WRAPS Report

July 2023

Blue Earth River Watershed Restoration and Protection Strategies Report

MINNESOTA POLLUTION CONTROL AGENCY

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Key Terms and Abbreviations

Altered hydrology: Changes in the amount of and way that water moves through the landscape. Examples of altered hydrology include changes in river flow, precipitation, subsurface drainage, impervious surfaces, wetlands, river paths, vegetation, and soil conditions. These changes can be climate and/or human-caused.

Animal Units (AU): A term typically used in feedlot regulatory language. One AU is roughly equivalent to 1,000 pounds of animal but varies depending on the specific animal.

Aquatic consumption impairment (AqC): Streams are impaired for impacts to AqC when the tissue of fishes from the water body contains unsafe levels of a human-impacting pollutant. The Minnesota Department of Health (MDH) provides safe consumption limits.

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

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

Best management practice (BMP): A BMP is a term used to describe a type of water pollution control. These can be a structural practice that is physically built to capture water and treat pollution, or a management practice used to limit or control pollution, usually at its source.

Biological Impairment: A biological impairment is an impairment to the AqL beneficial use due to a low fish and/or aquatic macroinvertebrate (bug) IBI score.

Designated (or Beneficial) Use: Water bodies are assigned a designated use based on how the water body is used. Typical beneficial uses include drinking, swimming, fishing, fish consumption, agricultural uses, and limited uses. Water quality standards for pollutants or other parameters are developed to determine if water bodies are meeting their designated use.

Flow-weighted Mean Concentration (FWMC): The total mass of a pollutant delivered (by water) over a set period of time by the total volume of water over that same period of time. Typical units are milligrams per liter (mg/L).

Geographic Information Systems (GIS): A GIS is a system designed to capture, store, manipulate, analyze, manage, and present all types of spatial or geographical data.

Hydrologic Simulation Program-Fortran (HSPF): A computer model developed to simulate hydrology and water quality at the watershed scale.

Hydrologic Unit Code (HUC): A HUC is assigned by the United States Geological Survey (USGS) for each watershed. HUCs are organized in a nested hierarchy by size. For example, the Minnesota River Basin is assigned a HUC-04 of 0702 and the Blue Earth River Watershed is assigned a HUC-08 of 07020009.

Impairment: Water bodies are listed as impaired if water quality standards are not met for designated uses including AqL, AqR, and AqC.

Index of Biological 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).

Nonpoint source pollutants: Pollutants that are from diffuse sources; most of these sources are not regulated. Nonpoint sources include agricultural field run-off, agricultural drain tile discharge, storm water from smaller cities and roads, bank, bluff, and ravine failures, atmospheric deposition, failing septic systems, animals, and other sources.

Point source pollutants: Pollutants that can be directly attributed to one location; generally, these sources are regulated by permit. Point sources include wastewater treatment plants, industrial dischargers, storm water discharge from larger cities, and storm water runoff from construction activity (construction storm water permit).

Pollutant: Parameters (e.g., bacteria, total suspended solids, etc.) that have a water quality standard and can be tested for directly. Pollutants affect all beneficial uses.

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.

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).

Stream Class: A classification system for streams to specify the stream's beneficial or designated uses.

Stream Class 2B: The quality of Class 2B surface waters shall be such as to permit the propagation and maintenance of a healthy community of cool or warm water sport or commercial fish and associated AqL and their habitats. These waters shall be suitable for AqR of all kinds, including bathing, for which the waters may be used.

Stream reach: "Reaches in the network are segments of surface water with similar hydrologic characteristics. Reaches are commonly defined by a length of stream between two confluences, or a lake or pond. Each reach is assigned a unique reach number and a flow direction. The length of the reach, the type of reach, and other important information are assigned as attributes to each reach." (USGS 2014d)

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 AqL.

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

Water body Identifier (WID): The unique WID for each river reach comprised of the USGS eight-digit HUC plus a three-character code unique to each individual reach.

Yield (water, pollutant, crop, etc.): The amount of mass, volume, or depth per unit land area (e.g., lbs/ac, in/ac).

