16UM056	2.77	WWm	MTS	EXS	EXS	IF	IF	--	IF	IF	IF	IMP	--
	South	07010104-522 *Pike Creek*	10EM026, 16UM031	6.99	WWg	MTS	MTS	EXS	MTS	EXS	MTS	MTS	MTS	IF	IMP	IMP

HUC-12	Management Zone	WID *Reach name,* *Reach description*	Biological Station ID	Reach length (miles)	Use class*	Aquatic life indicators:									Aquatic life	Aquatic rec. (Bacteria)
						Fish IBI	Invert IBI	Dissolved oxygen	TSS	Secchi Tube	Chloride	pH	Ammonia -NH_3	Eutrophication		
Pike Creek (0701010409-02)		*T129 R30W S21, west line to Mississippi R*														

Abbreviations for Indicator Evaluations: **MTS** = Meets Standard; **EXS** = Fails Standard; **IF** = Insufficient Information

Abbreviations for Use Support Determinations: **--** = No Data, **NA** = Not Assessed, **IF** = Insufficient Information, **SUP** = Full Support (Meets Criteria); **IMP** = Impaired (Fails Standards)

Key for Cell Shading: = existing impairment, listed before 2018 reporting cycle; = new impairment; = full support of designated use; = insufficient information.

Abbreviations for Use Class: **WWg** = Warmwater general, **WWm** = Warmwater modified, **WWe** = Warmwater exceptional, **CWg** = Coldwater general, **CWe** = Coldwater exceptional, **LRVW** = Limited resource value water

*Assessments were completed using proposed use classifications changes that have not yet been written into rule.

Table 30. Assessment status of lakes in the MRBW.

Aggregated HUC-12	Management zone	Lake name	DNR ID	Aquatic life indicators:			Aquatic recreation indicators:			Aquatic life use	Aquatic recreation use
				Fish IBI	Chloride	Pesticides ***	Total phosphorus	Chlorophyll-a	Secchi		
Lower Rice River (0701010401-01)	North	Portage	01-0069-00	MTS	MTS	--	EXS	EXS	EXS	SUP	IMP
		Long	01-0089-00	IF	MTS	--	MTS	MTS	MTS	IF	SUP
		Dam	01-0096-00	MTS	MTS	--	MTS	EXS	MTS	SUP	IF
		Gun	01-0099-00	IF	MTS	--	MTS	IF	IF	IF	IMP
		Wilkins	01-0102-00	MTS	MTS	--	MTS	MTS	MTS	SUP	SUP

Aggregated HUC-12	Management zone	Lake name	DNR ID	Aquatic life indicators:			Aquatic recreation indicators:			Aquatic life use	Aquatic recreation use
				Fish IBI	Chloride	Pesticides ***	Total phosphorus	Chlorophyll-a	Secchi		
		French	01-0104-00	IF	IF	--	MTS	MTS	MTS	IF	SUP
		Fleming	01-0105-00	MTS	MTS	--	EXS	EXS	EXS	SUP	IMP
		Turner	01-0074-00	--	MTS	--	IF	EXS	NA	IF	IF
Lower Rice River (0701010401-01)	North	Newstrom	01-0097-00	--	--	--	IF	--	IF	--	IF
		Jenkins	01-0100-00	--	IF	--	IF	IF	IF	IF	IF
Upper Rice River (0701010401-02)	North	Sugar	01-0087-00	MTS	MTS	--	MTS	MTS	MTS	SUP	SUP
		Sheriff	01-0027-00		IF	--	IF	IF	MTS	IF	IF
		Swamp	01-0092-00		MTS	--	IF	IF	NA	IF	IF
Ripple River (0701010402-01)	North	Clear	01-0093-00	MTS	MTS	--	MTS	MTS	MTS	SUP	SUP
		Nord	01-0117-00	MTS	MTS	--	MTS	MTS	MTS	SUP	SUP
		Elm Island	01-0123-00	EXS	MTS	--	EXS	EXS	EXS	IMP	IMP
		Lone	01-0125-00	MTS	MTS	--	MTS	MTS	MTS	SUP	SUP
		Ripple	01-0146-00	MTS	MTS	--	EXS	EXS	EXS	SUP	IMP
		Mallard	01-0149-00	--	--	--	IF	IF	IF	--	IF
		Farm Island	01-0159-00	MTS	MTS	--	MTS	IF	MTS	SUP	SUP
		Hammal	01-0161-00	MTS	MTS	--	MTS	MTS	MTS	SUP	SUP
		Hanging Kettle	01-0170-00	MTS	MTS	--	MTS	IF	MTS	SUP	IF
		Diamond	01-0171-00	--	MTS	--	IF	EXS	EXS	IF	IF
		Little Pine	01-0176-00	MTS	--	--	--	--	MTS	SUP	SUP
		Spirit	01-0178-00	MTS	MTS	--	MTS	MTS	MTS	SUP	SUP
		Hickory	01-0179-00	MTS	--	--	MTS	MTS	MTS	SUP	SUP
		Birch	01-0206-00	--	--	--	IF	IF	IF	--	IF
		Johnson	01-0232-00	--	--	--	IF	IF	IF	--	IF
		Killroy	01-0238-00	--	--	--	IF	--	--	--	IF

Aggregated HUC-12	Management zone	Lake name	DNR ID	Aquatic life indicators:			Aquatic recreation indicators:			Aquatic life use	Aquatic recreation use
				Fish IBI	Chloride	Pesticides ***	Total phosphorus	Chlorophyll-a	Secchi		
Ripple River (0701010402-01) (cont.)	North (cont.)	Bay	18-0034-00	MTS	MTS	--	MTS	MTS	MTS	SUP	SUP
		Knieff	18-0035-00	--	--	--	--	--	MTS	--	IF
		CROOKED (SUGAR BAY)	18-0041-01	--	--	--	MTS	MTS	MTS	--	SUP
		CROOKED (MAIN BAY)	18-0041-02	MTS	--	--	MTS	MTS	MTS	SUP	SUP
		Hanks	18-0044-00	MTS	--	--	MTS	MTS	MTS	SUP	SUP
		Portage	18-0050-00	MTS	--	--	MTS	MTS	MTS	SUP	SUP
		Rice	18-0053-00	--	--	--	NA	NA	NA	IF	NA
		Shirt	18-0072-00	--	--	--	MTS	MTS	MTS	--	SUP
		Arbor	18-0080-00	--	--	--	MTS	MTS	MTS	--	SUP
Little Willow River (0701010403-01)	North	Sitas	01-0134-00	--	--	--	IF	--	IF	--	IF
		Waukenabo	01-0136-00	MTS	MTS	--	MTS	EXS	EXS	SUP	IMP
		Round	01-0137-00	IF	MTS	--	MTS	MTS	MTS	IF	SUP
		Esquagamah	01-0147-00	IF	MTS	--	EXS	EXS	EXS	IF	IMP
		Blind	01-0188-00	MTS	MTS	--	EXS	EXS	EXS	SUP	IMP
		Unnamed	01-0285-00	--	--	--	IF	--	--	--	IF
		West	01-0287-00	--	--	--	IF	--	IF	--	IF
		Upper Blind	01-0331-00	--	--	--	IF	--	--	--	IF
		Unnamed	01-0419-00	--	--	--	IF	--	IF	--	IF
		Terry	18-0162-00	--	--	--	IF	--	IF	--	IF
		Stark	18-0169-00	MTS	MTS	--	MTS	MTS	MTS	SUP	SUP
City of Aitkin-Mississippi River (0701010404-01)	North	Island	18-0129-00	--	IF	--	MTS	MTS	MTS	IF	SUP
		Upper Dean	18-0170-00	MTS	IF	--	EXS	EXS	EXS	SUP	IMP
		Lower Dean	18-0181-00	--	--	--	IF	IF	IF	--	IF

Aggregated HUC-12	Management zone	Lake name	DNR ID	Aquatic life indicators:			Aquatic recreation indicators:			Aquatic life use	Aquatic recreation use
				Fish IBI	Chloride	Pesticides ***	Total phosphorus	Chlorophyll-a	Secchi		
City of Aitkin-Mississippi River (0701010404-01) (cont.)	North (cont.)	Rogers	18-0184-00	MTS	--	--	MTS	MTS	MTS	SUP	SUP
Cedar Creek (0701010404-02)	North	Blue	01-0181-00	--	MTS	--	MTS	MTS	MTS	IF	SUP
		Pickerel	01-0182-00	--	IF	--	IF	IF	IF	IF	IF
		Townline	01-0207-00	MTS	--	--	--	--	MTS	SUP	IF
		Sunset	01-0208-00	MTS	--	--	--	--	--	SUP	IF
		Cedar(Main Basin)	01-0209-01	MTS	MTS	--	MTS	MTS	MTS	SUP	SUP
		Cedar(N.E. Arm)	01-0209-02	--	--	--	--	--	MTS	--	IF
		Cedar(West Bay)	01-0209-03	--	MTS	--	MTS	MTS	MTS	IF	SUP
		Black	18-0059-00	--	IF	--	MTS	MTS	MTS	IF	SUP
		Portage	18-0069-00	--	--	--	--	--	MTS	--	IF
		Hamlet	18-0070-00	--	--	--	--	--	MTS	--	IF
		Placid	18-0076-00	--	--	--	--	--	MTS	--	SUP
		Casey	18-0087-00	--	--	--	EXS	EXS	EXS	--	IMP
Sisabagamah Creek (0701010404-03)	North	Rabbit	01-0091-00	MTS	IF	--	MTS	MTS	MTS	SUP	SUP
		Section Ten	01-0115-00	MTS	MTS	--	MTS	MTS	MTS	SUP	SUP
		Section Twelve	01-0120-00	MTS	IF	--	MTS	MTS	MTS	SUP	SUP
		Sisabagamah	01-0129-00	MTS	MTS	--	MTS	MTS	MTS	SUP	SUP
		Hanson	01-0132-00	MTS	MTS	--	MTS	IF	MTS	SUP	SUP
City of Brainerd-Mississippi River (0701010405-01)	North and Central	Black Bear	18-0140-00	MTS	IF	--	MTS	MTS	MTS	SUP	SUP
		Russell	18-0142-00	--	--	--	IF	--	IF	--	IF
		Rice	18-0145-00	--	--	--	EXS	IF	MTS	--	IF

Aggregated HUC-12	Management zone	Lake name	DNR ID	Aquatic life indicators:			Aquatic recreation indicators:			Aquatic life use	Aquatic recreation use
				Fish IBI	Chloride	Pesticides ***	Total phosphorus	Chlorophyll-a	Secchi		
City of Brainerd-Mississippi River (0701010405-01) (cont.)	North and Central (cont.)	Silver	18-0239-00	MTS	IF	--	MTS	MTS	MTS	SUP	SUP
		Fawn	18-0240-00	--	MTS	--	EXS	EXS	EXS	IF	IMP
		Upper Mission	18-0242-00	MTS	--	--	MTS	IF	MTS	SUP	SUP
		Lower Mission	18-0243-00	MTS	--	--	EXS	EXS	MTS	SUP	IMP
		Little Bass	18-0254-00	--	IF	--	MTS	MTS	MTS	IF	SUP
		Bass	18-0256-00	MTS	--	--	MTS	MTS	MTS	SUP	SUP
		Bonnie	18-0259-00	--	--	--	MTS	MTS	MTS	--	SUP
		Bass	18-0306-00	MTS	MTS	--	MTS	MTS	MTS	SUP	SUP
		GILBERT (EAST BAY)	18-0320-01	MTS	--	--	MTS	MTS	MTS	IF	SUP
		GILBERT (WEST BAY)	18-0320-02	--	--	--	--	--	MTS	--	IF
		Gilbert (South Bay)	18-0320-03	--	--	--	--	--	--	NA	NA
		Sorenson	18-0323-00	--	--	--	MTS	MTS	MTS	--	SUP
		Perch	18-0371-00	MTS	--	--	MTS	MTS	MTS	SUP	SUP
		Island	18-0383-00	--	--	--	IF	IF	IF	--	IF
		Unnamed	18-0527-00	--	IF	--	IF	IF	IF	IF	IF
Rabbit River (0701010405-02)	North	Agate	18-0060-00	--	IF	--	MTS	IF	MTS	IF	SUP
		Cascade	18-0061-00	--	--	--	MTS	MTS	IF	--	SUP
		Reno	18-0067-00	--	IF	--	MTS	MTS	MTS	IF	SUP
		Rice	18-0068-00	--	--	--	IF	--	IF	--	IF
		Serpent	18-0090-00	MTS	--	--	MTS	MTS	MTS	SUP	SUP
		Rabbit (East Portion)	18-0093-01	MTS	MTS	--	MTS	MTS	MTS	SUP	SUP
		Rabbit (West Portion)	18-0093-02	MTS	MTS	--	MTS	MTS	MTS	SUP	SUP
		Black Hoof	18-0117-00	MTS	IF	--	IF	EXS	MTS	SUP	IF
		Little Black Hoof	18-0118-00	--	--	--	--	--	IF	--	IF

Aggregated HUC-12	Management zone	Lake name	DNR ID	Aquatic life indicators:			Aquatic recreation indicators:			Aquatic life use	Aquatic recreation use
				Fish IBI	Chloride	Pesticides ***	Total phosphorus	Chlorophyll-a	Secchi		
Rabbit River (0701010405-02) (cont.)	North (cont.)	East Mahnomen	18-0126-01	--	--	--	NA	NA	NA	--	NA
		Clinker	18-0131-00	--	IF	--	MTS	MTS	MTS	IF	SUP
		Turner	18-0135-00	--	--	--	MTS	MTS	MTS	--	SUP
		Little Rabbit	18-0139-00	NA	IF	--	MTS	MTS	MTS	NA	SUP
		Unnamed	18-0433-00	--	--	--	EXS	EXS	IF	--	IF
		Portsmouth Mine	18-0437-00	--	--	--	SUP	SUP	SUP	--	SUP
		Pennington Mine	18-0439-00	--	IF	--	IF	IF	IF	IF	IF
		Unnamed	18-0504-00	--	--	--	MTS	MTS	NA	--	SUP
Nokasippi River (0701010406-01)	Central	Clearwater	18-0038-00	MTS	MTS	--	MTS	MTS	MTS	SUP	SUP
		Upper South Long	18-0096-00	MTS	--	--	MTS	EXS	IF	SUP	IF
		Eagle	18-0099-00	--	IF	--	MTS	MTS	MTS	IF	SUP
		Unnamed	18-0102-00	--	--	--	--	--	MTS	--	IF
		Nokay	18-0104-00	MTS	MTS	--	MTS	IF	MTS	SUP	SUP
		Dog	18-0107-00	--	--	--	--	--	IF	--	IF
		Grave	18-0110-00	--	--	--	EXS	EXS	EXS	IF	IMP
		Wolf	18-0112-00	--	--	--	MTS	MTS	NA	--	SUP
		Lookout	18-0123-00	NA	--	--	--	--	IF	--	IF
		South Long	18-0136-00	MTS	--	--	MTS	EXS	MTS	SUP	IF
		West Twin	18-0148-01	--	--	--	MTS	MTS	MTS	--	SUP
		East Twin	18-0148-02	--	--	--	MTS	IF	MTS	--	SUP
		Unnamed	18-0154-00	--	--	--	IF	--	IF	--	IF
		Sebie	18-0161-00	--	--	--	EXS	EXS	EXS	--	IMP
Daggett Brook (0701010406-02)	Central	Jack Pine	18-0023-00	--	--	--	IF	--	IF	--	IF

Aggregated HUC-12	Management zone	Lake name	DNR ID	Aquatic life indicators:			Aquatic recreation indicators:			Aquatic life use	Aquatic recreation use
				Fish IBI	Chloride	Pesticides ***	Total phosphorus	Chlorophyll-a	Secchi		
Little Elk River (0701010407-01)	South	Round	49-0056-00	MTS	--	--	MTS	MTS	MTS	SUP	SUP
		Big	77-0063-00	IF	MTS	--	MTS	IF	MTS	IF	SUP
		Pine Island	77-0067-00	MTS	--	--	MTS	MTS	MTS	SUP	SUP
		Kominek Pond	77-0378-00	--	--	--	IF	IF	--	--	IF
Swan River (0701010408-01)	South	Pine	49-0081-00	MTS	--	--	MTS	MTS	MTS	SUP	SUP
		Long	49-0086-00	--	--	--	MTS	MTS	MTS	--	SUP
		Mound	77-0007-00	MTS	MTS	--	MTS	MTS	MTS	SUP	SUP
		Trace	77-0009-00	--	IF	--	EXS	EXS	EXS	IF	IMP
		Twin	77-0021-00	--	IF	--	IF	IF	IF	IF	IF
		Mons	77-0022-00	MTS	--	--	MTS	MTS	MTS	SUP	SUP
		Big Swan	77-0023-00	MTS	MTS	--	IF	EXS	MTS	SUP	IMP
		Bass	77-0024-00	IF	--	--	MTS	MTS	MTS	IF	SUP
		Pepin	77-0025-00	NA	--	--	--	--	MTS	NA	IF
		Moose	77-0026-00	EXS	--	--	EXS	EXS	MTS	IMP	IMP
		Long	77-0027-00	MTS	--	--	MTS	MTS	MTS	SUP	SUP
		Buck	77-0029-00	--	--	--	MTS	MTS	MTS	--	SUP
		Lady	77-0032-00	MTS	IF	--	MTS	MTS	MTS	SUP	SUP
		Little Swan	77-0034-00	MTS	--	--	MTS	MTS	MTS	SUP	SUP
		Beauty	77-0035-00	MTS	--	--	MTS	MTS	MTS	SUP	SUP
City of Little Falls-Mississippi River (0701010409-01)	Central and South	Crow Wing	18-0155-00	EXS	MTS	--	EXS	EXS	EXS	IMP	IMP
City of Little Falls-Mississippi River	Central and South (cont.)	Green Prairie Fish	49-0035-00	EXS	--	--	MTS	MTS	MTS	IMP	SUP

Aggregated HUC-12	Management zone	Lake name	DNR ID	Aquatic life indicators:			Aquatic recreation indicators:			Aquatic life use	Aquatic recreation use
				Fish IBI	Chloride	Pesticides ***	Total phosphorus	Chlorophyll-a	Secchi		
(0701010409-01) (cont.)											

Abbreviations for Indicator Evaluations: -- = No Data, **MTS** = Meets Standard; **EXS** = Exceeds Standard; **IF** = Insufficient Information

Abbreviations for Use Support Determinations: **--** = No Data, **NA** = Not Assessed, **IF** = Insufficient Information, **SUP** = Full Support (Meets Criteria); **IMP** = Not Support (Impaired, exceeds standard)

Key for Cell Shading: = existing impairment, listed before 2018 reporting cycle; = new impairment; = full support of designated use; = insufficient information.

DNR Lake Summaries for 11 lakes assessed as impaired or vulnerable based on the Fish-based Index of Biotic Integrity (FIBI) in the Mississippi River - Brainerd Watershed

Summary: Gun Lake (01-0099-00) Fish Community and Stressors based on the Fish-based Index of Biotic Integrity (FIBI).

Fish Community:

- Two Fish IBI surveys score just below the impairment threshold (45) for FIBI Tool 2, and within the 90% Confidence Interval: The FIBI scores from recent surveys are 44 (2016) and 42 (2013). Based on this, Gun Lake was assessed for biological health and determined to be vulnerable to future impairment based on the FIBI. A subsequent 2019 survey also had a score of 44.
- The FIBI scores are most positively influenced by low catches of tolerant species. The scores are most negatively influenced by a relatively low biomass of insectivores sampled in the trap net gears and low number and proportion of intolerant species sampled compared to similar lakes.
- Overall species richness was low with 21 native fish species were sampled. Northern Pike were most abundant species by biomass in gill nets. Bowfin and Northern Pike were the most abundant species by biomass in trap nets. Both nearshore surveys sampled small numbers of intolerant species (Blackchin Shiner, Blacknose Shiner, Iowa Darter, and Rock Bass).

Candidate Stressor:

- Eutrophication: Gun Lake is nutrient impaired due to total phosphorus and Chl-A measurements near or just above the standard. Gun Lake was listed for excess nutrients in 2010, and the listing continued in 2020. See the TMDL for detailed information about nutrient sources. Gun lake has a moderate sized contributing watershed (13:1 watershed:lake) with significant areas of Agriculture. Agricultural land use includes hay, pasture, rowcrop, and cranberry operations. There are recent efforts to convert agricultural land to natural land cover through WMA acquisition.

Inconclusive stressor:

- Physical habitat alteration: Gun Lake shoreline has large areas of diverse emergent and floating leaf vegetation. However, based on a Score the Shore survey, Gun Lake has moderate habitat alterations associated with shoreline development. The Score the Shore survey measured moderate to poor quality shoreline habitat on average at developed sites and high quality shoreline habitat on average at undeveloped sites, with an overall lakewide average score of 75/100. There are approximately 4 docks per km/shoreline. The aquatic vegetation community is diverse but often includes large areas of the non-native plant Curly-leaf Pondweed.

Recommendations:

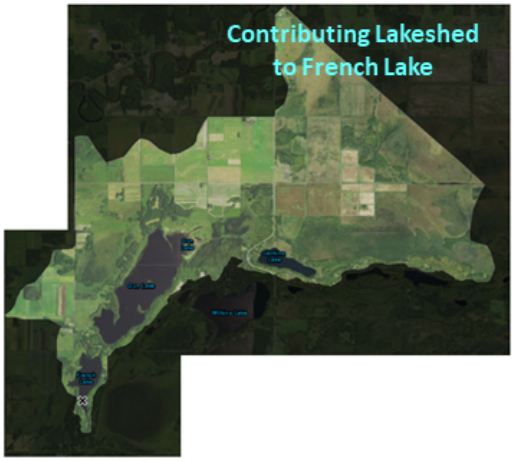
- Continue to implement or promote agricultural BMP's within the watershed to reduce nutrient and sediment inputs from the watershed, consult the TMDL report recommendations.
- Promote and maintain vegetated riparian areas with shoreline buffers and shoreline restoration projects.
- Limit removal of native aquatic plant communities.
- Continue to authorize permits for Curly-leaf Pondweed control measures, with monitoring to protect and promote native vegetation.

THIS IS A DRAFT SUMMARY OF PRELIMINARY STRESSOR ID INFORMATION, JUNE 2020. A final report will be published online.
For more information contact: Jacquelyn Bacigalupi, MnDNR Fisheries, IBI Program Supervisor, Jacquelyn.Bacigalupi@state.mn.us, (218)-203-4315

Summary: French Lake (01-0104-00) Fish Community and Stressors based on the Fish-based Index of Biotic Integrity (FIBI).

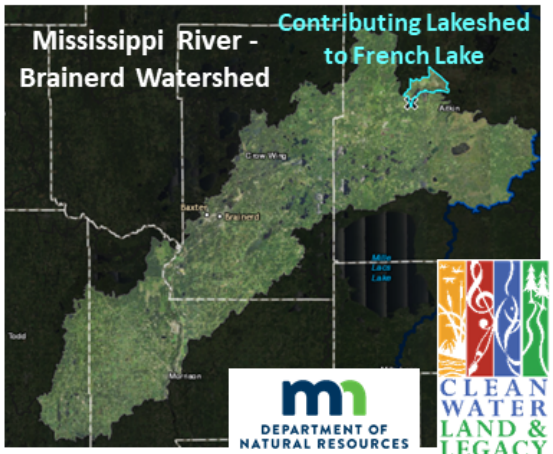
Fish Community:

- One Fish IBI surveys scored below the impairment threshold (38) for FIBI Tool 4. The FIBI survey conditions were very difficult with deep bog along much of shoreline, exacerbated by high water conditions during the survey. French Lake was assessed for biological health and determined to be vulnerable to future impairment based on the FIBI.
- The FIBI score was most negatively influenced by a lack of any small benthic species, only one intolerant species sampled (Blackchin Shiner), and the high abundance of omnivores and tolerant species sampled by the trap nets compared to similar lakes.
- Northern Pike and Yellow Bullhead were the most abundant species by biomass in gill nets. Bluegills and Bluntnose Minnows were the most commonly sampled species in each nearshore survey. Bowfin, Northern Pike, Bluegill, and Yellow Bullheads were most abundant by biomass in the trap nets.



