Watershed

December 2023

Crow Wing River Watershed Restoration and Protection Strategy Report Update 2023

MINNESOTA POLLUTION CONTROL AGENCY

CLEAN WATER LAND & LEGACY AMENDMENT

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Cover photo credit: Paul Schreiber

Document number: wq-ws4-97a

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Key terms and abbreviations

Assessment Unit Identifier (AUID): The unique water body identifier for each river reach comprised of the U.S. 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: Water bodies 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 water body. 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 water bodies.

Nitrate: the measurement generally reported as “Nitrate” in this report is a measurement of Nitrate+Nitrite N.

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 water bodies.

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.

Acronyms

1W1P	One Watershed, One Plan
AQL	Aquatic Life
AQR	Aquatic Recreation
BMP	Best management practice
Chl-*a*	Chlorophyll-a
CRSL	Camp Ripley Sentinel Landscape
DNR	Minnesota Department of Natural Resources
DO	Dissolved oxygen
E. coli	Escherichia coli
EPA	Environmental Protection Agency
FIBI	Fish Index of Biological Integrity
FWMC	Flow Weighted Mean Concentrations
HSPF	Hydrologic Simulation Program-Fortran
HUC	Hydrologic unit code
IBI	Index of Biological Integrity
IWM	Intensive watershed monitoring
MIBI	Macroinvertebrate Index of Biological Integrity
MDA	Minnesota Department of Agriculture
MPCA	Minnesota Pollution Control Agency
M	Meters
µg/L	Micrograms per Liter
N	Nitrogen
NCHF	North Central Hardwood Forests
NFMP	Nitrogen Fertilizer Management Plan
NLF	Northern Lakes and Forests
PTMApp	Prioritize, Target, Measure Application
SAM	Scenario Application Manager
SID	Stressor Identification
SPI	Stream Power Index
SWCD	Soil and Water Conservation District
TN	Total Nitrogen
TMDL	Total maximum daily load
TP	Total phosphorus
TSS	Total suspended solids
WID	Waterbody identification number
WHAF	Watershed Health Assessment Framework
WPLMN	Watershed Pollutant Load Monitoring Network
WRAPS	Watershed Restoration and Protection Strategy
WWTF	Wastewater Treatment Facilities

Minnesota's Watershed Approach

The arrow emphasizes the important connection between state water programs and local water management. Local partners are involved – and often lead – in each stage of this framework.

The State of Minnesota developed a watershed approach to focus holistically on each watershed's condition as the scientific basis of permitting, planning, implementation, and measurement of results. This process looks strategically at the drainage area as a whole instead of focusing on lakes and stream sections one at a time, thus increasing effectiveness and efficiency.

Every 10 years, each of Minnesota's 80 major watersheds are evaluated through monitoring/data collection and assessed against water quality standards to show trends in water quality and the impact of permitting requirements, as well as any restoration, or protection actions. A watershed restoration and protection strategies (WRAPS) report is then updated to provide technical information to support the implementation of restoration and protection projects by local partners through their One Watershed, One Plan (1W1P) comprehensive local water plan. The Minnesota Pollution Control Agency's (MPCA's) watershed work is tailored to meet local conditions and needs, based on factors such as watershed size, landscape diversity, and geographic complexity.

To identify and address threats to water quality in each watershed, WRAPS reports address both strategies for restoration for impaired waters, and strategies for protection for waters that are not impaired. 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.

Key aspects of the MPCA's watershed work are to develop and utilize watershed-scale computer models, perform biological stressor identification (SID), conduct problem investigation monitoring, and use other tools to identify strategies for addressing point and nonpoint-source pollution that will cumulatively achieve water quality targets. Point-source pollution comes from sources such as wastewater treatment plants or industrial facilities; nonpoint-source pollution is the result of runoff or containments not being absorbed in the soil. 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.

Minn. Stat. § 114D, also known as the Clean Water Legacy Act, sets out the policy framework for the Watershed Approach, including requiring the development and updating of WRAPS for all watersheds of the state. The Clean Water, Land, and Legacy Amendment approved by Minnesota voters in 2008 directs dollars from an increase in sales tax to a Clean Water Fund, which is overseen by the Clean Water Council. The Clean Water Fund provides resources to implement the Clean Water Legacy Act to achieve and maintain water quality standards in Minnesota through activities such as monitoring, watershed characterization and scientific study, planning, research, and on-the-ground restoration and protection activities.

Executive summary

The State of Minnesota has adopted a Watershed Approach for managing water quality for each of the 80 major watersheds in the state. Every 10 years, each major watershed undergoes surface water monitoring and assessment and has the opportunity for a WRAPS update project. The first intensive watershed monitoring (IWM) cycle began in the Crow Wing River Watershed in 2010, with the initial WRAPS report approved in 2015.

The Crow Wing River WRAPS Report Update 2023 is an update of the 2015 WRAPS report. This WRAPS report update summarizes water quality findings from the second round of IWM, SID, water quality research projects and studies. The goals of this updated WRAPS report are to:

1. Highlight differences and trends in watershed conditions over the last 10 years;
2. Share updated surface water quality resources, information, and tools for watershed stakeholders as they plan and implement best management practices (BMPs); and
3. Provide updated recommendations for prioritizing and targeting implementation throughout the watershed.

Overall, water quality conditions have not dramatically changed in the Crow Wing River Watershed since 2010. The following summary highlights these updated findings for lakes, streams, and overall watershed conditions.

<u>Condition of Lakes:</u>

- There were no new lakes determined to be impaired by nutrients
- Three lakes have impaired aquatic life (AQL) use, based on the Fish Index of Biological Integrity (FIBI).
- Three lakes are vulnerable to impairment by nutrients (phosphorus) and one for AQL use based on the FIBI.
- Of the 8 lakes that were designated as impaired 10 years ago, recent data shows that these lakes remain impaired with some parameters improving and some declining.
- There are 64 lakes within the Crow Wing River Watershed with clarity trend data. Of these, 36 lakes had improving water clarity, 16 lakes had a degrading clarity, and 12 lakes indicated no change.
- Twenty-three lakes (31% of those assessed) are being proposed for Exceptional Use designation based on their high-quality fish communities.

<u>Condition of Rivers and Streams:</u>

- There were a handful of new stream impairments identified during the second cycle of watershed monitoring. Two stream reaches were impaired by Escherichia coli *(E. coli*) bacteria, one stream had low dissolved oxygen (DO), one stream had an impairment of AQL for FIBI, and four streams had impairments of AQL for Macroinvertebrate Index of Biological Integrity (MIBI).

- The two new stream *E. coli* impairments fall within an existing TMDL completed in 2014, so a new TMDL is not necessary.
- Two stream reaches of Corey Brook are considered vulnerable to impairment of AQL.
- The 12 streams determined to be impaired in the first watershed assessment are still impaired 10 years later.
- Additional water quality monitoring on the Straight River shows a pattern of continued elevated nitrogen levels.

<u>Watershed and Climate Trends:</u>

- Trend analysis was completed on the Crow Wing River near Pillager (2008 through 2020)
    - Nitrate-nitrogen showed a significant increasing trend,
    - Total phosphorus (TP) showed a decreasing trend,
    - Total suspended solids (TSS) showed no significant trend,
    - Average yearly flow increased by approximately 65% over the 53-year period of record, average yearly flows have increased by roughly 800 cubic feet per second (cfs).
- The Department of Natural Resources (DNR) climate summary report for this watershed indicates the following for temperature and precipitation:
    - Temperature - the average, minimum and maximum temperatures show a slight increase, most notably in the winter.
    - Precipitation - data show a slight increase in precipitation in the fall, spring, and summer but a decrease during the winter.
- Watershed modeling revealed areas along the Straight River, Shell River, and Partridge River had higher amounts of sediment, nitrogen, and phosphorus.

<u>Watershed Restoration and Protection Goals:</u>

There are several areas that should be prioritized for implementation efforts to help protect the good water quality throughout the watershed, as well as improve waterbodies with existing impairments.

- Watershed wide strategies that should be considered are to reduce the conversion from forest land use to high intensity agricultural land use, as well as implementing BMPs that provide benefits beyond the site of installation including improving soil health, groundwater protection through better land management, livestock access to surface water controls, and nutrient management.
- Prioritize lakes and streams that are nearly/barely impaired (Lower Twin Lake, Mayo Lake, Sibley Lake, Portage Lake, and Rock Lake), as well as the Straight River, Shell, River, Partridge River, and Mayo Creek subwatersheds.
- BMPs recommended to improve water quality include septic system compliance, shoreline protection, in-lake management of curly leaf pondweed, stormwater management and increasing native vegetation along shorelines.

- Most of this watershed is still healthy, and efforts should be made to protect these areas. Examples of protection efforts outlined in the original WRAPS document that are still applicable this cycle include cold water fisheries, high-value sensitive lakes, wetland protection, agricultural pesticide management, source water protection, areas of biodiversity and sensitive shorelines.
- Several studies and tools were developed to help target protection and restoration efforts in the watershed. These include:
    - Straight River Nitrate Study
    - Partridge River *E. coli* Study
    - Prioritize, Target, Measure Application (PTMApp) for the Watershed
    - Terrain Analysis for Priority Watersheds
    - Phosphorus Heat Maps for Priority Watersheds

1. Watershed background and description

1.1 Watershed Approach and WRAPS

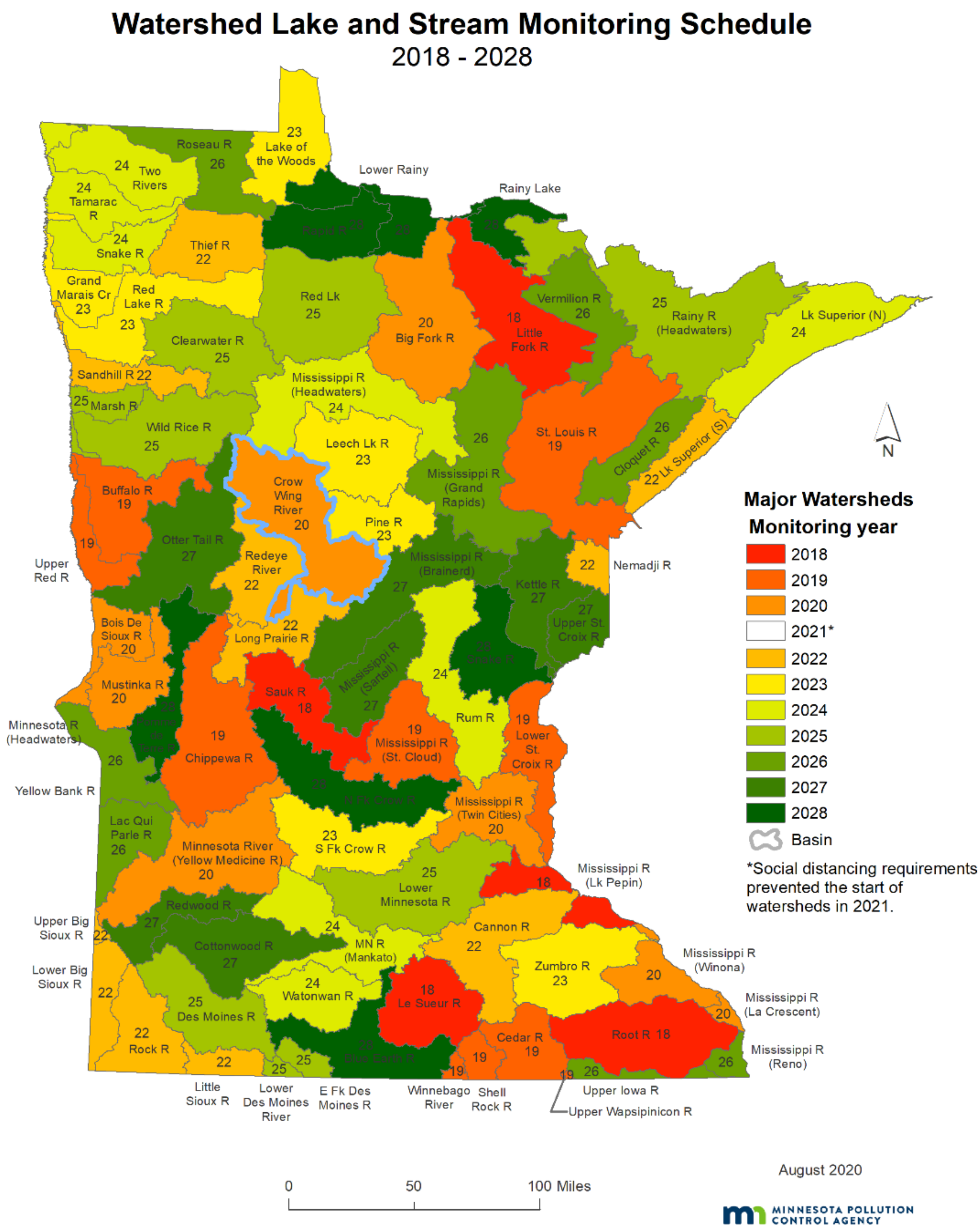
The State of Minnesota uses a "Watershed Approach" (MPCA 2015a) to assess and address the water quality of each of the state's 80 major watersheds on a 10-year cycle. In each cycle of the Watershed Approach, rivers, lakes, and wetlands across the watershed are monitored and assessed, water body restoration and protection strategies and local plans are developed, and conservation practices are implemented. Watershed Approach assessment work started in the Crow Wing River Watershed in 2010 and was revisited in 2020.

Much of the information presented in this report was produced in earlier Watershed Approach work, prior to the development of the WRAPS report. However, this WRAPS report update presents additional data and analyses and works to summarize results into a comprehensive story of the watershed's surface water quality.

Related Cycle 1 reports are listed below and can be found at: Crow Wing River | Minnesota Pollution Control Agency (state.mn.us)

- Crow Wing River Watershed Monitoring and Assessment Report
- Crow Wing River Watershed SID Report
- Crow Wing River WRAPS Report
- Crow Wing River Watershed TMDL Report

Figure 1. MPCA Watershed Monitoring Schedule



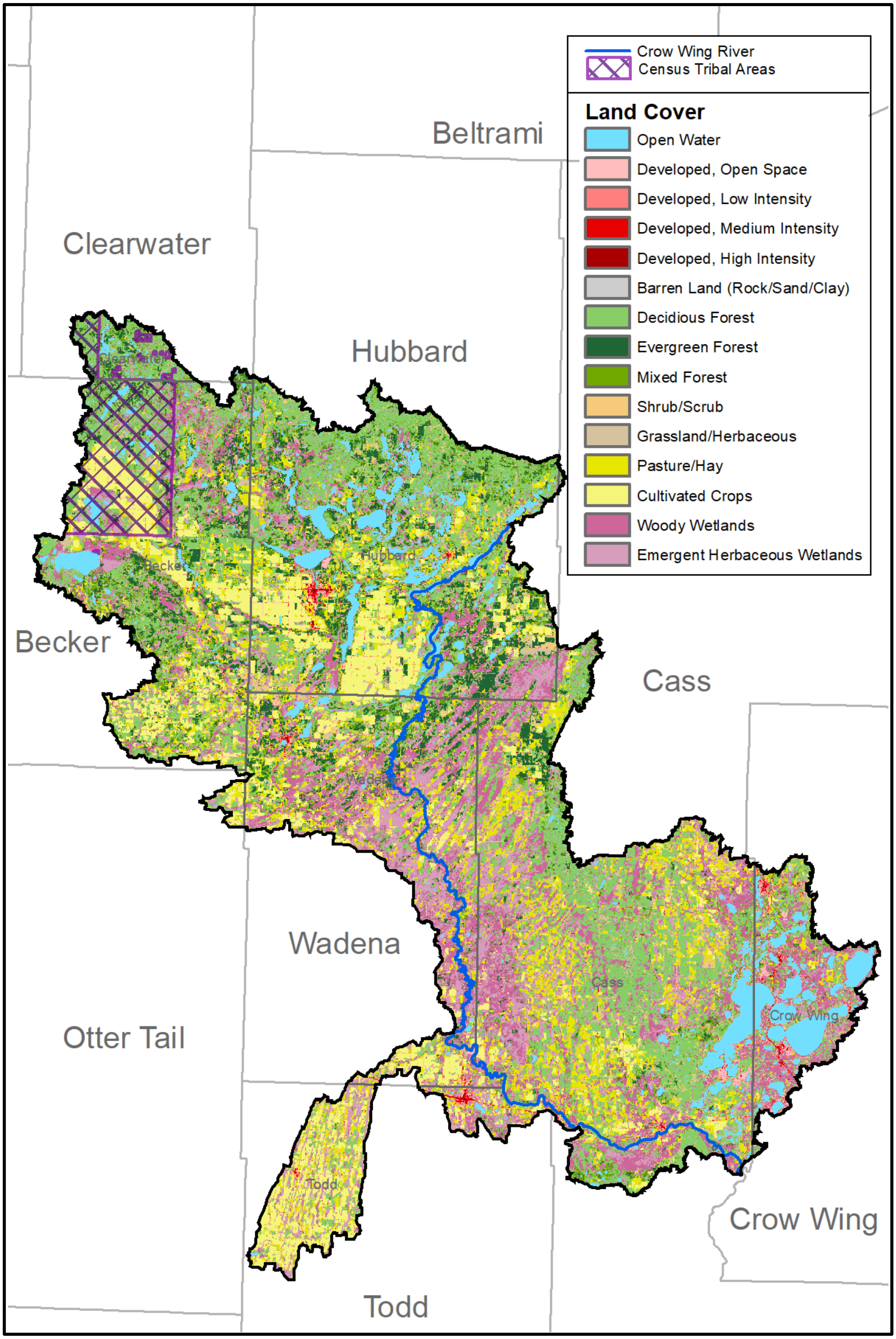
1.2 Watershed Description

The Crow Wing River Watershed covers approximately 1,964 square miles in north central Minnesota within the Upper Mississippi River Basin. The watershed is divided between the Northern Lakes and Forests (NLF) and North Central Hardwood Forests (NCHF) Ecoregions. This transitional landscape situated between the two ecoregions supports diverse populations of fish and wildlife.

Land use within the watershed includes a mixture of forest, wetland, residential/developed, and agricultural. The area is also lake rich, including approximately 627 lakes greater than 10 acres in size. The Crow Wing River itself originates in a series of 11 lakes, which together comprise an area of roughly 5,000 acres and are named sequentially from the First Crow Wing Lake through the Eleventh. The river originates and flows through this chain of lakes for roughly 20 miles in a southward direction, then flows approximately 80 miles to its confluence with the Mississippi River south of Brainerd at Crow Wing State Park. There are extensive opportunities in this watershed for fishing, hunting, hiking, and watercraft recreation due to its extensive abundance of lakes, rivers, and forests.

The watershed includes a portion of nine counties including Becker, Cass, Clearwater, Crow Wing, Hubbard, Morrison, Otter Tail, Todd, and Wadena, as well as the White Earth Tribal Nation (Figure 2). Major cities within the watershed include Park Rapids, Staples, and Nisswa. Camp Ripley is a military training facility located in central Minnesota and within the southern portion of the watershed. It is surrounded by the 750,000-acre Camp Ripley Sentinel Landscape (CRSL). Created in 2015, the CRSL consists of working and natural lands surrounding Camp Ripley with the purpose of protecting the training mission of the facility.

Figure 2. Land cover in the Crow Wing River Watershed



1.3 Assessing Water Quality

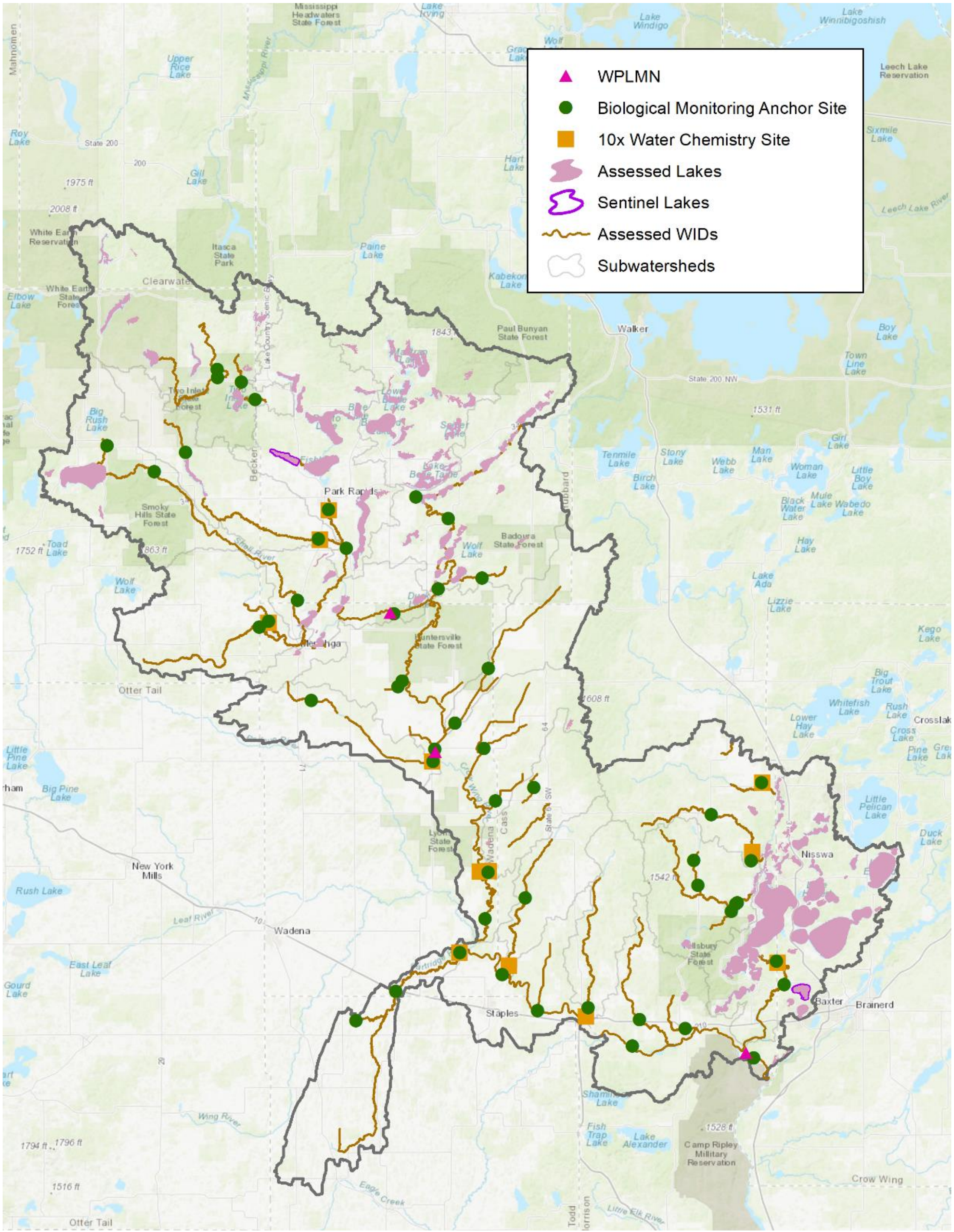
1.3.1 Lakes and Streams

The MPCA and partners conducted biological and chemical surveys on lakes, rivers, and streams in 2010-2011 and again in 2020-2021 to ascertain if the waterbodies met water quality standards for AQL, recreation, and fish consumption. The biological data collected from streams and rivers was also used to determine if any change in condition had occurred between the two time periods. The overall goal of these assessments is to ultimately determine which waters are healthy and in need of protection or are polluted and require restoration. Figure 3 shows the watershed monitoring locations.