Executive Summary

The State of Minnesota uses a "Watershed Approach" to assess and address the water quality of each of the state's 80 major watersheds on a 10-year cycle. This report summarizes the Minnesota Pollution Control Agency's (MPCA) Watershed Approach work findings, addressing the fishable, swimmable status of surface waters in the Blue Earth River Watershed. This work relies on a scientific approach by MPCA staff and a team of local watershed partners (soil and water conservation districts [SWCDs], counties, and other state agencies) to provide local knowledge and understanding of the area's water resource challenges, opportunities, and recommendations to achieve higher adoption of conservation practices within the watershed.

The majority of monitored stream reaches and lakes in the Blue Earth River Watershed are not meeting water quality standards for aquatic life (AqL; fishing, healthy fish populations) and aquatic recreation (AqR; swimming, wading). Several water body pollutants and stressors to the aquatic biology were identified. A source assessment, goals, and 10-year targets were developed for each pollutant and stressor. The pollutants and stressors (Appendix 4.1) along with their goals and 10-year targets are summarized in the Goals Overview (Section 2.2 Table 6) of the document.

Strategies to address the goals and 10-year targets were developed. Strategies Table A (Table 24) provides a high-level narrative estimate of the total changes necessary for all waters to be restored and protected, and Strategies Table B (Table 25) presents a suite of strategies and numeric adoption rates to meet the 10-year targets. With 87% of the watershed in cultivated crops, the largest opportunity for water quality improvement is from this land use. Key strategies include: water storage opportunities, improving soil health with cover crops and reduced tillage, improving manure and fertilizer application, and improving stream riparian habitat.

Priority areas to focus restoration and protection efforts were identified using multiple criteria, along with local input, and are presented in the Priorities Table (Table 26). Identified priorities include: restoring barely impaired waters, protecting waters already supporting beneficial uses, drinking/ground water, and critical wildlife habitat.

The biophysical means to restore and protect the watershed (i.e., the strategies) are fairly well understood. However, the transition to these sustainable practices is limited by social-based challenges. Some social-based challenges such as program inadequacies and undeveloped markets are outside the scope of local conservation staff influence. However, other challenges can be addressed successfully at this local level. Most of the changes that must occur to improve and protect water resources are voluntary; therefore, communities and individuals ultimately hold the power to restore and protect waters in the Blue Earth River Watershed. The Blue Earth River civic engagement process focused on growing community capacity to increase adoption of soil health practices and other key restoration strategies. Targeted audiences included farmer networks, elected officials, lake associations, and women in agriculture groups. A website and Geographic Information Systems (GIS) Story Map were developed to help share water quality and other watershed information with the general public. This work (summary and links in Section 3.2) was integrated into the strategies table and aligned with the citizen-based approach to develop, demonstrate, and spread information about best management practices (BMPs) by trusted leaders within the community.

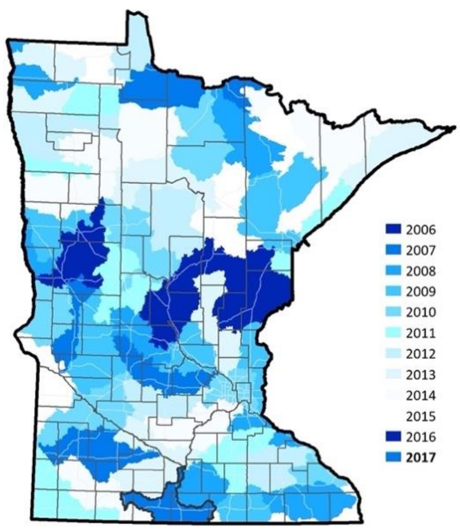
The farming community has been, and continues to be, a vital partner to conservation efforts in the Minnesota River Basin. Reducing sediment and nutrient impacts on water resources is important to Minnesota farmers who innovate and adopt new practices to improve the sustainability of their farms. Continued support from the State, local governments, and farm organizations will be critical to finding and implementing solutions that work for individual farmers and help achieve the goal of clean water.