Inconclusive stressors:

- Eutrophication: French Lake has fairly low average seasonal total phosphorus (~17.5 ppb) but a relatively large contributing watershed (75:1 watershed:lake) with significant areas of agricultural land. Agricultural land use includes hay, pasture, rowcrop, and cranberry operations. There are recent efforts to convert agricultural land to natural land cover through WMA acquisition.
- Physical habitat alteration: French Lake shoreline has large areas of waterlilies as well as some areas of rushes and other emergent vegetation. Based on a Score the Shore survey, French Lake has limited habitat alterations associated with shoreline development. The Score the Shore survey measured moderate quality shoreline habitat on average at developed sites and high quality shoreline habitat on average at undeveloped sites, with an overall lakewide average score of 86/100. There are approximately 3 docks per km/shoreline. The aquatic vegetation community is diverse but includes the non-native plant Curly-leaf Pondweed and recently Eurasian Water Milfoil.



Recommendations:

- No candidate cause identified. The difficult sampling conditions on French Lake may have influenced the FIBI score. Further, it is common to see lower species richness in lakes with low habitat diversity and with tannin stained water and each of those factors could be influencing the fish community on French Lake.
- Continue to implement or promote agricultural BMP's within the watershed to reduce nutrient and sediment inputs from the watershed.
- Promote and maintain vegetated riparian areas with shoreline buffers and shoreline restoration projects.
- Limit removal of native aquatic plant communities.

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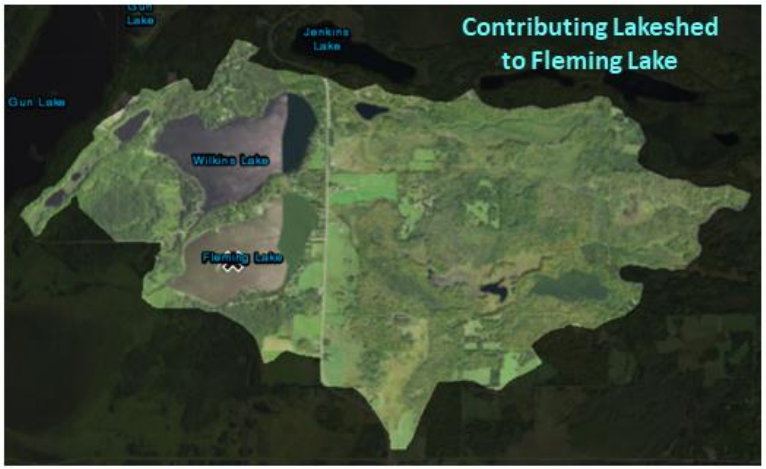
Summary: Fleming Lake (01-0105-00) Fish Community and Stressors based on the Fish-based Index of Biotic Integrity (FIBI).

Fish Community:

- One Fish IBI surveys scored just above the impairment threshold (24) for FIBI Tool 5, and within the 90% Confidence Interval: The FIBI score was 26. Based on this, Fleming Lake was assessed for biological health and determined to be vulnerable to future impairment based on the FIBI.
- The FIBI score was most negatively influenced by the lack of any intolerant species in the survey and the relatively low proportion of top carnivores sampled in the gill nets.
- Yellow Perch and Black Crappie dominated the gill net catch. Bowfin, Bluegill, Black Crappie, and Northern Pike accounted for most of the trap net biomass. Few species were sampled during the nearshore survey, with Bluegill and Yellow Perch most abundant.

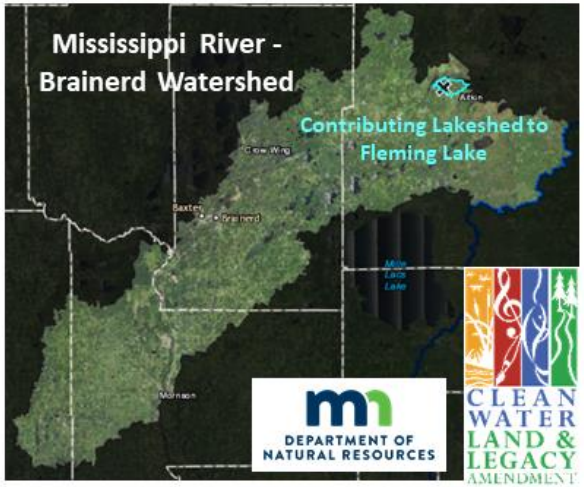


Candidate Stressor:

- Eutrophication: Fleming Lake is nutrient impaired with average seasonal total phosphorus of approximately 62. Fleming Lake was listed for excess nutrients in 2010, and the listing continued in 2020. See the TMDL for detailed information about nutrient sources. Fleming lake has a moderate sized contributing watershed (15:1 watershed:lake) with approximately 12% watershed disturbance (residential/impervious (4%), agriculture (8%)). Agricultural land use is primarily hay and pasture.

Inconclusive stressor:

- Physical habitat alteration: Fleming Lake shoreline has large areas of diverse emergent and floating leaf vegetation. However, based on a Score the Shore survey, Fleming Lake has moderate habitat alterations associated with shoreline development. The Score the Shore survey measured moderate to poor quality shoreline habitat on average at developed sites and high quality shoreline habitat on average at undeveloped sites, with an overall lakewide average score of 70/100. The aquatic vegetation community includes large areas of the non-native plant Curly-leaf Pondweed. A 2015 plant survey found curly leaf pondweed at 31% of nearshore sample plots.



Recommendations:

- Continue to implement or promote agricultural BMP's within the watershed to reduce nutrient and sediment inputs from the watershed, consult the TMDL report recommendations.
- Promote and maintain vegetated riparian areas with shoreline buffers and shoreline restoration projects.
- Limit removal of native aquatic plant communities.
- Continue to authorize permits for Curly-leaf Pondweed control measures, with monitoring to protect and promote native vegetation.

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Summary: Elm Island Lake (01-0123-00) Fish Community and Stressors based on the Fish-based Index of Biotic Integrity (FIBI).

Fish Community:

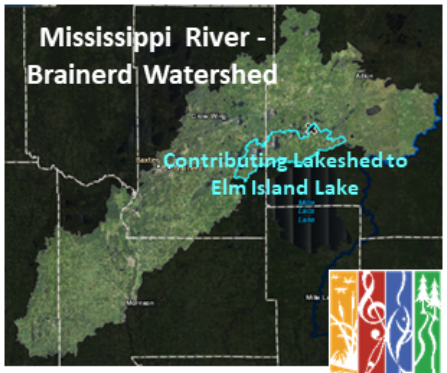
- Two Fish IBI surveys score below the impairment threshold (38) for FIBI Tool 4, and within the 90% Confidence Interval: The FIBI scores from recent surveys are 33 (2016) and 31 (2013). Based on these 2 surveys, Elm Island Lake was assessed for biological health and determined to be impaired (not supporting) based on the FIBI. A subsequent 2019 survey had a higher score, and will be used for future assessment decisions.
- The FIBI scores were most negatively influenced by the low number of intolerant species sampled (1 to 2 intolerant species per survey) and by a relatively high biomass of tolerant species (Black Bullhead) and a low biomass of insectivore species sampled in the trap net surveys. The scores were most positively influenced by a relatively high proportion of top carnivores sampled in the gill net surveys (Northern Pike).

Candidate Stressor:

- Eutrophication: Elm Island Lake is nutrient impaired with average seasonal total phosphorus of approximately 36. Elm Island Lake was listed for excess nutrients in 2010, and the listing continued in 2020. See the TMDL for detailed information about nutrient sources. Elm Island lake has a very large contributing watershed (116:1 watershed:lake) draining primarily wetland and forested land. There is approximately 16% watershed disturbance (residential/impervious (5%), agriculture (11%)). Agricultural land use is primarily hay and pasture with small amounts of row crops. The excessive ditching of the Ripple River watershed between Spirit Lake and Elm Island likely contribute to the increased nitrification of the system. Very low oxygen levels have been observed after recent high rain events that resulted in summer kills of fish in Elm Island. These acute rain events end up flushing the system of high BOD/COD waters that end up very quickly in Elm Island Lake.

Inconclusive stressor:

- Physical habitat alteration: Elm Island Lake shoreline has large areas of emergent and floating leaf vegetation, including extensive wild rice. However, based on a Score the Shore survey, Elm Island Lake has moderate habitat alterations associated with shoreline development. The Score the Shore survey measured moderate to poor quality shoreline habitat on average at developed sites and high quality shoreline habitat on average at undeveloped sites, with an overall lakewide average score of 81/100. There are approximately 5 docks per km/shoreline.



Recommendations:

- The water color and clarity of Elm Island Lake is heavily influenced by its place at the bottom of a large watershed and this likely impacts the habitat and the fish community.
- Continue to implement or promote agricultural BMP's within the watershed to reduce nutrient and sediment inputs from the watershed, consult the TMDL report recommendations.
- Promote and maintain vegetated riparian areas with shoreline buffers and shoreline restoration projects.
- Limit removal of native aquatic plant communities.
- Consider reclamation of natural channels in areas of intense ditching to minimize/slow down runoff potential in high rain events.

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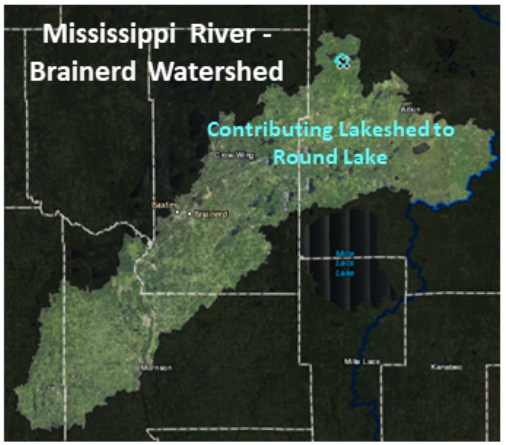
DEPARTMENT OF NATURAL RESOURCES

CLEAN WATER LAND & LEGACY AMENDMENT

Summary: Round Lake (01-0137-00) Fish Community and Stressors based on the Fish-based Index of Biotic Integrity (FIBI).

Fish Community:

- Two Fish IBI surveys score near the impairment threshold (45) for FIBI Tool 2, and within the 90% Confidence Interval: The FIBI scores from recent surveys are 37 (6/2017) and 51 (9/2017). Based on this, Round Lake was assessed for biological health and determined to be vulnerable to future impairment based on the FIBI.
- The FIBI scores are most positively influenced by the presence of intolerant species in the gill net catch (Burbot and Rock Bass), the high proportion of top carnivores (primarily Northern Pike and Walleye) in the gill net catch, and low number of tolerant species sampled. The scores are most negatively influenced by a low number of insectivore and vegetation dwelling species.
- Overall species richness was low with 16 and 20 native fish species sampled in the two surveys. Bluegill, Northern Pike and Walleye were the most abundant species by biomass in trap nets. The nearshore catch assemblage varied between surveys with Bluntnose Minnows, Spottail Shiners and Yellow Perch the most common species sampled.



Candidate Stressor:

- Physical habitat alteration: Round Lake shoreline has fragmented areas of rushes and other emergent vegetation, covering about 18 acres (out of 475 littoral acres). Further, based on a Score the Shore survey, Round Lake has poor shoreline habitat quality, associated with shoreline development. The Score the Shore survey measured poor quality shoreline habitat on average at developed sites and high quality shoreline habitat on average at undeveloped sites, with an overall lakewide average score of 61/100. This indicates trees, shrubs, and natural ground cover has been replaced with turf, rip rap, or structures. And, numerous channels through the vegetation were observed. Little undeveloped shoreline was observed. There are approximately 24 docks per km/shoreline on Round Lake, which is very high. High dock densities have been associated with decreases in intolerant fish species. Surveyors noted that Round Lake has fairly homogeneous substrate, with natural abundant sand flats, so there is some element of natural limitation of habitat.

Recommendations:

- Promote and maintain vegetated riparian areas with shoreline buffers and shoreline restoration projects.
- Limit removal of native aquatic plant communities.
- Promote woody habitat in shoreline areas for fish and wildlife habitat.
- Round Lake has a small watershed and excellent water quality which should be protected.

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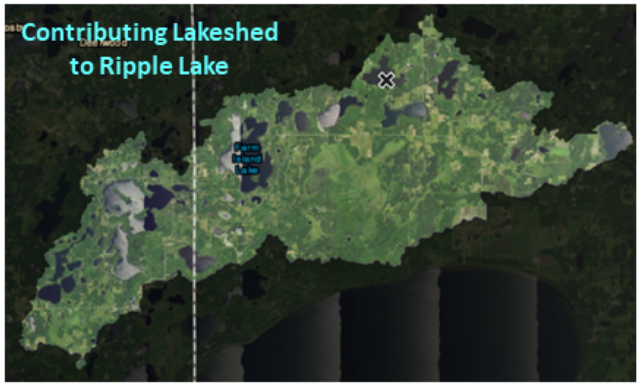
DEPARTMENT OF NATURAL RESOURCES

CLEAN WATER LAND & LEGACY AMENDMENT

Summary: Ripple Lake (01-0146-00) Fish Community and Stressors based on the Fish-based Index of Biotic Integrity (FIBI).

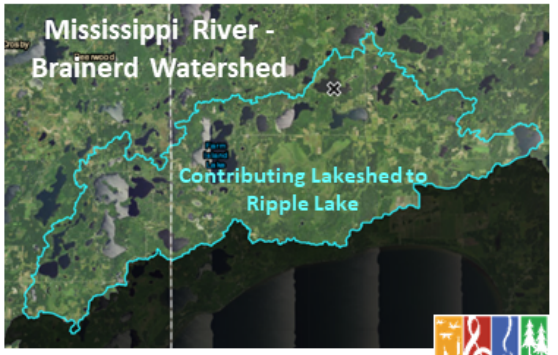
Fish Community:

- One Fish IBI surveys scored just above the impairment threshold (45) for FIBI Tool 2, and within the 90% Confidence Interval: The FIBI score was 52. Based on this, Ripple Lake was assessed for biological health and determined to be vulnerable to future impairment based on the FIBI.
- The FIBI score was most negatively influenced by the relatively high number of omnivore and tolerant species sampled and by a relatively high biomass of omnivore species (primarily Yellow Bullhead) sampled in the trap net surveys.
- Northern Pike and Walleye dominated the gill net catch. Yellow Bullhead, Bluegill, and Bowfin accounted for most of the trap net biomass. Brook Silverside, Bluegill, Bluntnose Minnow, and Golden Shiner were most abundant in the nearshore survey.



Candidate Stressor:

- Eutrophication: Ripple Lake is nutrient impaired with average seasonal total phosphorus of approximately 30. Ripple Lake was listed for excess nutrients in 2020. See the TMDL for detailed information about nutrient sources. Ripple lake has a very large contributing watershed (103:1 watershed:lake) draining primarily wetland and forested land. There is approximately 16% watershed disturbance (residential/impervious (5%), agriculture (11%)). Agricultural land use is primarily hay and pasture with small amounts of row crops. The excessive ditching of the Ripple River watershed between Spirit Lake and Elm Island likely contribute to the increased nitrification of the system.



Inconclusive stressor:

- Physical habitat alteration: Ripple Lake shoreline has large areas of emergent and floating leaf vegetation, including extensive wild rice.. Based on a 2015 Score the Shore survey, Ripple Lake has moderate habitat alterations associated with shoreline development. The Score the Shore survey measured moderate quality shoreline habitat on average at developed sites and high quality shoreline habitat on average at undeveloped sites, with an overall lakewide average score of 79/100. There are approximately 5 docks per km/shoreline.

Recommendations:

- The water color and clarity of Ripple Lake is heavily influenced by its place at the bottom of a large watershed and this likely impacts the habitat and the fish community. It is common to see lower species richness in lakes with tannin stained water, such as Ripple.
- Continue to implement or promote agricultural BMP's within the watershed to reduce nutrient and sediment inputs from the watershed, consult the TMDL report recommendations.
- Promote and maintain vegetated riparian areas with shoreline buffers and shoreline restoration projects.
- Limit removal of native aquatic plant communities.
- Consider reclamation of natural channels in areas of intense ditching to minimize/slow down runoff potential in high rain events.

THIS IS A DRAFT SUMMARY OF PRELIMINARY STRESSOR ID INFORMATION, JUNE 2020. A final report will be published online.
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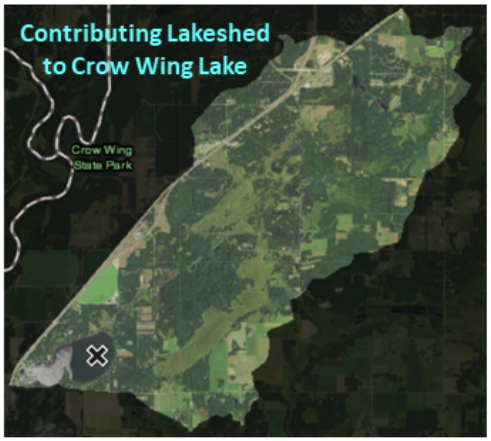
DEPARTMENT OF NATURAL RESOURCES

CLEAN WATER LAND & LEGACY AMENDMENT

Summary: Crow Wing Lake (18-0155-00) Fish Community and Stressors based on the Fish-based Index of Biotic Integrity (FIBI).

Fish Community:

- Two Fish IBI surveys score at and below the impairment threshold (38) for FIBI Tool 4, and within the 90% Confidence Interval: The FIBI scores from recent surveys are 38 (2016) and 33 (2010). Based on this, Crow Wing Lake was assessed for biological health and determined to be impaired (not supporting) based on the FIBI.
- The FIBI scores are most negatively influenced by a low number of intolerant species sampled (2), a high number of omnivore species (5-6), and relatively high biomass of omnivore species and low biomass of insectivore species in the trap net surveys.
- Yellow Bullhead and White Sucker were most abundant by biomass in the trap net surveys. The gill net surveys had different assemblages with Northern Pike, Walleye, and Yellow Bullhead most abundant in biomass in 2010, and Black Crappie, Walleye, Yellow Bullhead, Northern Pike, and White Sucker most abundant in 2016. The fish species sampled by each nearshore survey also differed with Sunfish species and Bluntnose Minnow most abundant in 2010 and Spottail Shiner, Yellow Perch, and Bluegill most abundant in 2016. The only intolerant species sampled were Banded Killifish and Iowa Darter, sampled in low numbers.



Candidate Stressors:

- Eutrophication: Crow Wing Lake is nutrient impaired with average seasonal total phosphorus of approximately. Crow Wing Lake was listed for excess nutrients in 2010, and the listing continued in 2020. See the TMDL for detailed information about nutrient sources. Crow Wing lake has a large contributing watershed (29:1 watershed:lake). There is approximately 24% watershed disturbance (residential/impervious (7%), agriculture (17%)). Agricultural land use is composed of hay and pasture, corn, and other row crops.
- Physical habitat alteration: Crow Wing Lake has limited areas of floating leaf and emergent vegetation on the western basin, totaling about 18 acres (of 210 littoral acres). Based on a 2015 Score the Shore (StS) survey, Crow Wing Lake has poor shoreline habitat quality, associated with shoreline development. The StS survey measured poor quality shoreline habitat on average at developed sites and high quality shoreline habitat on average at undeveloped sites, with an overall lakewide average score of 60/100. This indicates trees, shrubs, and natural ground cover has been replaced with turf, rip rap, or structures at most developed sites. Little undeveloped shoreline was observed. There are approximately 23 docks per km/shoreline on Crow Wing Lake, which is very high. High dock densities have been associated with decreases in intolerant fish species.

Inconclusive stressor:

- Altered interspecific competition: Common Carp are present in Crow Wing Lake.

Recommendations:

- Continue to implement or promote agricultural BMP's within the watershed to reduce nutrient and sediment inputs from the watershed, consult the TMDL report recommendations.
- Protect remaining forested land and wetland from land development.
- Promote and maintain vegetated riparian areas with shoreline buffers and shoreline restoration projects.
- Limit removal of native aquatic plant communities.

THIS IS A DRAFT SUMMARY OF PRELIMINARY STRESSOR ID INFORMATION, JUNE 2020. A final report will be published online.

For more information contact: Jacquelyn Bacigalupi, MnDNR Fisheries, IBI Program Supervisor, Jacquelyn.Bacigalupi@state.mn.us, (218)-203-4315

DEPARTMENT OF NATURAL RESOURCES

CLEAN WATER LAND & LEGACY AMENDMENT

Summary: Gilbert Lake (18-0320-00) Fish Community and Stressors based on the Fish-based Index of Biotic Integrity (FIBI).

Fish Community:

- Three Fish IBI surveys score near the impairment threshold (45) for FIBI Tool 2, and within the 90% Confidence Interval: The FIBI scores from recent surveys are 45 (2015), 44 (2014), and 51 (2012). Based on this, Gilbert Lake was assessed for biological health and determined to be vulnerable to future impairment based on the FIBI.
- The FIBI scores are most positively influenced by a high biomass of top carnivores in the gill net survey (primarily Northern Pike), the absence of tolerant species in any gear for the 2015 survey and only one tolerant species in the other two surveys (Green Sunfish), a low number of omnivore species in each survey (3), and a relatively nigh number of vegetation dwelling species (7) surveyed. The FIBI scores are most negatively influenced by a low proportion of small benthic dwelling species in the nearshore survey and a low proportion of insectivores and high proportion of omnivores in the trap net surveys.
- Northern Pike were most abundant by biomass in the gill net survey. The species sampled varied between the nearshore surveys, likely due to difficult sampling conditions, but each survey sampled small numbers of intolerant species.
- Gilbert Lake has no upstream lakes, and only a seepage outlet, very likely contributing to lower species richness

Inconclusive Stressors:

- Physical habitat alteration: There are moderate impacts to the fish habitat in Gilbert Lake from shoreline development. A 2015 Score the Shore survey measured moderate quality shoreline habitat on average at developed sites and high quality shoreline habitat on average at undeveloped sites, with an overall lakewide average score of 86/100. There are approximately 7 docks per km/shoreline on Gilbert Lake. Gilbert Lake has extensive areas of floating leaf vegetation on the main lake, and areas of emergent vegetation, primarily in the northwest bay. Gilbert Lake has experienced high water levels in recent years.
- Altered interspecific competition: Zebra mussels are present in Gilbert Lake.

Recommendations:

- Gilbert Lake has a small watershed and excellent water quality which should be protected. Currently approximately 17% of the watershed is developed as agricultural, residential, or other developed land. Remaining forested land and wetland should be protected from land development.
- Promote and maintain vegetated riparian areas with shoreline buffers and shoreline restoration projects.
- Limit removal of native aquatic plant communities.
- Promote woody habitat in shoreline areas for fish and wildlife habitat.
- Implement or promote agricultural BMP's within the watershed to reduce nutrient and sediment inputs from the watershed.