Water monitoring is essential to determining whether lakes and streams meet water quality standards designed to ensure that waters are fishable and swimmable. While local partners and state agencies monitor water quality on an ongoing basis, the MPCA conducts an intensive exam of major lakes and streams in each of the state's 80 watersheds every 10 years to detect any changes in water quality. This intensive monitoring looks at fish and macroinvertebrate communities as well as water chemistry to gauge water quality. The partners use the data to see which waters are healthy and need protection and which are impaired and need restoration.

Waters are considered impaired if they fail to meet water quality standards. More information on how waters are assessed can be found in the Guidance Manual for Assessing the Quality of Minnesota Surface Waters for Determination of Impairment: 305(b) Report and 303(d) List - 2022 (state.mn.us). The Crow Wing River Watershed Assessment and Trends Update provides additional information on lake and stream monitoring Crow Wing River Watershed Water assessment and trends update (state.mn.us) and the Tableau Viewer Water Quality Assessment Results Data Viewer | Tableau Public provides an interactive way to view the data. Section 2 below provides a summary of this information.

Figure 3. Watershed Monitoring Locations



1.3.2 Stressor Identification

When streams and lakes are found to have impaired fish and macroinvertebrates communities, the causes of these biological impairments are studied and identified in a process called SID. SID identifies the parameters negatively impacting the AQL populations, referred to as “stressors”. Stressors are identified using the Environmental Protection Agency (EPA) Caddis process. In short, stressors are identified based on the characteristics of the aquatic community in tandem with water quality information and other observations. This WRAPS report summarizes the streams SID results in Section 2.2.2, and the full report is available at Crow Wing Watershed Stressor Identification Report Update (state.mn.us). Results for Lake SID and the full report is stored in the Minnesota Digital Library DISCOVER MnWRL DIGITAL COLLECTIONS | WRL Digital Asset Management (mnpals.net).

1.3.3 Computer Modeling

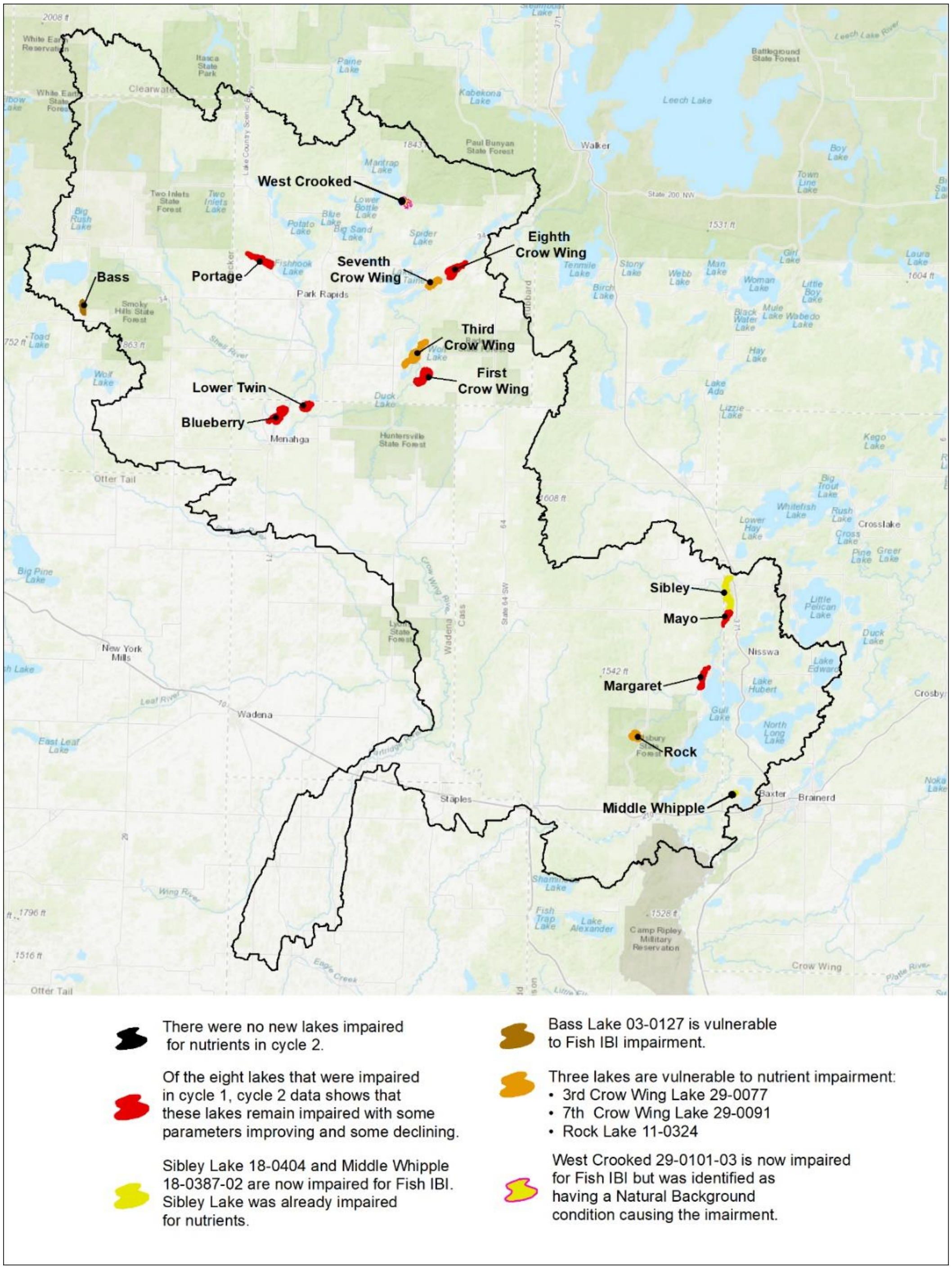
With the Watershed Approach, monitoring for pollutants and stressors is generally extensive, but not every stream or lake can be monitored due to financial and logistical constraints. Computer modeling can extrapolate the known conditions of the watershed to areas with less monitoring data. Computer models, such as Hydrological Simulation Program – FORTRAN (HSPF [USGS 2014c]), represent complex natural phenomena with numeric estimates and equations of natural features and processes. HSPF incorporates data including stream pollutant monitoring, land use, weather, soil type, etc. to estimate flow, sediment, and nutrient conditions within the watershed. HSPF model output provide a reasonable estimate of pollutant concentrations across watersheds. The output can be used for source assessment, TMDL calculations, and prioritizing and targeting conservation efforts. Modeled pollutant concentration yields are presented in Section 2.4.2.

2. Watershed conditions

2.1 Water Quality Conditions – Lakes

Section 2.1 provides an overview of the water quality assessment for lakes including a discussion on existing impaired lakes, and lakes that are vulnerable or near impairment of water quality standards. There were no new lakes found to be impaired due to nutrients during this assessment period, but three new lakes were determined to have impaired FIBI (Figure 4).

Figure 4. Water quality condition of lakes



2.1.1 New Lake Impairments, De-listings, or Re-categorizations

There were no new aquatic recreational (AQR) lake impairments identified in the watershed during the second cycle of monitoring. DNR fisheries did determine that Middle Whipple 18-0387-02, Sibley Lake 18-0404, and West Crooked Lake 29-0101-03 have impaired AQL. Sibley Lake had an existing impairment for AQR (nutrients) and a TMDL has been completed. The impairment for West Crooked Lake was determined to be the cause of natural conditions, so this lake will move to a Natural Background Category for AQL. Details about these fish impairments and recommendations to address them can be found in the Lake SID report stored in the Minnesota Digital Library DISCOVER MnWRL DIGITAL COLLECTIONS | WRL Digital Asset Management (mnpals.net). There were no lakes that had enough improvement in water quality to de-list from the impaired waters list.

2.1.2 Nearly/Barely Impaired Lakes, or Lakes Vulnerable to Impairment

Three lakes are considered vulnerable to impairment by nutrients based on TP, Chlorophyll-a (Chl-*a*) and Secchi disc depth measured in meters (m). These lakes are Rock Lake, Third Crow Wing Lake, and Seventh Crow Wing Lake. Bass lake is vulnerable to impairment of AQL (FIBI).

Table 1. Lakes nearing impaired water quality

Lakes Vulnerable to AQR Nutrient Impairment	**TP** µg/L	**Chla** µg/L	**Secchi (m)**
Northern Lakes and Forests (NLF) – Standard	<30	<9	>2.0
Rock Lake 11-0324 Max depth 17 feet, 98% Littoral	27.5	11.1	1.6
Rock Lake was previously assessed as meeting water quality standards in 2012. Two years of data were collected as part of Cycle 2 IWM. TP is elevated, very close to the applicable 30 µg/L standard. Chl-*a* and Secchi are both exceeding their respective standards. Rock Lake is vulnerable to impairment.			
Seventh Crow Wing 29-0091 Max Depth 33ft, 62% Littoral	28.5	14.7	2.6
This lake was assessed in 2012 as meeting standards. Multiple years' worth of chemistry data were available for review. Available data show Seventh Crow Wing Lake meeting but very close to the applicable NLF deep lake standard for TP (30 ug/L). Chl-*a* is confidently exceeding the 9 µg/L standard. Secchi is meeting the standard and showing evidence of an improving trend.			
North Central Hardwood Forest NCHF – General Standard	<40	<14	>1.4
Third Crow Wing 29-0077 Max depth 40 ft, 47% Littoral	22.2	9.4	1.1
Third Crow Wing Lake had insufficient information to assess in 2012. Based on land use analysis from 2012 assessment, the contributing watershed is primarily forested and the NLF - Aquatic Recreation Use (Class 2B) deep lake standards are applicable. Multiple years' worth of chemistry data was available for review. TP meets the standard while chl-*a* is right above the standard, and Secchi is exceeding the standard based on a huge dataset from a volunteer monitor that is showing a degrading trend.			
Lakes Vulnerable to AQL Fish IBI Impairment			
Bass Lake 03-0127 FIBI scores were below the impairment threshold but above the lower limit of the 90% confidence interval. The FIBI score from the supplemental historic survey was above the impairment threshold but below the upper limit of the 90% confidence interval. The recent FIBI scores were most positively influenced by the absence of tolerant species in the trap nets, whereas the scores were most negatively influenced by the relatively low number of small benthic dwelling species sampled across gears. A Score the Shore survey was completed to assess shoreline habitat in 2017 and resulted in a mean lake wide habitat score of 75 out of 100, indicating overall moderate quality lakeshore condition. Approximately 48% of the sites were developed. Developed sites generally scored lower, with a mean score of 62, while undeveloped sites had a mean score of 87. Bass Lake is listed at this time as having Inconclusive Information to determine AQL Use based on the FIBI, but vulnerable to future impairment.			

2.1.3 Existing Lake Impairments

Table 2 lists lakes that were impaired in Cycle 1 and have a completed TMDL. Current assessment data (Cycle 2) shows that these lakes remain impaired, with some parameters improving and some declining. A complete list of lakes with Cycle 1 and Cycle 2 data can be found in Appendix A.

Table 2. Status of existing impaired lakes

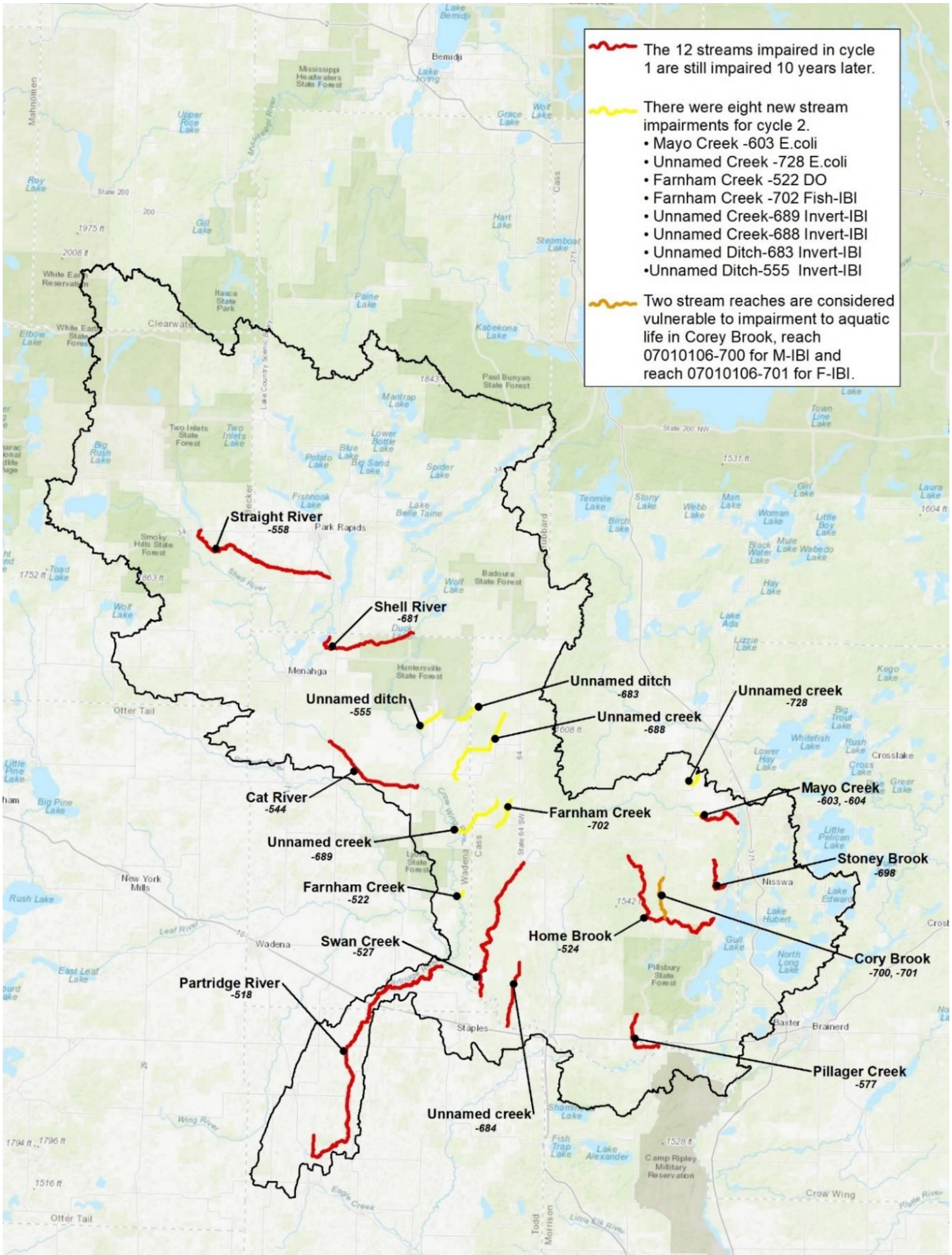
Impaired Lake Name	**Cycle**	**TP** µg/L	**Chla** µg/L	**Secchi (m)**
North Central Hardwood Forest NCHF – shallow Lake Standard		<60	<20	>1.0
Blueberry 80-0034	1	93	52	.9
	2	88.2	46	.9
This lake was previously assessed in 2012 and was listed as impaired by nutrients. Current data shows the lake is well above the applicable NCHF shallow lake standard for TP (60 µg/L) and chl-*a,* and Secchi is just below the [1m] standard and showing no identifiable change. Existing nutrients impairment designation will remain.				
First Crow Wing 29-0086	1	59.5	32	1.1
	2	52.6	26.4	1.4
This lake was previously assessed and was listed as impaired by nutrients. One year of data was collected in 2020. Available data shows TP slightly below the applicable 60 ug/L standard for NCHF - Aquatic Recreation Use shallow lakes, albeit with high standard error. Chl-*a* is above the 20 µg/L standard, also with high standard error. Secchi is meeting the 1 m standard. Existing impairment designation remains.				
North Central Hardwood Forest NCHF – General Standard		<40	<14	>1.4
Lower Twin 80-0030	1	40	15	1.9
	2	41.2	16.6	2.1
This lake was previously assessed and was listed as impaired by nutrients. Current data shows Lower Twin Lake just above the applicable NCHF deep lake standard for TP (40 µg/L), and chl-*a* is confidently exceeding the 14 µg/L standard. Secchi is meeting the standard and showing evidence of no change. Existing nutrients impairment designation will remain.				
Northern Lakes and Forests NLF – Standard		<30	<9	>2.0
Eighth Crow Wing 29-0072	1	29	14	2.7
	2	32.3	18	2.4
This lake was previously assessed and was listed as impaired by nutrients. Multiple years of data collected during the assessment window corroborates the previous assessment, showing exceedances of the applicable standards. TP is slightly above the standard (and right at it when standard error is considered) and chl-*a* is more than double the standard. Secchi is slightly above the standard (meeting) and showing no trend. Existing nutrients impairment designation will remain.				
Margaret 11-0222	1*	77	26	1.4
	2	45	30.8	1.6
This lake was previously assessed and was listed as impaired by nutrients. One year of data was collected as part of Cycle 2 IWM. Available data corroborates the previous assessment, showing clear exceedances of the applicable standards. Existing nutrients impairment designation will remain. **Lake Margaret was impaired in 2005, prior to cycle 1.*				
Mayo 18-0408	1	36	18	2.0
	2	29.6	11.3	1.5
This lake was previously assessed and was listed as impaired by nutrients. One year of data was collected as part of Cycle 2 IWM, and some additional data from several projects spanning multiple years was available for				

Impaired Lake Name	Cycle	**TP** µg/L	**Chla** µg/L	Secchi (m)
review. Available data corroborates the previous assessment, showing TP right below/at the impairment threshold, and chl-*a* and Secchi both exceeding. Existing nutrients impairment designation will remain. Note that lake is barely impaired.				
Portage 29-0250	1	51	22	1.3
	2	34	14.2	2.1
Portage Lake was listed as impaired by nutrients in 2006. Robust chemistry datasets indicates that Portage Lake is still impaired, with TP and chl-*a* exceeding the applicable NLF - AQR Use lake standards. Very large Secchi dataset (partially courtesy of a volunteer monitor) shows Secchi just above the standard, and right at the standard when standard error is taken into consideration. Existing nutrients impairment designation will remain.				
Sibley 18-0404	1	33	20	1.5
	2	36	17.7	1.7
This lake was previously assessed and was listed as impaired by nutrients. Available data corroborates the previous assessment, showing clear exceedances of the applicable standards for TP, chl-*a*, and Secchi. Existing nutrients impairment designation will remain.				

2.2 Water Quality Conditions – Streams

Section 2.2 provides an overview of the water quality assessment for streams, including a discussion on existing impaired streams, new stream impairments, and streams that are vulnerable or near impairment of water quality standards (Figure 5).

Figure 5. Stream assessments



2.2.1 New Stream Impairments

There were a handful of new stream impairments identified during the second cycle of watershed monitoring. Two stream reaches were impaired by *E. coli*, one stream had low DO, one stream had an impairment to AQL for FIBI, and four streams had impairments to AQL for MIBI. The table below provides additional information on the new impairments.