1. Introduction and Background

1.1 Watershed Approach and WRAPS

The State of Minnesota uses a "Watershed Approach" (MPCA 2015a) to monitor and assess the waters of the state on a watershed basis on a 10-year cycle, and subsequently address the water quality of each of the state's 80 major watersheds. 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 or updated as needed, and conservation practices are implemented. Intensive Watershed Monitoring (IWM) monitoring and assessment work started in the Blue Earth River Watershed in 2017 (Figure 1).

Figure 1: Minnesota's Watershed Approach. Work in the Blue Earth River Watershed (outlined) started in 2017. Watershed Approach work starts in approximately eight major watersheds each year.



Much of the information presented in this Watershed Restoration and Protection Strategies (WRAPS) report was produced in earlier Watershed Approach reports linked below. However, the WRAPS report presents additional data and analyses and works to summarize results into a comprehensive story of and approach to the watershed's surface water quality. To ensure the WRAPS strategies and other analyses appropriately represent the Blue Earth River Watershed, local and state natural resource and conservation professionals (referred to as the WRAPS Local Work Group [LWG]; see group members listed on inside of front cover) were convened to develop civic engagement activities, review and inform the report, and advise on technical analyses.

Two key products of this WRAPS report are the strategies table and the priorities table (Section 3.3 and 3.4), each developed with the WRAPS LWG. The strategies table outlines high-level strategies and estimated adoption rates necessary to restore and protect water bodies in the Blue Earth River Watershed, including social strategies that are key to achieving the physical strategies. The priorities table presents criteria to identify priority areas for water quality improvement, including specific examples of water bodies and areas that meet the prioritizing criteria. Additional tools and data layers that can be used to refine priority areas and target strategies within those priority areas are listed in Appendix 4.4.

The ***scope*** of the report is surface water bodies and their AqL and AqR beneficial uses as currently assessed by the MPCA, including issues relevant to these surface water quality beneficial uses.

The primary ***audience*** for the WRAPS report is local planners and conservation practice implementers who will use the report in local water planning and implementation efforts; the secondary audience may include decision-makers, neighboring downstream states, agricultural business, governmental agencies, and other stakeholders.

This WRAPS is not a regulatory document but is legislatively required per the Clean Water Legacy legislation on WRAPS (ROS 2022). This report is designed to meet these requirements, including an opportunity for public comment, which was provided via a public notice in the State Register from May 8, 2023 through June 7, 2023. The WRAPS report concisely summarizes an extensive amount of information. The reader may want to review the supplementary information provided (links and references in document) to fully understand the summaries and recommendations made within this document.

More background information on the Blue Earth River Watershed can be found at:

Watershed Health Assessment Framework (DNR 2019a)

Blue Earth River Monitoring and Assessment Report (MPCA 2020a)

Blue Earth River Watershed, Climate Summary for Watersheds (DNR 2019b)

Blue Earth River Watershed Characterization Report (DNR 2021)

Blue Earth River Watershed Stressor Identification Report (MPCA 2021a)

1.2 Watershed Description

The Blue Earth River takes its name from the Dakota phrase "Makato Osa Watapa," or "the river where blue earth is gathered." Native peoples gathered the deposits of bluish-green clay that could be found along the banks of the river. The Blue Earth River Watershed drains close to 1,000,000 acres. Approximately 775,000 of the acres are in south central Minnesota including the counties of Blue Earth, Cottonwood, Faribault, Freeborn, Jackson, Martin, and Watonwan (Figure 2). The remaining acres drain parts of northern Iowa.

The landscape is mainly flat in the upper reaches of the watershed where the vast majority of the land use is farmland dominated by warm-season, annual cultivated row crops (Figure 3). The most common crops are field corn and soybeans (Figure 4). The river increases in slope in the “knick zone”, an area that begins near the town of Vernon Center. Here the river falls to meet the elevation of the Minnesota River, which is significantly lower due to past glacial influences. The “knick zone” has been shown to be the major contributor of sediment delivered to the Minnesota River from the Blue Earth River Watershed (Gran 2016).