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Summary: Green Prairie Fish Lake (49-0035-00) Fish Community and Stressors based on the Fish-based Index of Biotic Integrity (FIBI).

Fish Community:

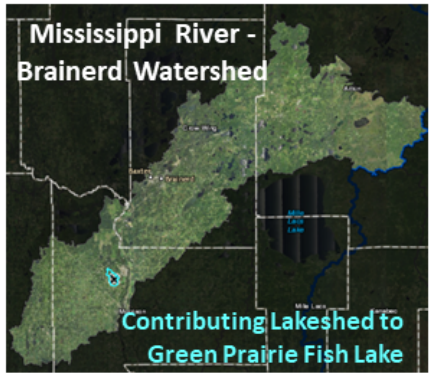
- Two recent Fish IBI surveys scored below the impairment threshold (38) for FIBI Tool 4. The FIBI scores from two 2017 surveys are 33 and 31. Based on this, Green Prairie Fish Lake was assessed for biological health and determined to be impaired (not supporting) based on the FIBI.
- The FIBI scores are most negatively impacted by absence of any intolerant species and a low number of vegetation dwelling species. The overall FIBI scores are most positively influenced by the low number of omnivorous species sampled.
- Northern Pike, Walleye, and Yellow Bullhead were most abundant by biomass in the gill nets. Yellow Bullhead and Bluegill were most abundant by biomass in the trap net survey. Small gamefish (primarily sunfish species, Largemouth Bass, and Yellow Perch) accounted for most of the fish caught during the nearshore surveys..

Inconclusive stressors:

- Eutrophication: Green Prairie Fish Lake has an average seasonal total phosphorus of approximately 28.4, with a moderate sized contributing watershed (15:1 watershed:lake). Much of the contributing watershed is classified as wetland, and there is approximately 24% watershed disturbance (residential/impervious (4%), agriculture (20%)). Agricultural land use includes hay, pasture, and cultivated crops.
- Physical habitat alteration: There are moderate impacts to the fish habitat in Green Prairie Fish Lake from shoreline development. A 2016 Score the Shore survey measured low to moderate quality shoreline habitat on average at developed sites and high quality shoreline habitat on average at undeveloped sites, with an overall lakewide average score of 75/100. There are approximately 7 docks per km/shoreline. Green Prairie Fish Lake shoreline has very limited areas of emergent and floating leaf vegetation, totally only about 2.3 acres. The aquatic vegetation community includes the non-native plant Curly-leaf Pondweed.

Recommendations:

- Candidate causes are inconclusive. The lack of connectivity to other lakes and naturally homogenous sandy habitat may be limiting species richness on Green Prairie Fish Lake.
- Promote and maintain vegetated riparian areas with shoreline buffers and shoreline restoration projects.
- Limit removal of native aquatic plant communities.
- Promote woody habitat in shoreline areas for fish and wildlife habitat.
- Protect remaining forested land and wetland from land development.
- Continue to implement or promote agricultural BMP's within the watershed to reduce nutrient and sediment inputs from the watershed.



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DEPARTMENT OF NATURAL RESOURCES

CLEAN WATER LAND & LEGACY AMENDMENT

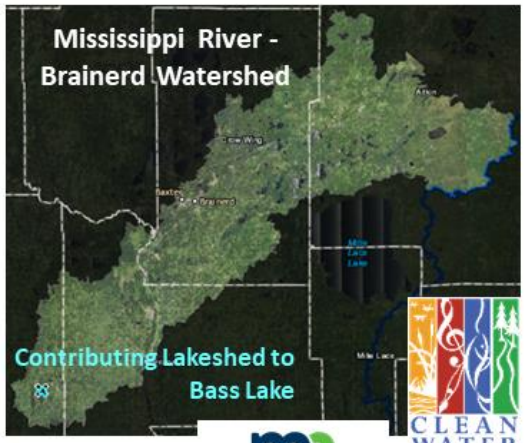
Summary: Bass Lake (77-0024-00) Fish Community and Stressors based on the Fish-based Index of Biotic Integrity (FIBI).

Fish Community:

- Three recent Fish IBI surveys scored below the impairment threshold (45) for FIBI Tool 2. The FIBI scores from 2016, 2017, and 2018 surveys are 39, 38, and 35. Two older surveys conducted in 2010 scored above the impairment threshold with scores of 56 and 51. Sampling was very difficult on Bass Lake due to steep shoreline drop offs and high water. Based on this survey data, Bass Lake was assessed for biological health and determined to be vulnerable to future impairment based on the FIBI.
- The overall FIBI scores are most negatively impacted by a relatively high biomass of omnivores (Yellow Bullhead) in the trap nets and low numbers of cyprinid and native species. The overall FIBI scores are most positively influenced by the relatively high biomass of top carnivores in gill nets (primarily Northern Pike), a low number of omnivore species in each survey, and a single tolerant species, Green Sunfish.
- Northern Pike were most abundant by biomass in the gill nets. Yellow Bullhead were most abundant by biomass in the trap net survey with significant catches of Northern Pike and sunfish species. Banded Killifish were the only intolerant species sampled during the 2016, 2017, and 2018 surveys. Green Sunfish was the only tolerant species sampled.

Inconclusive stressors:

- Physical habitat alteration: There are limited impacts to the fish habitat in Bass Lake from shoreline development. A 2017 Score the Shore survey measured moderate quality shoreline habitat on average at developed sites and high quality shoreline habitat on average at undeveloped sites, with an overall lakewide average score of 89/100. There are approximately 3 docks per km/shoreline. There are often cattle with direct access to the lake. Bass Lake shoreline has very limited areas of emergent and floating leaf vegetation, totally only about 1.7 acres. The aquatic vegetation community is limited by the steep shoreline slopes.



Recommendations:

- Candidate causes are inconclusive. The lack of connectivity to other lakes may be limiting species richness on Bass Lake.
- Bass Lake has a small watershed and excellent water quality which should be protected. Currently approximately 41% of the watershed is developed as agricultural, residential, or other developed land. Remaining forested land and wetland should be protected from land development.
- Promote and maintain vegetated riparian areas with shoreline buffers and shoreline restoration projects.
- Limit removal of native aquatic plant communities.
- Promote woody habitat in shoreline areas for fish and wildlife habitat.
- Continue to implement or promote agricultural BMP's within the watershed to reduce nutrient and sediment inputs from the watershed.

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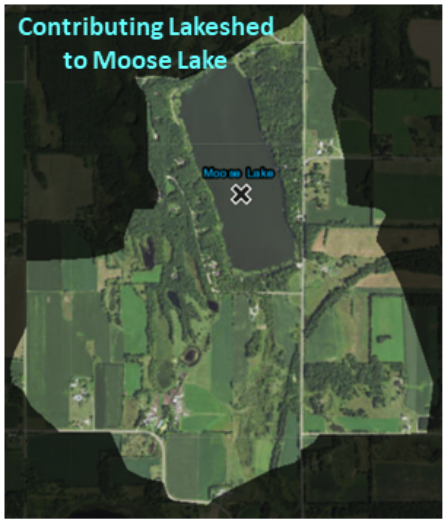
DEPARTMENT OF NATURAL RESOURCES

CLEAN WATER LAND & LEGACY AMENDMENT

Summary: Moose Lake (77-0026-00) Fish Community and Stressors based on the Fish-based Index of Biotic Integrity (FIBI).

Fish Community:

- Two recent Fish IBI surveys scored at or below the impairment threshold (38) for FIBI Tool 4. The FIBI scores from 2012 and 2014 surveys are 30 and 38. Based on this survey data, Moose Lake was assessed for biological health and determined to be impaired (not supporting) based on the FIBI.
- The overall FIBI scores are most negatively impacted by the low number of intolerant species (1, Iowa Darter) and relatively low biomass of insectivores and high biomass of omnivores in the trap nets (significant catches of Yellow Bullhead). In the 2012 survey, 3 tolerant species were surveyed which very negatively impacted the score. The overall FIBI scores are most positively influenced by the absence of tolerant species sampled in the in the trap net survey.
- Northern Pike and Walleye were most abundant by biomass in the gill nets. Yellow Bullhead were most abundant by biomass in the trap net survey. Small gamefish (primarily sunfish species and Largemouth Bass) were most common in the nearshore surveys.



Candidate Stressor:

- Eutrophication: Moose Lake is nutrient impaired with average seasonal total phosphorus of approximately 58.4. Moose Lake was listed for excess nutrients in 2020. See the TMDL for detailed information about nutrient sources. Moose lake has a relatively small sized contributing watershed (8:1 watershed:lake) but high watershed disturbance. Approximately 60% of the watershed is in land cover classified as disturbed (residential/impervious (5%), agriculture (56%)). Agricultural land use is primarily corn and soybeans, with areas of hay and pasture. There is agricultural landuse in the shoreland area of Moose Lake. According to fisheries surveys, Moose Lake has limited transparency, frequent algae blooms, and oxygen depletions below the thermocline.

Inconclusive stressor:

- Physical habitat alteration: Moose Lake shoreline has substantial beds of floating leaf vegetation and limited areas of emergent vegetation, totaling about 8.5 acres. Based on a 2015 Score the Shore survey, Moose Lake has moderate habitat alterations associated with shoreline development. The Score the Shore survey measured moderate shoreline habitat on average at developed sites and high quality shoreline habitat on average at undeveloped sites, with an overall lakewide average score of 86/100. There are approximately 7 docks per km/shoreline.

Recommendations:

- Continue to implement or promote agricultural BMP's within the watershed to reduce nutrient and sediment inputs from the watershed, consult the TMDL report recommendations.
- Promote and maintain vegetated riparian areas with shoreline buffers and shoreline restoration projects.
- Limit removal of native aquatic plant communities.
- Promote woody habitat in shoreline areas for fish and wildlife habitat.

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7. Appendix B

Table 31. Key for strategies column.

Parameter (including nonpollutant stressors)	Strategy Key	
	Description	**Example BMPs/actions**
Total Suspended Solids (TSS)	Improve upland/field surface runoff controls: Soil and water conservation practices that reduce soil erosion and field runoff, or otherwise minimize sediment from leaving farmland	Cover crops
		Water and sediment basins, terraces
		Rotations including perennials
		Conservation cover easements
		Grassed waterways
		Strategies to reduce flow - some of flow reduction strategies should be targeted to ravine subwatersheds
		Residue management - conservation tillage
		Forage and biomass planting
		Open tile inlet controls - riser pipes, french drains
		Contour farming
		Field edge buffers, borders, windbreaks and/or filter strips
		Stripcropping
	Protect/stabilize banks/bluffs: Reduce collapse of bluffs and erosion of stream bank by reducing peak river flows and using vegetation to stabilize these areas.	Strategies for altered hydrology (reducing peak flow)
		Streambank stabilization
		Riparian forest/herbaceous buffer
		Livestock access control/exclusion - controlled stream crossings
	Stabilize ravines: Reducing erosion of ravines by dispersing and infiltrating field runoff and increasing vegetative cover near ravines. Also may include earthwork/regrading and revegetation of ravine.	Field edge buffers, borders, windbreaks and/or filter strips
		Contour farming and contour buffer strips
		Diversions
		Water and sediment control basin
		Terrace
		Conservation crop rotation
		Cover crop
		Residue management - conservation tillage
	Stream Channel Restoration	Addressing road crossings (direct erosion) and floodplain cut-
		Clear water discharge: urban areas, ag tiling, etc. – direct
		Two-stage ditches
		Large-scale restoration – channel dimensions match current
		Re-meander channel and connect to floodplain
		Ditch Abandonment
		Stream channel restoration using vertical energy dissipation:
	Improve forestry management	Proper Water Crossings and road construction
		Forest Roads - Cross-Drainage
		Maintaining and aligning active Forest Roads

Parameter (including nonpollutant stressors)	Strategy Key	
	Description	**Example BMPs/actions**
		Closure of Inactive Roads & Post-Harvest
		Location & Sizing of Landings
		Invasive species control
		Actively seek landowners willing to participate in the Sustainable Forest Incentive Act (SFIA)
		Riparian Management Zone Widths and/or filter strips
	Improve urban stormwater management [to reduce sediment and flow]	See MPCA Stormwater Manual: http://stormwater.pca.state.mn.us/index.php/Information_on_pollutant_removal_by_BMPs
Nitrogen (TN) or Nitrate	Increase fertilizer and manure efficiency: Adding fertilizer and manure additions at rates and ways that maximize crop uptake while minimizing leaching losses to waters	Nitrogen rates at Maximum Return to Nitrogen (U of MN recommendations)
		Timing of application closer to crop use (spring or split applications)
		Nitrification inhibitors
		Manure stockpiles meeting 7020 rules
		Manure application based on nutrient testing, calibrated equipment, recommended rates, and so on.
	Store and treat tile drainage waters: Managing tile drainage waters so that nitrate can be denitrified or so that water volumes and loads from tile drains are reduced	Saturated buffers
		Restored or constructed wetlands
		Controlled drainage
		Woodchip bioreactors
		Two-stage ditch
	Increase vegetative cover/root duration: Planting crops and vegetation that maximize vegetative cover and capturing of soil nitrate by roots during the spring, summer, and fall.	Conservation cover (easements/buffers of native grass & trees, pollinator habitat)
		Perennials grown on marginal lands and riparian lands
		Cover crops
		Rotations that include perennials
		Crop conversion to low nutrient-demanding crops (e.g., hay).
Phosphorus (TP)	Improve upland/field surface runoff controls: Soil and water conservation practices that reduce soil erosion and field runoff, or otherwise minimize sediment from leaving farmland.	Strategies to reduce sediment from fields (see above - upland field surface runoff)
		Constructed wetlands
		Pasture management
	Reduce bank/bluff/ravine erosion.	Strategies to reduce TSS from banks/bluffs/ravines (see above for sediment)
	Increase vegetative cover/root duration: Planting crops and vegetation that maximize vegetative cover and minimize erosion and soil losses to waters, especially during the spring and fall.	Conservation cover (easements/buffers of native grass & trees, pollinator habitat)
		Perennials grown on marginal lands and riparian lands
		Cover crops
		Rotations that include perennials
		Open lot runoff management to meet 7020 rules

Parameter (including nonpollutant stressors)	Strategy Key	
	Description	**Example BMPs/actions**
	Preventing feedlot runoff: Using manure storage, water diversions, reduced lot sizes and vegetative filter strips to reduce open lot phosphorus losses.	Manure storage in ways that prevent runoff
	Improve fertilizer and manure application management: Applying phosphorus fertilizer and manure onto soils where it is most needed using techniques that limit exposure of phosphorus to rainfall and runoff.	Soil phosphorus testing and applying nutrients on fields needing phosphorus
		Fertilizer rates matching University of MN recommendations
		Precision nutrient timing and management
		Incorporating/injecting nutrients below the soil
		Manure application meeting all 7020 rule setback requirements
	Address failing septic systems: Fixing septic systems so that on-site sewage is not released to surface waters. Includes straight pipes.	Sewering around lakes
		Eliminating straight pipes, surface seepages
	Reduce in-water loading: Minimizing the internal release of phosphorus within lakes	Rough fish management
		Consulting with the DNR for recommendations on managing and restoring a healthy native vegetation population.
		Alum treatment
		Lake drawdown
		Hypolimnetic withdrawal
	In-lake TP treatment	Consulting with the DNR for recommendations on managing and restoring a healthy native vegetation population.
		Alum Treatments
	Improve forestry management	See forest strategies for sediment control
	Reduce Industrial/Municipal wastewater TP	Municipal and industrial treatment of wastewater P
		Upgrades/expansion. Address inflow/infiltration.
	Treat tile drainage waters: Treating tile drainage waters to reduce phosphorus entering water by running water through a medium which captures phosphorus	Phosphorus-removing treatment systems, including bioreactors
	Improve urban stormwater management	See MPCA Stormwater Manual: http://stormwater.pca.state.mn.us/index.php/Information_on_pollutant_removal_by_BMPs
E. coli	Reducing livestock bacteria in surface runoff: Preventing manure from entering streams by keeping it in storage or below the soil surface and	Strategies to reduce field TSS (applied to manured fields, see above)
		Improved field manure (nutrient) management
		Adhere/increase application setbacks
		Improve feedlot runoff control

Parameter (including nonpollutant stressors)	Strategy Key	
	Description	**Example BMPs/actions**
	by limiting access of animals to waters.	Animal mortality facility
		Manure spreading setbacks and incorporation near wells and sinkholes
		Manure stockpiles meeting 7020 rules
		Rotational grazing and livestock exclusion (pasture management)
	Reduce urban bacteria: Limiting exposure of pet or waterfowl waste to rainfall.	Pet waste management
		Filter strips and buffers
		See MPCA Stormwater Manual: http://stormwater.pca.state.mn.us/index.php/Information_on_pollutant_removal_by_BMPs
	Address failing septic systems: Fixing septic systems so that on-site sewage is not released to surface waters. Includes straight pipes.	Replace failing septic (SSTS) systems
		Maintain septic (SSTS) systems
	Reduce Industrial/Municipal wastewater bacteria.	Reduce straight pipe (untreated) residential discharges
		Reduce WWTP untreated (emergency) releases
Dissolved Oxygen	Reduce phosphorus.	See strategies above for reducing phosphorus
	Increase river flow during low-flow years.	See strategies above for altered hydrology
	In-channel restoration: Actions to address altered portions of streams.	Goal of channel stability: transporting the water and sediment of a watershed without aggrading or degrading
		Restore riffle substrate
Chloride	Road salt management.	[Strategies currently under development within Twin Cities Metro Area Chloride Management Plan]
Altered hydrology; peak flow and/or low base flow (FIBI/MIBI)	Increase living cover: Planting crops and vegetation that maximize vegetative cover and evapotranspiration especially during the high-flow spring months.	Grassed waterways
		Cover crops
		Conservation cover (easements & buffers of native grass & trees, pollinator habitat)
		Rotations including perennials
	Improve drainage management: Managing drainage waters to store tile drainage waters in fields or at constructed collection points and releasing stored waters after peak flow periods.	Treatment wetlands
		Restored wetlands
	Reduce rural runoff by increasing infiltration: Decrease surface runoff contributions to peak flow through soil and water conservation practices.	Conservation tillage (no-till or strip till with high residue)
		Water and sediment basins, terraces

Parameter (including nonpollutant stressors)	Strategy Key	
	Description	**Example BMPs/actions**
	Improve urban stormwater management.	See MPCA Stormwater Manual: http://stormwater.pca.state.mn.us/index.php/Information_on_pollutant_removal_by_BMPs
	Improve irrigation water management: Increase groundwater contributions to surface waters by withdrawing less water for irrigation or other purposes.	Groundwater pumping reductions and irrigation management
Poor Habitat (Fish/Macroinvertebrate IBI)	Improve riparian vegetation: Planting and improving perennial vegetation in riparian areas to stabilize soil, filter pollutants, and increase biodiversity.	50-foot vegetated buffer on waterways
		One rod ditch buffers
		Lake shoreland buffers
		Increase conservation cover: in/near waterbodies, to create corridors
		Improve/increase natural habitat in riparian, control invasive species
		Tree planting to increase shading
		Streambank and shoreline protection/stabilization
		Wetland restoration
		Accurately size bridges and culverts to improve stream stability
	Restore/enhance channel: Various restoration efforts largely aimed at providing substrate and natural stream morphology.	Retrofit dams with multi-level intakes
		Restore riffle substrate
		Two-stage ditch
		Dam operation to mimic natural conditions
		Restore natural meander and complexity
Water Temperature	Urban stormwater management	See MPCA Stormwater Manual: http://stormwater.pca.state.mn.us/index.php/Information_on_pollutant_removal_by_BMPs
	Improve riparian vegetation: Actions primarily to increase shading, but also some infiltration of surface runoff.	Riparian vegetative buffers
		Tree planting to increase shading
Connectivity (FIBI)	Remove fish passage barriers: Identify and address barriers.	Remove impoundments
		Properly size and place culverts for flow and fish passage
		Culvert Inventory
		Conduct desktop recon of stream crossings
		Manage beaver dams
		Construct by-pass
Monitoring	Increase/Targeted monitoring	Conduct source assessment for identified pollutant
		Conduct continuous DO analysis
		Conduct water quality monitoring on identified waterbody

Parameter (including nonpollutant stressors)	Strategy Key	
	Description	**Example BMPs/actions**
		Monitor drained wetlands along corridor to determine if cause for low DO
Education	Public Outreach	Provide education opportunities to lakeshore property owners on importance of shoreline protection
		Implement DNR "Score Your Shore"
		Provide information to local landowners on impacts of pet waste on local waterbodies
All [protection-related]	Implement volume control/limited-impact development: This is aimed at development of undeveloped land to provide no net increase in volume and pollutants.	See MPCA Stormwater Manual: http://stormwater.pca.state.mn.us/index.php

8. Appendix C

A discussion of each scenario and a summary of the results are presented below, including maps with the existing HSPF model reach loads and percent reduction/increase from existing conditions for flow, TSS, TP, and TN for each scenario (Figures 17 through 40).

8.1 Scenario 1

Scenario 1 estimates the impacts of increasing the amount of developed area around population centers and lakes. In subwatersheds surrounding population centers, 15% of forest and agricultural lands are converted to developed land, while subwatersheds that explicitly represent a lake have increases in septic loads by 15%. While it is assumed that any new development surrounding lakes would be completed with septic systems in full compliance, increases in septic loading were used as a proxy to simulate increases in development around lakes. Subwatersheds targeted for increases in development are located in all three of the management zones with a focus around Brainerd, Crosby/Ironton, Aitkin, and Little Falls. Subwatersheds targeted for increases in septic loading are primarily located in the northern management zone. Locations of the specific watersheds with increased development are indicated by stripped areas in Figures 21 through 24 and included in Table 32.

HSPF-estimated reach responses for modeled parameters are depicted by subwatershed in Figures 20 through 23 for flow, TSS, TP, and TN, respectively.

- Moderate increases in TSS (0% to 11%) and TP (0% to 11%) reach loads are seen in subwatersheds surrounding the population centers.
- Very slight increases (0% to 3%) of TN reach loads are seen in the same subwatersheds.
- Most impacts are localized with minimal downstream impacts. The Mississippi River at the outlet of the watershed has less than a 1% change for all of the constituents.

Table 32. Percent change from existing conditions for each reach with land cover changes in Scenario 1.

Reach ID	Flow (%)	TSS (%)	TP (%)	TN (%)
A42	0.0	0.0	0.0	0.1
A44	0.0	0.0	0.0	0.1
A74	0.0	0.0	0.0	0.1
A78	0.0	0.0	0.0	0.1
A81	0.3	–0.9	1.3	–0.1
A90	0.0	0.0	0.1	0.0
A92	0.0	0.0	0.1	0.2
A94	0.0	0.0	0.1	0.3
A96	0.0	0.0	0.1	0.2
A104	0.0	0.0	0.0	0.1
A105	0.0	0.0	0.1	0.1
A107	0.4	0.7	4.9	0.7
A110	0.0	0.0	0.3	0.0

Reach ID	Flow (%)	TSS (%)	TP (%)	TN (%)
A131	0.0	0.0	0.2	0.2
A133	0.0	0.0	0.2	0.3
A134	0.0	0.0	0.2	0.2
A135	0.0	0.0	0.2	0.2
A218	0.0	0.0	0.0	0.1
A222	0.0	0.0	0.1	0.1
A232	0.0	0.0	0.0	0.1
A234	3.4	11.2	5.7	–2.3
A235	2.8	7.0	1.6	0.1
A237	2.8	7.3	10.0	2.8
A270	0.0	0.1	0.5	0.0
A271	3.2	8.0	5.5	2.8
A273	2.8	4.6	5.7	1.9
A275	1.8	–1.1	10.8	0.5
A290	0.1	0.1	0.3	0.1
A312	3.8	5.4	–	–
A320	0.0	0.0	0.0	0.6
A360	0.0	0.0	0.0	0.0
A380	0.0	0.0	0.0	0.0
A400	0.0	0.0	0.0	0.0
A490	0.1	0.1	0.7	–0.2
A510	0.1	0.1	0.7	–0.2
A515	0.0	0.0	0.1	0.0
A530	0.1	0.1	0.7	–0.3
A547	1.6	–1.7	8.0	–2.3
A590	0.1	0.1	0.7	–0.3

8.2 Scenario 2

Scenario 2 estimates the impacts of increasing development while also implementing Minimum Impact Design Standards (MIDS). The increase in development for Scenario 2 is the same as Scenario 1: 15% of forest and agricultural lands are converted to developed land while subwatersheds that explicitly represent a lake have increases in septic loads by 15%, with MIDS reductions applied to the subwatersheds with increases in developed land cover. For this analysis the MIDS reductions applied were 91% for TSS, 81% for TP, and 20% for TN [Barr Engineering, Inc. 2011]. Locations of the specific subwatersheds with increased development and MIDS are indicated by stripped areas in Figures 25 through 28 and included in Table 33.