Table 3. New stream impairements

Stream Name and Reach	Impairment Description	Comments
Mayo Creek -603 Unnamed Creek to Unnamed Creek	*E. coli* - Available data show exceedance of the geometric mean standard for July, along with elevated values across other months with available data. Additionally, there is one June sample that exceeds the individual standard. Stream still has impaired AQR due to *E. coli* bacteria. Also, TP is more than double the standard of 50 µg/L, but not enough data to assess for River Eutrophication.	A TMDL was developed and approved by EPA, which encompasses this reach, so a new TMDL is not required. See Appendix B for additional information.
Unnamed Creek -728 Unnamed Creek, Headwaters to Unnamed Creek	*E. coli* – Available data show exceedance of the geometric mean standard for September along with multiple exceedances of the individual standard. Impaired AQR due to *E. coli* bacteria. Also, TP is confidently above the applicable standard of 50 µg/L, but not enough data to assess for River Eutrophication.	A TMDL was developed and approved by EPA, which encompasses this reach. See Appendix B for additional information.
Farnham Creek -522 Farnham Creek, Unnamed Creek to Crow Wing River	DO, FIBI – This reach is impaired due to low DO and a low FIBI score. The MIBI score improved and is meeting standards, so this parameter is recommended for delisting based on unknown reasons.	Recommend deferring a TMDL on this reach until we can better understand why some parameters are still impaired and some improving.
Farnham Creek -702 Unnamed ditch to T136 R32W S21, west line	FIBI score was below both the applicable threshold and lower confidence interval indicating impaired biological condition. Assessed as nonsupporting of AQL.	See Stressor ID table below
Unnamed Creek-689 Unnamed ditch to Crow Wing River	MIBI - The most recent sample produced an IBI score within the lower confidence interval. Habitat selection at this site is limited to small woody debris and performs relatively well given the poor habitat in this reach. Suggest designation of nonsupport of AQL based on macroinvertebrates and retaining the existing impairment. This site is “barely impaired” based on invertebrates showing a slight improvement and scoring within the lower confidence limit.	See Stressor ID table below. Note this stream is considered barely impaired.
Unnamed Creek-688 Headwaters to Beaver Creek	The MIBI score is approximately 22 points below the general use threshold. Samplers observed excess sediment in pools, groundwater influence, animal access to stream, animal trampling, low DO (0.99 µg/L), and mid-channel bars.	See Stressor ID table below

Stream Name and Reach	Impairment Description	Comments
Unnamed Ditch-683 Unnamed ditch to Big Swamp Creek	The MIBI score is approximately 15 points below the general use threshold. Bank was the sole habitat sampled. Samplers observed bank issues, beaver dams, and wetland riparian characteristics. Recommend designation of nonsupport of AQL based on macroinvertebrates.	See Stressor ID table below
Unnamed Ditch-555 Unnamed Creek to Unnamed Creek	The MIBI score is approximately 28 points below the general use threshold. Bank was the sole habitat sampled. Samplers observed low DO (1.1 µg/L), cutting below the root line (indicating the channel is incised), groundwater influence, and wetland characteristics. Recommend designation of nonsupport of AQL based on MIBI.	See Stressor ID table below

2.2.2 Stressors to Stream Biological Impairments

Five stream reaches were further investigated to determine the stressors causing biological impairment. A summary of the main stressors for each reach are provided in the table below. Please review the entire SID report [Crow Wing Watershed Stressor Identification Report Update (state.mn.us)] for additional information.

Table 4. Summary of stressors for biological impaired streams

Stream Reach	Stressors to Biology		
	Hydrology	**Habitat**	**Water Chemistry**
Farnham Creek -702	Altered hydrology is the primary stressor to the biology in Farnham Creek. Poor sinuosity, poor channel development, and fine sediment were noted within the MSHA assessment.	Due to creating a channel through several wetlands, sand has covered all the coarse substrates that would exist naturally, creating poor habitat.	No indications of water chemistry impacting the biological stressors to this reach.
Unnamed Creek-689	Lack of stream flow throughout the summer months is affecting the invertebrate communities, as many habitats are dry during various times of the season. Water levels were extremely low during 6/17/2021 fish sample. Field notes indicate standing water with a very minimal amount of flow.	Important habitat types have been removed by the historical ditching process.	The macroinvertebrate TIVs were able to be used, which indicated that phosphorus has the potential to be a stressor to the AQL, with DO and TSS not appearing to be stressors.
Unnamed Creek-688	Lack of baseflow in periods of low precipitation. This was evident in 2021 and 2022 as the channel dried out in August and September of both years.	Erosion from streambank failure causes poor habitat through fine sediment smothering substrates.	Water samples collected in 2022 indicated that phosphorus concentrations are routinely above the 0.100 mg/L standard in late

Stream Reach	Stressors to Biology		
	Hydrology	Habitat	Water Chemistry
			May through August, as well as periods of low DO levels.
Unnamed Ditch-683	Recent and regular ditch maintenance alters the historic flow conditions.	Important habitat types have been removed by the ditching process. Any habitat that was available before 2021 was lost during the ditch cleaning process that occurred in May and June of 2021.	The elevated TP and unstable DO levels within the chemistry dataset collected on Trib. to Big Swamp Creek further indicate that TP and DO are stressors to the AQL within the ditch.
Unnamed Ditch-555	The main stressor to the macroinvertebrate community is a lack of baseflow and the channel going dry.	A lack of suitable habitat is also a stressor to the invertebrates as the channel has fine sediment along with a lack of pools, riffles and runs.	As the streamflow drops the channel has elevated iron floc, low DO and elevated phosphorus concentrations.

2.2.3 Streams Vulnerable to Impairment or Nearly/Barely Impaired

Two stream reaches are considered vulnerable to impairment to AQL in Corey Brook, reach 07010106-700 for MIBI and reach 07010106-701 for FIBI. Detailed information can be found in the table below.

Table 5. Streams that are nearly/barely impaired

Stream Reach	Discussion
Cory Brook 07010106-700 FIBI T135 T30W S16, north line to Home Brook	This general use reach of Cory Brook has one station with assessable fish data (10UM096). This station was sampled twice in 2021. The early season sample was quite similar to Cycle 1 data, although one sensitive species was absent (Pearl Dace). The corresponding FIBI score was just below the threshold, but well within the lower confidence limit. This sample falls below the lower confidence limit and lacks any sensitive taxa. Given the discrepant results observed at this location, potential drought impacts, and beaver activity, an overall assessment of inconclusive for fish data is warranted. Additional fish monitoring should occur in the near future to determine if the low score from September is anomalous, or if it represents a shift in the fish community that results in an impairment.
Cory Brook 07010106-701 FIBI T135 R30W S9 north line to south line	One fish visit to one unique station (20UM007) on this coldwater reach. In early June of 2021, a fish survey was conducted capturing five taxa including brook trout, a sensitive species indicative of coldwater. The sample also included Pearl Dace, another sensitive species. The resulting FIBI score was just above the general use threshold, yet within the upper confidence interval. Based on the fish community and corresponding FIBI score, recommend support for AQL, but suggest checking the vulnerable box given the proximity of the fish community to the general use threshold, and Cory Brook's relatively poor biological performance on both this waterbody identification number (WID) and the downstream WID 700.

2.2.4 Existing Stream Impairments

Table 6 shows the streams that were found to be impaired in Cycle 1 and updated information gathered during the second cycle of assessments. Of the 10 stream reaches that were impaired by *E. coli* in Cycle 1, those that were sampled in Cycle 2 remain impaired.

The 12 streams impaired in Cycle 1 are still impaired 10 years later.

Table 6. Status of existing impaired streams from Cycle 1

Stream ID	Impairment	Data update and comments
Partridge River (07010106-518)	*E. coli*	New data confirms previous listing for *E. coli*. Geometric mean standards are not being met for 3 out of 3 available months. *E. coli* impairment remains. Additional analysis was conducted on the Partridge River and can be found in Appendix C.
Home Brook (07010106-524)	*E. coli*	Not sampled Cycle 2, the existing *E. coli* impairment remains.
Swan Creek (07010106-527)	*E. coli*, DO, MIBI	Available data shows exceedance of the geometric mean standard for June. *E. coli*, DO and MIBI impaired listings remain.
Cat River (07010106-544)	*E. coli*	New *E. coli* dataset shows exceedances of the geometric mean standard for June, July, and August, confirming the existing AQR impairment.
Pillager Creek (07010106-577)	*E. coli*	Not sampled Cycle 2, the existing *E. coli* impairment remains.
Mayo Creek (07010106-604)	*E. coli*	Large set of new *E. coli* data shows exceedances of the geometric mean standard for June, August, and September. Additionally, there were two exceedances of the individual standard. *E. coli* impairment remains.
Unnamed Creek (07010106-684)	*E. coli*	Not sampled Cycle 2, the existing *E. coli* impairment remains.
Stoney Brook (07010106-698)	*E. coli*	Available data shows exceedance of the geometric mean standard for June. *E. coli* listing remains.
Corey Brook (07010106-700)	*E. coli*	Not sampled Cycle 2, the existing *E. coli* impairment remains.
Farnham Creek (07010106-702)	*E. coli*	Not sampled Cycle 2, the existing *E. coli* impairment remains.
Shell River (07010106-681)	DO	DO lacks sufficient pre-9AM DO measurements for assessment, showing no exceedances on a small dataset. Larger dataset shows four exceedances through discrete sampling, most of which are close to the 5mg/L AQL standard. Overall exceedances are below impairment threshold and insufficient to delist, so recommend IF for DO at parameter level. Existing DO impairment remains.
Straight River (07010106-558)	DO	Available DO data is showing continued impairment, with exceedance rates well above the impairment threshold on both pre-9AM and all DO datasets, both of which show discrete samples exceeding across several years. Existing DO impairment should remain. See section 2.2.5 and for a detailed discussion on the Straight River water quality study.

2.2.5 Straight River Water Quality Study

The Straight River is one of the top stream trout fisheries in Minnesota and located in a part of the state that has few trout streams. The stream lies in an area with exceptionally sandy soils, which continue to be sand to depths of up to 70 feet or more below the ground surface. Such soils allow for the formation of substantial surficial aquifers. The Straight River Watershed lies atop part of the Pineland Sands Aquifer. After MPCA's initial Crow Wing River Watershed IWM effort in 2010-2011 and subsequent formal assessment in 2012 of a DO impairment of the Straight River, follow-up sampling was done to better understand phosphorus and nitrogen concentrations and dynamics in the Straight River. This report will be available on the MPCA's Crow Wing River Watershed webpage once it is completed (Crow Wing River | Minnesota Pollution Control Agency (state.mn.us)).

2.3 Watershed Trends

2.3.1 Lake Clarity Trends

There are 64 lakes within the Crow Wing River Watershed with clarity trend data. Of these, 36 lakes had in improving water clarity, 16 lakes had a degrading clarity, and 12 lakes indicated no change as shown in the table below.

Table 7. List of lakes with clarity trend data

Lake Name	Lake ID	County	Trends
Bad Medicine	03-0085-00	Becker	Improving
Boot	03-0030-00	Becker	Improving
Straight	03-0010-00	Becker	Degrading
Gull	11-0305-00	Cass	Improving
Lost	11-0219-00	Cass	Degrading
Margaret	11-0222-00	Cass	No Change
Sylvan (Southwest Bay)	11-0304-01	Cass	Improving
Upper Gull	11-0218-00	Cass	No Change
Long Lost	15-0068-00	Clearwater	Improving
Clark	18-0374-00	Crow Wing	No Change
Edna	18-0396-00	Crow Wing	Degrading
Edward	18-0305-00	Crow Wing	Improving
Hubert	18-0375-00	Crow Wing	Improving
Little Hubert	18-0340-00	Crow Wing	Improving
Middle Cullen	18-0377-00	Crow Wing	No Change
Nisswa	18-0399-00	Crow Wing	Improving
North Long	18-0372-00	Crow Wing	Improving
Red Sand	18-0386-00	Crow Wing	Degrading
Round	18-0373-00	Crow Wing	Improving
Roy	18-0398-00	Crow Wing	Improving
Sibley	18-0404-00	Crow Wing	No Change
West Twin	18-0409-00	Crow Wing	Degrading
White Sand	18-0379-00	Crow Wing	Improving

Lake Name	Lake ID	County	Trends
Bad Axe	29-0208-00	Hubbard	Improving
Belle Taine	29-0146-00	Hubbard	Improving
Big Bass	29-0032-00	Hubbard	Improving
Big Sand	29-0185-00	Hubbard	Improving
Big Stony	29-0143-00	Hubbard	No Change
Dead	29-0110-00	Hubbard	Degrading
Duck	29-0142-00	Hubbard	Improving
Eagle	29-0256-00	Hubbard	Improving
East Crooked	29-0101-01	Hubbard	Improving
Eleventh Crow Wing (Main)	29-0036-01	Hubbard	Improving
Emma	29-0186-00	Hubbard	Improving
First Crow Wing	29-0086-00	Hubbard	Degrading
Fish Hook	29-0242-00	Hubbard	No Change
Gilmore	29-0188-00	Hubbard	Improving
Hinds	29-0249-00	Hubbard	Improving
Island	29-0088-00	Hubbard	Improving
Little Sand	29-0150-00	Hubbard	Improving
Long	29-0161-00	Hubbard	Degrading
Lord	29-0248-00	Hubbard	Improving
Lower Bottle	29-0180-00	Hubbard	Degrading
MANTRAP (HOME BAY)	29-0151-05	Hubbard	Degrading
MANTRAP (WEST ARM)	29-0151-04	Hubbard	Degrading
Middle Crooked	29-0101-02	Hubbard	Improving
Ninth Crow Wing	29-0025-00	Hubbard	Degrading
Palmer	29-0087-00	Hubbard	No Change
PEYSENSKE (MAIN BAY)	29-0169-01	Hubbard	Improving
Portage	29-0250-00	Hubbard	Improving
Potato	29-0243-00	Hubbard	Improving
Second Crow Wing	29-0085-00	Hubbard	No Change
Seventh Crow Wing	29-0091-00	Hubbard	Improving
Shallow	29-0089-00	Hubbard	Improving
Sixth Crow Wing	29-0093-00	Hubbard	No Change
Skunk	29-0212-00	Hubbard	Degrading
SPIDER (EAST BAY)	29-0117-02	Hubbard	Improving
SPIDER (NE/SW BAY)	29-0117-01	Hubbard	Degrading
Stocking	29-0172-00	Hubbard	Improving
Third Crow Wing	29-0077-00	Hubbard	Degrading
Lower Twin	80-0030-00	Wadena	No Change
Morgan	80-0038-00	Wadena	Degrading
Spirit	80-0039-00	Wadena	Improving
Stocking	80-0037-00	Wadena	No Change

2.3.2 Stream Biological Trends

Paired t-tests of FIBI and MIBI scores were used to evaluate if biological conditions of the watershed's rivers and streams have changed between time periods. A similar change analysis was not completed for lakes because comparable fish community data had not been collected during Cycle 1 of IWM. Independent tests were performed on each community with 34 sites evaluated for macroinvertebrates and 29 sites evaluated for fish (i.e., sites that were sampled in both time periods). The average MIBI score for the watershed increased by 9.6 points between 2010 and 2021, representing a statistically significant positive change. FIBI scores across the Crow Wing River Watershed decreased by 0.2 points, which did not indicate a statistically significant change.

Context for the change analysis results is provided by a characterization of the conditions under which biological monitoring occurred in 2010-2011 and 2020-2021. In 2010, the Crow Wing River Watershed experienced above normal rainfall (+ 5.1 in) and below normal temperature (-2.0°F) during the May to September time period. In 2020, the watershed had normal rainfall (-0.5 in) and air temperature (-0.3°F) over the May to September time period. Due to protocols and safety measures put into place as a result of the pandemic, fish communities were not sampled in rivers and streams until 2021 and that summer was characterized by extreme drought conditions (-7.9 in/+4.4 F). Since there was such variation between the three years of biological monitoring in this watershed, there is a high likelihood that any observed changes in biological condition at either the watershed or individual site scale are at least partially due to differences in climatic conditions.

2.3.3 Stream Water Quality and Flow Trends

The Watershed Pollutant Load Monitoring Network (WPLMN) has three monitoring stations within the Crow Wing River Watershed (Figure 3). The Shell River is monitored four miles upstream of its confluence with the Crow Wing River, which is approximately 22 miles upstream of the city of Nimrod. The Crow Wing River is monitored at two locations, with the upstream station being at the city of Nimrod and the downstream station being below the Sylvan Dam roughly five miles southeast of Pillager. The Shell River and the Crow Wing River at Nimrod are both subwatershed stations that are sampled from snow melt through October 31 annually (since 2015), versus the Crow Wing River near Pillager (major watershed station), which has had water samples collected year-round (since 2008). All three stations are considered long-term with monitoring continuing indefinitely into the future. Sites are monitored for TSS, TP, and Nitrate-Nitrogen (Watershed Pollutant Load Monitoring Network (WPLMN) Data Viewer | Tableau Public).

Crow Wing River near Pillager Trends (2008-2020)

- Nitrate-nitrogen showed a significant* increasing trend
- TP showed a decreasing trend
- TSS showed no significant trend
- Average yearly flow increased by approximately 65% over the 53-year period of record, average yearly flows have increased by roughly 800 cfs.
    - The statistical significance threshold is 90%. The 2001-2020 flow and non-flow corrected trends at the Crow Wing River at Pillager show a significant increasing trend."

All concentrations in Table 8 are expressed as the average Flow Weighted Mean Concentrations (FWMC), which is the average concentration of a pollutant in all the water that passed a monitoring station over the course of the monitoring period.

Table 8. Comparison of average total FWMC for the Shell and Crow Wing Rivers (Crow Wing River at Nimrod and Shell River 2015-2020, Crow Wing River at Pillager 2008-2020). Concentrations of nutrients and sediment at three long term monitoring stations.

Station	Station ID	TSS (mg/L)	NO2+NO3 (mg/L)	TP (mg/L)
Shell River near Huntersville	S003-442	3.5	0.61	0.032
C.W. River at Nimrod	S001-326	5.7	0.34	0.049
C.W. River at Pillager	S001-926	4.7	0.37	0.055

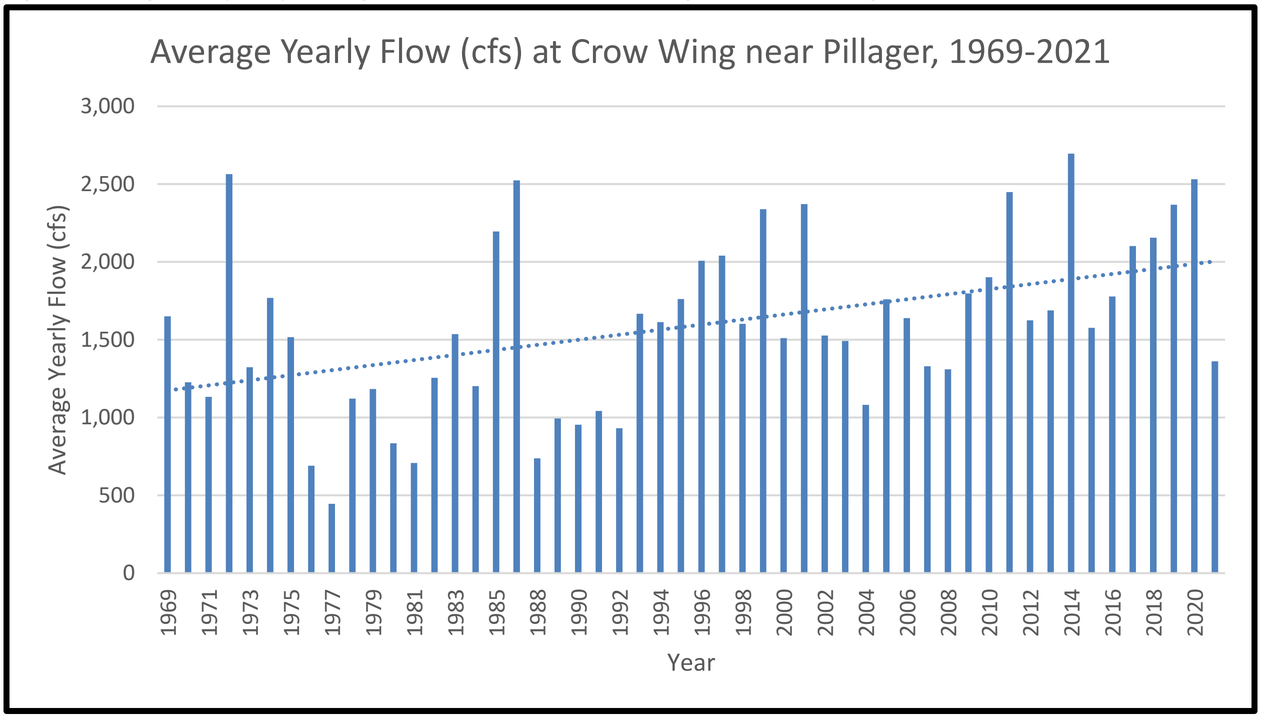
Nitrate-nitrogen concentrations at the three stations are slightly higher than the neighboring watersheds to the north and east but lower than those to the south and west. Furthermore, the nitrate concentrations are variable depending on the time of year, with concentrations being higher during the spring and late fall and lower during the early summer to early fall timeframes. The increased crop land found within this watershed, more than in those to the north and east, specifically near the headwaters and along the Shell River may play a role in the increased Nitrate concentrations found within this system. It is likely that nitrates from both point and non-point sources such as, but not limited to, septic systems, manure and/or fertilizer applications on croplands and decomposition of soils and organic matter, are entering the stream from overland flow during spring snowmelt and fall rain events when crops are absent. During the summer when crops are present, nitrates enter the stream less via overland flow, rather infiltrating the soil and groundwater below. Nitrate impacts from groundwater have a more significant impact on the stream when flows are low and there is minimal overland flow. During this time there is less water within the stream to dilute the nitrates entering via groundwater. Nitrate impacted groundwater that enters these rivers during periods of low streamflow may cause an increase in nitrate concentrations due to less dilution by the river. Other possible sources of nitrates could include overland flow as well as other point and nonpoint sources.

Similarly, TP and TSS concentrations within the watershed are both representative of the transitioning seen in Minnesota from lower concentrations found north and east to the higher concentrations in the southern and western portions of the state. A common pattern exists at all three stations where TSS and TP concentrations increase with flow. This relationship is strong at the two Crow Wing River stations and although the relationship is weaker, a relationship still exists at the Shell River station. Increased flow and pollutant concentrations are commonly associated with rising flows following heavy rain events. This information likely suggests that phosphorus is bound within the sediment particles on the landscape and when rain events erode the topsoil and/or riverbanks surrounding these rivers, the sediment that is washed into the river carries along with it phosphorus. Pollutant concentrations then are reduced as flow decreases within the rivers after most precipitation has runoff.

At a broader scale, the concentrations found within this watershed can be compared to those within the Mississippi River to gauge the impact that the Crow Wing River Watershed has on the Mississippi River, specifically the section located within central Minnesota. The Crow Wing River Watershed pollutant concentrations were compared to those found at the next downstream monitoring location on the Mississippi River, which is located two miles west of Royalton, Minnesota. In total, the Crow Wing River Watershed contributes 17% of the total drainage area and 31% of the total flow volume to the Royalton station. Nitrates are the largest contributing pollutant at 46% of the annual load at Royalton while TP and TSS inputs have a lesser impact, although still significant, contributing 35% and 20% of the average loads, respectively.