Another feature of the Blue Earth River Watershed is the Rapidan Dam. Constructed in 1910 for generating electricity, the dam impounds the river 12 miles upstream from its mouth. This impoundment creates a more than 6-mile-long reservoir of 318 acres and contains an estimated 11 million cubic yards of accumulated sediment (Rapidan Dam Removal Feasibility Study). Below the

Rapidan Dam, the river runs through a gorge, which features canyons, waterfalls, limestone cliffs, and rapids.

By volume, the Blue Earth River and its tributary watersheds, the Watonwan and Le Sueur, accounted for 35% of the Minnesota River's flow at the rivers' confluence from 2007 to 2020. It also contributed 61% of the sediment to the Minnesota River for the same time period (MPCA calculation from United States Geological Survey (USGS) and Watershed Pollutant Load Monitoring Network (WPLMN) data).

Topography in the Blue Earth River Watershed (Figure 5) reflects the effects of glaciers and varies from nearly level to gently rolling hills. The soils in the Blue Earth River Watershed are mainly glacial deposits. These soils range from very poorly drained to moderately drained soils and tend to be a mixture of clay, silt, sand, and gravel. Areas of the former glacial lakebed are dominated by poorly drained clay and silt soils. Most of the wet soils have been artificially drained. Prior to development and land use changes beginning in the 1850s, the native vegetation was predominantly tall grass prairie and wetlands.

Nearly 65% of stream reaches in this watershed have been channelized, rerouted, dredged, or otherwise altered from their natural channel condition. Long reaches of unaltered, natural channel stream are almost exclusively limited to higher order streams; nearly all the low order streams and small tributaries in this watershed have been altered in some manner.

Figure 2: The Blue Earth River Watershed. The stream line size in this image is used to indicate the relative average stream flow and stream reaches are labeled by the last three digits of the Watershed Identifier (WID).