HSPF-estimated reach responses for modeled parameters are depicted by subwatershed in Figures 25 through 28 for flow, TSS, TP, and TN, respectively.

- Slight to moderate decreases in TSS (0% to 13%), TP (0% to 7%), and TN (0% to 10%) reach loads were noted for subwatersheds that had large increases in developed land area associated with MIDS reductions. Certain subwatersheds still see small increases of TN (0% to 2%), which is likely because of MIDS reductions being lower for TN than TSS or TP.
- Decreases in TSS, TP, and TN loading were relatively localized, with the outlet of the watershed seeing decreases less than 1%.

Table 33. Percent change from existing conditions for each reach with land cover changes in Scenario 2.

Reach ID	Flow (%)	TSS (%)	TP (%)	TN (%)
A42	0.0	0.0	0.0	0.1
A44	0.0	0.0	0.0	0.1
A74	0.0	0.0	0.0	0.1
A78	0.0	0.0	0.0	0.1
A81	–1.0	–2.3	–1.3	–0.2
A90	0.0	0.0	–0.1	0.0
A92	0.0	0.0	0.1	0.2
A94	0.0	0.0	0.1	0.3
A96	0.0	0.0	0.1	0.2
A104	0.0	0.0	0.0	0.1
A105	0.0	0.0	0.1	0.1
A107	–0.8	–0.9	0.0	0.5
A110	–0.1	0.0	–0.1	0.0
A131	0.0	0.0	0.2	0.2
A133	0.0	0.0	0.2	0.3
A134	0.0	0.0	0.2	0.2
A135	0.0	0.0	0.2	0.2
A218	0.0	0.0	0.0	0.1
A222	0.0	0.0	0.1	0.1
A232	0.0	0.0	0.0	0.1
A234	–3.3	–8.9	–5.5	–9.6
A235	–2.6	–3.2	–0.1	–1.0
A237	–3.8	–6.1	–1.0	1.0
A270	–0.1	–0.1	–2.0	–0.1
A271	–2.7	–3.2	–1.0	1.6
A273	–3.3	–4.6	–1.5	0.7
A275	–5.0	–8.8	–2.6	–1.2
A290	–0.1	–0.1	–1.0	–0.1
A312	–5.4	–13.2	–7.1	–5.7
A320	0.0	0.0	0.0	0.6
A360	0.0	0.0	0.0	0.0
A380	0.0	0.0	0.0	0.0

Reach ID	Flow (%)	TSS (%)	TP (%)	TN (%)
A400	0.0	0.0	0.0	0.0
A490	–0.1	–0.1	–0.9	–0.1
A510	–0.1	–0.1	–0.9	–0.1
A515	0.0	0.0	0.1	0.0
A530	–0.1	–0.1	–0.9	–0.1
A547	–4.4	–7.5	–3.5	–3.4
A590	–0.1	–0.1	–0.9	–0.1

8.3 Scenario 3

Scenario 3 estimates the impacts of increasing forestry activity by converting 15% of mature forest to young forest in subwatersheds that have greater than 45% of the area covered in forests. The subwatersheds targeted are primarily in the northern management zone with some subwatersheds in the central management zone and are indicated by the stripped areas in Figures 29 through 32 and included in Table 34.

HSPF-estimated reach responses for modeled parameters are depicted by subwatershed in Figures 29 through 32 for flow, TSS, TP, and TN, respectively.

- Very slight increases in TSS (0% to 4%), TP (0% to 4%), and TN (0% to 2%) reach loads were widely noted for assessed subwatersheds. This is largely attributed to small differences in HSPF model parameterization in young versus mature forests.
- Downstream impacts are minimal with the outlet of the watershed seeing an increase of less than 0.1%.

Table 34. Percent change from existing conditions for each reach with land cover changes in Scenario 3.

Reach ID	Flow (%)	TSS (%)	TP (%)	TN (%)
A15	0.3	0.4	0.4	0.3
A19	0.4	0.5	0.5	0.4
A21	1.0	1.6	1.6	0.9
A23	0.5	0.6	0.6	0.5
A25	1.0	1.7	1.7	0.9
A27	0.7	0.8	0.8	0.6
A29	0.8	1.3	1.3	0.8
A31	0.9	1.3	1.3	0.8
A32	0.8	2.7	2.7	0.9
A35	0.8	1.0	1.0	0.7
A42	0.9	1.5	1.5	1.0
A44	0.8	1.8	1.8	1.0
A51	0.7	0.9	0.9	0.6
A78	0.2	1.1	1.1	0.2
A131	0.9	0.7	0.7	0.8

Reach ID	Flow (%)	TSS (%)	TP (%)	TN (%)
A133	0.9	0.5	0.5	0.8
A134	0.8	1.4	1.4	0.9
A154	0.4	3.2	3.2	0.4
A158	0.8	3.5	3.5	0.9
A159	0.9	2.9	2.9	0.9
A161	1.0	3.0	3.0	0.9
A162	0.9	3.8	3.8	1.0
A171	1.0	1.0	1.0	1.0
A172	1.1	0.7	0.7	1.0
A175	1.1	1.0	1.0	1.0
A190	0.1	0.1	0.1	0.1
A217	1.5	-0.6	-0.6	1.3
A218	1.3	0.7	0.7	1.5
A232	0.8	1.4	1.4	0.9
A320	0.9	2.0	2.0	1.0
A371	1.1	1.5	1.5	1.0
A405	0.4	0.5	0.5	0.3
A513	0.7	0.9	0.9	0.5
A567	1.1	0.1	0.1	0.9

8.4 Scenario 4

Scenario 4 estimates the impacts of converting 5% of forest, grassland, and pasture/hay areas to cropland. Subwatersheds with more than 15% of the area in cropland were selected for Scenario 4. Subwatersheds that met this criterion were in the southwestern part of the MRBW in the southern and central management zones. The locations of these subwatersheds are indicated by the stripped areas in Figures 33 through 36 and included in Table 35.

HSPF-estimated reach responses for modeled parameters are depicted by subwatershed in Figures 33 through 36 for flow, TSS, TP, and TN, respectively.

- Moderate increases in TSS (0% to 5%), TP (0% to 9%), and TN (0% to 5%) reach loads were seen in subwatersheds with increases in cropland.
- Increases in TSS, TP, and TN loading were relatively localized, with the outlet of the watershed seeing an increase of less than 1%.

Table 35. Percent change from existing conditions for each reach with land cover changes in Scenario 4.

Reach ID	Flow (%)	TSS (%)	TP (%)	TN (%)
A411	0.6	3.4	6.8	3.8
A430	0.1	1.1	2.1	1.0
A437	0.6	3.7	6.5	3.4
A450	0.2	1.6	3.3	1.7

Reach ID	Flow (%)	TSS (%)	TP (%)	TN (%)
A491	0.4	2.5	3.4	2.3
A511	0.2	3.3	5.5	3.1
A530	0.0	0.1	0.1	0.1
A535	0.5	2.0	6.1	3.6
A537	0.5	3.8	9.0	4.7
A539	0.3	3.5	8.7	4.4
A543	0.4	3.1	7.8	3.9
A545	0.5	2.7	6.9	3.8
A547	0.3	3.0	8.1	4.3
A555	0.2	3.0	4.5	2.7
A558	0.0	0.9	0.7	0.5
A562	0.3	3.5	4.4	4.7
A563	0.4	4.6	6.2	5.0
A565	0.4	4.9	5.9	4.6
A579	0.3	5.1	8.1	4.3
A581	0.2	2.4	4.4	2.5
A583	0.2	3.9	6.7	3.6
A585	0.2	2.7	5.0	2.7
A590	0.0	0.2	0.5	0.2

8.5 Scenario 5

Scenario 5 estimates the cumulative impacts of Scenarios 3 and 4 with the addition of agricultural BMPs and forestry management practices. Agricultural BMPs were added to all subwatersheds that had land cover conversion to agriculture simulated. Agricultural BMPs applied include conservation cover perennials (5% implementation rate), cover crops, and nutrient management, with each applied at a 30% implementation rate. Forestry BMPs were added to all subwatersheds that simulated mature forest conversion to young forest. Forestry BMPs include riparian management zones and erosion control practices implemented at a 100% implementation rate. These implementation rates were selected to simulate a best-case scenario that is achievable. The locations of subwatersheds with land cover changes and BMPs implemented are indicated by the stripped areas in Figures 37 through 40 and listed in Table 36.

HSPF-estimated reach responses for the modeled parameters are depicted by subwatershed in Figures 37 through 40 for flow, TSS, TP, and TN, respectively.

- Scenarios 3 and 4 result in increases in pollutant loading while the implementation of BMPs in Scenario 5 results in the majority of subwatershed seeing a decrease in TSS reach loads; however, a majority of the subwatersheds still see increases, although smaller, in TP and TN reach loads.

- Increases in TSS (0% to 4%), TP (0% to 5%), and TN (0% to 2%) reach loads are less than Scenario 4, and decreases in TSS (0% to 11%), TP (0% to 3%), and TN (0% to 2%) reach loads are seen in certain subwatersheds.
- The greatest areas of pollutant reductions caused by this scenario are in subwatersheds with high percentages of area already existing as agriculture and high suitability for BMP implementation. This leads to a higher BMP application rate, which leads to the higher reductions because BMPs are applied to all cropland, not specifically the newly converted cropland.
- Impacts to reach TSS, TP, and TN loading were relatively localized, with the outlet of the watershed seeing a percent change of less than 1%.

Table 36. Percent change from existing conditions for each reach with land cover changes in Scenario 5.

Reach ID	Flow (%)	TSS (%)	TP (%)	TN (%)
A15	0.3	0.3	0.3	0.3
A19	0.4	0.4	0.4	0.4
A21	1.0	1.2	0.8	0.9
A23	0.5	0.5	0.5	0.5
A25	1.0	1.3	0.9	0.9
A27	0.7	0.7	0.6	0.6
A29	0.8	1.0	0.8	0.8
A31	0.9	1.1	0.7	0.8
A32	0.8	2.5	0.9	0.8
A35	0.7	0.8	0.7	0.7
A42	0.9	1.4	1.0	1.0
A44	0.8	1.7	1.0	1.0
A51	0.7	0.8	0.6	0.6
A78	0.0	0.0	0.0	0.0
A131	0.9	0.6	0.8	0.8
A133	0.9	0.5	0.7	0.8
A134	0.8	1.3	0.9	0.9
A154	0.0	0.0	0.0	0.0
A158	0.8	2.9	0.9	0.9
A159	0.9	2.4	0.9	0.9
A161	1.0	2.6	1.0	0.9
A162	0.9	3.5	1.1	1.0
A171	1.0	0.7	1.0	1.0
A172	1.1	0.4	1.0	1.0
A175	1.1	0.9	1.1	1.0
A190	0.1	0.1	0.1	0.1
A217	1.5	–1.0	1.2	1.3
A218	1.3	0.2	1.4	1.5

Reach ID	Flow (%)	TSS (%)	TP (%)	TN (%)
A232	0.8	1.3	0.9	0.9
A320	0.9	1.7	1.1	1.0
A371	1.1	1.4	0.8	1.0
A405	0.4	0.4	0.3	0.3
A411	1.2	–3.3	2.5	1.5
A430	0.3	–0.7	1.0	0.6
A437	1.3	–1.9	3.1	1.9
A450	0.5	–0.9	1.5	0.9
A491	1.0	–9.8	–2.7	–1.9
A511	0.5	–6.5	1.1	0.3
A513	0.9	0.2	0.9	0.6
A530	0.0	0.0	0.1	0.0
A535	1.1	–0.5	3.4	2.0
A537	1.1	–1.2	4.2	2.1
A539	0.6	–1.8	5.0	2.4
A543	0.8	–0.9	3.9	1.8
A545	1.0	–0.7	3.7	2.0
A547	0.7	–2.2	4.1	2.0
A555	0.5	–10.0	–1.2	–1.3
A558	0.0	–10.7	–2.0	–1.7
A562	0.7	–8.8	–0.5	–0.3
A563	0.9	–5.3	1.5	1.1
A565	1.0	–4.8	1.8	1.1
A567	1.1	0.1	0.8	0.9
A579	0.7	–4.8	3.1	1.4
A581	0.6	–2.3	1.4	0.7
A583	0.7	–4.2	2.3	1.1
A585	0.6	–2.5	1.6	0.7
A590	0.1	–0.1	0.2	0.1

Figure 17. HSPF flow for existing conditions in the MRBW.

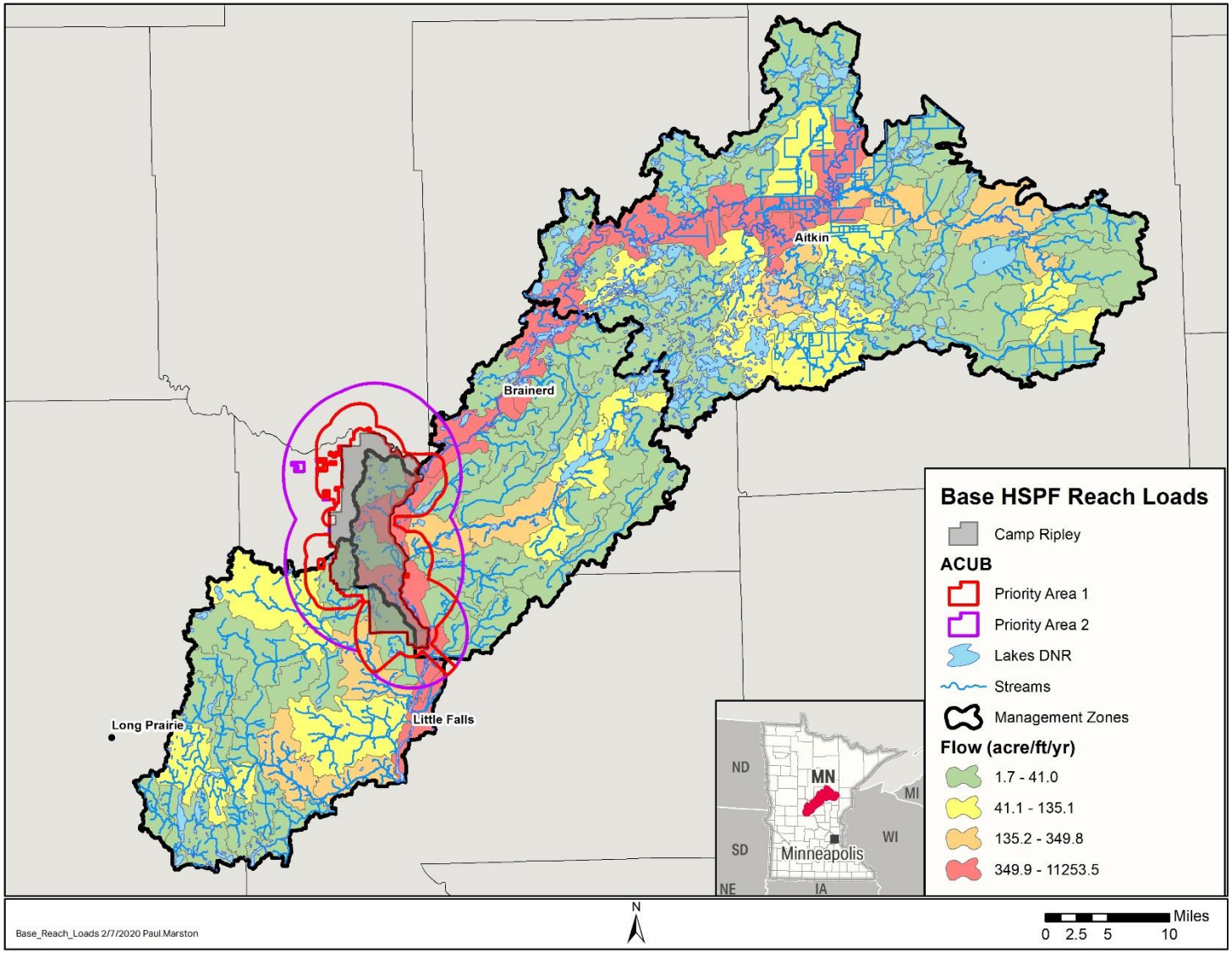


Figure 18. HSPF TSS loads for existing conditions in the MRBW.

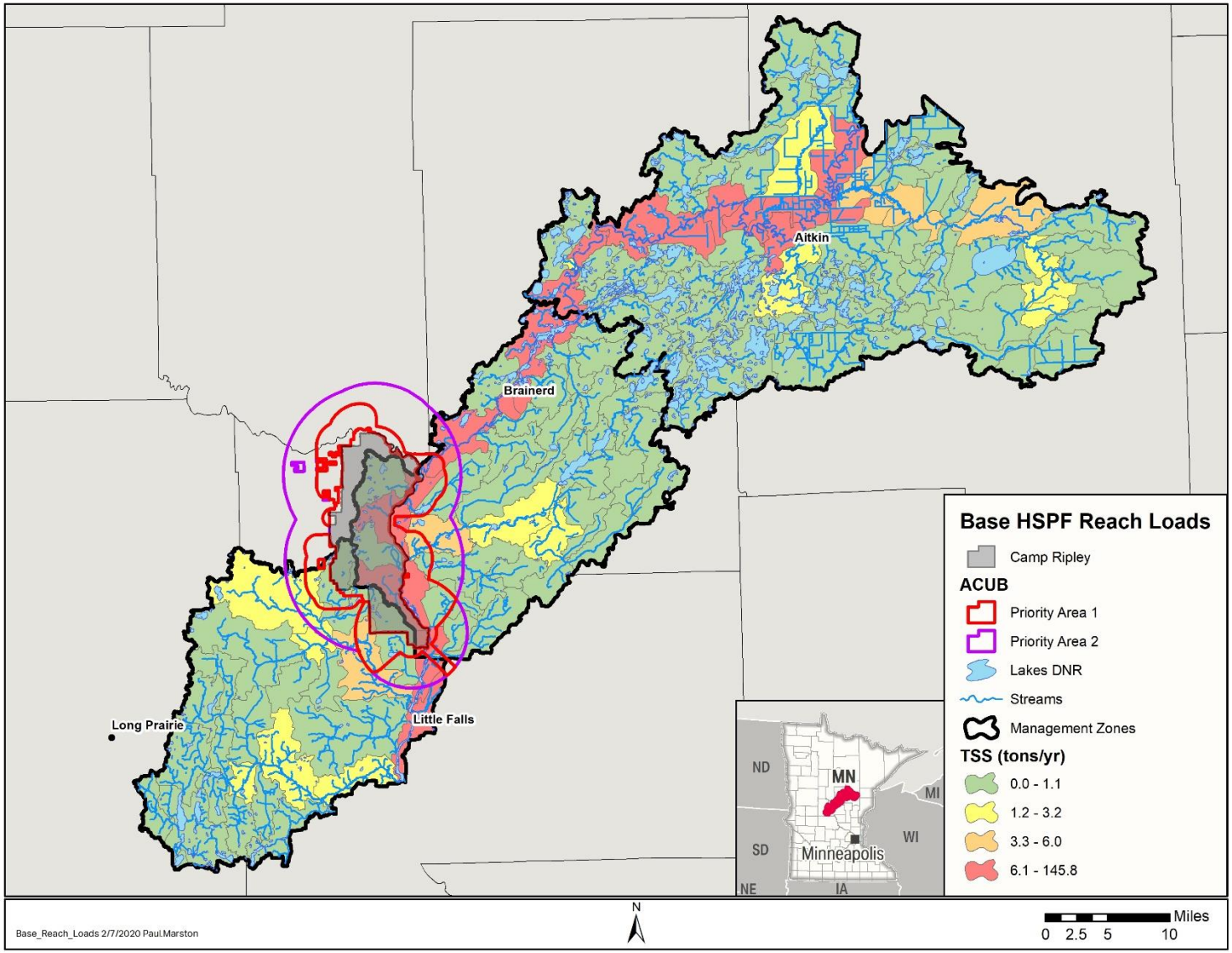


Figure 19. HSPF TP loads for existing conditions in the MRBW.

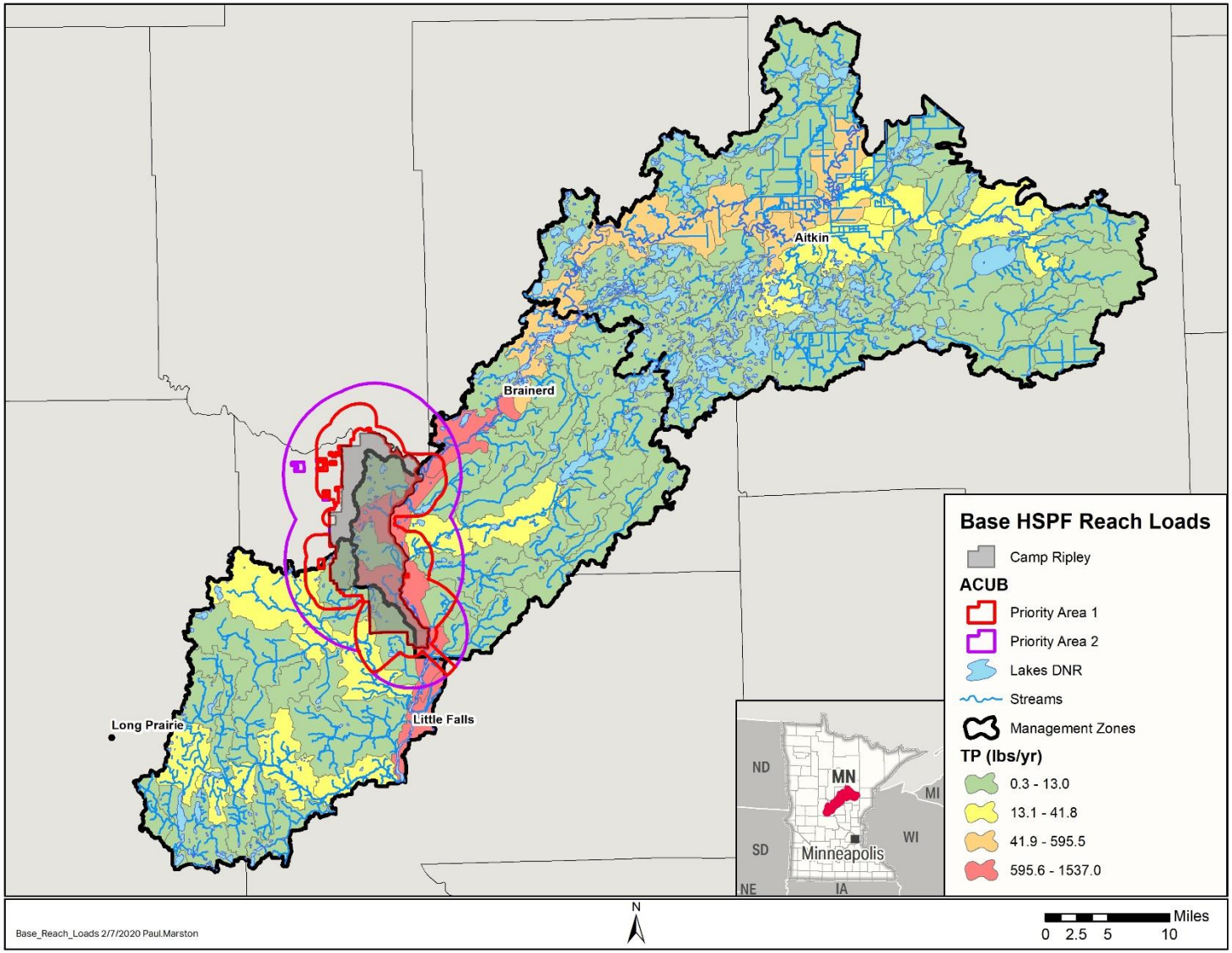


Figure 20. HSPF TN loads for existing conditions in the MRBW.