Trend analysis was conducted for the Crow Wing River at Pillager location (2008 through 2020) and showed mixed results between parameters. Nitrate-nitrogen results showed a significant increasing trend, TP showed a decreasing trend, while TSS showed no significant change over this time period. Figure 6 displays the long term yearly average flow data of the Crow Wing River near Pillager from 1969 to 2021. The figure shows that over the 53-year period of record, average yearly flows have increased by roughly 800cfs (approximately 65%). Flow changes are very important for downstream waters (i.e., the Mississippi River) because more flow means more overall pollutant load (mass) even if pollutant concentrations are unchanged. It should be noted that the flows at this station are controlled by the "Sylvan Dam" located immediately upstream of the sampling location. The dam; however, would have a limited impact on long-term average flows.

Figure 6. Long term yearly average flow data of the Crow Wing River near Pillager from 1969 to 2021



Although this watershed does have a high percentage of natural landscapes, it does have abundant areas of agricultural lands scattered throughout. Water quality concentrations show this transition, with pollutant concentrations generally beginning to increase in this region from northeast to southwest. This watershed has low levels of TSS, moderate nitrate-nitrogen concentrations, and TP levels that increase from north to south, slightly exceeding the Central River Nutrient Region TP standard. All concentrations are higher than those in watersheds to the north and east, but lower than those to the south and west. Additional maps and supporting data can be found at https://www.pca.state.mn.us/water/watershed-pollutant-load-monitoring.

2.3.4 Climate Trends

> **Temperature** - the average, minimum and maximum temperatures show a slight increase, most notably in the winter.
>
> **Precipitation** - data show a slight increase in precipitation in the fall, spring, and summer but a decrease during the winter.

According to the DNR Climate Summary for the Crow Wing Watershed (June 2019), climate measurements are showing a shift in foundational climate conditions. Other ecological processes are changing in response. Communities and individuals making decisions about managing land and water resources for infrastructure, flood protection, habitat protection, water supply, and other needs must be aware of this shift and informed about its potential impacts.

The DNR Climate Summary Report for the Crow Wing Watershed summarizes climate data using 30-year averages and compares the most recent 30-year average (1989 through 2018) to the entire climate record average (1895 through 2018). This approach generates values for the amount of change (deviation) seen in the most recent 30 years when compared to the entire 120-year period of record for temperature and precipitation.

According to the climate summary report and summarized in the table below, the average, minimum and maximum temperatures show a slight increase, most notably in the winter. The precipitation data show a slight increase in precipitation in the fall, spring and summer but a decrease during the winter. Additional details about this climate summary report (https://www.dnr.state.mn.us/whaf/about/watershed-reports.html), as well as the Watershed Health Assessment Framework (WHAF) tool as a whole, can be found at Watershed Health Assessment Framework | Minnesota DNR (state.mn.us).

Table 9. Crow Wing River Watershed Climate Trends

Time Period	Watershed Average Departure			
	Average Temperature (degrees)	Minimum Temperature (degrees)	Maximum Temperature (degrees)	Average Precipitation (inches)
Annual	1.4°	1.8°	1.1°	0.6"
Winter (Dec. - Feb.)	2.8°	3.3°	2.3°	-0.1"
Spring (March - May)	1.3°	1.4°	1.1°	0.1"
Summer (June - Aug.)	0.5°	0.9°	0.1°	0.0"
Fall (Sept. Nov.)	1.1°	1.4°	0.8°	0.6"

The Natural Resources Research Institute assessed climate vulnerabilities and developed strategies to build and enhance climate resilience for the CRSL, which covers a portion of the Crow Wing River Watershed. The CRSL consists of working and natural lands surrounding Camp Ripley with the purpose of protecting the training mission of the facility. The study evaluated and selected global climate models that are expected to perform well in the region. It modeled stream water quantity and quality under different land use and climate scenarios. The study characterized the landscape using Geographic Information Systems and modeled high-quality habitat for at-risk species. The study also evaluated and ranked parcels for conservation and restoration opportunities including afforestation plans for individual parcels. The complete study can be found at the University of Minnesota Digital Library (CRSL; Climate Resilience Analysis and Strategic Plan Amendments (umn.edu))

2.3.5 Wastewater Treatment Facility Trends

Annual loading data from WWTFs located in the watershed was compiled from 2000 through 2022 for TP, TSS, and TN values. As shown in the figures below, TP and TSS have been decreasing over time. The TN data was estimated until 2012. Since 2012, the majority of the load is still estimated but from facility specific sampling. TN has shown an overall level trend.

Figure 7. WWTF Total Phosphorus Loads 2000-2022

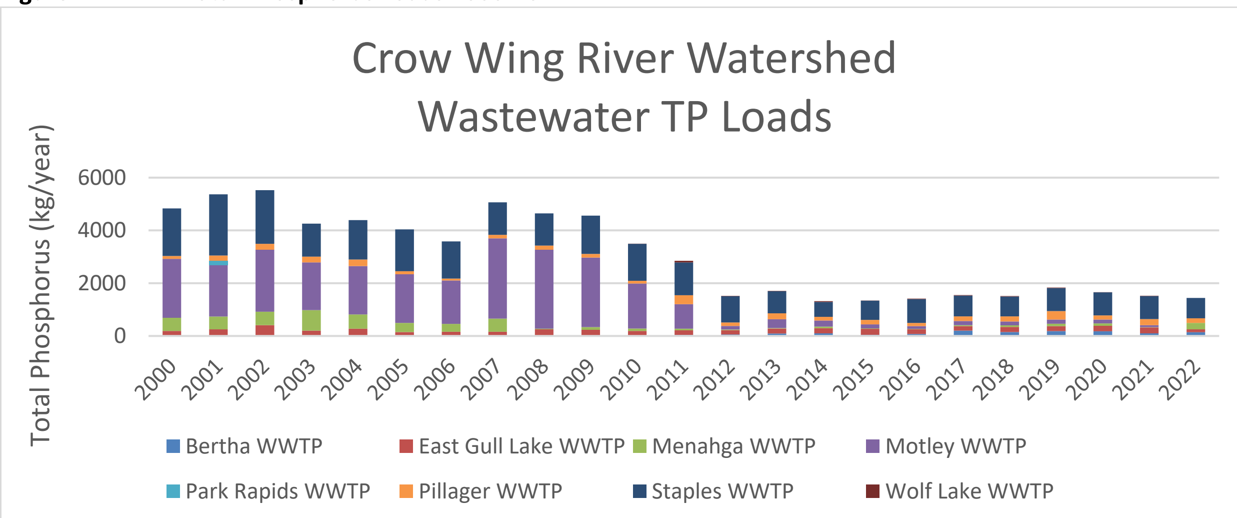


Figure 8. WWTF Total Suspended Solids Load 2000-2022

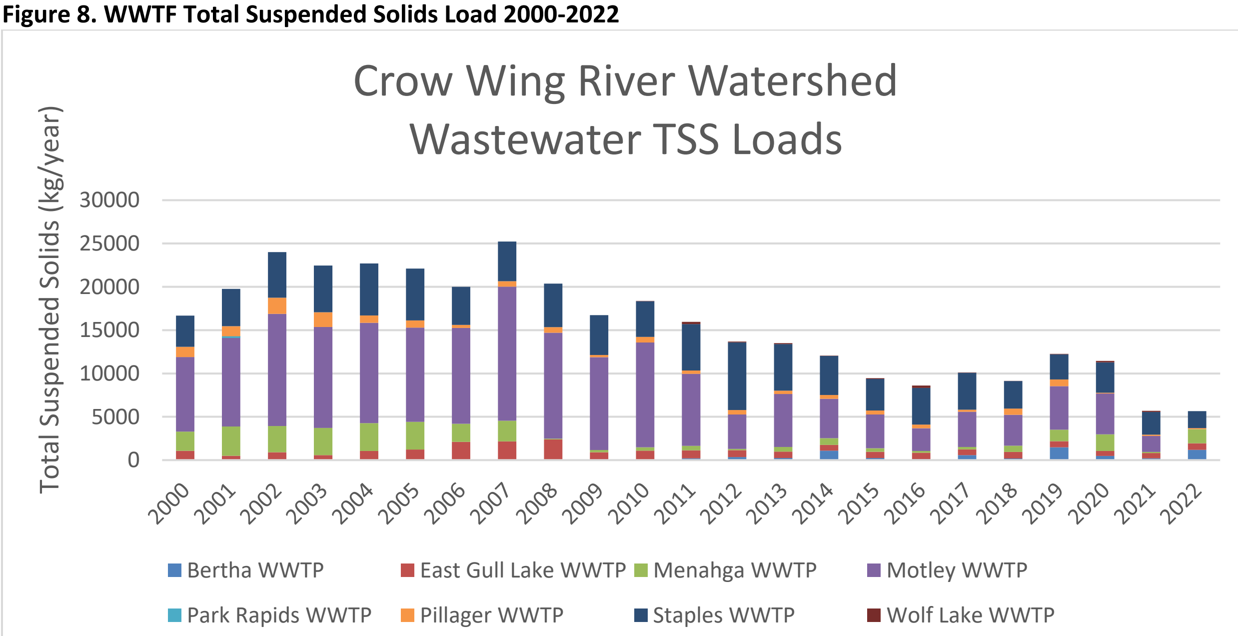
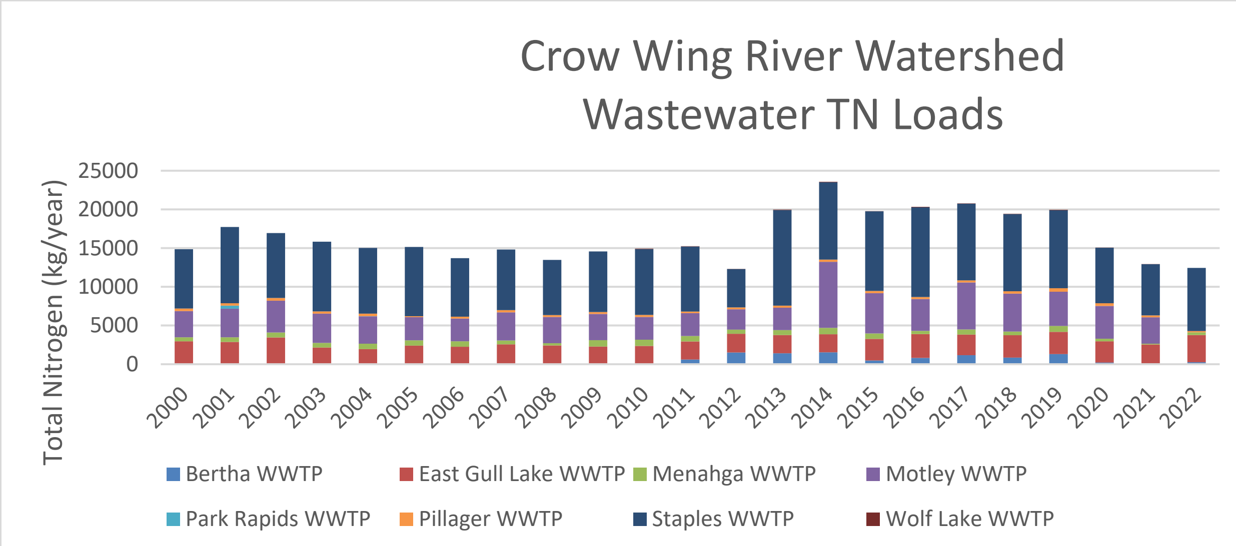


Figure 9. WWTF Total Nitrogen Load 2000-2022



There are two facilities within the watershed that have been assigned wasteload allocations (WLA) for specific TMDLs. Wolf Lake WWTF has a WLA for the Blueberry Lake Nutrient Impairment TMDL. According to the monitoring data for the facility, Wolf Lake WWTP has consistently met its 23 kg/yr TP WLA. Bertha WWTF has a WLA for the Partridge River *E. coli* Impairment TMDL. According to the monitoring data for this facility, Bertha WWTP has consistently met its fecal coliform effluent limit for the TMDL, which is an indicator that effluent is effectively disinfected and therefore is achieving its *E. coli* WLA.

2.4 Watershed Models

2.4.1 Hydro Conditioning, PTMApp, Terrain Analysis and Phosphorus Heat Maps

Houston Engineering was contracted to develop models consisting of hydro conditioning and PTMApp for the entire Crow Wing Watershed that will provide the ability to target projects and measure progress at a smaller scale. Terrain analysis and phosphorus heat maps were developed for the Gull River, Fishhook River, Belle Taine, and Headwaters subwatersheds. The terrain analysis includes flow lines to target stormwater projects around lakes and the phosphorus heat maps will be utilized for targeting projects where the most phosphorus export is occurring. These modeling tools will assist with implementation efforts and can be found in Appendix D.

2.4.2 HSPF Models

HSPF models were used to identify values (ranges) of runoff, TP, nitrogen and sediment across the watershed at a larger scale than the models described in the previous section. The gradients can be used to prioritize or locate appropriate BMPs throughout the watershed. These figures were created using the HSPF Scenario Application Manager (SAM) v2.12. Data for these figures came from the MPCA's 2020 Crow Wing River Watershed HSPF model outputs for the 1996 through 2020 time period. Modeled sediment and nutrients were calibrated by the MPCA using the MPCA's WPLMN's loading information. Modeled hydrology was calibrated by RESPEC consultants.

Figure 10. Modeled TSS in the watershed.

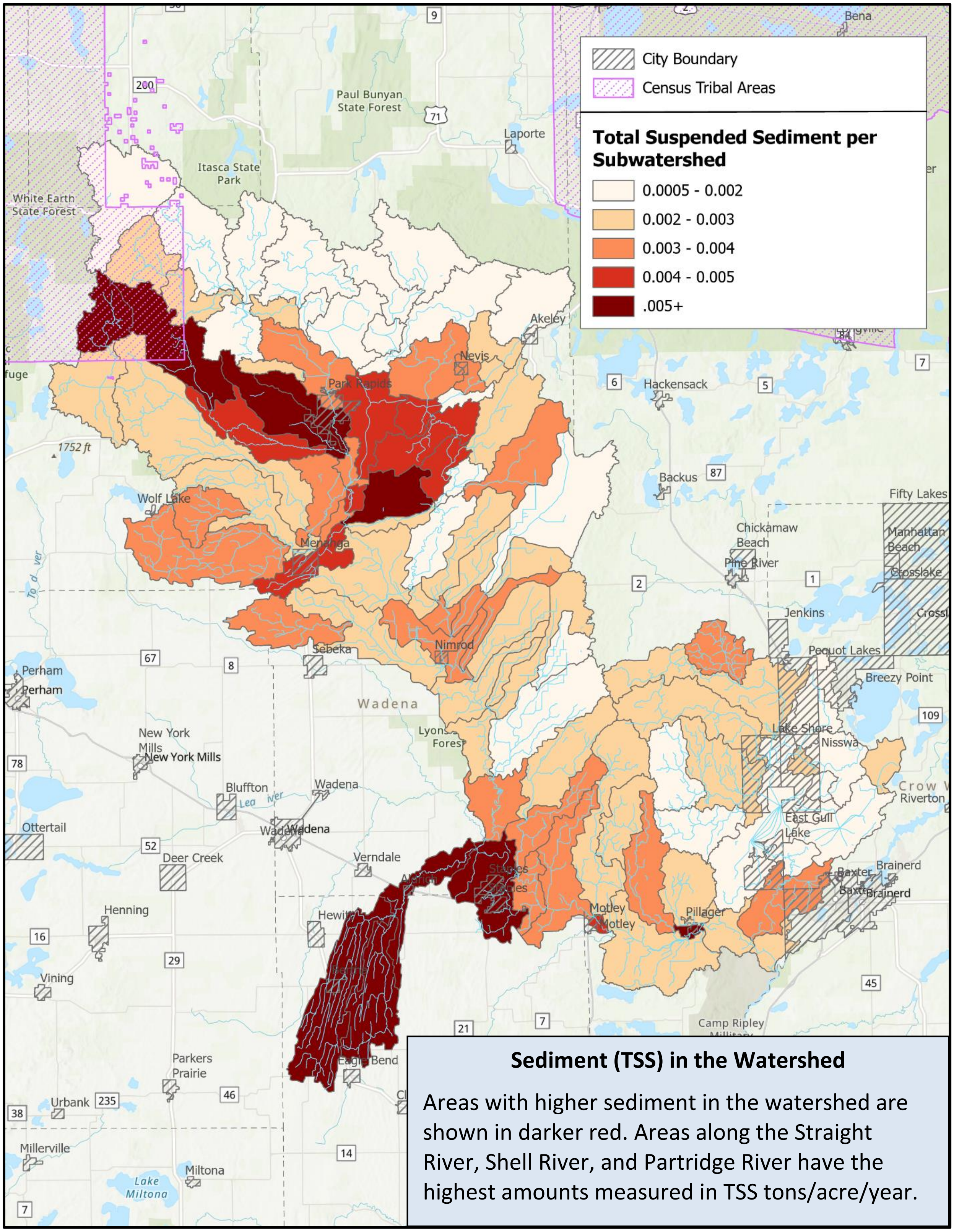


Figure 11. Modeled Total Nitrogen in the Watershed

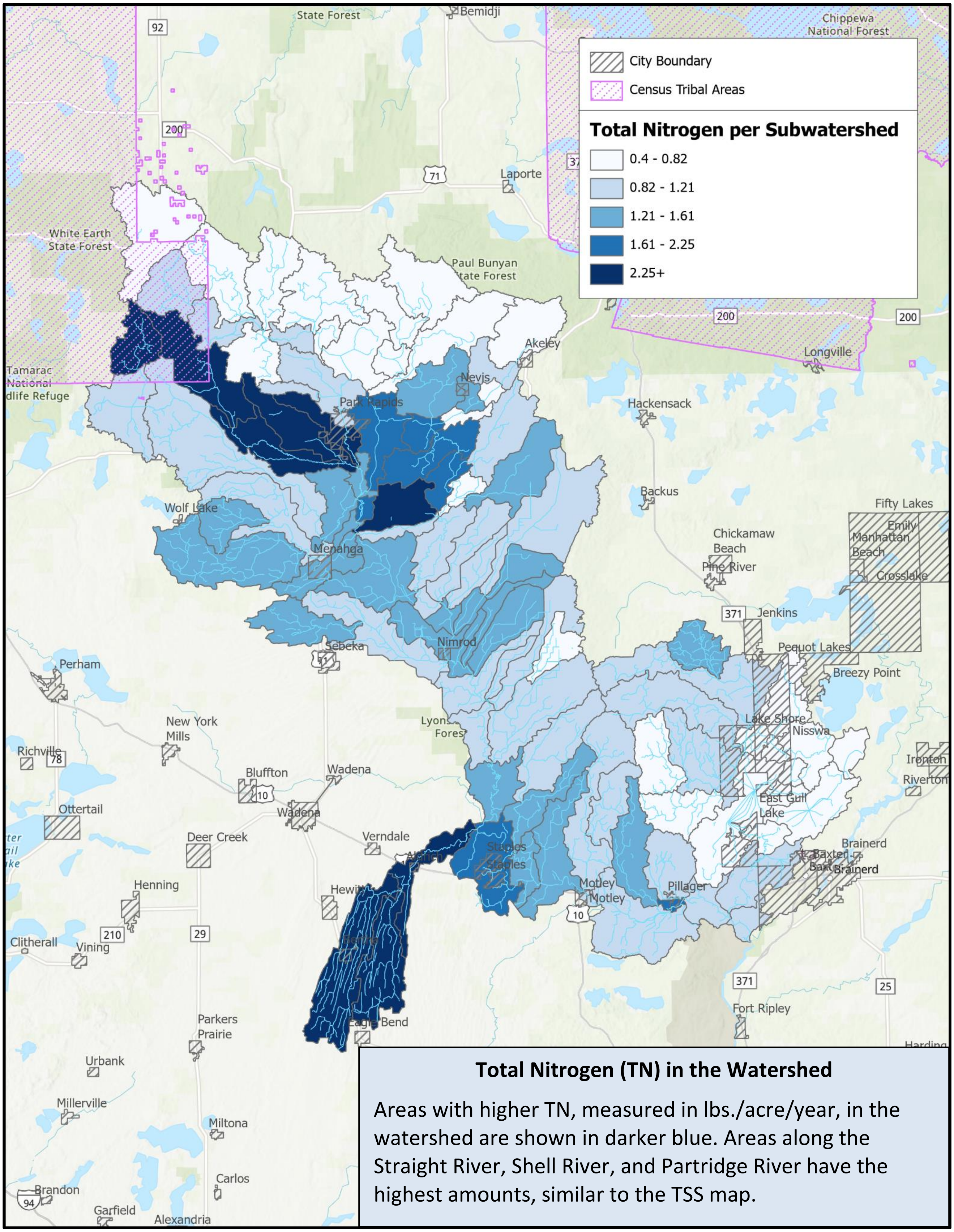
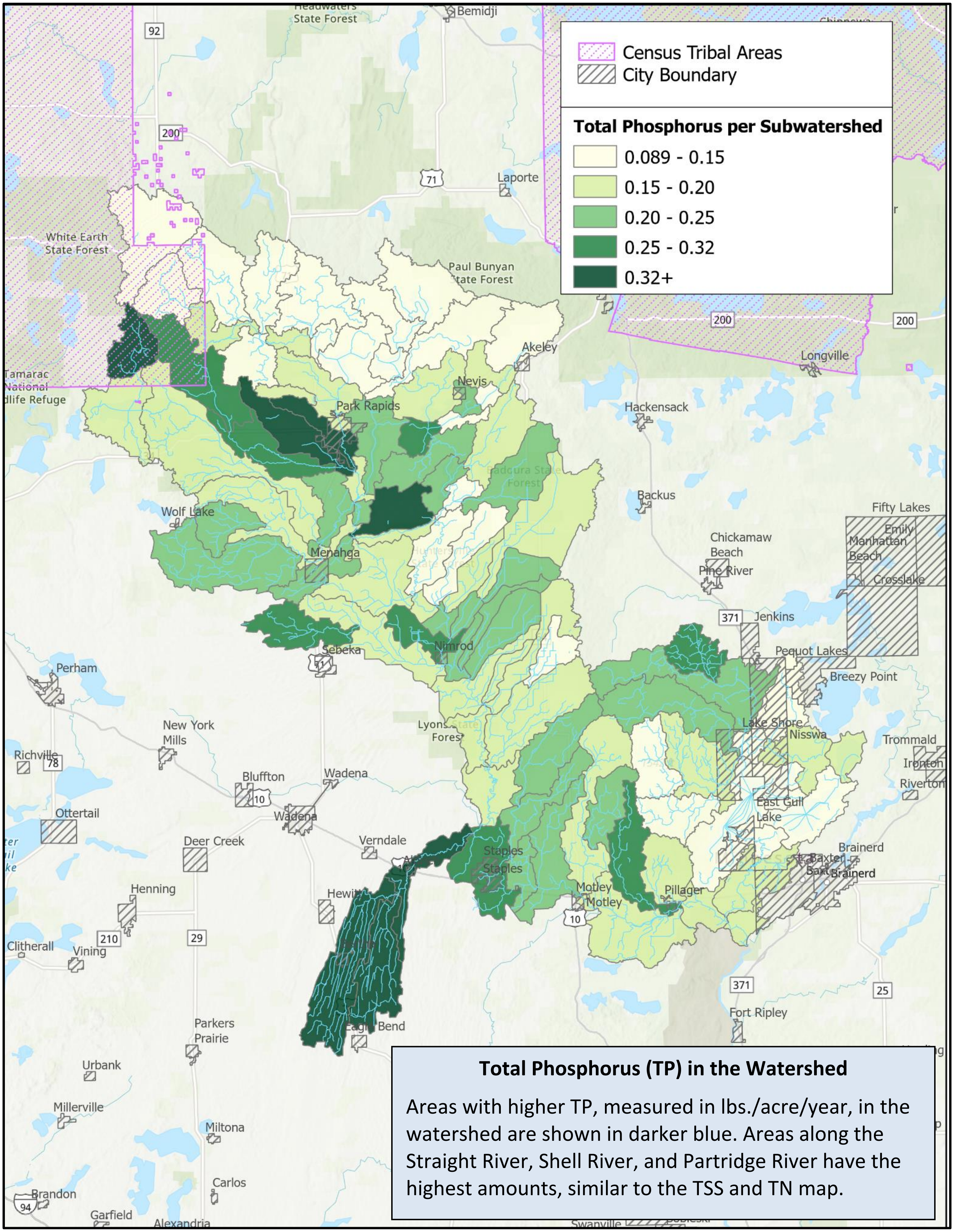