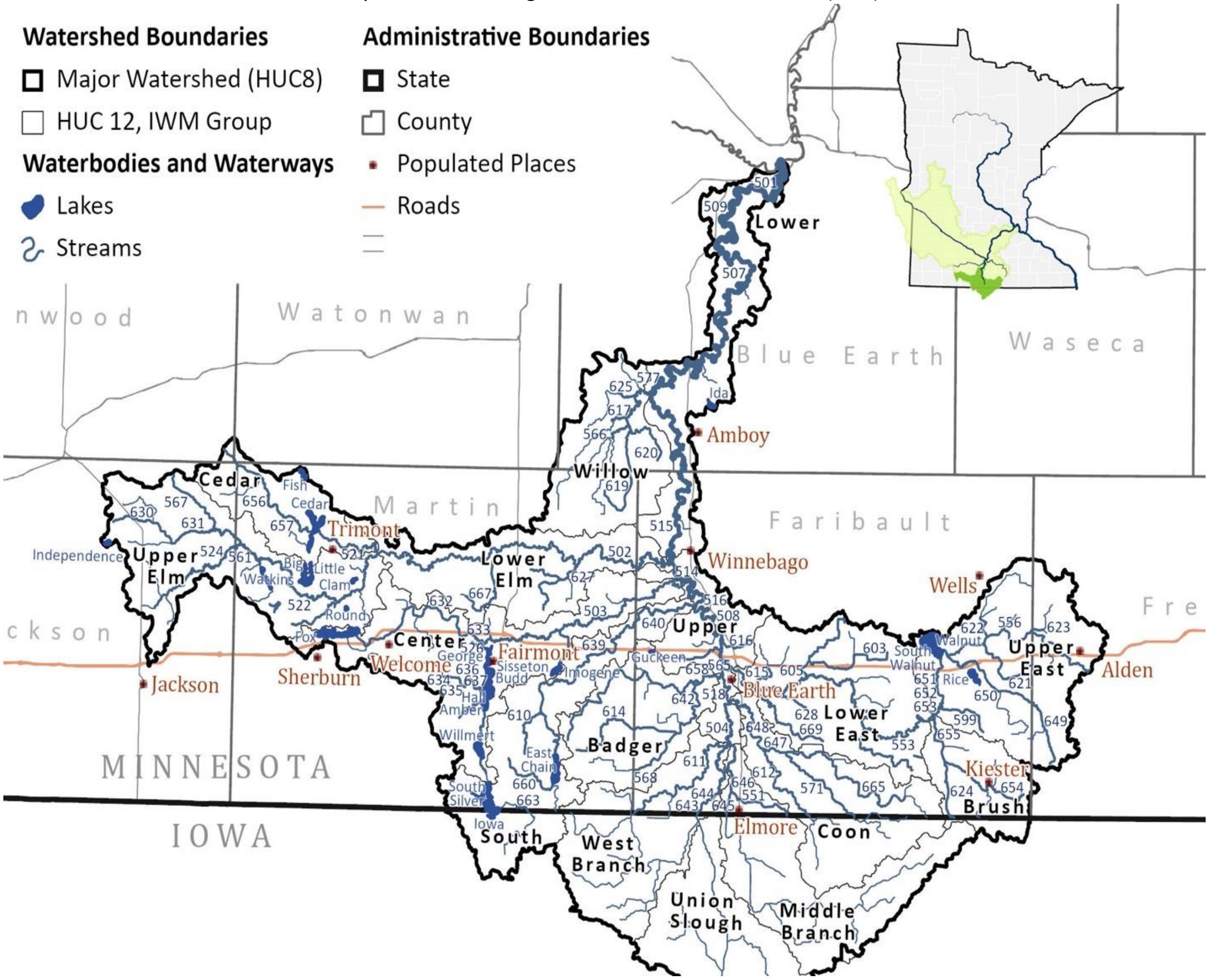


Figure 3: Land use in the Blue Earth River Watershed. Land use is dominated by cultivated crops and the breakdowns are shown in the figure key.