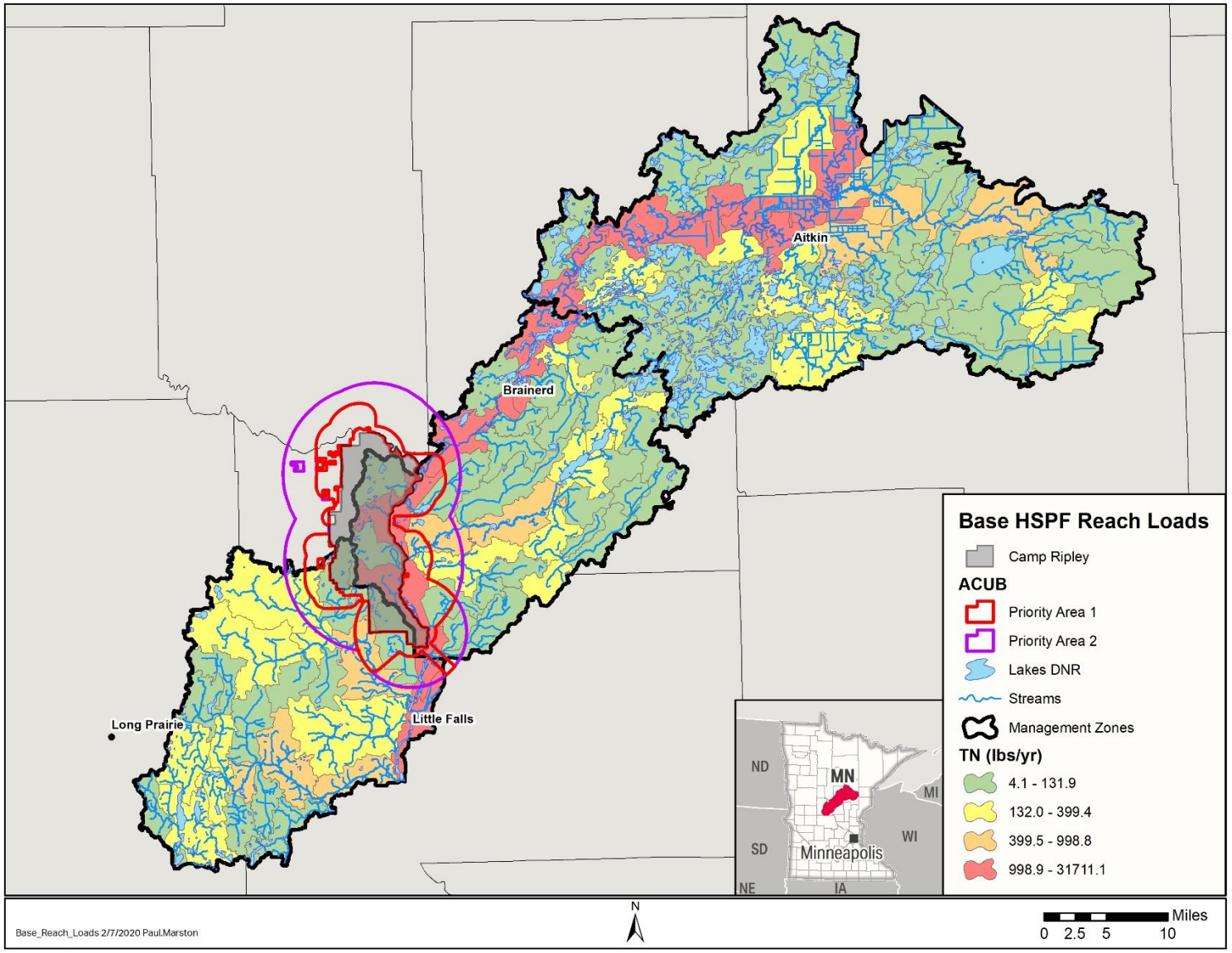


Figure 21. Scenario 1 increase in development percent increase in flow.

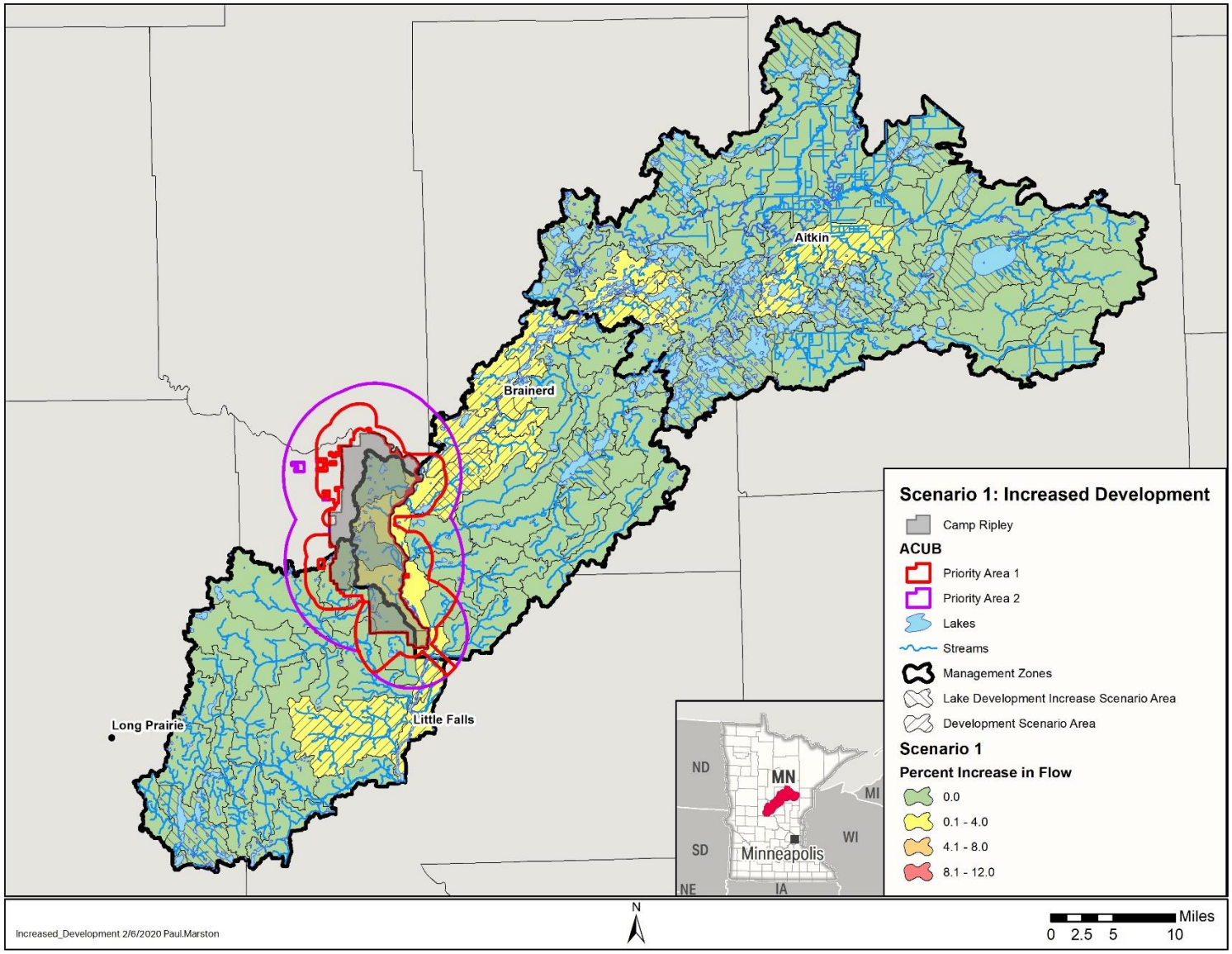


Figure 22. Scenario 1 increase in development percent increase in TSS loading.

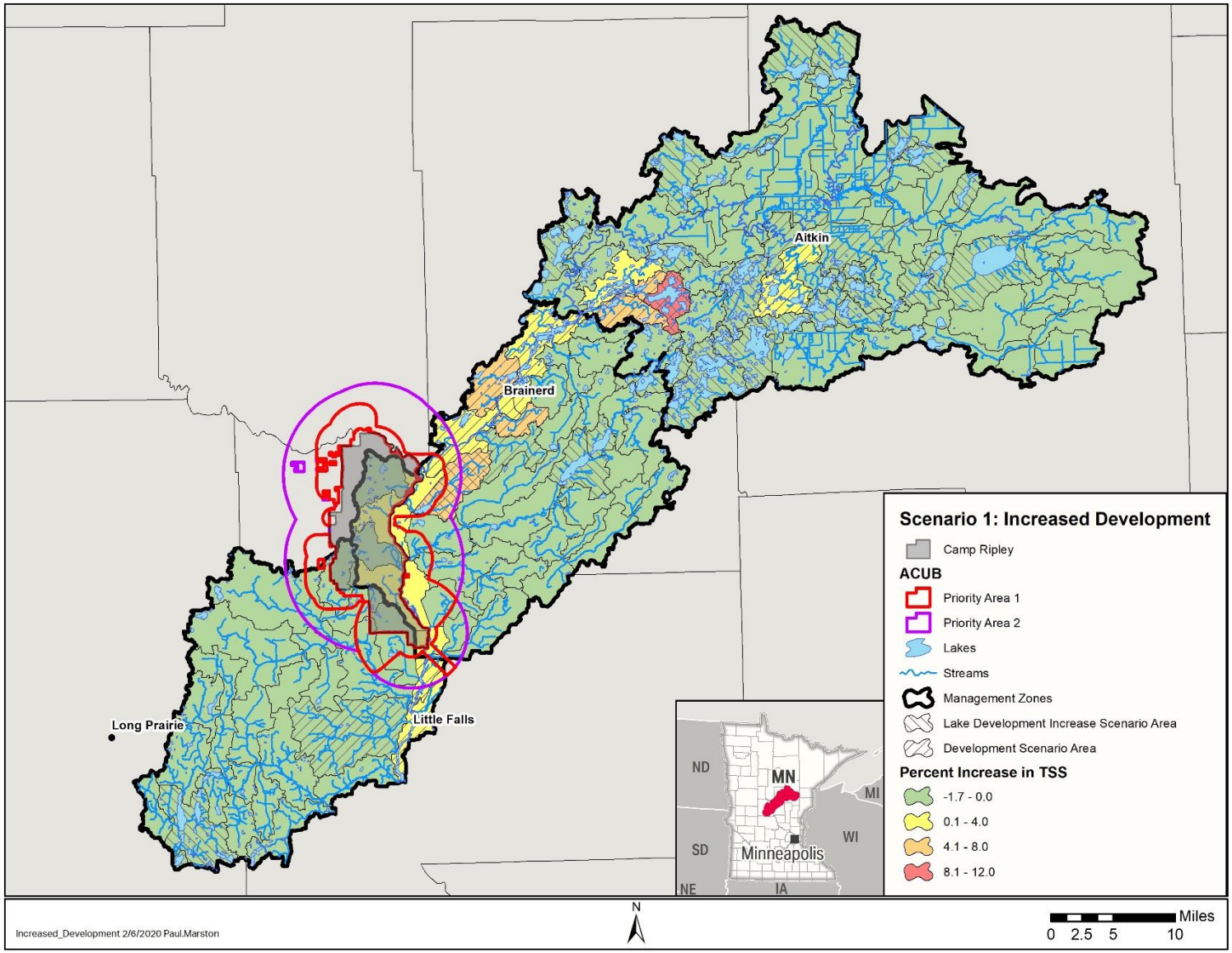


Figure 23. Scenario 1 increase in development percent increase in TP loading.

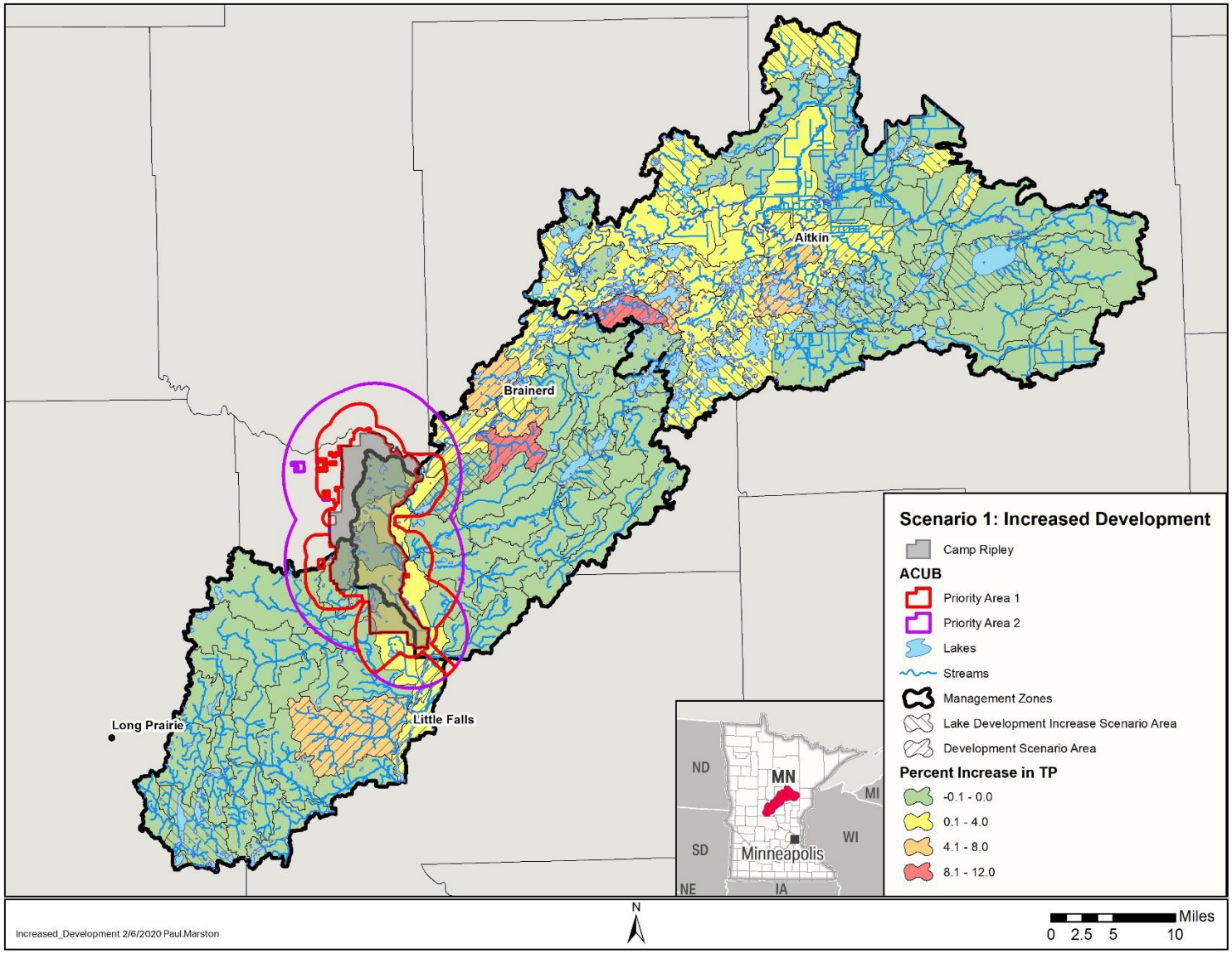


Figure 24. Scenario 1 increase in development percent increase in TN loading.

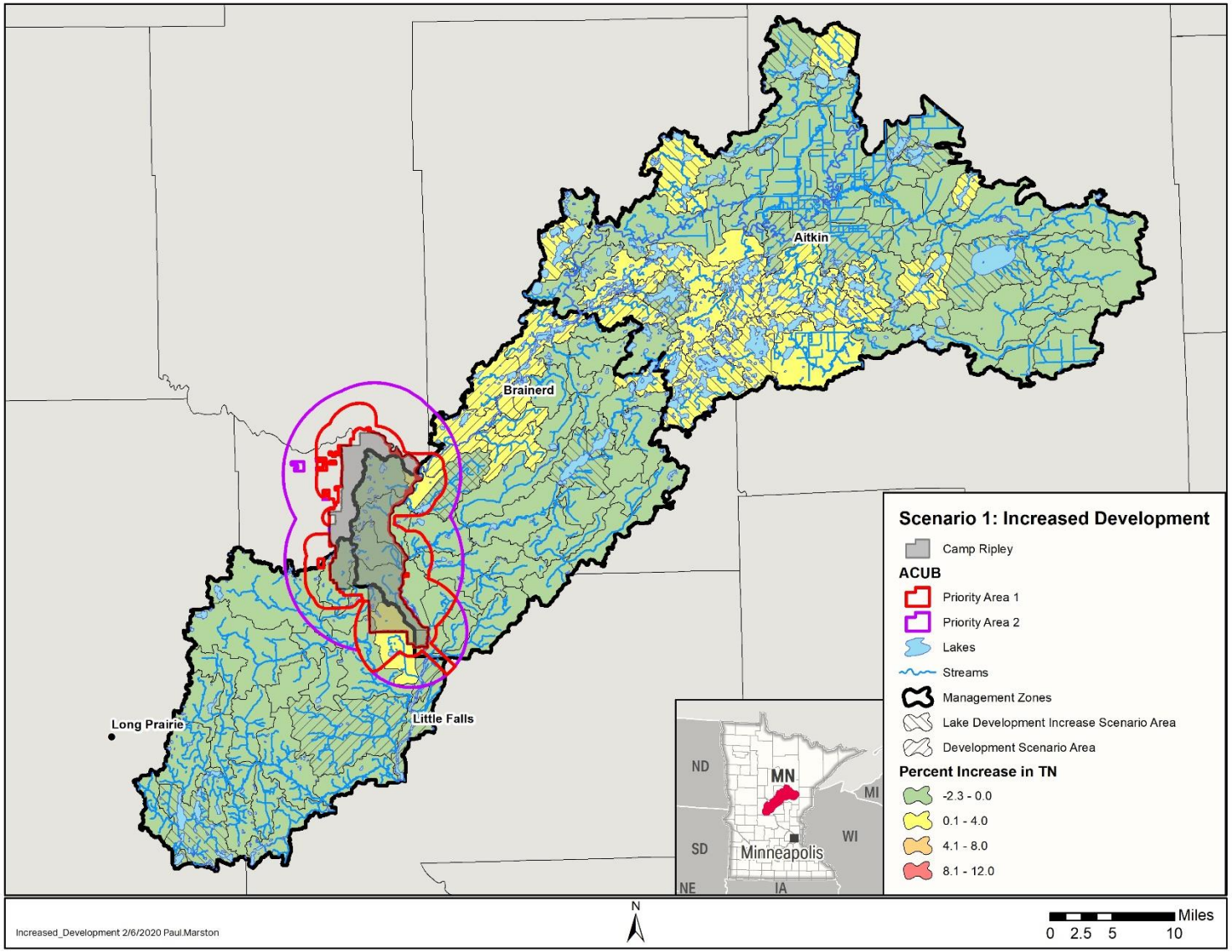


Figure 25. Scenario 2 increase in development with adoption of MIDS percent reduction in flow.

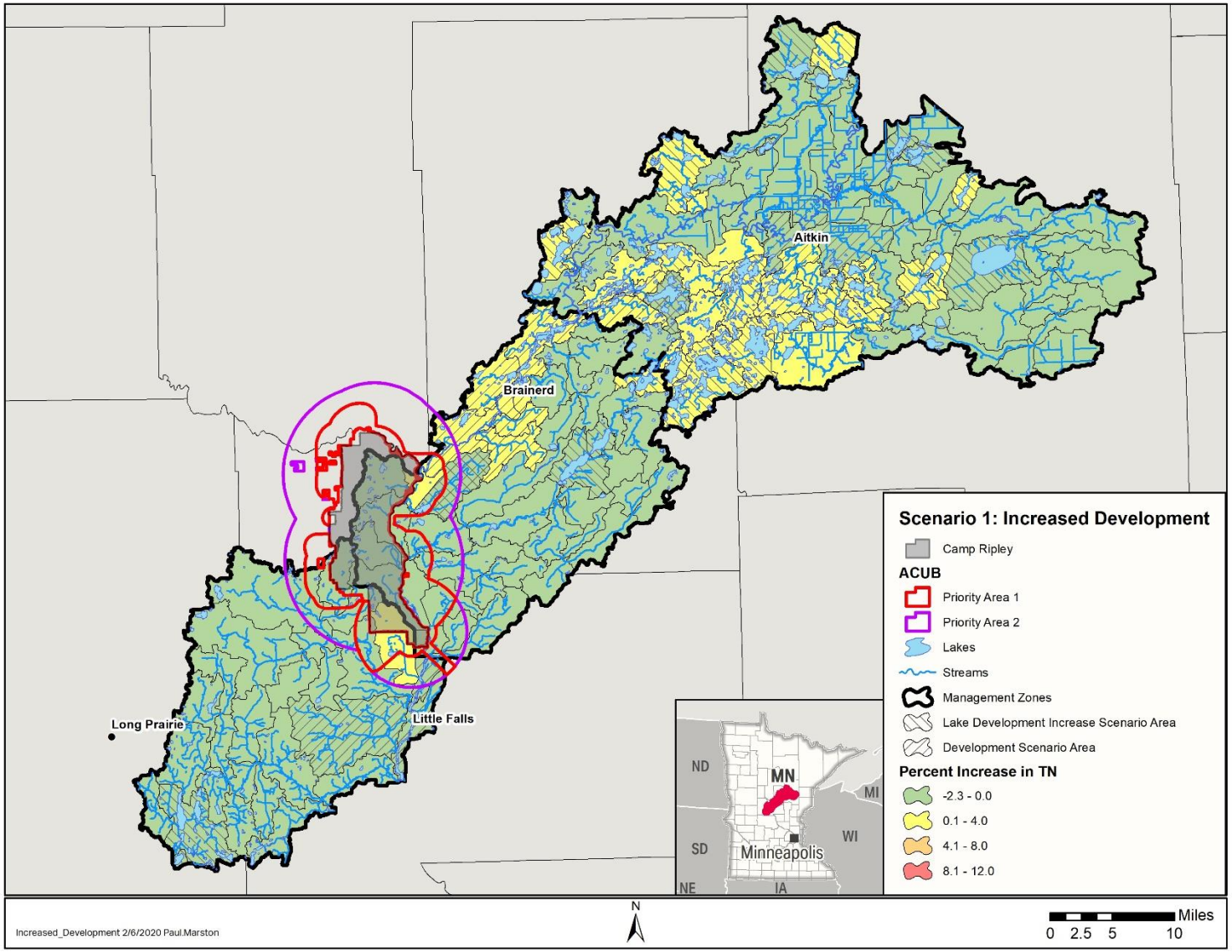


Figure 26. Scenario 2 increase in development with adoption of MIDS percent reduction in TSS loading.