Figure 12. Modeled Total Phosphorus in the Crow Wing River Watershed



3. Goals and recommendations

It is important to take the information gathered during this second cycle of watershed monitoring and adaptively manage to develop priority areas to focus implementation efforts. The MPCA is required by the Clean Water Act to monitor and assess waters in the state and then develop strategies to restore waters that do not meet standards. Minnesota also has the opportunity to work with local partners who specialize in implementing BMPs that can address many of these impaired waters, as well as protecting high value lakes and streams, through the 1W1P framework [One Watershed, One Plan | MN Board of Water, Soil Resources (state.mn.us)](). The timing of the Crow Wing River 1W1P planning process being awarded funding in 2022 and this WRAPS report update in 2023 makes it ideal to use both information from this report and that framework to focus on implementation, community involvement, and outreach. Below are the recommendations from the MPCA as priority areas to consider for future implementation.

3.1 Existing Impaired Waters and those vulnerable to impairment.

3.1.1 Lakes

As discussed in Section 2, there are eight lakes that are impaired by excess nutrients, and three lakes that are approaching nutrient impairment. Lower Twin Lake, Mayo Lake, Sibley Lake, and Portage Lake are lakes with existing impairments that are not too far away from meeting the standard, and Rock Lake is nearing impairment. These are good lakes to prioritize for implementation efforts and have the potential to be removed from, or kept off in the case of Rock Lake, the impaired waters list if standards are achieved.

There are also several impaired lakes in the Crow Wing Chain of Lakes. First and Eighth Crow Wing Lake are currently impaired, Seventh and Third Crow Wing Lake are vulnerable to becoming impaired. Looking at these lakes from a minor watershed scale to focus on implementation efforts may be valuable.

BMPs that would be recommended to improve water quality include septic system compliance, shoreline protection, in-lake management of curly leaf pondweed, stormwater management and increasing native vegetation along the shore. The phosphorus heat maps and terrain analysis modeling tools (Appendix E) will be useful in locating BMPs for these waterbodies, as well as targeting projects on protection lakes.

There are several additional BMPs recommended to address the FIBI impairments in Middle Whipple and Sibley Lake beyond the strategies recommended above. Strategies include promoting the growth of native aquatic vegetation (floating-leaf and emergent vegetation in particular) and protect existing stands, preventing the spread of aquatic invasive species, and maintaining upstream and downstream connectivity for fish passage in Sibley Lake.

3.1.2 Streams

3.1.2.1 Straight River

The Straight River is a priority area for implementation. This high-value trout stream has an existing DO impairment as well as increased nitrates from surrounding land use and groundwater impacts. The HSPF models shows this area with high nitrogen, phosphorus, and TSS, likely from the conversion of forested areas to irrigated crop lands and other intensive land use within this subwatershed.

The following recommended implementation efforts could be considered:

- Slow conversion to row crop agriculture through conservation reserve partnerships or other land protection efforts.
- Protect riparian habitat along the river through easements or other land protection efforts.
- Establish more restrictive zoning to increase river setbacks.
- Develop ordinances to protect groundwater from agricultural nitrate loads.
- Protect groundwater levels, quality, and contribution to surface water features. Support the Park Rapids/Straight River Groundwater Management Area Effort.

3.1.2.2 Shell River

The Shell River is another priority area for implementation. This stream was listed as impaired due to low DO in 2014 and recent data collected during this cycle conclude that it is still impaired. The HSPF models also show this area to have higher nitrogen, phosphorus, and TSS, likely from intensive land use within this subwatershed. The Shell River flows into Lower Twin Lake, which is impaired by nutrients, so any nutrient reduction efforts in the Shell River Watershed will help reduce nutrients to Lower Twin Lake.

The following recommended implementation efforts could be considered:

- Focus BMPs on Upper and Lower Twin Lake
- Restore channelized sections of the river upstream of Upper and Lower Twin Lakes
- Manage livestock and feedlots to prevent impacts to water resources

3.1.2.3 Partridge River

The Partridge River system (07010106-518) flows for 33.2 miles before meeting the Crow Wing River 4.7 miles northwest of Staples. The Partridge River system also includes the Little Partridge River (07010106-547, and -551), which flows for 22.3 miles from Pendergast Lake to the Partridge River, meeting the Partridge River about 2.5 miles southeast of Aldrich. Water chemistry data have been collected at five stations on the Partridge River and Little Partridge River from 2004 through 2021. The Partridge River is impaired by *E. coli*, and a TMDL was completed; however, *E. coli* levels are still high.

In the fall of 2022, SID staff traveled throughout the Partridge River Subwatershed, with a focus on areas that may be contributing to the *E. coli* issues within the Little Partridge River and the Partridge River. A detailed report of this effort is found in Appendix C. Throughout most of the length of the Partridge River, there is a good riparian buffer. However, there are some areas such as the upstream side of the

195th Avenue and the downstream side of the 231st Avenue crossings where cattle are still allowed access to the river, which impacts the habitat for AQL, and creates a source for *E. coli*.

Although two crossings were noted as potential sources on the Partridge River, most of the issues found within the Partridge River Subwatershed were noted on the Little Partridge River. Throughout the field and aerial map surveys, seven crossings were noted as having evidence of cattle access to the river. These crossings included 494th Street, 171st Avenue, County Road 77, 470th Street, County Road 76, County Road 24, and 420th Street. Recent imagery shows that the 420th Steet and County Road 24 crossings have improved, which may be due to cattle being fenced out of the river.

Todd Soil and Water Conservation District (SWCD) has done an extensive job of properly closing eight manure pits, in return significantly reducing bacteria, nitrogen, and phosphorus. They are currently working on closing several more. There are other BMPs that would also help address the *E. coli* impairment. Fencing cattle out of the Partridge River and Little Partridge River will benefit the AQL within the rivers and reduce the amount of *E. coli*. Focusing on the larger operations that still have cattle with access to the Little Partridge River would have the biggest impact. Limiting the cattle access to small access points or finding alternative ways to water the cattle in these areas would make the biggest impact to the subwatershed. Although there are some small areas that are still in need of attention on the Partridge River, focusing on the Little Partridge River seems prudent. Other strategies that should also be considered include improving riparian buffers where they are lacking, improving nutrient and manure management, as well as stream restoration in channelized areas.

3.1.2.4 Mayo Creek

Mayo Creek was found to be impaired by *E. coli* during the first watershed assessment. Two additional upstream reaches were found to be impaired this cycle and existing reaches still exceed the standard for *E. coli*. Implementation should be targeted in this subwatershed to address these impairments, as well as improving the stream water quality before it enters impaired Sibley and Mayo lakes downstream. This area has numerous feedlots and pasture areas. Several sites were cited for feedlot violations, which have been addressed. Recommended BMPs for implementation to help address water quality issues include livestock access control, culvert management, and manure management.

3.2 Protecting Water Quality

Listed below, the original WRAPS report highlighted several areas on which to focus protection efforts that are still relevant today. The strategy table in the original WRAPS report listed protection strategies for priority lakes and streams. Appendix D of the original WRAPS report also contains helpful information on the ranking and management for the numerous lakes in the watershed.

- **Cold Water Fisheries** - Cold water fishes such as brook, rainbow and brown trout, and cisco (tullibee), need clean, cold and well oxygenated water to survive. Poor watershed land use practices and ineffective septic systems can add too many nutrients to cold water fisheries and upset the ecological balance that sustains these sensitive habitats.
- **High Value Sensitive Lakes** - Many of the lakes in the Crow Wing River Watershed are high value, sensitive lakes. Small changes in nutrient loading to these large, excellent water quality lakes is likely to result in large changes in water clarity, and/or these lakes contain sensitive

plant and fish species. These include the following lakes: Big Sand, Little Sand, Belle Taine, Blue, Bad Medicine, Boot, and Long Lost.

- **Lakes near Water Quality Thresholds** – These are discussed in Section 3.1.1 above.
- **Shoreline Development** - A healthy shoreline supports a diverse community of fish and wildlife by providing native vegetation that fulfills their habitat needs where land and water meet. Native vegetation provides important water quality functions by slowing and filtering water runoff as it moves to the lake or stream. Shorelines with a diverse mixture of native plants extending inland as well as offshore of the bank are more resilient to wave and ice erosion.
- **Wetland Protection** - Wetlands are beneficial because they store water, which is metered out slowly to either surface waters or groundwater. Many of the wetlands in the Crow Wing River Watershed are highly connected to streams, being immediately adjacent to stream edges.
- **Forest Conversion** - Large tracts of forested land have recently been converted to row crop agriculture in the north-central portion of the watershed. Fisheries research has shown that healthy watersheds with intact forests are fundamental to good fish habitat. If land in the watershed is less than 25% disturbed and the remaining 75% is permanently protected forest, the lakes and streams in the watershed will have a high probability of sustaining a healthy ecosystem. The undisturbed forest cover allows water to infiltrate into the ground rather than running off directly to lakes and streams.
- **Agricultural Pesticide Management** - Citizens have expressed concerns about nutrients and pesticides in the watershed. The Minnesota Department of Agriculture (MDA) monitors extensively for pesticides in Minnesota's water resources. They are the lead agency for all aspects of pesticide environmental and regulatory functions.
- **Road Culvert Placement** - Stream channel crossings have potential to become physical barriers to fish movement. Crossings can either be culverts (metal corrugated tubes or concrete boxes) or bridges. The crossings can become barriers when they are not installed properly, either due to incorrect sizing for the site or at the wrong elevation and/or slope.
- **Source-water Ground Water Protection** - The north-central portion of this watershed is known to have high nitrates in the groundwater due to the combination of agricultural land use and sandy soils. The MDA 2013 Nitrogen Fertilizer Management Plan (NFMP) is the state's blueprint for prevention or minimization of the impacts of nitrogen fertilizer on groundwater. The strategies in the NFMP are based on voluntary BMPs, intended to engage local communities in protecting groundwater from nitrate contamination.
- **Areas of Biodiversity** - A site's biodiversity significance rank is based on the presence of rare species populations, the size and condition of native plant communities within the site, and the landscape context of the site (for example, whether the site is isolated in a landscape dominated by cropland or developed land, or whether it is connected or close to other areas with intact native plant communities). MBS Site Biodiversity Significance Ranks | Minnesota DNR (state.mn.us).

- **Sensitive Shorelines** - Sensitive areas are places that provide unique or critical ecological habitat. These areas along the shore or in near-shore areas of the lake are crucial to the health and well-being of fish, wildlife, and native plants.

Another consideration for protection includes waterbodies that are proposed as exceptional use. Exceptional Use lakes are those that are closest to natural or undisturbed conditions. There is a need to protect and maintain high quality lakes in Minnesota. Within this watershed, the lakes listed in Table 10 are considered exceptional use.

Table 10. Exceptional use lakes

Lake ID	Name	Notes
03001700	Two Inlets	Exceptional Use
03003000	Boot	Exceptional Use
03008800	Bass	Exceptional Use
11030400	Sylvan	applies to 11-0304-01, -02
11030500	Gull	Exceptional Use
18037600	Upper Cullen	Exceptional Use
18037700	Middle Cullen	Exceptional Use
18040900	West Twin	Exceptional Use
29002500	Ninth Crow Wing	Exceptional Use
29003600	Eleventh Crow Wing	applies to 29-0036-01, -02
29004500	Tenth Crow Wing	Exceptional Use
29007200	Eighth Crow Wing	Exceptional Use
29008700	Palmer	Exceptional Use
29009100	Seventh Crow Wing	Exceptional Use
29009200	Fifth Crow Wing	Exceptional Use
29009300	Sixth Crow Wing	Exceptional Use
29016100	Long	Exceptional Use
29018400	Blue	Exceptional Use
29024200	Fish Hook	Exceptional Use
29024300	Potato	Exceptional Use
29025400	Island	Exceptional Use
29025600	Eagle	Exceptional Use
80003000	Lower Twin	Exceptional Use

3.3 Environmental Justice

The MPCA is committed to ensuring that every Minnesotan has healthy air, sustainable lands, clean water, and a better climate. This WRAPS Report Update strives to support meaningful involvement of watershed residents regardless of race and income status, as well as equitable restoration and protection of water quality resources.

The following strategies are examples of efforts that will benefit all citizens within and beyond the Crow Wing River Watershed:

- Protecting areas within and near the White Earth Tribal Lands from types of development and impacts that negatively affect important land and water resources.
- Implementing BMPs that provide multiple benefits for all people, beyond the location of installation. The following BMPs provide benefits on-site as well as reducing climate impacts:
    - Soil health practices
    - Excluding livestock from public water ways
    - Proper manure management

3.4 Monitoring and Data Collection

There are several recommendations for future monitoring to be considered. The MPCA has a detailed statewide monitoring approach outlined in the [Minnesota's Water Quality Monitoring Strategy 2021 to 2031 (state.mn.us)](). The following describes different types of monitoring to be considered in the watershed.

WPLMN - All WPLMN stations record streamflow on a continuous basis every year, either year-round or during open water (non-ice cover) conditions. Water quality samples are also collected on a regular basis year-round during these same periods, such that on-going records of load can be calculated. With this design, between 20 to 35 mid-stream grab samples are collected per year from each load monitoring station. Monitoring is targeted to characterize: major precipitation events, particularly spring runoff; base flow conditions, which typically occur during the winter months; and background flow conditions, primarily during the summer months. The water quality samples are analyzed for TSS, nitrate, phosphorus, total Kjeldahl nitrogen (subset of sites), orthophosphate (subset of sites), pH, conductivity and transparency. These water quality and discharge data are then used to compute annual pollutant loads for nitrate-plus-nitrite nitrogen, TP, dissolved orthophosphate, and TSS. The sites in this watershed are the Shell River near Huntersville (S003-444), the Crow Wing River at Nimrod (S001-326) and the Crow Wing River at Pillager (S001-926).

Stream Biological Monitoring – Sites that were sampled in 2020 to 2021 are likely to be monitored again during the next 10-year monitoring effort. The Blueberry River is also one of the statewide long-term biological monitoring sites and will be sampled every two years.

Stream Chemistry 10X sites - Sites that were sampled in 2020 to 2021 are likely to be monitored again during the next 10-year monitoring effort. Streams with existing impairments due to *E. coli* are recommended be sampled again to determine if water quality is improving or declining, especially those area that have had focused implementation.

Lake Water Quality Sampling – Lakes that will be monitored during the next assessment cycle have not been selected yet but will likely include many of the lakes that have been monitored in the past. It is recommended to sample the lakes that are impaired or vulnerable to impairment to determine if water quality is improving. Portage Lake (13-0027-00-207) is a part of the state’s Sentinel Lake program and will be monitored annually.

Lake IBI Sampling – For the next assessment cycle, DNR will be sampling a suite of 15 “anchor lakes” that will be from a stratified random sample of previously sampled lakes, as well as most or all lakes assessed as impaired, vulnerable, or as exceptional use, and any that might be requested by stakeholders or that might be experiencing significant impacts from new stressors.

Straight River Study – it is recommended that continued monitoring occur on the Straight River to understand water quality trends. Three sites should be monitored every five years for nitrate-nitrite N, DO, and sonde parameters (2025 to 2026 and 2030 to 2031). These site locations are located on the Straight River upstream of Highway 71, 3 miles south of Park Rapids (10UM041, S002-960), Straight River at 590th Avenue/Becker Line Road. (S008-454), and the Straight River at County Road 123 Bridge (S004-793).

4. Public Participation

Public outreach

Public outreach refers to education, outreach, marketing, training, technical assistance, and other methods of working with stakeholders to achieve water resource management goals. In this second cycle of the watershed approach there was less emphasis on public outreach for the WRAPS Report Update. This is because of active engagement already occurring in the watershed and because outreach activities were not identified as a WRAPS Update priority task.

Although public outreach was not a focus of this WRAPS Update process, numerous meetings and opportunities for involvement were provided throughout this assessment cycle. The following is a list of stakeholder meetings held by the MPCA and/or local partners regarding the watershed assessment and WRAPS Update process.

- 11/13/2019 – meeting with stakeholders and agency staff to discuss monitoring locations for watershed assessment.
- 7/16/2020 – stakeholder meeting to discuss WRAPS Update project charter, funding, and review of Cycle 1 data.
- 2/4/2021 – stakeholder meeting to discuss water quality updates from the first year of monitoring.
- 4/20/2022 – stakeholder meeting to discuss water quality assessments for lakes and streams in the watershed.
- 5/9/2022 – stakeholder meeting to discuss WRAPS Update, coordination with 1W1P efforts, and project workplan.
- 4/5/2023 – stakeholder meeting to discuss draft reports (monitoring and assessment report, SID report and the WRAPS Update).
- 6/15/2023 – technical advisory meeting for the 1W1P effort.
- 6/27/23 – citizen meeting in Nisswa for the 1W1P kickoff.

Public notice for comments

An opportunity for public comment on the draft WRAPS Report Update was provided via a public notice in the State Register from October 9, 2023, through November 8, 2023. There were two comment letters received and responded to as a result of the public comment period.