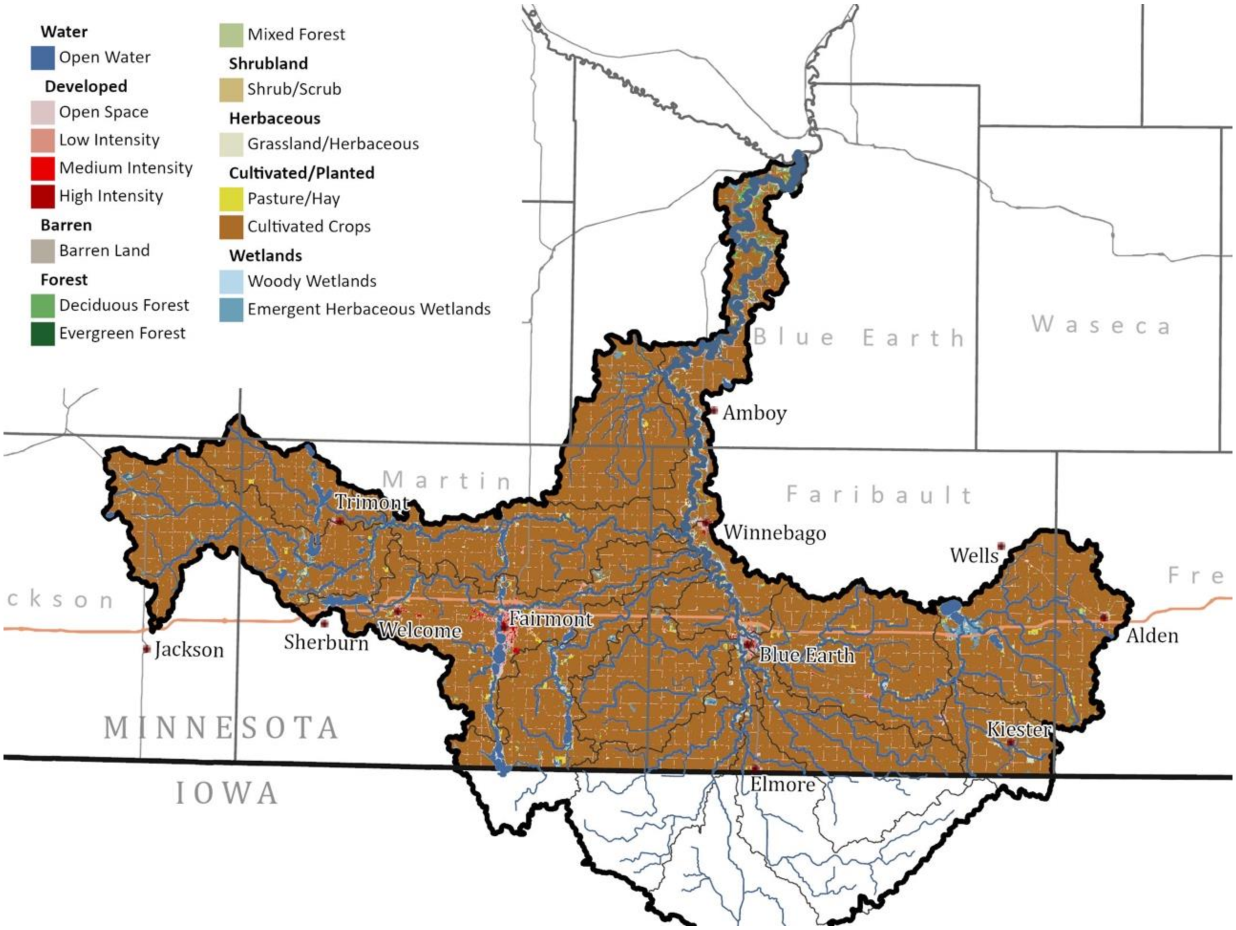


Figure 4: Blue Earth River Watershed cultivated crops. The Blue Earth River Watershed is dominated by cultivated crops, primarily corn and soybeans.