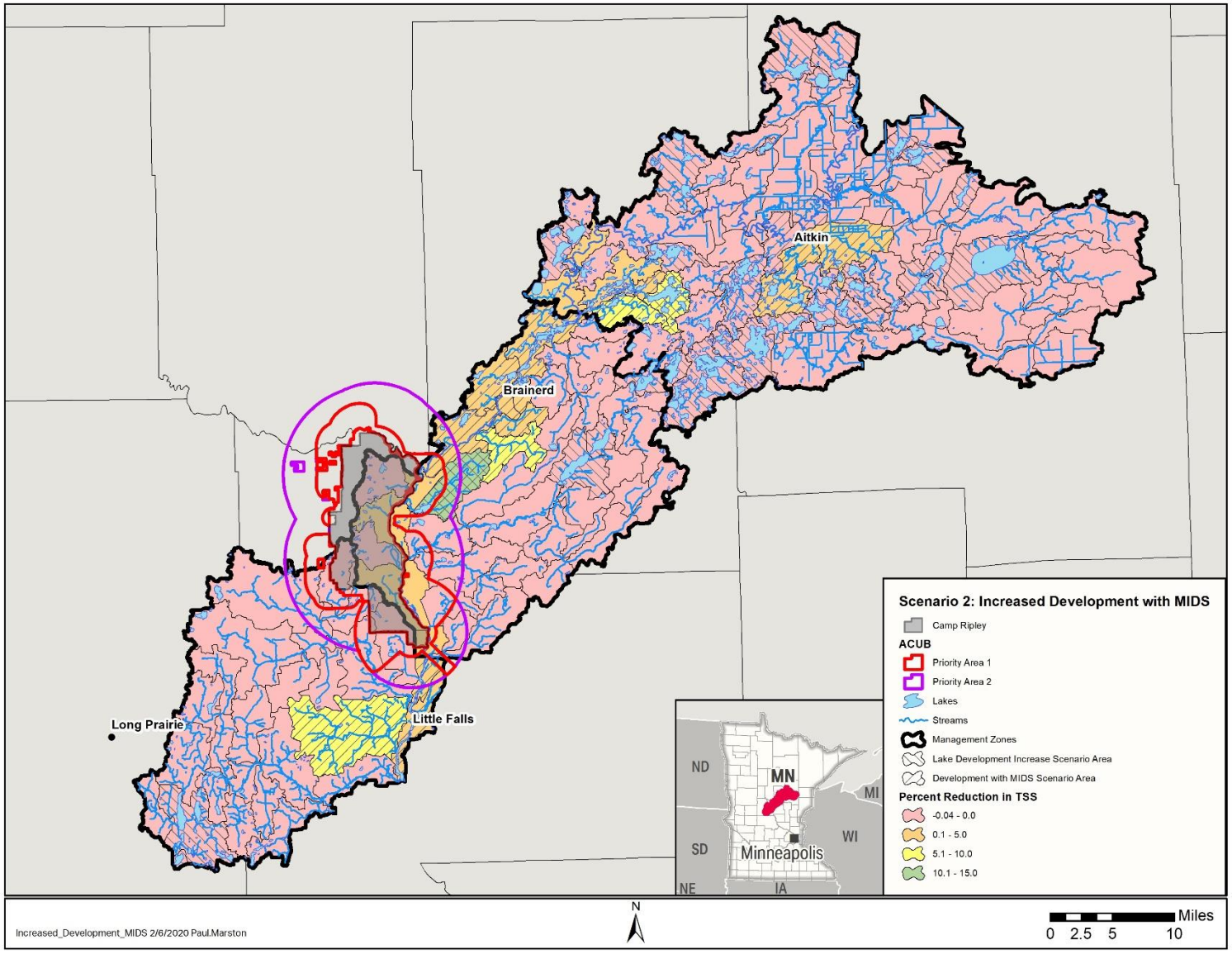


Figure 27. Scenario 2 increase in development with adoption of MIDS percent reduction in TP loading.

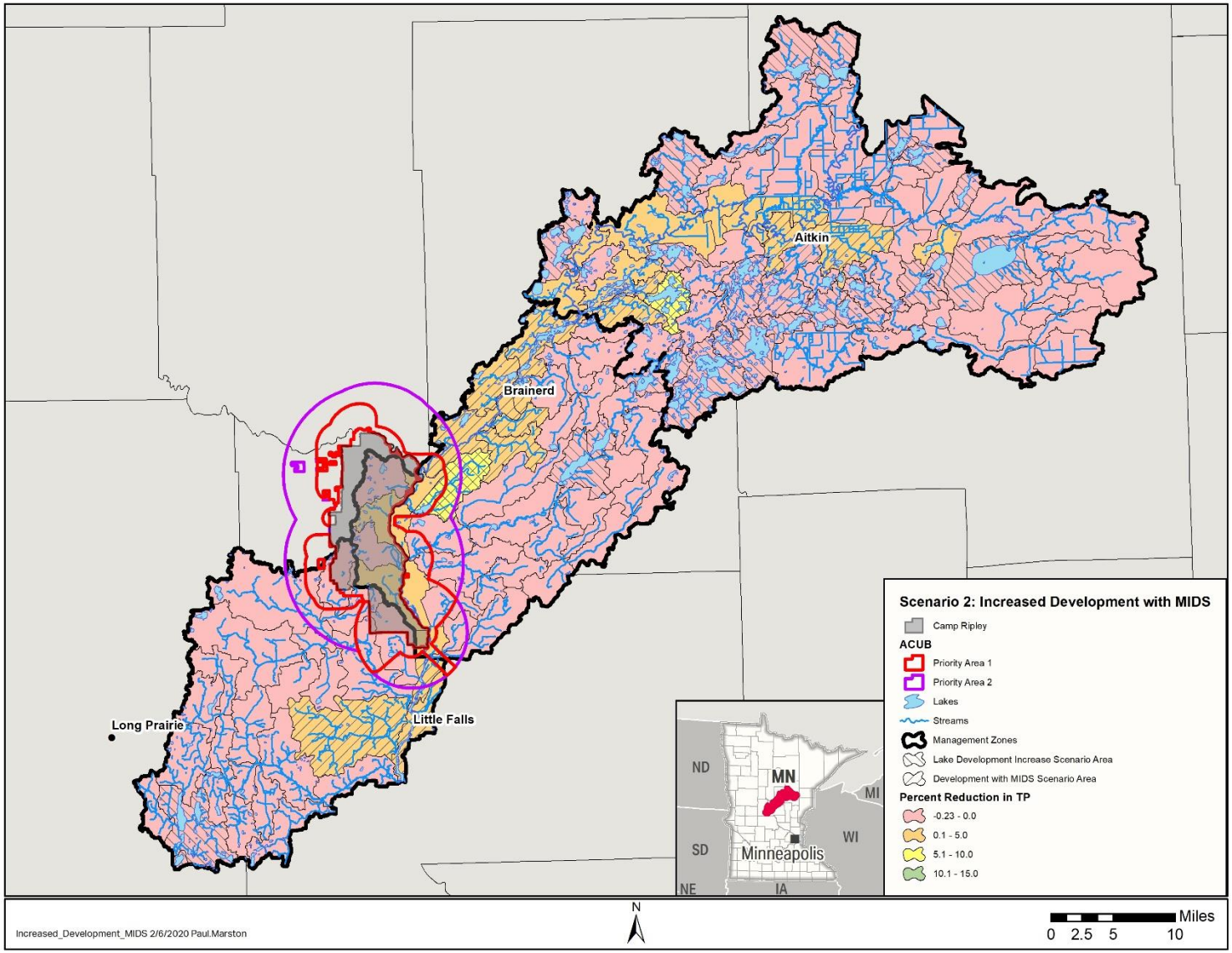


Figure 28. Scenario 2 increase in development with adoption of MIDS percent reduction in TN loading.

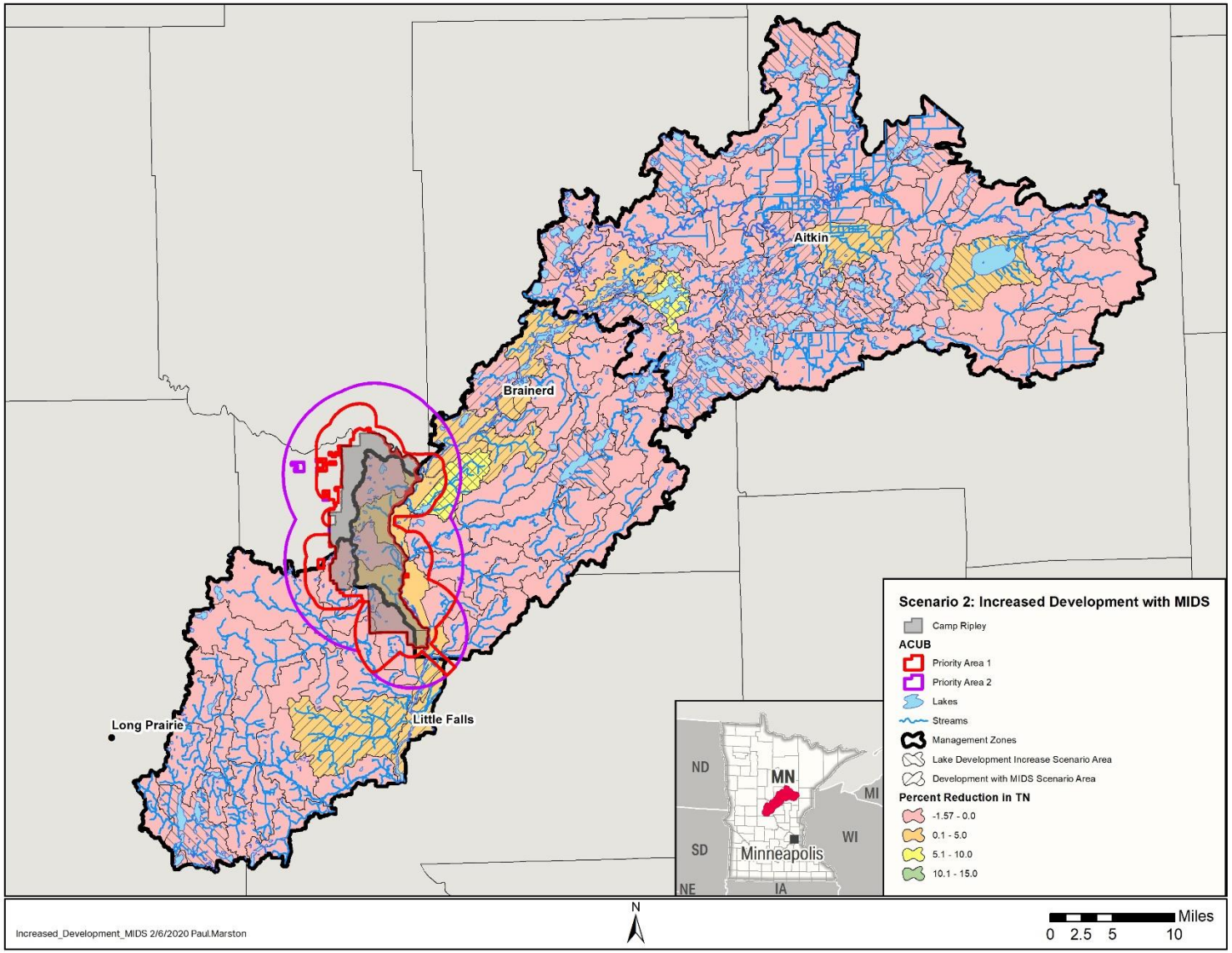


Figure 29. Scenario 3 increase in forestry percent increase in flow.

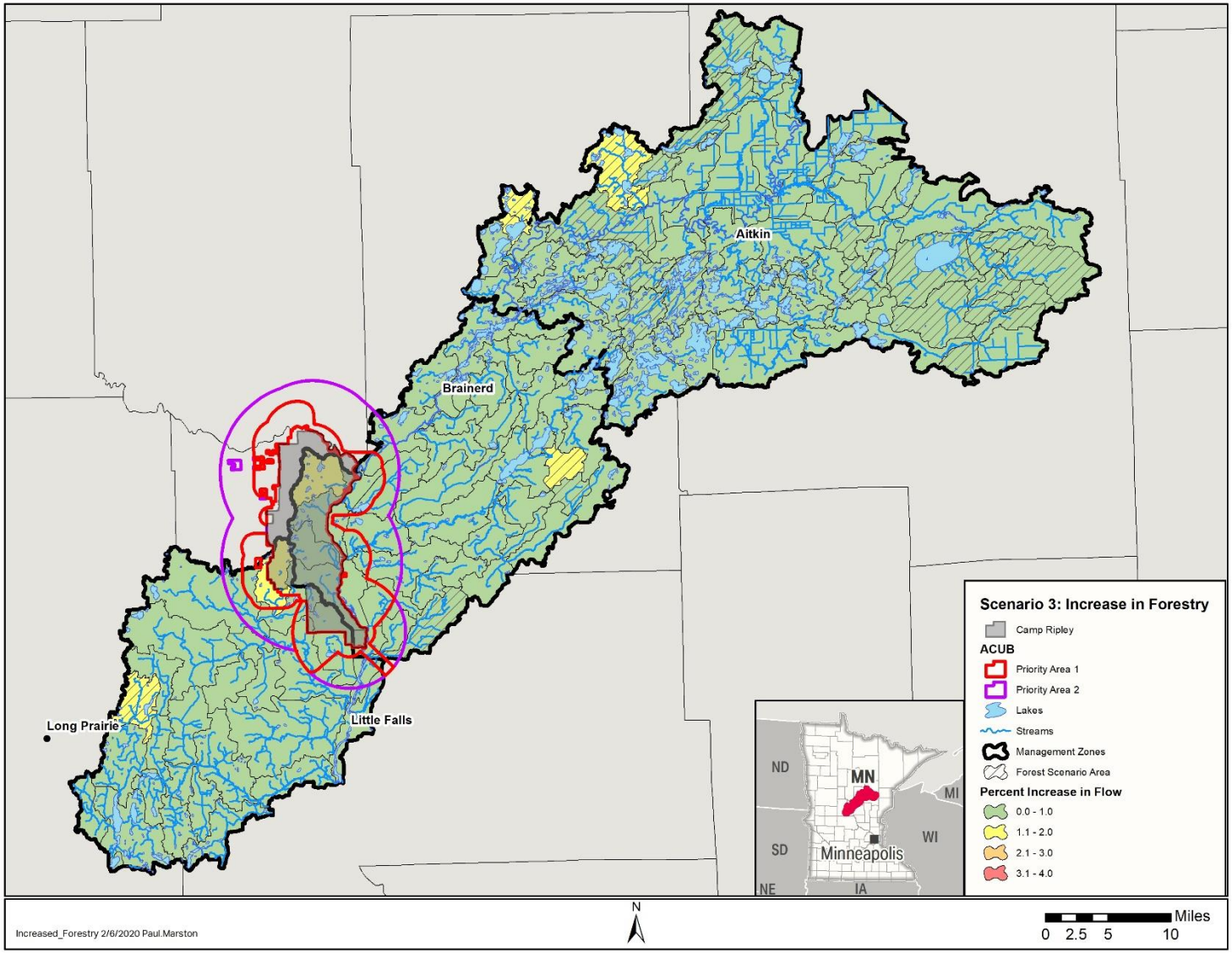


Figure 30. Scenario 3 increase in forestry percent increase in TSS loading.

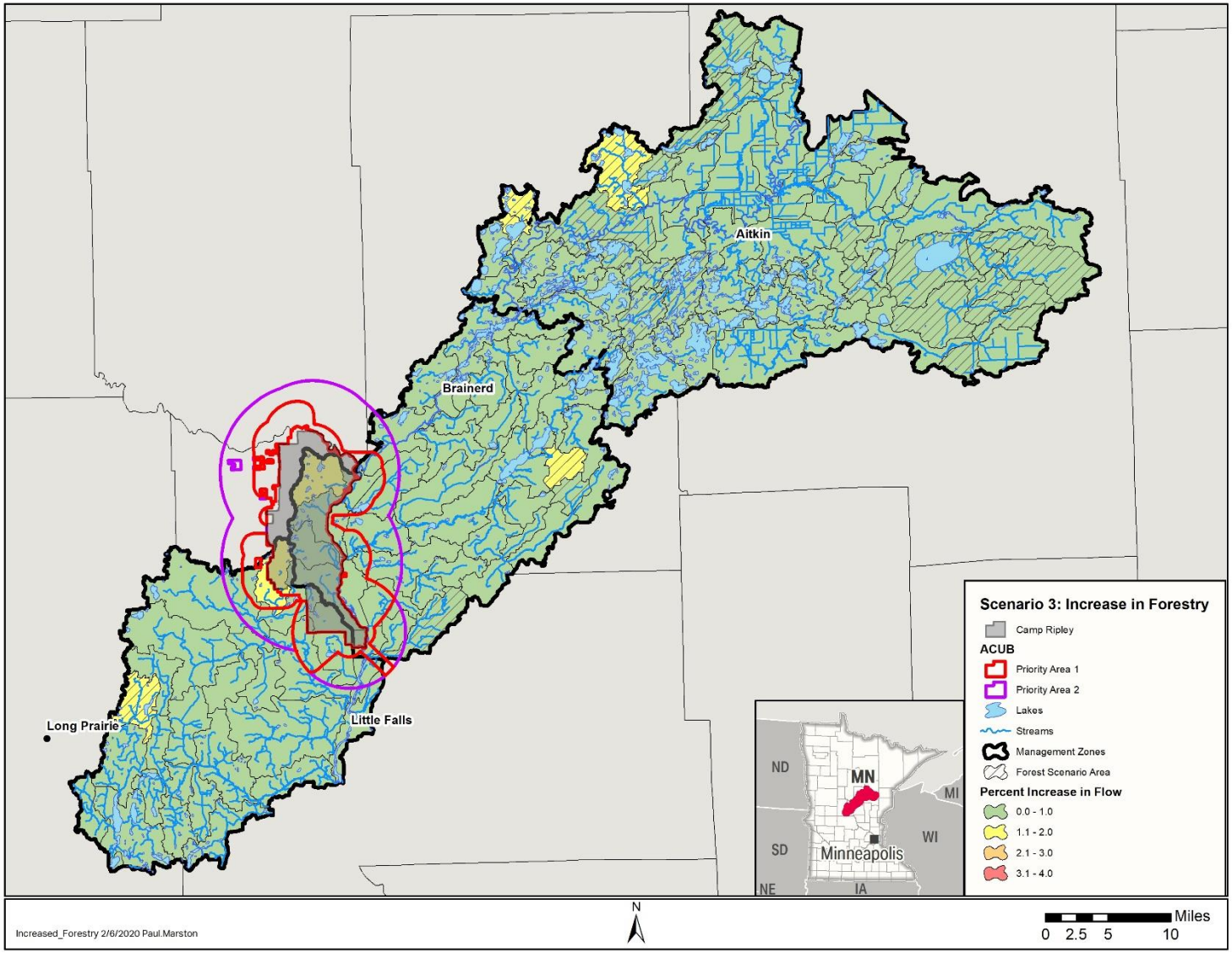


Figure 31. Scenario 3 increase in forestry percent increase in TP loading.

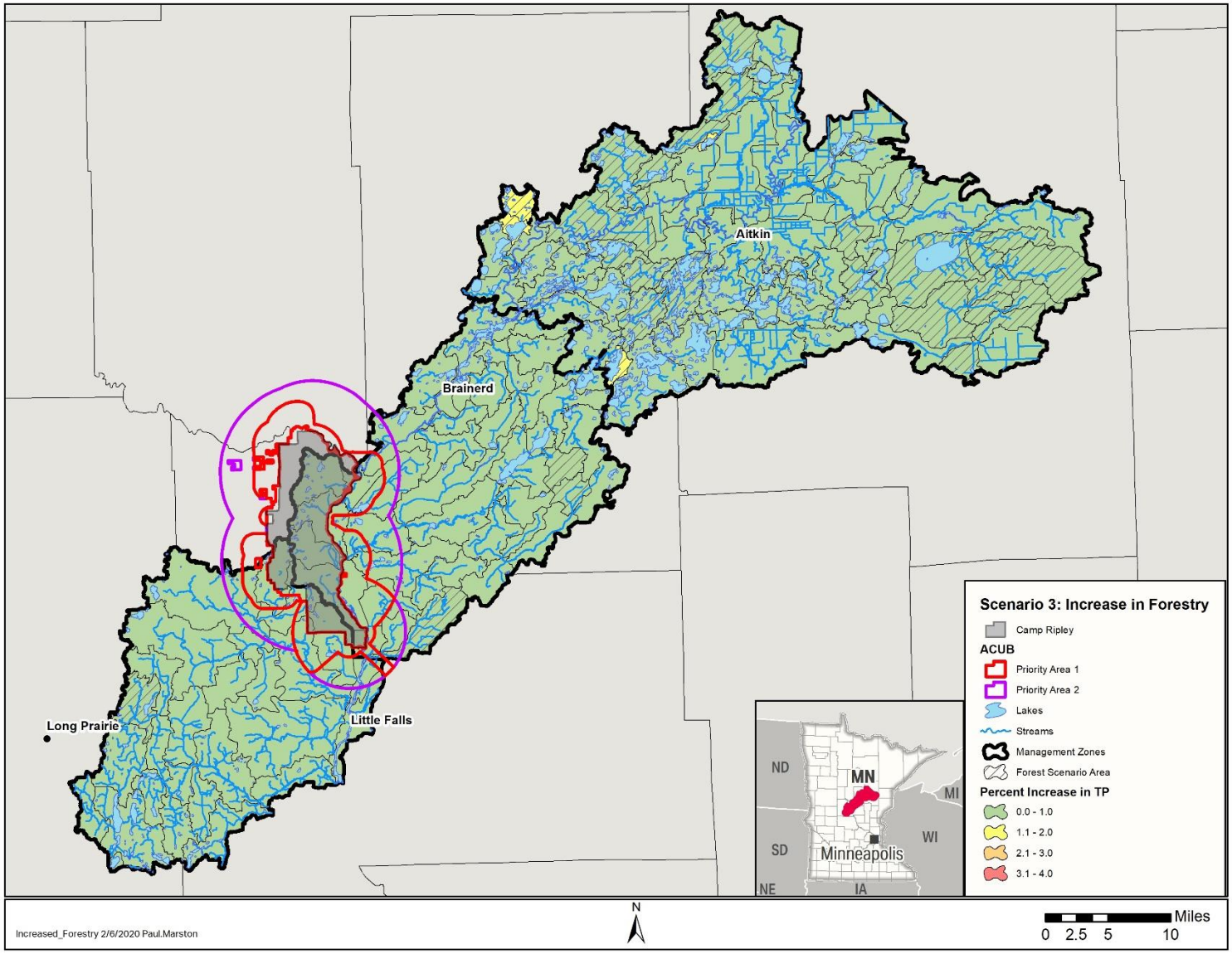


Figure 32. Scenario 3 increase in forestry percent increase in TN loading.