5. References

Minnesota Department of Natural Resources (DNR). 2019. Climate Summary for Watersheds. Crow Wing River. Climate Summary for Watersheds, Crow Wing River (state.mn.us)

Minnesota Pollution Control Agency (MPCA). 2023. Crow Wing River Watershed Stressor Identification update June 2023. Crow Wing Watershed Stressor Identification Report Update (state.mn.us)

Minnesota Pollution Control Agency (MPCA). Watershed approach to water quality | Minnesota Pollution Control Agency (state.mn.us)

Minnesota Pollution Control Agency (MPCA). 2014 Minnesota Nutrient Reduction Agency. Watershed approach to water quality | Minnesota Pollution Control Agency (state.mn.us)

Minnesota Department of Natural Resources (DNR). 2009 Guidelines for Assessing Biodiversity Significance Ranks MBS Site Biodiversity Significance Ranks | Minnesota DNR (state.mn.us)

6. Appendices

A – Lake Data Comparison from Cycle 1 (2010-2011) to Cycle 2 (2020-2021)

B – Mayo Creek TMDL 4A Request Form

C – Partridge River Analysis

D – Terrain Analysis and Phosphorus Heat Maps for Select Subwatersheds

Appendix A: Cycle 1 (2010-2011) and Cycle 2 (2020-2021) Lake Water Quality Data

Lake ID	LAKE NAME	Mean TP		Mean Chl-*a*		Mean Secchi		AQR Assessment		AQL Assessment	Comments
		C1	C2	C1	C2	C1	C2	C1	C2	C2	
03-0005-00	Shipman	19	-	7	-	3	-	IF	-		
03-0007-00	Blueberry	31	-	17	-	2.5	3.1	IF	IF		Need TP & Chl-a data
03-0010-00	Straight	22	16.3	11	10.3	3	2.3	FS	FS	FS	
03-0017-00	Two Inlets	21.7	17.5	8.5	8	2.4	2.7	FS	FS	FS	AQL = Exceptional
03-0029-00	Hungry Man	12.1	10.5	2	2.6	4	4.4	FS	FS		
03-0030-00	Boot	8.2	8	1.2	1.8	6.8	5.4	FS	FS	FS	AQL = Exceptional
03-0039-00	Abners	41	21	-	2.3	-	2.8	IF	IF		Only 1 sample taken
03-0066-00	Gyles	12	29	-	8.9	-	1.1	IF	IF		Only 1 sample taken
03-0082-00	Wahbegon	11.8	-	2.3	-	2.7	-	FS	-		
03-0085-00	Bad Medicine	8.3	5.9	2.1	1.2	7.2	7.4	FS	FS	IC	
03-0088-00	Bass	19.6	23.7	5.6	7.3	3.5	2.8	FS	FS	FS	AQL = Exceptional
03-0096-00	Big Basswood	18.1	17.8	3.7	4.8	1.8	.9	FS	FS		
03-0102-00	Shell	27	20	10	4.9	1.7	2.3	IF	IF	FS	AQR - Not enough data
03-0103-00	Big Rush	15	13.8	-	3.5	1.6	1.8	IF	IF		AQR - Not enough data
03-0104-00	Aspinwall	14	-	2	-	1.4	-	FS	-		
03-0120-00	Mud	17	18	4	6.3	2.5	-	FS	IF		Only 1 sample taken
03-0124-00	Dumbbell	33	-	-	-	1.2	-	IF	-		
03-0127-00	Bass	16	13.3	7	5.1	3.4	3.9	FS	FS	IC	AQL – Vulnerable to impairment
03-0786-00	Unnamed	46.1	25	10	2	1.7	-	NA	IF		Only 1 sample taken
11-0216-00	Agate	14	14.5	2	4.2	3.3	3.2	FS	FS		
11-0218-00	Upper Gull	24	21	10	9.6	2.7	3.2	IF	FS	FS	
11-0219-00	Lost	-	-	-	-	2.6	-	IF	-		
11-0220-00	Ray	13	12.2	7	4.9	2.9	3	IF	FS	FS	
11-0221-00	Spider	16	-	10	-	2.6	-	IF	-		
11-0222-00	Margaret	77*	45	26*	30.8	1.4*	1.6	NS	NS	FS	
11-0225-00	Upper Loon	32	-	12	-	2.3	-	IF	-		

Lake ID	LAKE NAME	Mean TP		Mean Chl-*a*		Mean Secchi		AQR Assessment		AQL Assessment	Comments
11-0226-00	Loon	18	12	4	3.8	3.7	4.1	FS	FS		
11-0304-01	Sylvan (SW Bay)	14	7	3	3.1	5.1	5.5	FS	FS	FS	
11-0304-02	Sylvan (NE Bay)	9	5	1	1.7	6	6	FS	FS	FS	AQL – Exceptional Use
11-0305-00	Gull	22	13.8	9	3.2	3.2	4.5	FS	FS	FS	AQL – Exceptional Use
11-0320-00	Pillager	11	9.3	2	2.8	5.3	4.5	FS	FS		
11-0324-00	Rock	21	27.5	6	11.1	2.2	1.6	FS	FS		AQR - vulnerable to impairment
11-0500-00	Spider	16	15.5	6	4.9	3.5	3.3	FS	FS	FS	
11-0777-00	Unnamed	31	-	-	-	0.8	-	IF	-		
11-0780-00	Unnamed	30	-	-	-	2	-	NA	-		
18-0304-00	Perch	25	15.6	5	5.8	1.5	1.9	FS	FS		
18-305-00	Edward		15.8		4.6		4.6		FS	FS	
18-0326-00	Mud	32		43				NA			
18-0327-00	Rice	29		4		1		IF			
18-0329-00	Garden	17	13.4	4	3.7	1.4	1.5	FS	FS		
18-0330-00	Unnamed	27		7		5.5		IF			
18-0332-00	Guida		18.5		5.2		1.2		FS		
18-0335-00	Mollie	20		8		1.7		FS			
18-0336-00	Twin	112		21		1.4		NA			
18-0337-00	Unnamed	27		7				IF			
18-0338-00	Gladstone	17	14	5	6.1	3.5	3.3	FS	FS	FS	
18-0339-00	Moody	14		4		3.6		IF			
18-0340-00	Little Hubert	17	16.3	3	3.4	4.3	4.9	FS	FS		
18-0341-00	Crystal	35	16	11	9.6	1.2	2.2	IF	IF		AQR - Not enough data
18-0372-00	North Long	18	14.8	5	4.1	4.5	4.1	FS	FS	FS	
18-0373-00	Round	25	16.5	12	4.1	3.2	4.2	FS	FS	FS	
18-0374-00	Clark	21	16.1	5	5.4	3	2.9	FS	FS	FS	
18-0375-00	Hubert	16	10.2	3	3.5	4.6	5.1	FS	FS	FS	
18-0376-00	Upper Cullen	25	21.3	9	10	2.9	2.7	FS	FS	FS	AQL – Exceptional Use
18-0377-00	Middle Cullen	19	14.8	5	5.2	4	3.7	FS	FS	FS	AQL – Exceptional Use
18-0379-00	White Sand	20	17.7	6	4.4	3.3	3.7	FS	FS	FS	
18-0386-00	Red Sand	24	17.3	4	3.8	3.2	2.7	FS	IF	NA	AQR - Not enough data

Lake ID	LAKE NAME	Mean TP		Mean Chl-*a*		Mean Secchi		AQR Assessment		AQL Assessment	Comments
18-0387-02	Middle Whipple	15	11.5	4	3.7	3.3	2.9	FS	FS	NS	
18-0388-00	Love	20		6		2.9		FS			
18-0389-00	Moburg	22		3				IF			
18-0392-00	Hartley	18	13.3	2	3.9	4.6	4.4	FS	FS		
18-0396-00	Edna	11	8.3	3	3.1	4.6	4.3	FS	FS		
18-0397-00	Fawn	11		4		3.8	4.4	FS			AQR - Not enough data
18-0398-00	Roy	20	9.8	7	3.1	2.8	4.3	FS	FS	FS	
18-0399-00	Nisswa	20	11	9	2.3	2.3	4	FS	FS	FS	
18-0402-00	Bass	23	14.9	4	5.2	4	3.2	FS	FS		
18-0403-00	Lower Cullen	21	16.2	7	5.1	3.7	3.7	FS	FS	FS	
18-0404-00	Sibley	33	36	20	17.7	1.5	1.7	NS	NS	NS	
18-0405-00	Rice	144				1.3		NA			
18-0407-00	East Twin	10	6	3	3.1	5.2	4.9	FS	FS	FS	
18-0408-00	Mayo	36	29.6	18	11.3	2	1.5	NS	NS	FS	AQR - lake is barely impaired
18-0409-00	West Twin	9	6.5	2	2.8	5.7	4.2	IF	FS	FS	AQL – Exceptional Use
18-0544-00	Unnamed	144				0.3		IF			
29-0002-00	Mow	11	8.3	4	2.7	4.5	4.3	FS	FS		
29-0005-00	Tripp	16		5		3.2		FS			
29-0006-00	Oelschlager Slough	21	20	4	3.7	1.4	-	NA	IF		Only 1 sample taken
29-0017-00	Ham	13	13.4	4	3.5	2.8	3.8	FS	FS		
29-0020-00	Loon	15		5		1.7		FS			
29-0025-00	Ninth Crow Wing	19	19.6	7	7.3	3.1	2.8	FS	FS	FS	AQL – Exceptional Use
29-0032-00	Big Bass	9	5.8	2	2.1	6.4	6.2	FS	FS	FS	
29-0034-00	Upper Bass					3.4		IF			
29-0036-01	11 Crow Wing (Main)	12	10.6	4	2.8	4.3	5.1	FS	FS	FS	AQL – Exceptional Use
29-0036-02	11 Crow Wing (East)	14	9.4	5	3.3	4.2	5.4	IF	FS	FS	AQL – Exceptional Use
29-0045-00	Tenth Crow Wing	20	14.3	5	5.8	2.9	3.1	FS	FS	FS	AQL – Exceptional Use
29-0072-00	Eighth Crow Wing	30	32.3	14	18	2.7	2.4	NS	NS	FS	AQL – Exceptional Use

Lake ID	LAKE NAME	Mean TP		Mean Chl-*a*		Mean Secchi		AQR Assessment		AQL Assessment	Comments
29-0074-00	Indian	9		3		5.7		FS			
29-0077-00	Third Crow Wing	27	22.2	12	9.4	1.4	1.1	IF	IC	FS	AQR - vulnerable to impairment
29-0078-00	Fourth Crow Wing	26	19.3	8	1.9	2.3	2.5	FS	FS	FS	
29-0081-00	Wolf	18		3		3.2		FS			
29-0083-00	Bladder	17		2		2		FS			
29-0085-00	Second Crow Wing	22	23.7	11	9.5	2.1	2.6	FS	FS	FS	
29-0086-00	First Crow Wing	59	52.6	32	26.4	1.1	1.4	NS	NS	FS	
29-0087-00	Palmer	12	11	4	4	3.9	3.2	FS	FS	FS	AQL – Exceptional Use
29-0088-00	Island	14	13.3	5	5.1	3.7	4.5	FS	FS	FS	
29-0089-00	Shallow	13	11.3	3	3	2.3	2.5	FS	FS		
29-0090-00	Deer	13	13.6	4	3.9	4.2	2.7	FS	FS		
29-0091-00	Seventh Crow Wing	26	28.5	13	14.7	2.3	2.6	FS	FS	FS	AQR - vulnerable to impairment AQL – Exceptional Use
29-0092-00	Fifth Crow Wing	23	22.4	10	9.9	2.8	2.8	FS	FS	FS	AQL – Exceptional Use
29-0093-00	Sixth Crow Wing	22	22.5	10	10.4	2.6	2.7	FS	FS	FS	AQL – Exceptional Use
29-0098-00	Waboose	15	10.8	5	3.6	4.4	5	FS	FS		
29-0101-01	East Crooked	8	7.1	1	2.2	6.5	6.9	IF	FS	FS	
29-0101-02	Middle Crooked	15	12.3	4	3.7	3.5	4	FS	FS		
29-0101-03	West Crooked	12	7.8	2	2.6	4.8	5	FS	FS	NS	AQL = Natural Background
29-0110-00	Dead	16	10	4	3.9	6.2	5.7	IF	FS	IF	
29-0117-01	Spider (NE/SW Bay)	11	10.1	4	3.1	5.5	5.1	FS	FS	FS	
29-0117-02	Spider (East Bay)					5.5		IF		FS	
29-0142-00	Duck	20	16.2	8	6.7	2.3	3	FS	FS	FS	
29-0143-00	Big Stony	14	11.1	5	3.4	3.9	3.4	FS	FS	FS	
29-0146-00	Belle Taine	11	8.6	3	2.7	5.7	6.1	FS	FS	FS	
29-0148-00	Upper Bottle	15	13.2	4	4.1	4.5	4.6	FS	FS	FS	

Lake ID	LAKE NAME	Mean TP		Mean Chl-*a*		Mean Secchi		AQR Assessment		AQL Assessment	Comments
29-0149-00	Ojibway	17	12.5	4	2.7	5.3	4.5	FS	FS		
29-0150-00	Little Sand	9	7.2	2	1.7	6.4	6.7	FS	FS	FS	
29-0151-01	Mantrap (E. Basin)	19	18	5	5	4.1	4.2	FS	FS	FS	
29-0151-02	Mantrap (Mid. Basin)	22		5		3.2	3	FS	IF	FS	AQR - Not enough data
29-0151-04	Mantrap (West Arm)					4.3	3.8	IF	IF	FS	
29-0151-05	Mantrap (Home Bay)					4.7	4.4	IF	IF	FS	
29-0157-00	Upper Twin	41	32.5	4	2.9	2.2	2.2	FS	FS		
29-0161-00	Long	13	12.3	5	5.2	3.2	2.9	FS	FS	FS	AQL – Exceptional Use
29-0162-00	Boulder	13	18.1	5	5.1	3.9	3.4	FS	FS	FS	
29-0164-00	Sweitzer	19		4		2.5		FS			
29-0169-01	Peysenske (Main Bay)	16	18.3	4	3.4	2.8	4	FS	FS		
29-0169-02	Peysenske (E. BAY)	16		4		1.6		IF			
29-0170-00	Ida	9		2		7.2		IF			
29-0172-00	Stocking	25	21.7	9	7.9	3.1	3.1	FS	FS		
29-0177-00	Rice	25		9		1.9		FS			
29-0178-00	Pickerel	16	15	5	3.9	4	3.7	FS	FS	FS	
29-0180-00	Lower Bottle	12	10.6	3	2.8	4.6	4.4	FS	FS	FS	
29-0184-00	Blue	10	8.4	2	1.9	5.1	4.9	FS	FS	FS	AQL – Exceptional Use
29-0185-00	Big Sand	9	6.8	2	1.9	7	7.6	FS	FS	FS	
29-0186-00	Emma	16	13.1	4	2.9	4.2	5.3	FS	FS		
29-0188-00	Gilmore	10	9.4	3	2.2	4.4	6	FS	FS		
29-0208-00	Bad Axe	14	14	4	3.8	4.9	4.8	FS	FS	IF	
29-0212-00	Skunk	12	15.5	3	3	6.1	5.2	FS	FS		
29-0242-00	Fish Hook	17	14.9	5	4.4	3.5	3.2	FS	FS	FS	AQL – Exceptional Use
29-0243-00	Potato	14	12	5	4.1	3.4	3.4	FS	FS	FS	AQL – Exceptional Use
29-0247-00	Moran	15	14.8	5	3.9	3.7	3.8	FS	FS		
29-0248-00	Lord	14		6		4.1		FS			
29-0249-00	Hinds	15	14.2	4	3.6	4.3	4.6	FS	FS	FS	

Lake ID	LAKE NAME	Mean TP		Mean Chl-*a*		Mean Secchi		AQR Assessment		AQL Assessment	Comments
29-0250-00	Portage	51	34	22	14.2	1.2	2.1	NS	NS	NA	
29-0254-00	Island	22	19	9	7.2	2.5	2.7	FS	FS	FS	AQL – Exceptional Use
29-0256-00	Eagle	19	19.2	7	9.2	3.1	3.4	FS	FS	FS	AQL – Exceptional Use
29-0313-00	Little Mantrap	11.4	7.8	3.4	2.5	5.4	5.2	FS	FS	FS	
29-0504-00	Fish Hook River Dam	15		4		3.3		NA			
49-0036-01	Sylvan (Main)	60		12		2		NA			
49-0036-02	Sylvan (N. Basin)	32		8		2.8		NA			
80-0003-00	Simon	12				1.4		IF			
80-0022-00	Yaeger	46	27		3.6		-	IF	IF		Only 1 sample taken
80-0027-01	Jim Cook (West)	14		2		1.1		IF			
80-0030-00	Lower Twin	40	41.2	15	16.6	1.9	2.1	NS	NS	FS	AQL – Exceptional Use
80-0034-00	Blueberry	93	88.2	52	46	0.9	.9	NS	NS	FS	
80-0037-00	Stocking	45	39.1	21	14.6	1.8	2	FS	FS	IF	
80-0038-00	Morgan	11	9.2	2	3.6	6.3	4.9	FS	FS		
80-0039-00	Spirit	20	16	5	3.8	3.8	4.5	FS	FS		

Cycle 1 data from the 2015 Monitoring and Assessment Report and Cycle 2 data obtained from CARL.
* Cycle 1 data for Margaret Lake was taken from the TMDL. C1 = Cycle 1 C2 = Cycle 2
FS = Full Support
NS = Not Supporting
IF = Insufficient Data
NA = Not Assessed
Chl-*a* = Chlorophyll-a
TP = Total Phosphorus

Appendix B: Impairment recategorization request

Table A – Impairments

Add rows as needed.

WID (AUID)	Water body name	Description	Impairment(s)
07010106-728	Unnamed Creek	Headwaters to Unnamed creek.	*E. coli*
07010106-603	Mayo Creek	Unnamed creek to Unnamed creek.	*E. coli*

Table B – TMDL information

Date	4/13/2022
Requestor	Bonnie Finnerty/Jeff Strom
Watershed	Crow Wing River
TMDL ID	PRJ07651-001
TMDL Report	2014 TMDL Crow Wing River Watershed TMDL Study (state.mn.us)
Project manager	Bonnie Finnerty

Table C – Stressor identification results

Include for biological impairments.

SID report	Not applicable—not a biological impairment
SID staff	Not applicable—not a biological impairment

Which pollutant stressors have been addressed by a TMDL (and are 4A)? Not applicable - not a biological impairment

Stressor	Check (X) if applicable	Comments
TSS/turbidity	Not applicable—not a biological impairment	
Temperature		
Chloride/hardness		
Nitrogen		
Phosphorus		
Ammonia		
Dissolved oxygen		
pH		
Other		

Table D - Justification

Summarize the conclusions reached in TMDL and SID reports to justify the recategorization to 4A.

Proposed action	*State the impairments you intend to categorize and the List year they will go into effect:* Categorize Mayo Creek and Unnamed Creek as 4A for list year 2024
Rationale	*Lay out why a move to 4A is appropriate, e.g., "all pollutant stressors were addressed by this TMDL":* The new *E. coli* impairments were addressed by the existing *E. coli* TMDL for Mayo Creek WID 07010106-604. These WIDs are located upstream of WID 07010106-604 (see Figures 1 and 2). There are no wasteload allocations for this TMDL (see Figure 3), and there are no new point sources that need WLAs. There is one industrial stormwater permitted surface discharge; however, industrial stormwater *E. coli* WLAs are not assigned in Minnesota because there are no fecal bacteria or *E. coli* benchmarks associated with the industrial stormwater general permit (MNR050000). There are no permitted MS4s in the watershed, and there are no MS4s that are expected to be permitted in the near future. Both WIDs are held to the same *E. coli* standards for AQR as WID 07010106-604 (126 org/100 mL as a monthly geometric mean and 1,260 org/100 mL as a single value). The stream use classification for all reaches is 2Bg. The TMDL's source assessment is still valid in that the primary sources of *E. coli* are livestock and wildlife. Implementation will include working with local farmers to reduce impacts from cattle/manure. Land use has not significantly changed since the original TMDL.
Background	*Any additional information, such as timing of listings and approved TMDLs:*

Figure 13. Location of new *E. coli* impairments upstream of existing impaired reach

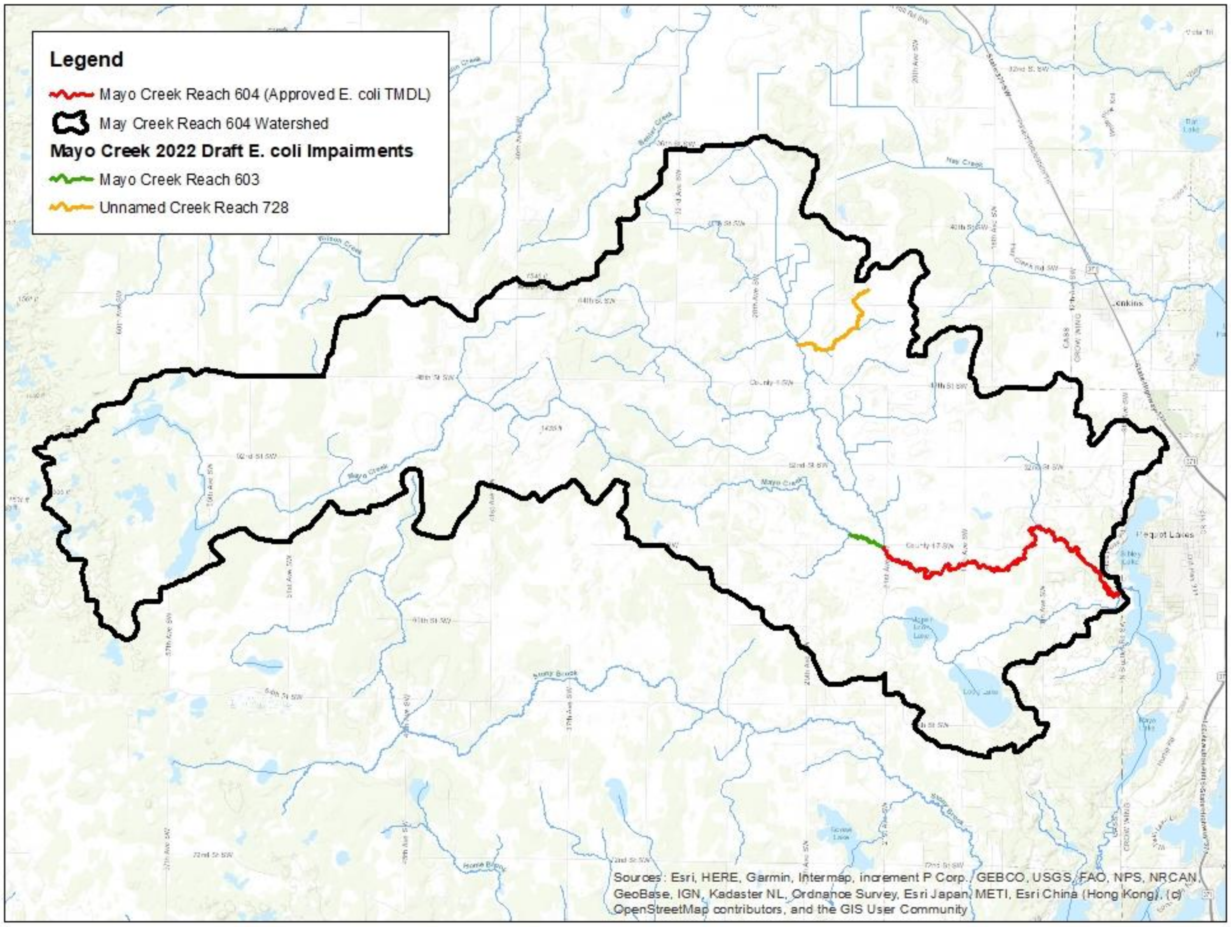


Figure 14. Location of watershed area used in 2014 TMDL

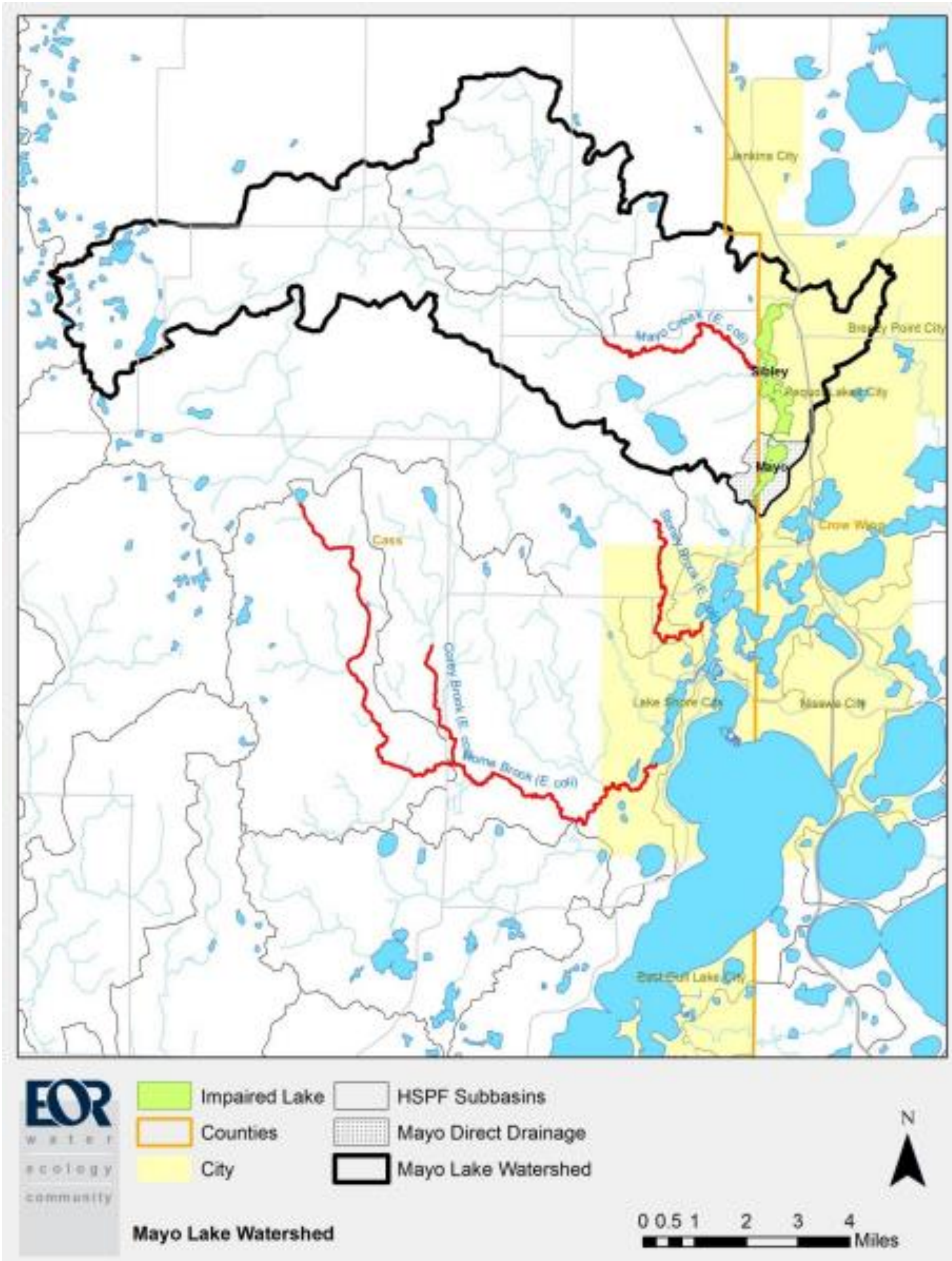


Figure 15. 2014 TMDL allocation table

Mayo Creek Probability of Exceedance (%)