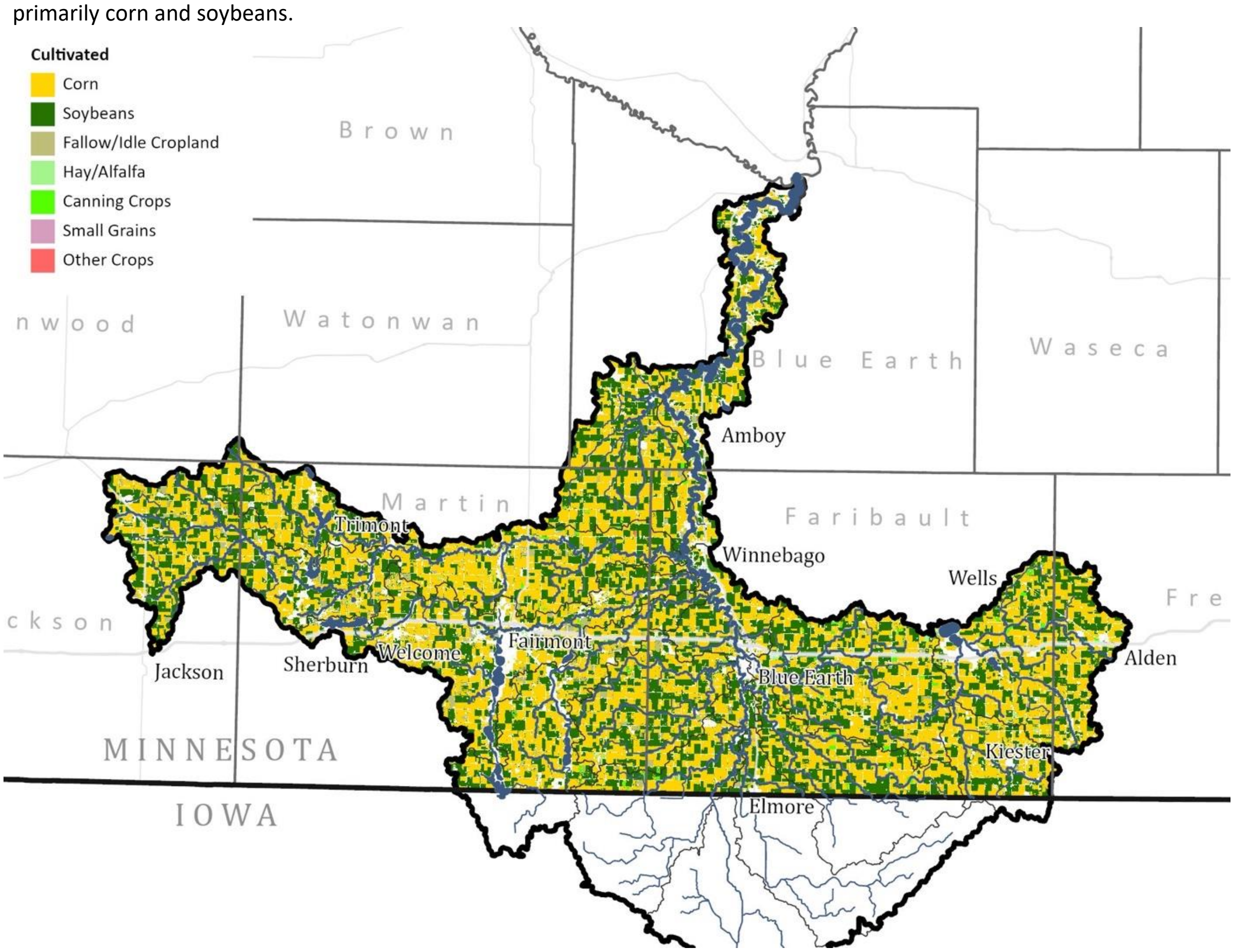
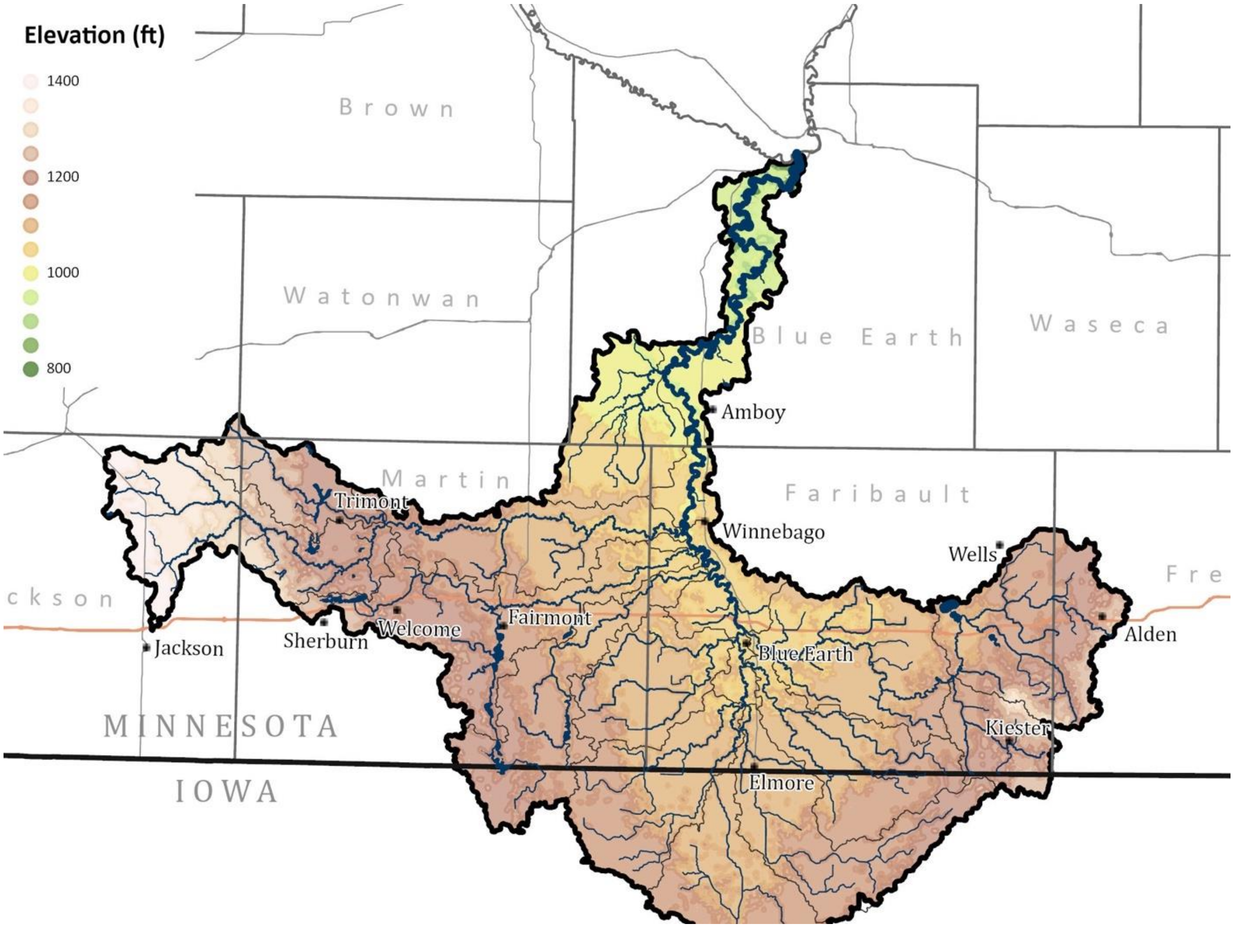