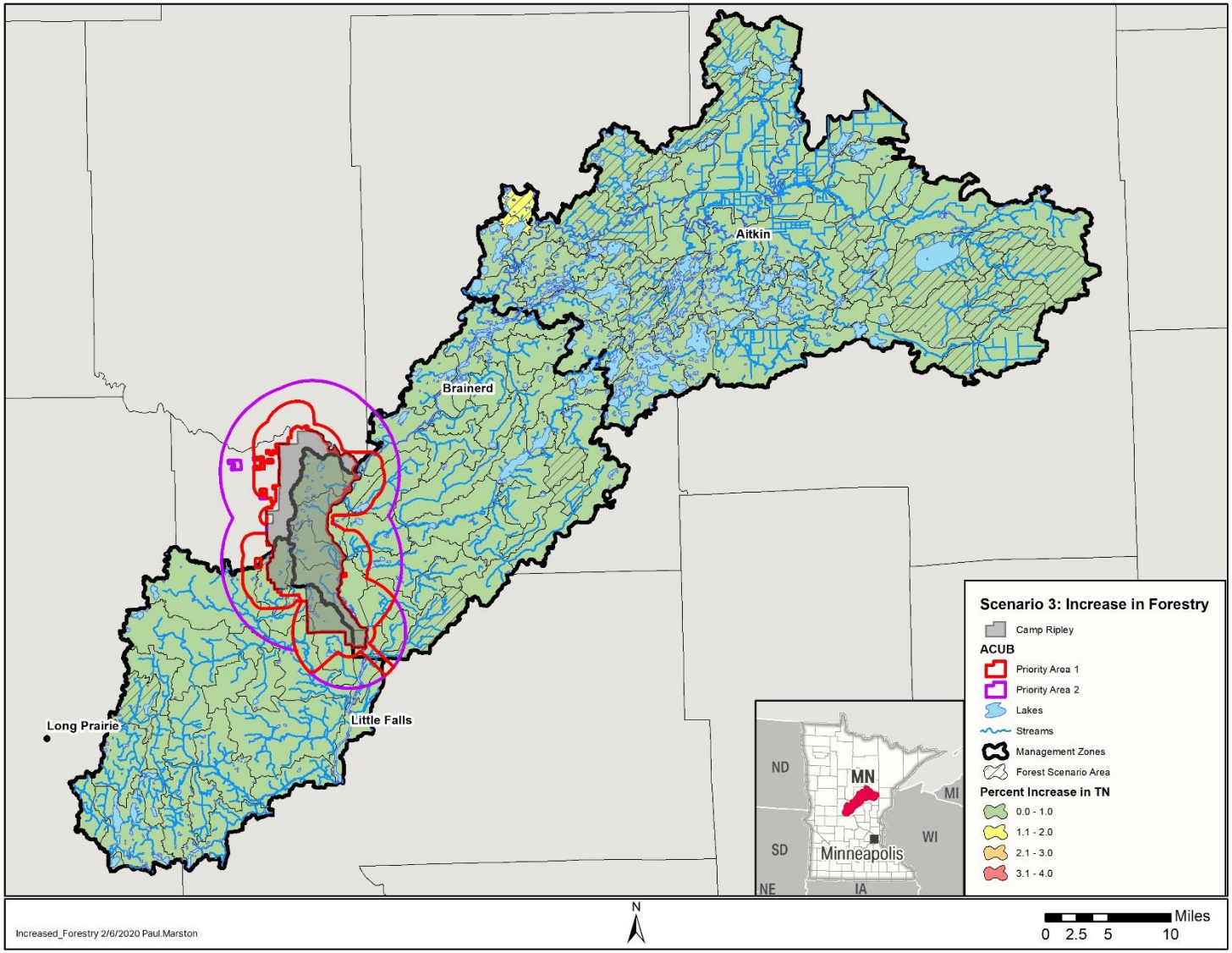


Figure 33. Scenario 4 increase in cropland percent increase in flow.

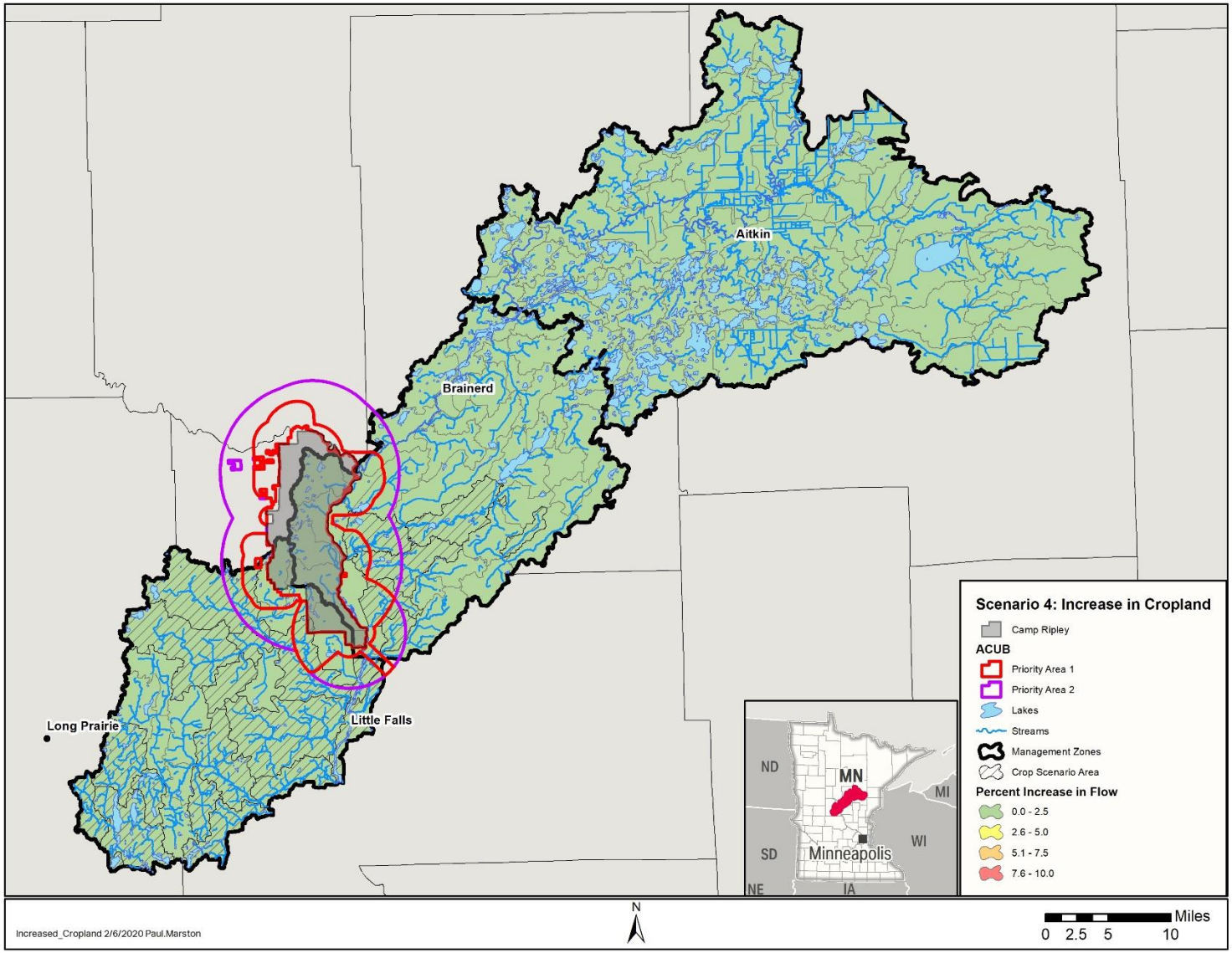


Figure 34. Scenario 4 increase in cropland percent increase in TSS loading.

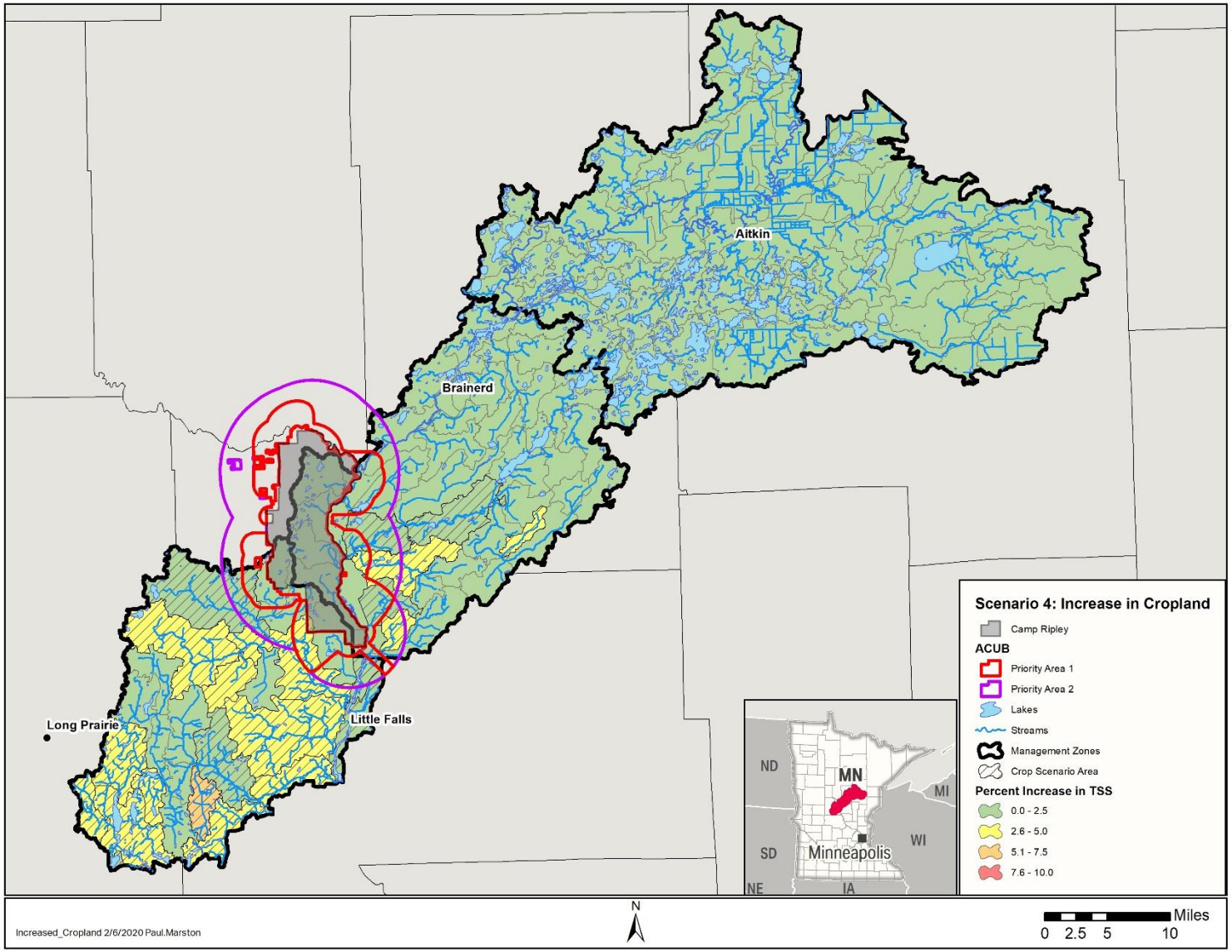


Figure 35. Scenario 4 increase in cropland percent increase in TP loading.

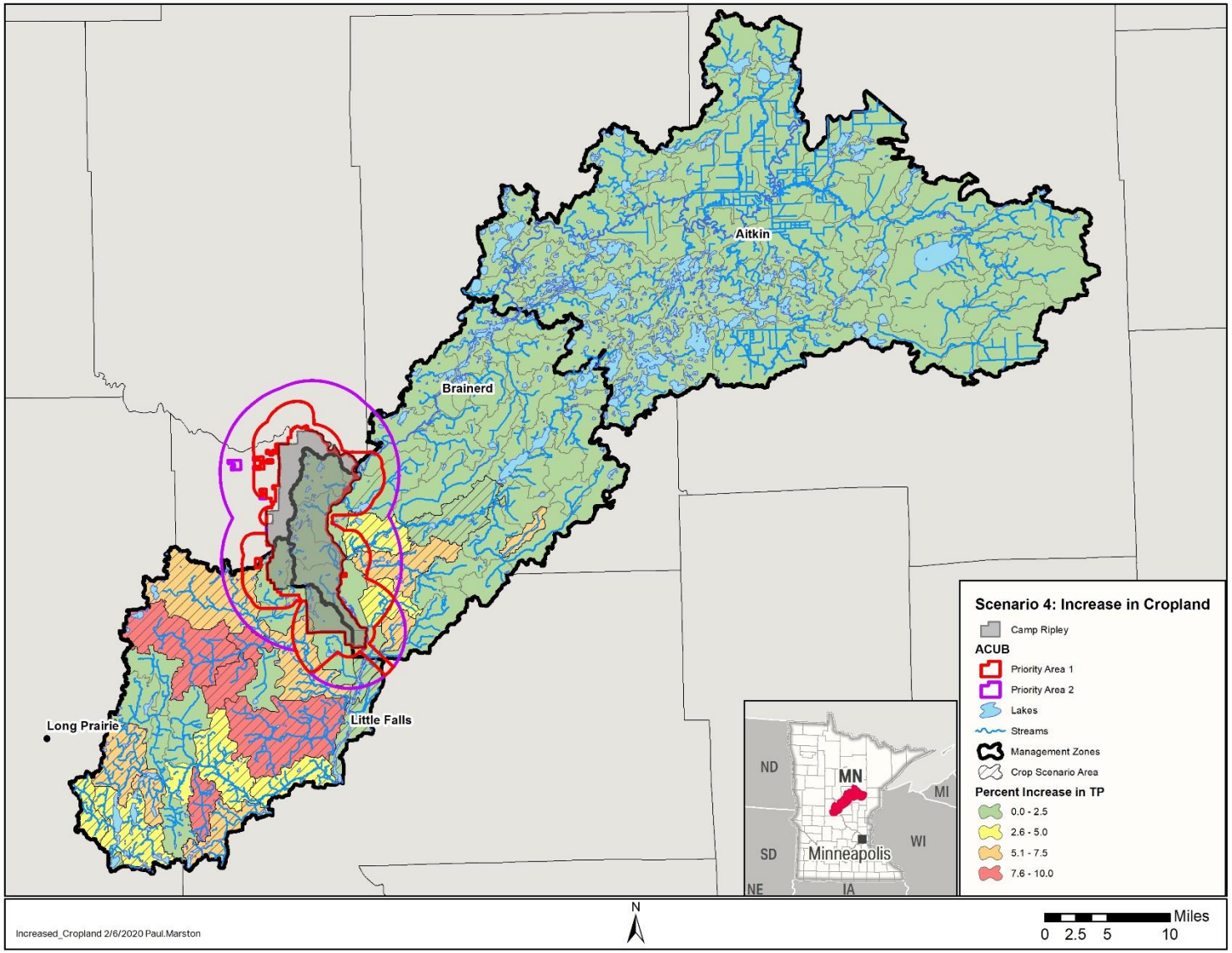


Figure 36. Scenario 4 increase in cropland percent increase in TN loading.

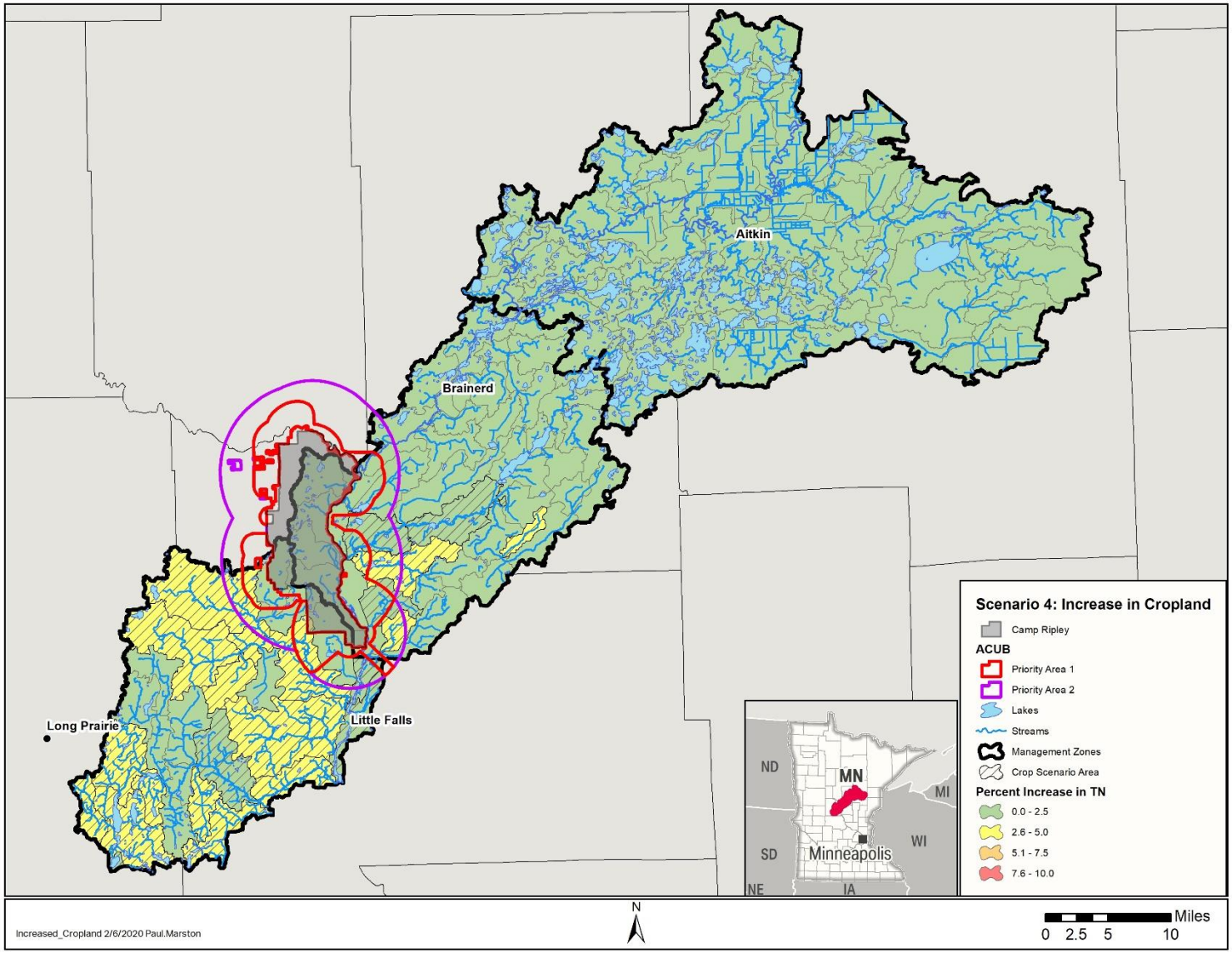


Figure 37. Scenario 5 cumulative percent reduction in flow.

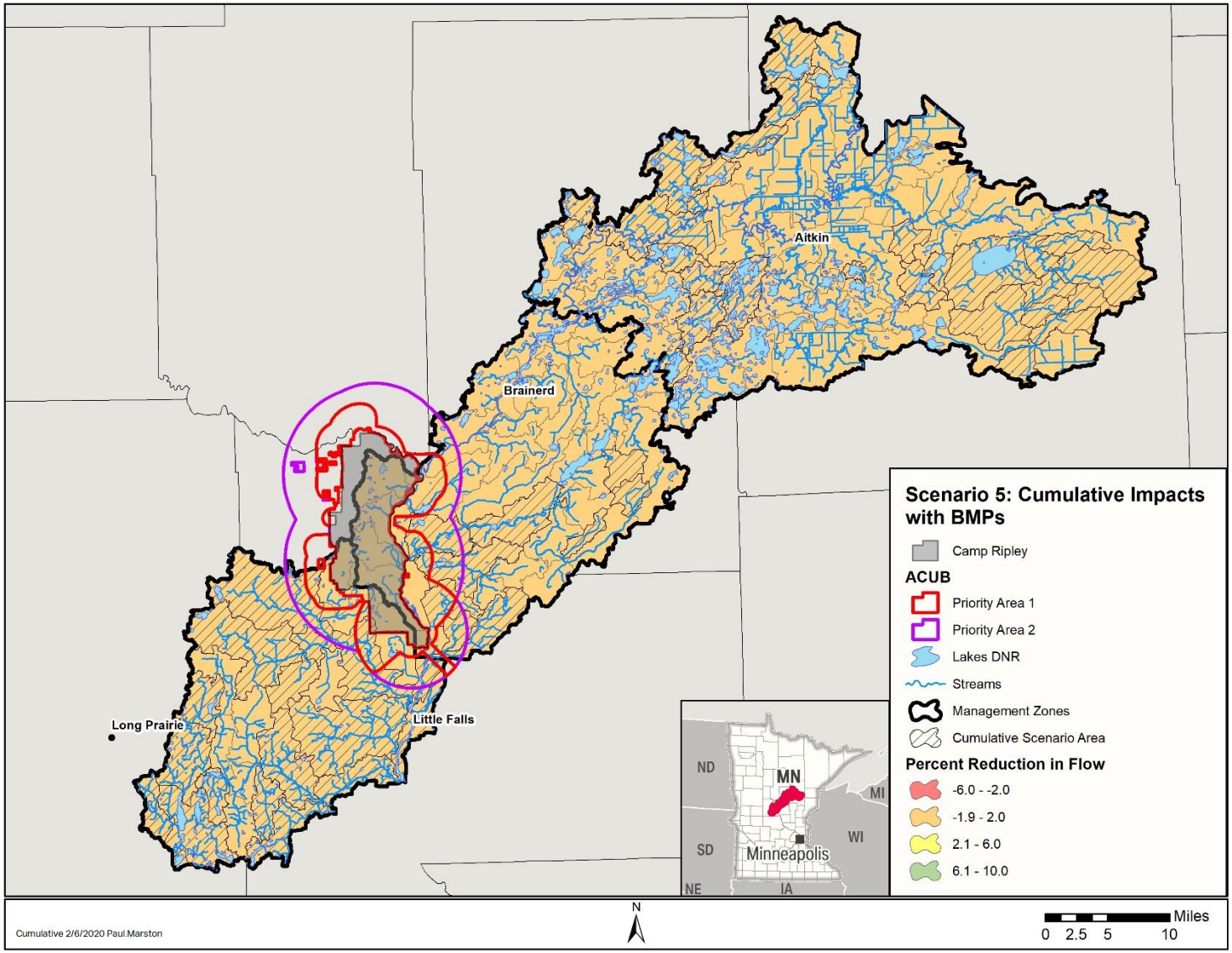


Figure 38. Scenario 5 cumulative percent reduction in TSS loading.