Table 37. Mayo Creek *E. coli* TMDL and Allocations

Mayo Creek (07010106-604) Load Component		Flow Regime				
		High	Moist	Mid	Dry	Low
		Billion organisms per day				
Existing Load		**99.4**	**30.4**	**25.4**	**No Data**	**No Data**
Wasteload Allocation		*n/a*	*n/a*	*n/a*	*n/a*	*n/a*
Load Allocations	*Watershed runoff*	*66.5*	*30.2*	*21.6*	*15.5*	*8.3*
	Total LA	**66.5**	**30.2**	**21.6**	**15.5**	**8.3**
MOS		**7.4**	**3.4**	**2.4**	**1.6**	**0.9**
Total Loading Capacity		**73.9**	**33.6**	**24.0**	**16.1**	**9.2**
Estimated Load Reduction		**26%**	**0%**	**6%**	**N/A**	**N/A**

Bacteria Source Summary

- High potential from wildlife (ducks)
- High potential from livestock (cattle)

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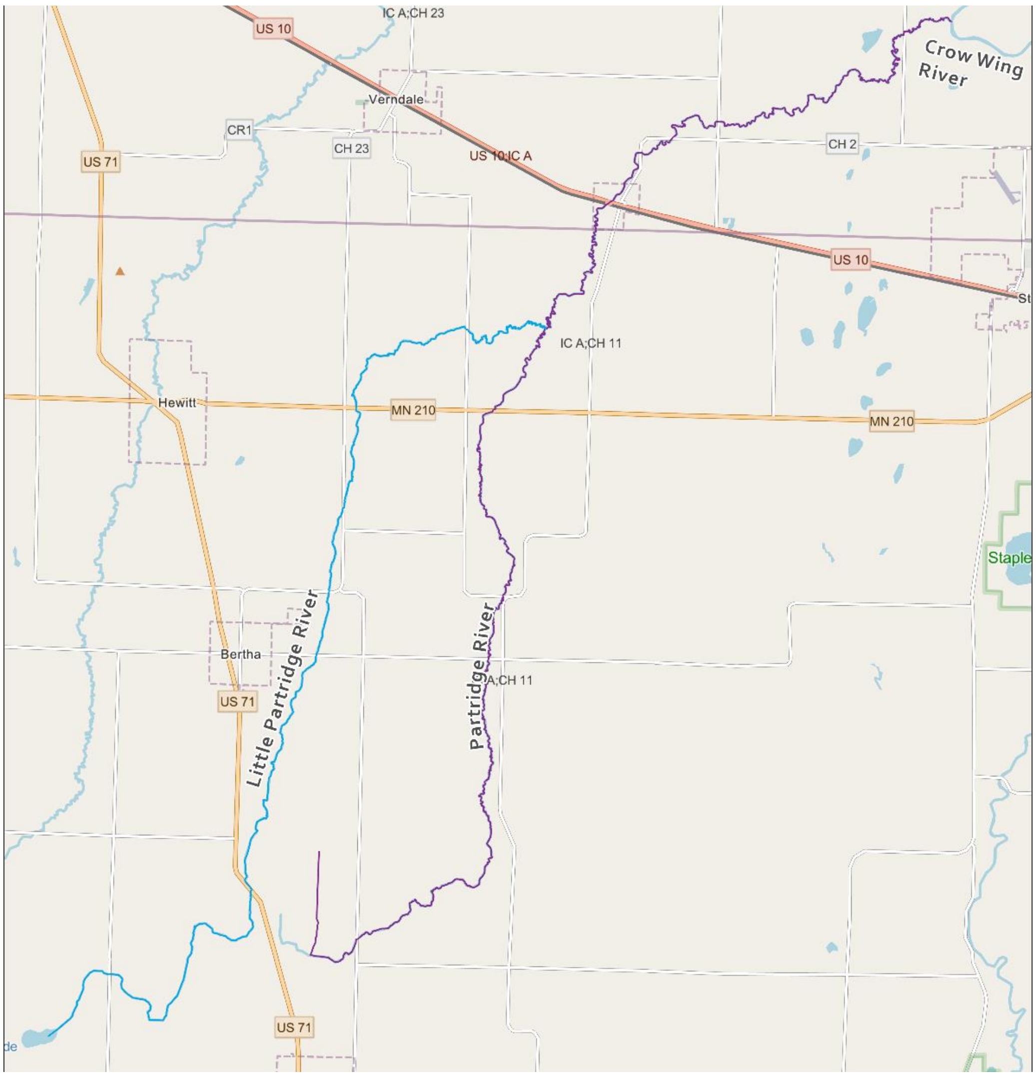
Appendix C: Partridge River Analysis

Partridge River Subwatershed

The Partridge River system (07010106-518) flows for 33.2 miles before meeting the Crow Wing River 4.7 miles northwest of Staples. The Partridge River system also includes the Little Partridge River (07010106-547, and -551), which flows for 22.3 miles from Pendergast Lake to the Partridge River, meeting the Partridge River about 2.5 miles SE of Aldrich (Figure 16).

Figure 16. Map of the Little Partridge River and Partridge River flow pattern.



Water chemistry data have been collected at five stations (S011-704, S016-627, S006-638, S004-037, and S002-961) (data available at https://webapp.pca.state.mn.us/surface-water/search) on the Partridge River and Little Partridge River from 2004-2021 (Figure 17, Table 1), including fecal coliform and *E. coli* data.

Figure 17. Map of the water chemistry stations on the Little Partridge River and Partridge River.

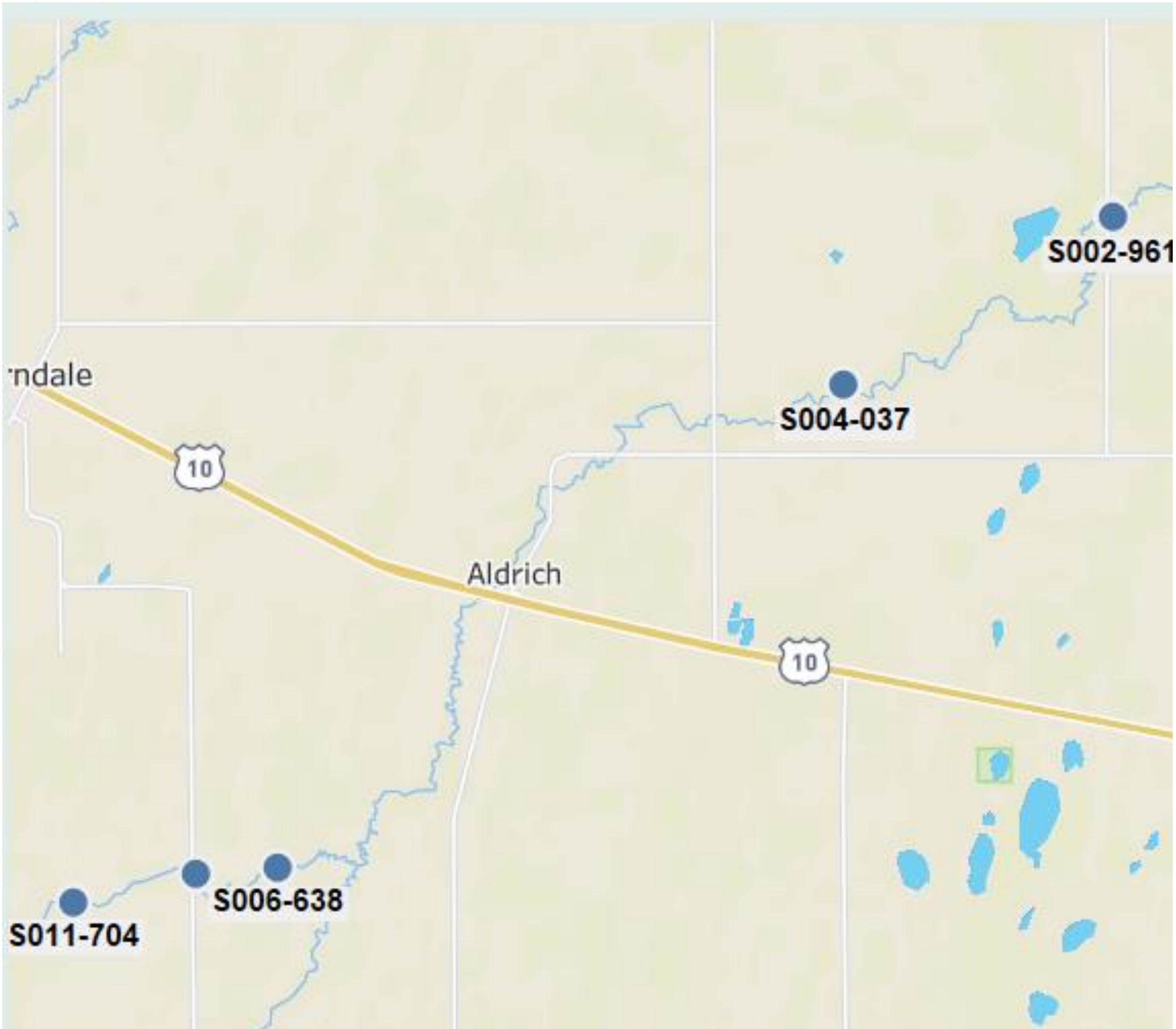


Table 11. Water chemistry data collected on the Partridge River and Little Partridge River

Stream AUID	EQuIS Code	Parameter	Count of Samples	Avg. Result	Median Result	Min. Result	Max. Result
07010106-518	S002-961	Ammonia-nitrogen	23	0.12	0.08	0.05	0.48
		Biochemical oxygen demand, standard conditions	25	1.65	1.2	0.5	8.1
		Dissolved oxygen	72	9.61	9.54	5.36	14.91
		Escherichia coli	37	251.32	195.6	21.6	866.4
		Fecal Coliform	26	182.96	161	9	496
		Inorganic nitrogen (nitrate and nitrite)	73	1.15	0.84	0.1	3.6
		pH	98	8.06	8.1	7.04	9.05
		Phosphorus	82	0.06	0.04	0.01	0.39
		Specific conductance	71	506.24	522	43	643
		Temperature, water	72	15.62	16.77	1.57	24.81
		Total suspended solids	73	4.65	3	1	30
		Transparency, tube with disk	41	99.37	100	88	100
	S004-037	Temperature, water	177	16.2	17.8	0.56	27.22
		Transparency, tube with disk	177	68.3	60	30	100
		Dissolved oxygen	1	1.17	1.17	1.17	1.17
		pH	1	7.63	7.63	7.63	7.63
		Phosphorus	1	0.1	0.1	0.1	0.102
		Specific conductance	1	567	567	567	567
		Temperature, water	1	20.2	20.2	20.2	20.2
		Transparency, tube with disk	1	100	100	100	100
07010106-551	S006-638	Dissolved oxygen	2	6.89	6.89	5.97	7.8
		pH	2	7.86	7.86	7.8	7.91
		Phosphorus	1	0.16	0.16	0.16	0.16
		Specific conductance	2	592	592	579	605
		Temperature, water	2	16.05	16.05	10.2	21.9
		Total suspended solids	1	5.6	5.6	5.6	5.6
		Transparency, tube with disk	2	98.5	98.5	97	100
		Volatile suspended solids	1	1.6	1.6	1.6	1.6
	S011-704	Dissolved oxygen	2	4.48	4.48	2.64	6.32
		Inorganic nitrogen (nitrate and nitrite)	1	0.08	0.08	0.08	0.076
		pH	2	7.61	7.61	7.56	7.66
		Phosphorus	1	0.11	0.11	0.11	0.114
		Specific conductance	2	633	633	569	697
		Temperature, water	2	16.55	16.55	12.3	20.8
		Total suspended solids	1	9.6	9.6	9.6	9.6
		Transparency, tube with disk	2	67.25	67.25	66.5	68
		Volatile suspended solids	1	6	6	6	6
	S016-627	Inorganic nitrogen (nitrate and nitrite)	1	0.61	0.61	0.61	0.605
		Phosphorus	1	0.08	0.08	0.08	0.081
		Total suspended solids	1	3.6	3.6	3.6	3.6

In the fall of 2022, SID staff traveled throughout the Partridge River Subwatershed, with a focus on areas that may be contributing to the *E. coli* issues within the Little Partridge River and the Partridge River. The river has a good riparian buffer throughout most of the length of the Partridge River (Figure 18).

Figure 18. The Partridge River with a wide riparian buffer.

However, there are some areas such as the upstream side of the 195th Ave (Figure 19) and the downstream side of the 231st Ave (Figure 20) crossings where cattle are still allowed access to the river, which impacts the habitat for AQL, and creates a source for *E. coli*.

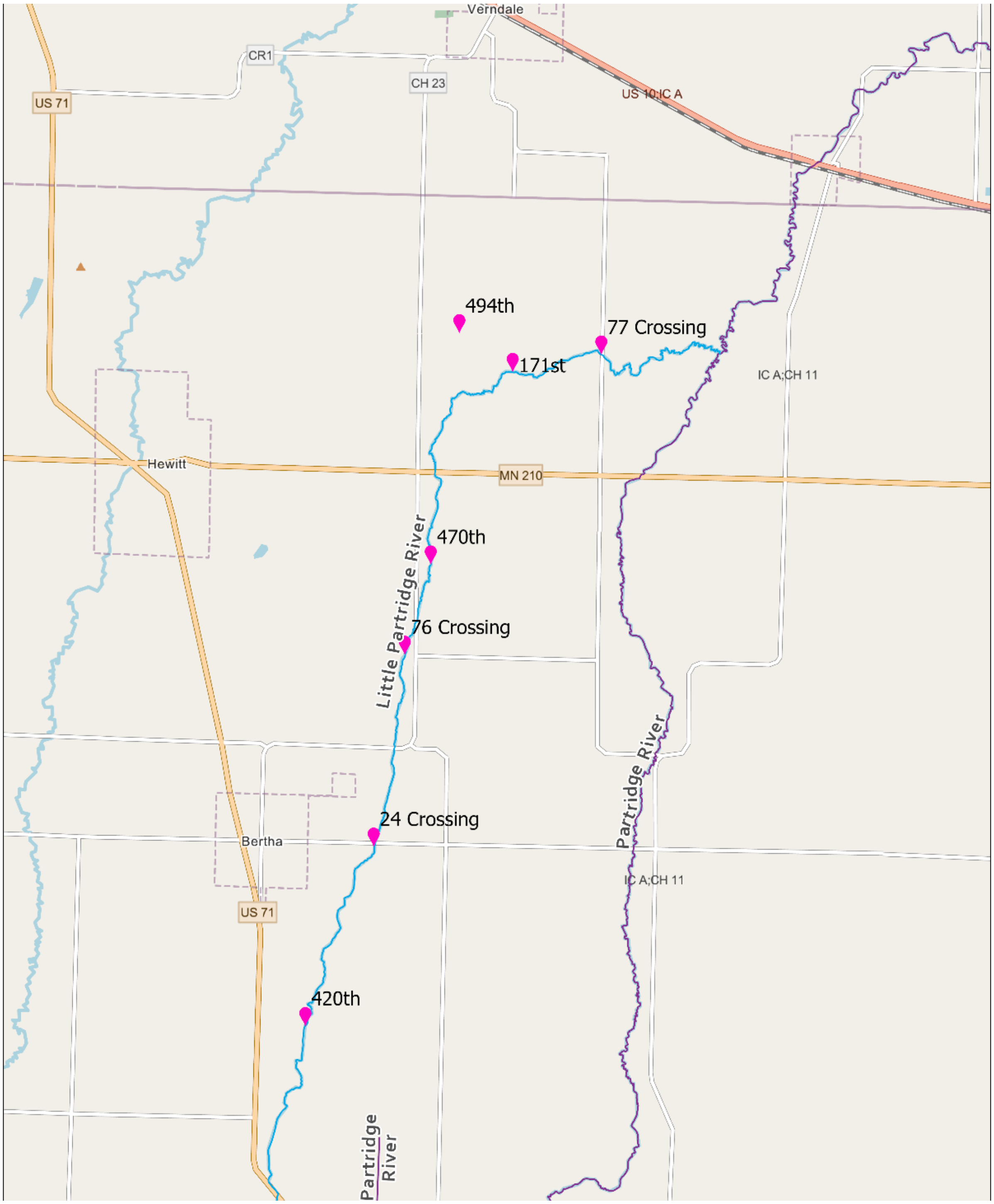
Figure 19. The 195th Ave crossing on the Partridge River with direct cattle access to the river.

The 195th Ave crossing on the Partridge River, with direct cattle access to the river.

Figure 20. Cattle access to the Partridge River at the 231st Ave crossing.

Although two crossings were noted as potential sources on the Partridge River, most of the issues found within the Partridge River Subwatershed were noted on the Little Partridge River. Throughout the field and aerial map surveys, seven crossings were noted as having evidence of cattle access to the river (Figure 20). These crossings included 494th St, 171st Ave, CR 77, 470th St, CR 76, CR 24, and 420th St. Recent imagery shows that the 420th St and CR 24 crossings have improved, which may be due to cattle being fenced out of the river.

Figure 21. Map of the Partridge River and Little Partridge River flowage, showing crossings with potential cattle access.



Recommendations:

Fencing cattle out of the Partridge River and Little Partridge River will benefit the AQL within the rivers and reduce the amount of *E. coli*. Focusing on the larger operations that still have cattle with access to the river, on the Little Partridge River, would have the biggest impact. Limiting the cattle access to small access points or finding alternative ways to water the cattle in these areas would make the biggest impact to the subwatershed. Although there are some small areas that are still in need of attention on the Partridge River, focusing on the Little Partridge River seems prudent.

Appendix D: Hydro Conditioning, PTMApp, Terrain Analysis and Phosphorus Heat Maps

Houston Engineering was contracted to develop models consisting of hydro conditioning and PTMApp for the entire Crow Wing Watershed that will provide the ability to target projects and measure progress at a smaller scale. Terrain analysis and phosphorus heat maps were developed for the Gull River, Fishhook River, Belle Taine, and Headwaters subwatersheds. The terrain analysis includes flow lines to target stormwater projects around lakes and the phosphorus heat maps will be utilized for targeting projects where the most phosphorus export is occurring. The GIS shapefiles are also available to conduct further analysis.