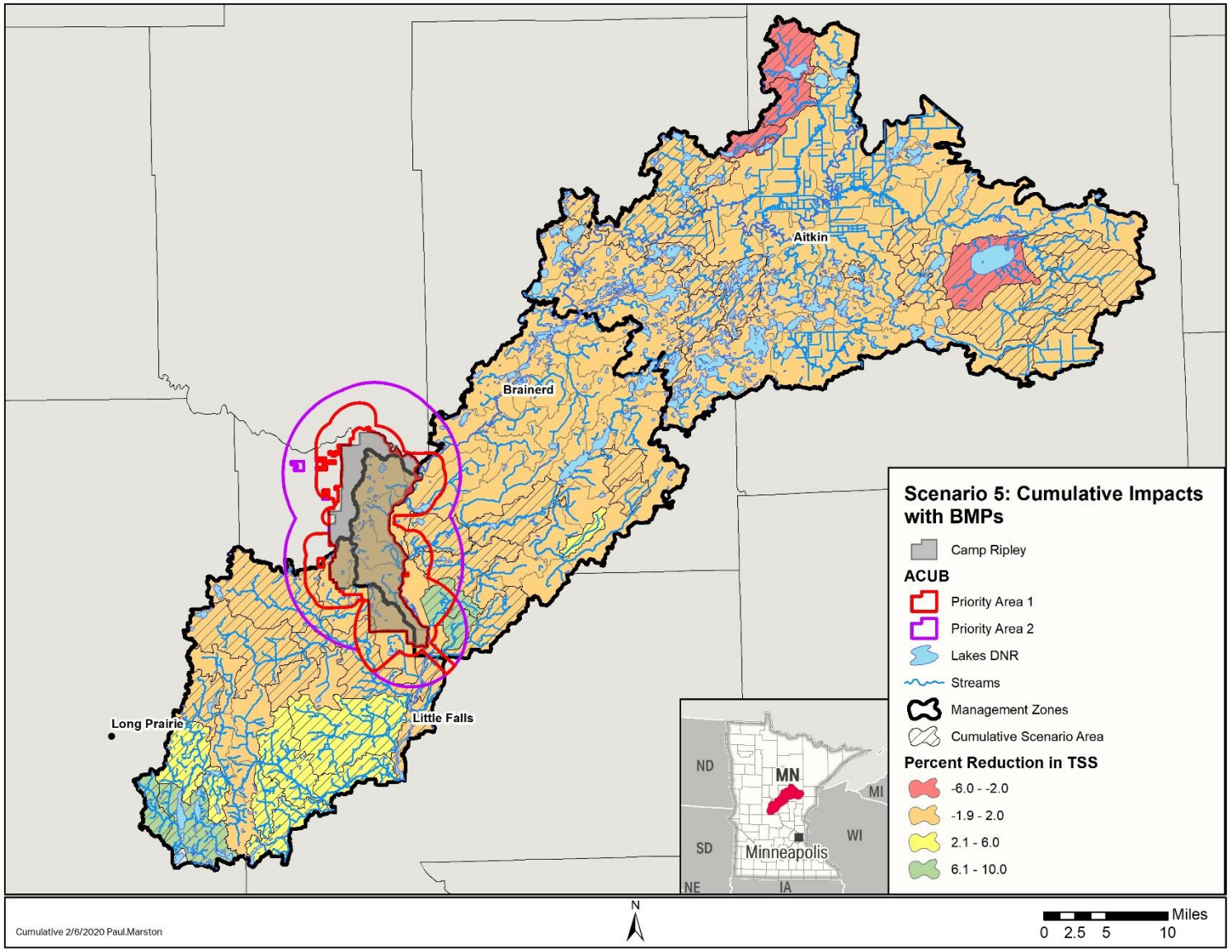


Figure 39. Scenario 5 cumulative percent reduction in TP loading.

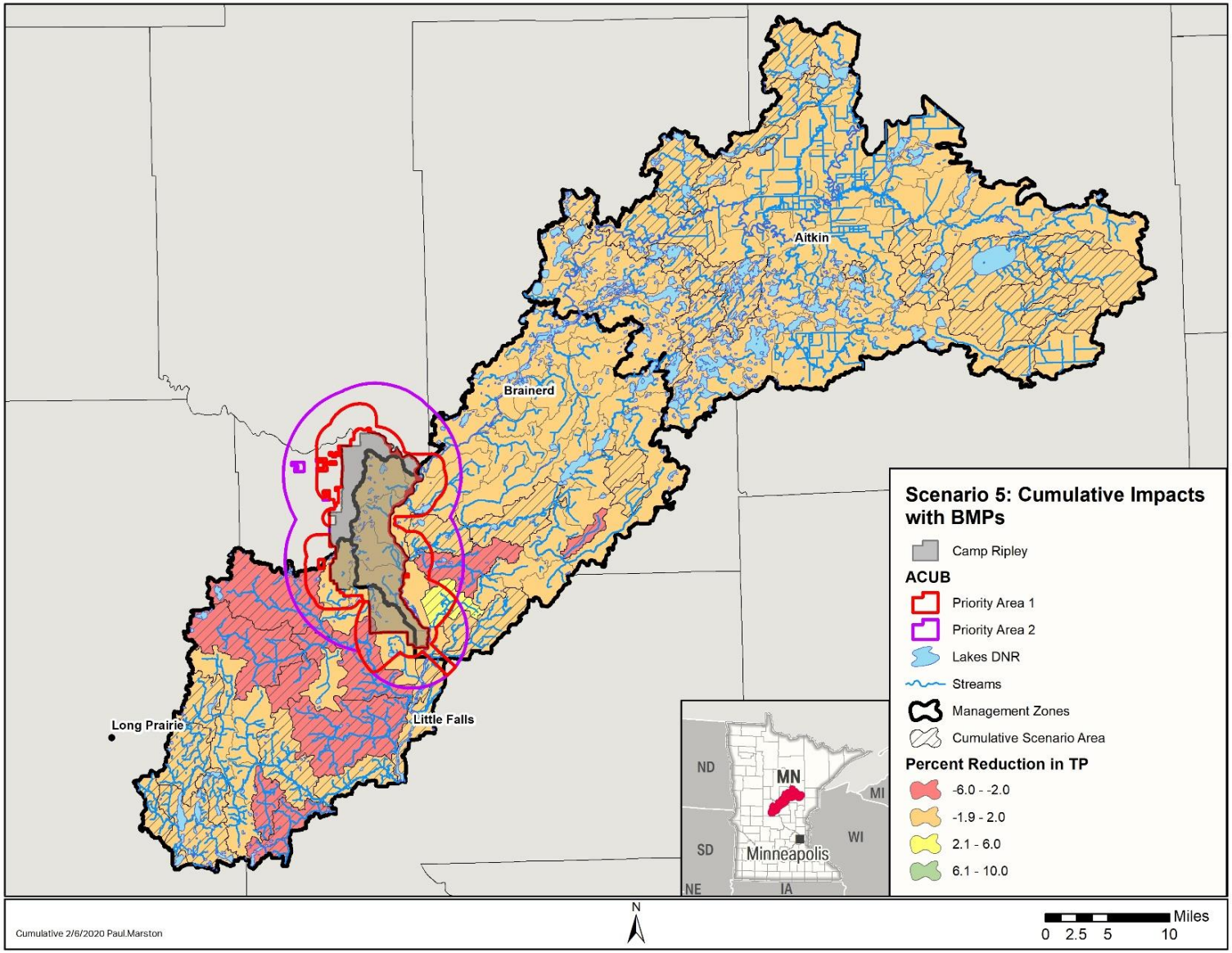
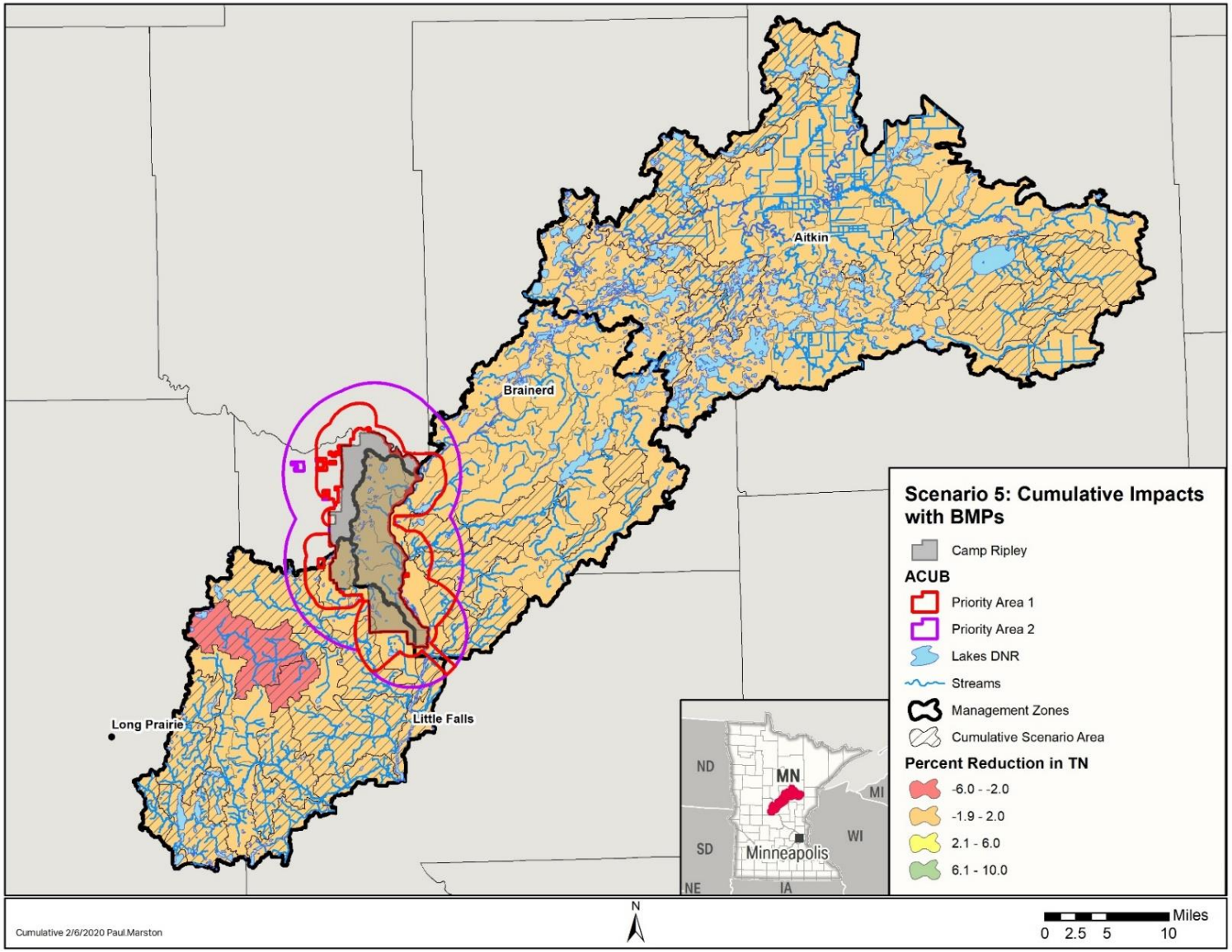


Figure 40. Scenario 5 cumulative percent reduction in TN loading.



9. Appendix D

Lake prioritization metrics for all lakes with available data are provided in Table 37 below.

Table 37. Lake prioritization metrics.

Lake Name	Lake ID	Management Zone	Lake Acres	Watershed Acres	Mean TP (ug/L)	Mean Secchi (m)	Water Clarity Trend	Percent Disturbed Land cover in Lakeshed	LPSS Priority Class	LBCA Priority Class	Lake of Biological Significance	Cisco Refuge Lake	Near Water Quality Standard	Protection Candidates Based on FIBI Score	Lake Protection and Prioritization Rating
Agate	18-0060-00	North	187.0	754.2	22.3	3.6	No evidence of trend	3%	Higher	High					
Bass	18-0306-00	North	399.1	641.8	12.4	4.0	No evidence of trend	29%	Highest	Highest					
Bass	18-0256-00	North	285.2	647.4	20.0	3.3	Increasing trend	12%	Highest	Higher				Yes	
Bass	77-0024-00	South	122.6	640.4	17.6	4.0		59%	Highest	Higher	Outstanding	Yes			
Bay	18-0034-00	North	2329.9	16970.4	12.8	4.0	Increasing trend	10%	Highest	Highest				Yes	
Beauty	77-0035-00	South	240.1	1792.3	21.8	2.7	No evidence of trend	9%	Higher	High	Moderate				
Big	77-0063-00	South	297.1	1629.2	22.1	2.3		11%	Higher	Higher					
Birch	01-0206-00	North	441.5	1193.9	17.5	1.7		1%	High	High					
Black	18-0059-00	North	106.4	706.3	12.6	3.2		9%	Higher	High					
Black Bear	18-0140-00	North	218.1	4562.8	11.8	3.7		4%	High	High	Outstanding			Yes	
Black Hoof	18-0117-00	North	201.1	4837.0	34.5	2.2		14%	Higher	High			Yes	Yes	
Blue	01-0181-00	North	53.5	177.0	7.2	4.1			High	High					
Bonnie	18-0259-00	North	76.1	241.2	19.9	4.4	Increasing trend	9%	Higher	High					
Buck	77-0029-00	South	61.3	3730.7	19.0	3.7		38%	Higher	High					
Buckhead	77-0011-00	South	49.7	390.0	37.0	1.2		7%	High	High			Yes		
Camp	01-0155-00	North	59.1	659.8	20.0	1.6		4%	High	High					
Cascade	18-0061-00	North	44.1	170.6	16.0	2.4		22%	Higher	High					
Casey	18-0087-00	North	59.6	947.9	136.8	0.7		15%	High	High			Yes		
Cedar	01-0209-00	North	1725.8	26052.8	13.4	3.2	Decreasing trend	8%	Highest	Highest	Outstanding	Yes		Yes	
Clear	01-0093-00	North	573.5	833.8	11.8	4.8	Increasing trend	23%	Highest	Highest					
Clearwater	18-0038-00	North	905.5	2504.1	18.5	4.0	Decreasing trend	8%	Highest	Highest					
Clinker	18-0131-00	North	80.7	5481.5	14.0	3.9		10%	High	High					
Crooked	18-0041-00	North	462.7	1483.0	13.7	4.6	Increasing trend	13%	Highest	Highest		Yes			
Dam	01-0096-00	North	597.7	9000.5	21.2	3.0	No evidence of trend	3%	Higher	High					
Diamond	01-0171-00	North	81.9	64890.8	27.9	1.8		7%	High	High			Yes		
Eagle	18-0099-00	Central	246.0	12353.1	15.8	2.6		6%	Higher	High					
Farm Island	01-0159-00	North	2005.2	26566.6	20.1	3.3	No evidence of trend	10%	Higher	Higher	Moderate				
French	01-0104-00	North	149.3	11141.7	19.9	2.2		19%	High	High					
Gilbert	18-0320-01	Central	356.6	5091.5	11.7	5.1	Decreasing trend	13%	Highest	Higher					
Gilbert (West Bay)	18-0320-02	Central	57.2	5091.5	16.3	3.2	No evidence of trend	13%	Higher	High					
Grave	18-0110-00	Central	168.6	8412.5	52.1	1.0		9%	High	High			Yes		

Lake Name	Lake ID	Management Zone	Lake Acres	Watershed Acres	Mean TP (ug/L)	Mean Secchi (m)	Water Clarity Trend	Percent Disturbed Land cover in Lakeshed	LPSS Priority Class	LBCA Priority Class	Lake of Biological Significance	Cisco Refuge Lake	Near Water Quality Standard	Protection Candidates Based on FIBI Score	Lake Protection and Prioritization Rating
Green Prairie Fish	49-0035-00	South	182.5	2768.2	28.6	2.2	No evidence of trend	21%	Higher	High					
Hammal	01-0161-00	North	375.5	1782.1	15.4	3.0	Decreasing trend	6%	Highest	Higher					
Hanging Kettle	01-0170-00	North	318.0	68371.6	28.3	2.1	Decreasing trend	7%	Highest	High			Yes		
Hanks	18-0044-00	North	164.7	5028.1	12.6	4.0	Increasing trend	8%	Higher	High				Yes	
Hanson	01-0132-00	North	143.3	1315.6	20.0	2.5		5%	Higher	High					
Hickory	01-0179-00	North	211.6	28773.6	13.9	3.4		10%	High	High				Yes	
Island	18-0129-00	North	125.9	1348.9	14.8	3.1		4%	Higher	High					
Jenkins	01-0100-00	North	114.1	353.0	12.0	2.7		15%	Highest	Higher	Moderate				
Lady	77-0032-00	South	176.5	4880.1	22.8	3.8		56%	Highest	Higher	Outstanding			Yes	
Little Bass	18-0254-00	North	94.9	1568.6	10.5	6.1		7%	High	High					
Little Pine	01-0176-00	North	226.3	27585.7	18.7	5.0	No evidence of trend	9%	High	High	Outstanding			Yes	
Little Rabbit	18-0139-00	North	172.2	28641.3	23.1	2.7		16%	High	High					
Little Swan	77-0034-00	South	164.4	35603.9	21.4	3.1		43%	High	High	Outstanding				
Lone	01-0125-00	North	433.5	1000.4	8.6	6.8	Decreasing trend	14%	Highest	Highest					
Long	01-0089-00	North	434.7	5900.6	17.3	3.3	Decreasing trend	3%	Highest	High	Outstanding	Yes			
Long	77-0027-00	South	398.7	6822.2	24.1	3.6	Increasing trend	49%	Highest	Higher	High			Yes	
Long	49-0086-00	South	115.4	2015.2	22.9	2.8		23%	Higher	High					
Lower Dean	18-0181-00	North	366.3	17513.3	32.0	0.7		2%	High	High	Outstanding		Yes		
Mahnomen	18-0126-01	North	237.9	19240.4	45.7	2.1		18%	High	High			Yes		
Mallard	01-0149-00	North	346.2	2701.6	22.0	0.9		5%	Higher	High	Outstanding				
Mons	77-0022-00	South	94.5	717.6	17.0	3.8		34%	Highest	Higher	Outstanding			Yes	
Mound	77-0007-00	South	270.3	991.8	15.5	4.9	No evidence of trend	13%	Highest	Higher	Outstanding			Yes	
Newstrom	01-0097-00	North	77.6	4144.7	72.0	0.8		2%	High	High	Outstanding		Yes		
Nokay	18-0104-00	Central	703.6	15792.9	20.9	2.8	No evidence of trend	7%	Higher	High				Yes	
Nord	01-0117-00	North	418.2	1516.4	18.3	2.9	Decreasing trend	8%	Highest	Higher					
Pennington Mine	18-0439-00	North	61.9	218.1	7.0	6.4		44%	Highest	Highest					
Perch	18-0371-00	Central	265.9	891.7	12.2	4.8	No evidence of trend	51%	Highest	Highest					
Pickerel	01-0182-00	North	98.9	1210.6	61.0	1.1		5%	High	High			Yes		
Pine	49-0081-00	South	177.7	908.7	11.8	5.2	No evidence of trend	21%	Highest	Highest	High				
Pine Island	77-0067-00	South	238.2	805.8	13.8	3.3	Increasing trend	20%	Highest	Highest	Outstanding			Yes	
Placid	18-0076-00	North	183.4	1267.3	17.3	4.7	No evidence of trend	6%	Higher	High	Moderate				
Portage	18-0069-00	North	129.9	4098.2	18.0	3.2	No evidence of trend	10%	Higher	High		Yes			
Portage	01-0069-00	North	372.4	3306.8	31.3	1.5	No evidence of trend	4%	Higher	High			Yes		
Portage	18-0050-00	North	286.8	3115.2	16.6	3.6	Increasing trend	6%	Highest	Higher					
Portsmouth Mine	18-0437-00	North	145.6	1362.3	6.0	5.9		21%	Highest	Highest					

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Rabbit	01-0091-00	North	211.6	4117.0	12.7	3.1	No evidence of trend	6%	Higher	Higher					
Rabbit (East Portion)	18-0093-01	North	669.6	4826.0	13.4	3.8	Increasing trend	10%	Highest	Highest				Yes	
Rabbit (West Portion)	18-0093-02	North	535.9	4826.0	13.9	4.1	Increasing trend	10%	Highest	Higher				Yes	
Reno	18-0067-00	North	167.5	642.3	17.4	2.3		23%	Highest	Higher	High				
Rice	18-0053-00	North	158.7	2264.9	48.3	0.6		4%	High	High	Outstanding		Yes		
Rice	18-0068-00	North	158.2	2311.4	28.0	1.2		12%	High	High	Outstanding		Yes		
Rice	18-0121-00	North	68.3	272.0	23.0	0.9		9%	Higher	High	Outstanding				
Rice	18-0145-00	Central	418.4	4485719.6	35.7	1.8		5%	High	High			Yes		
Rogers	18-0184-00	North	240.0	1117.8	12.1	4.9	No evidence of trend	6%	Highest	Higher	Moderate				
Round	01-0137-00	North	634.0	1439.0	9.9	4.8	Decreasing trend	9%	Highest	Highest					
Round	18-0147-00	Central	139.0	100332.6	52.3	1.3		12%	High	High			Yes		
Round	49-0056-00	South	127.1	1584.0	21.7	3.2	Increasing trend	11%	Higher	High	Moderate				
Section Ten	01-0115-00	North	435.6	3891.6	20.3	2.7		6%	Higher	High	Outstanding				
Section Twelve	01-0120-00	North	170.0	2572.9	23.6	2.2	Decreasing trend	4%	Highest	High	Outstanding				
Serpent	18-0090-00	North	1116.3	6382.6	16.6	5.0	Decreasing trend	22%	Highest	Highest					
Sheriff	01-0027-00	North	88.4	348.1	29.1	2.6		2%	High	High			Yes		
Shirt	18-0072-00	North	231.5	1001.1	12.8	4.4		8%	Highest	Higher	Moderate				
Silver	18-0239-00	North	208.4	430.8	16.1	4.4	Decreasing trend	24%	Highest	Highest					
Sissabagamah	01-0129-00	North	405.8	5178.0	17.6	2.6		6%	Higher	High					
Sorenson	18-0323-00	Central	92.0	135.1	10.1	4.6	Increasing trend	13%	Highest	Higher					
South Long	18-0136-00	Central	1309.1	49194.2	33.5	2.2	Increasing trend	11%	Higher	High			Yes		
Spectacle	01-0156-00	North	99.6	498.1	29.0	1.3		4%	High	High			Yes		
Spirit	01-0178-00	North	523.4	30315.8	13.2	3.8	Increasing trend	10%	Higher	High	Outstanding				
Stark	18-0169-00	North	217.3	2178.2	19.5	2.2	No evidence of trend	4%	Higher	High					
Sugar	01-0087-00	North	415.9	1179.1	12.2	4.4	Decreasing trend	4%	Highest	Higher	Outstanding				
Swamp	01-0092-00	North	271.5	2317.5	29.9	1.1		1%	High	High	Moderate		Yes		
Turner	01-0074-00	North	63.2	452.4	29.5	1.9		8%	Higher	High			Yes		
Turner	18-0135-00	North	56.9	6724.6	14.6	5.3		9%	High	High					
Twin	77-0021-00	South	120.5	2838.7	39.4	3.0		48%	Higher	High	Outstanding		Yes		
Upper Dean	18-0170-00	North	259.2	4157.2	38.5	1.3		4%	Higher	High			Yes		
Upper Mission	18-0242-00	North	881.6	6042.8	23.6	3.0	Increasing trend	8%	Higher	Higher				Yes	
Upper South Long	18-0096-00	Central	804.3	39723.5	23.9	2.1	No evidence of trend	11%	Higher	High	Outstanding			Yes	
Wilkins	01-0102-00	North	348.9	1572.8	19.9	4.4	Increasing trend	7%	Highest	Higher					
Wolf	18-0112-00	North	188.7	578.7	17.1	1.0		5%	Higher	High					