Figure 22. Phosphorus Heatmap for Fishhook River Subwatershed

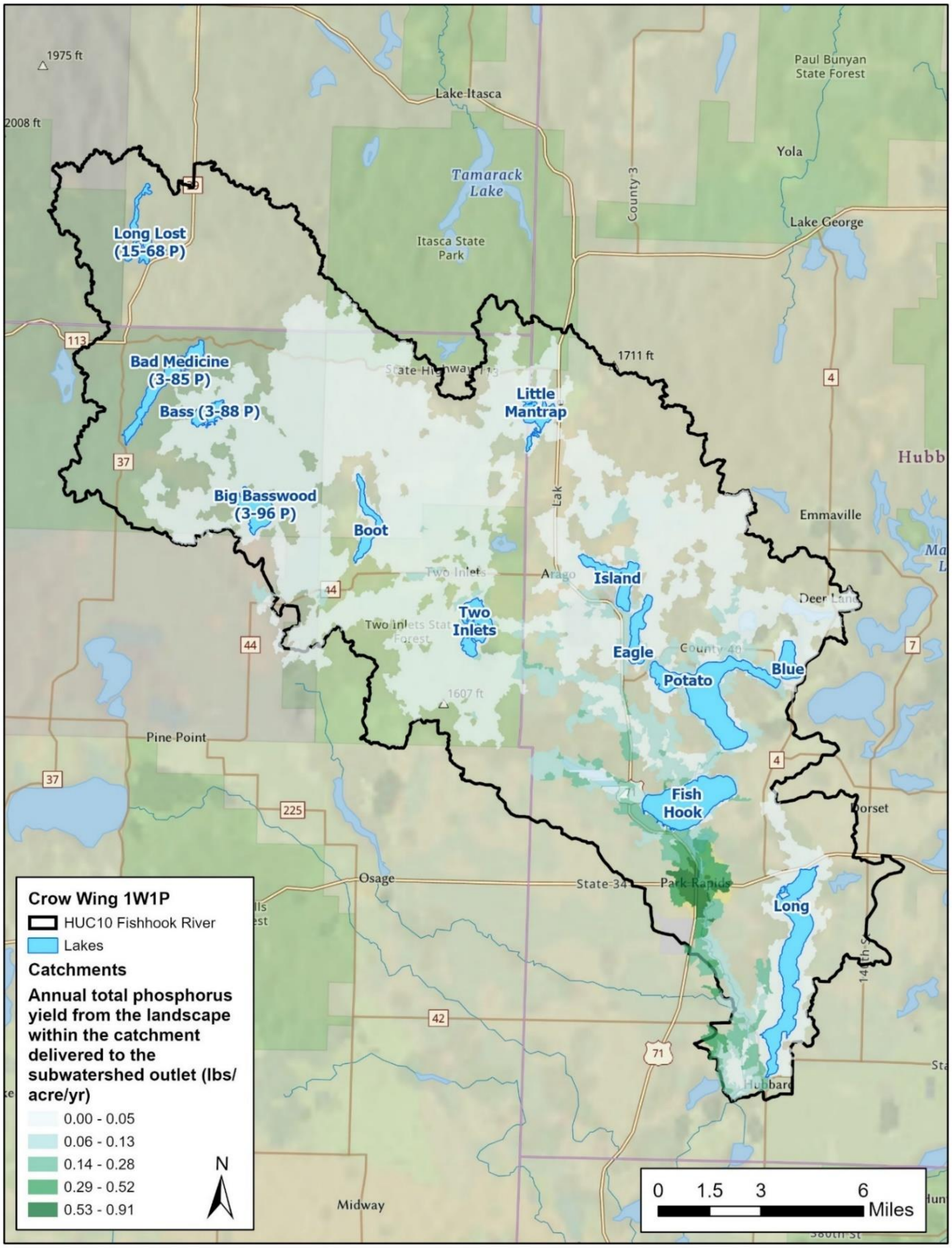


Figure 23. Phosphorus Heatmap for Gull River Subwatershed

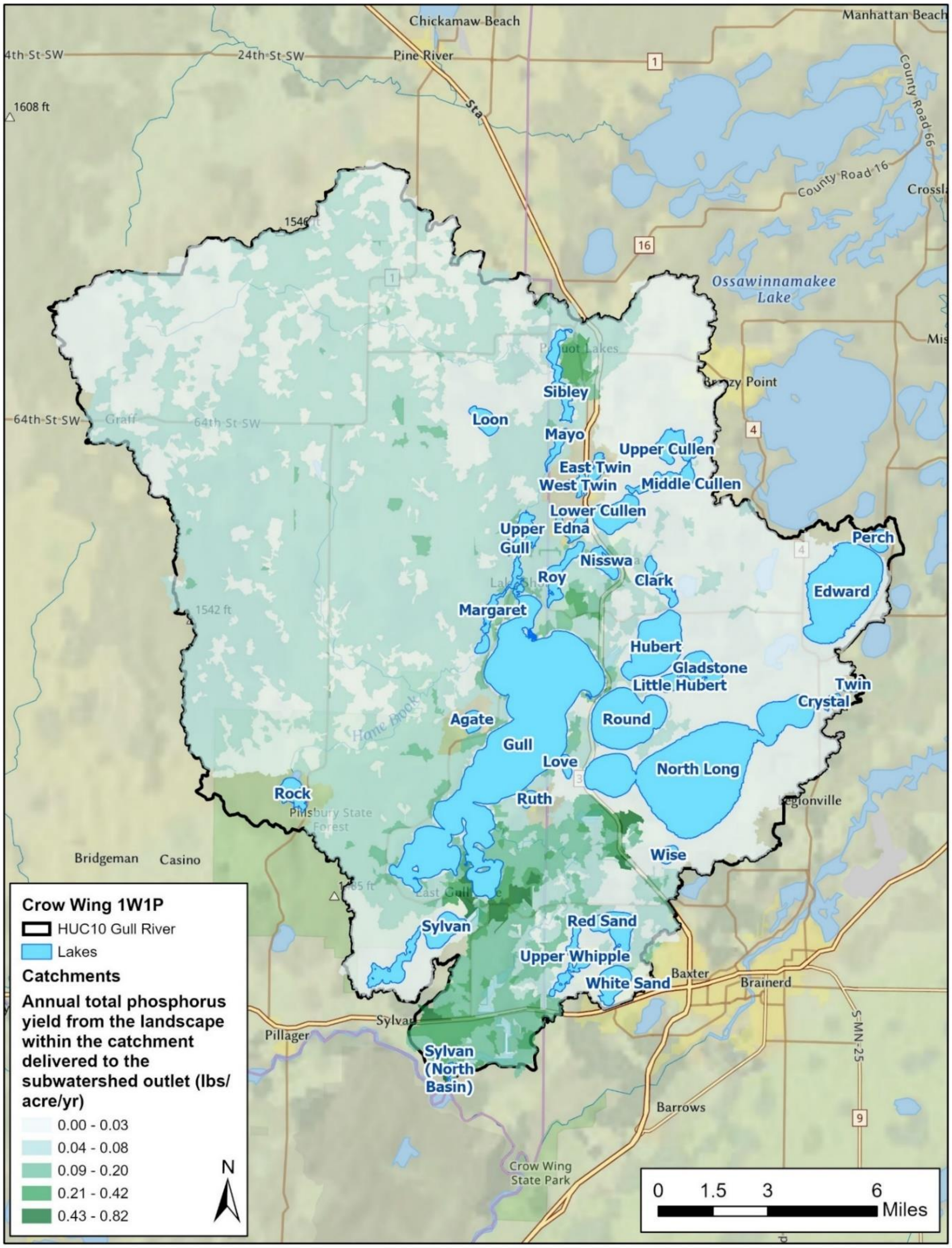


Figure 24. Phosphorus Heatmap for the Headwaters Crow Wing River Subwatershed

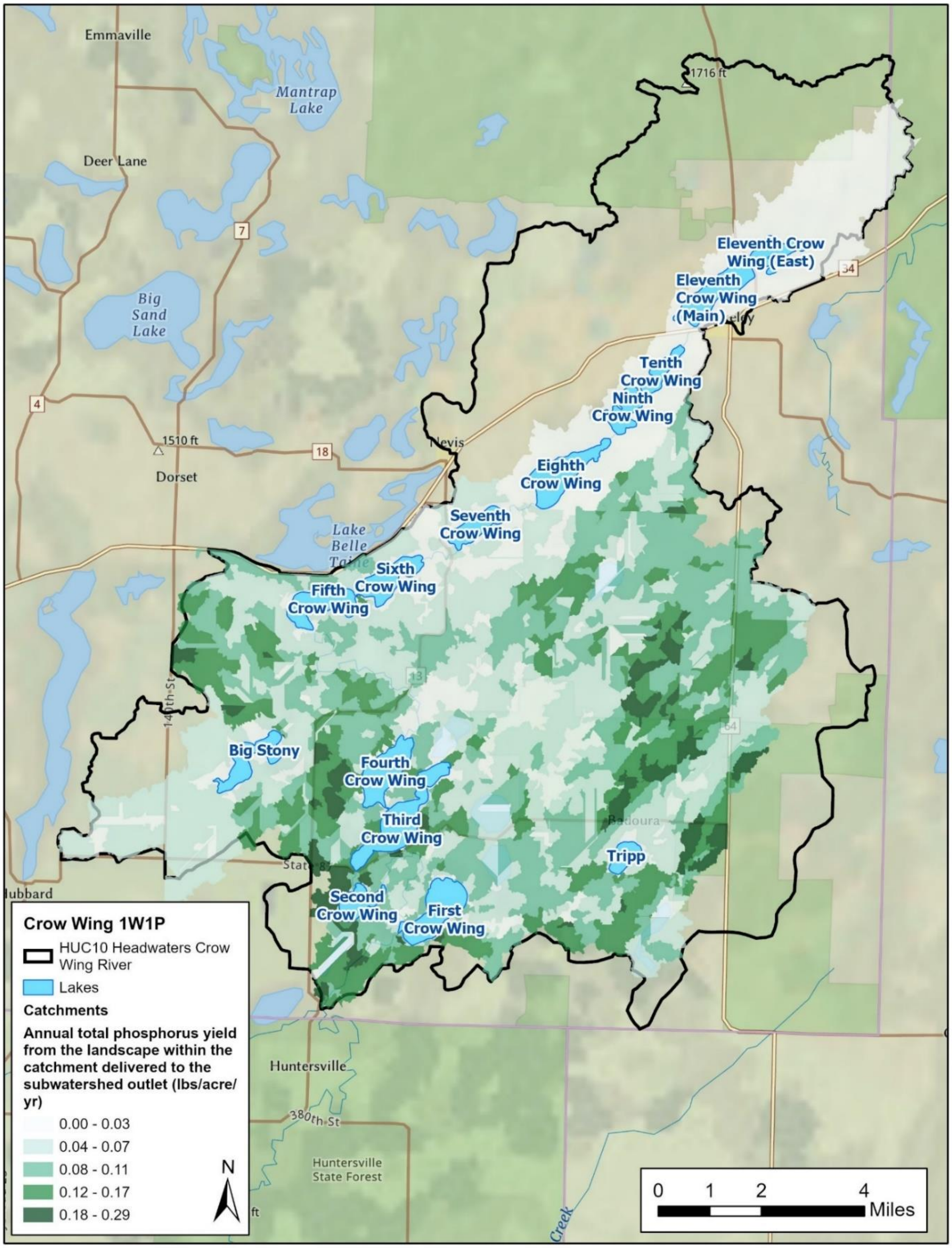


Figure 25. Phosphorus Heatmap for Lake Belle Taine Subwatershed

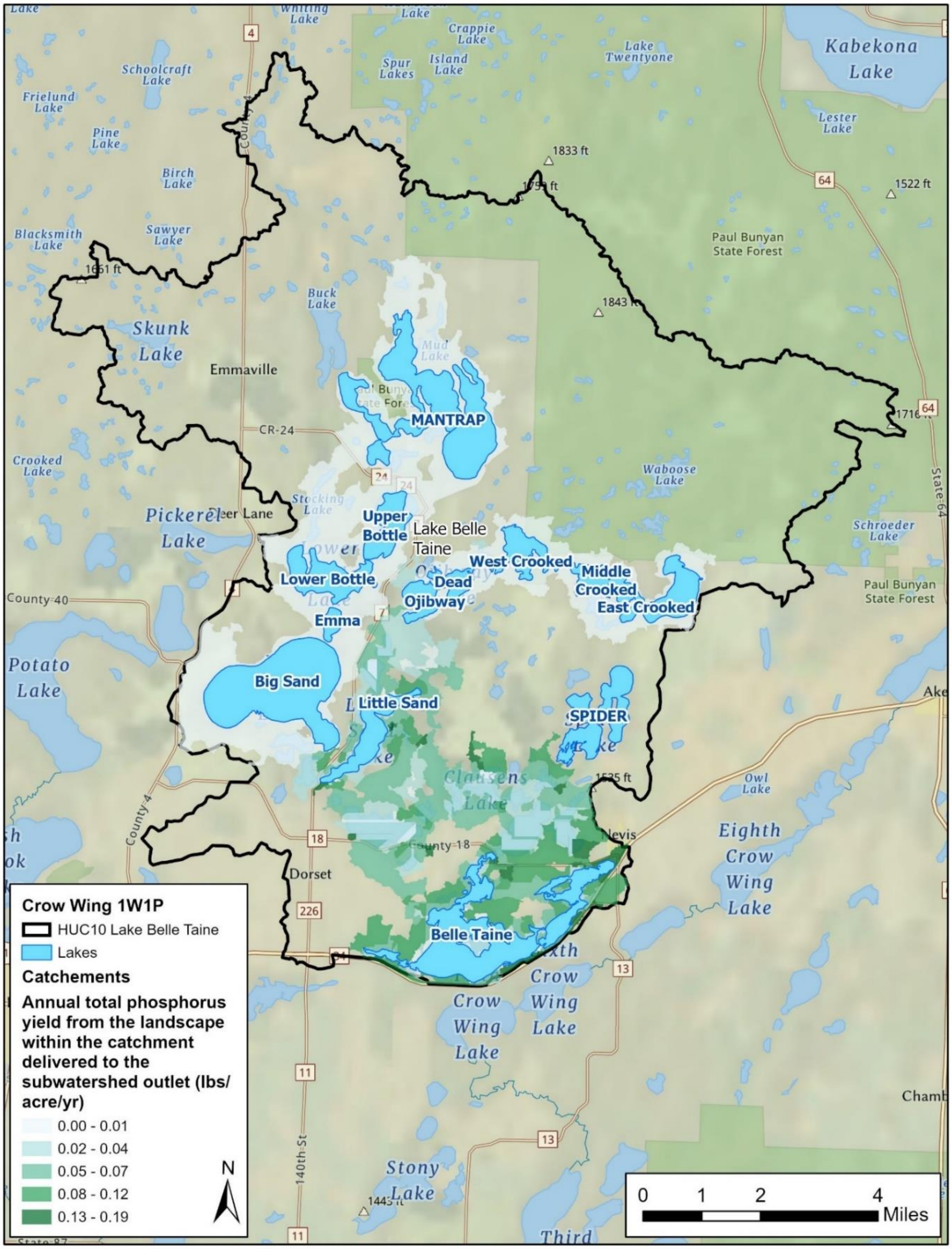


Figure 26. Phosphorus Heatmap for Mayo Lake

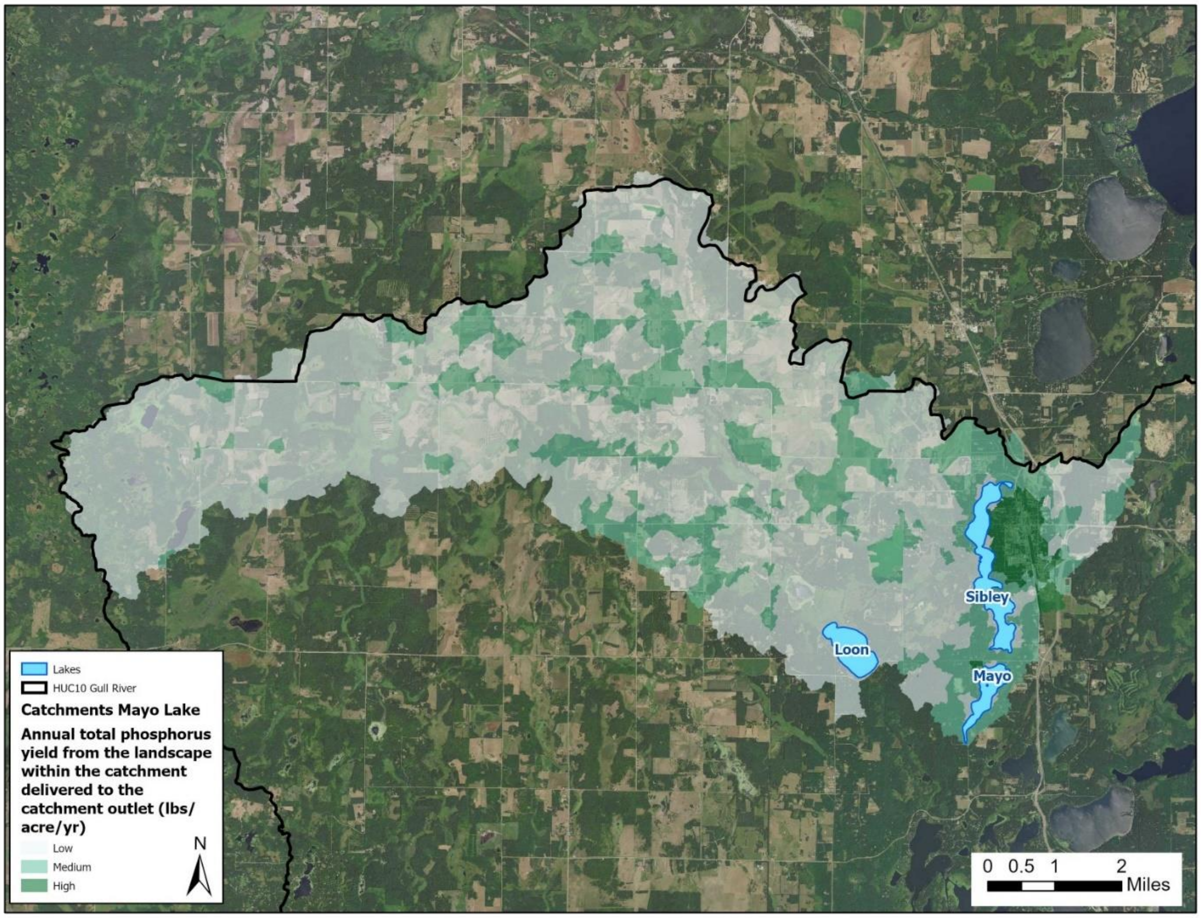


Figure 27. Example of Terrain Analysis for Mayo Lake with SPI=Stream Power Index

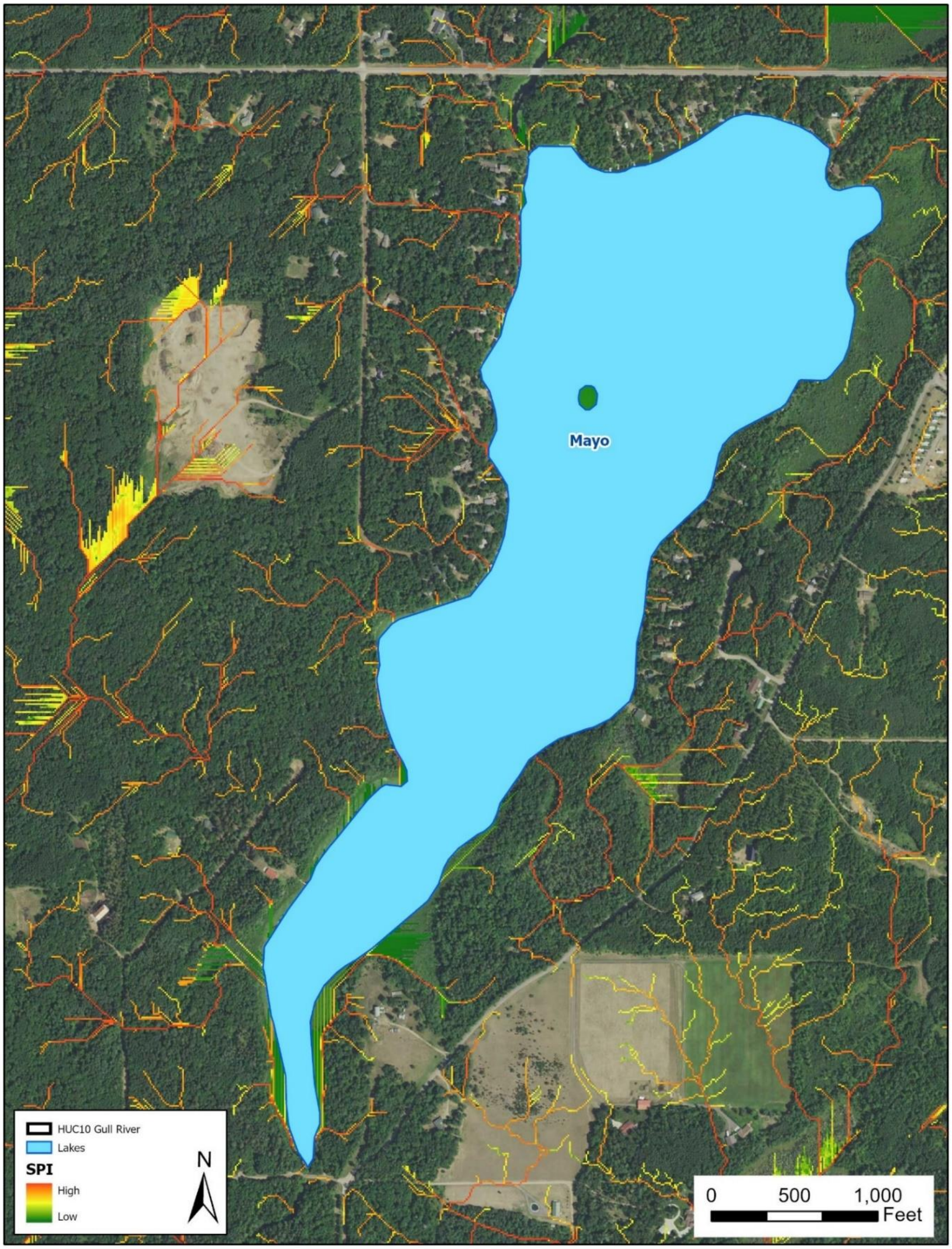


Figure 28. Terrain Analysis with Phosphorus Heatmap for Mayo Lake with SPI = Stream Power Index