Figure 5: Blue Earth River Watershed elevation. The Blue Earth River Watershed has an elevation change of approximately 725 feet of fall from the upland areas to the outlet at the Minnesota River. Large areas of similar color illustrate flatter areas of the watershed. The drastic change in color near the Minnesota River Valley illustrates the significant drop in elevation from the uplands to the Minnesota River.



1.3 Assessing Water Quality

Assessing water quality is a complex process with many steps including: developing water quality standards, monitoring the water, ensuring the monitoring data set is comprehensive and accurately represents the water, and local professional review. A summary of process steps that were considered is included below.

Water Quality Standards

Water quality is not expected to be as clean as it would be under undisturbed, "natural background" conditions. However, water bodies are expected to support designated (or beneficial) uses including: fishing (AqL), swimming (AqR), and eating fish (aquatic consumption [AqC]). Water quality standards (MPCA 2022a; also referred to as "standards") are set after extensive review of data about the pollutant concentrations that allow support of different designated uses and include natural background conditions.

Water Quality Monitoring and Assessment

To determine if water quality is supporting its designated use, data on the water body are compared to relevant standards. Some commonly monitored parameters include: nitrogen, phosphorus, *Escherichia coli* (*E. coli*) bacteria, and AqL (fish and aquatic macroinvertebrates, referred to simply as bugs for the remainder of the report) populations. When parameters in a water body do not meet the water quality standard, the water body is considered impaired (MPCA 2022b). When parameters in a water body meet the water quality standard, the water body is considered supporting of beneficial uses. If the monitoring data sample size is not robust enough to ensure that the data adequately represent the water body, or if monitoring results are unclear regarding the condition of the water body, an assessment is delayed until further data are collected; this is referred to as inconclusive or insufficient findings.

Several parameters are considered for the assessment of each designated use. For AqR assessment, streams are monitored for bacteria and lakes are monitored for clarity and phosphorus concentrations. For AqL assessment, streams are monitored for both AqL populations and pollutants that are harmful to these populations, and lakes are monitored for AqL (fish populations and habitat). A water body is considered impaired for AqL populations (referred to as “bio-impaired”) when low or imbalanced fish or bug populations are found (as determined by the Index of Biological Integrity [IBI] score).

This WRAPS report summarizes the water quality and monitoring assessment results, but the full report is available at Blue Earth River Watershed Monitoring and Assessment Report (MPCA 2020a).

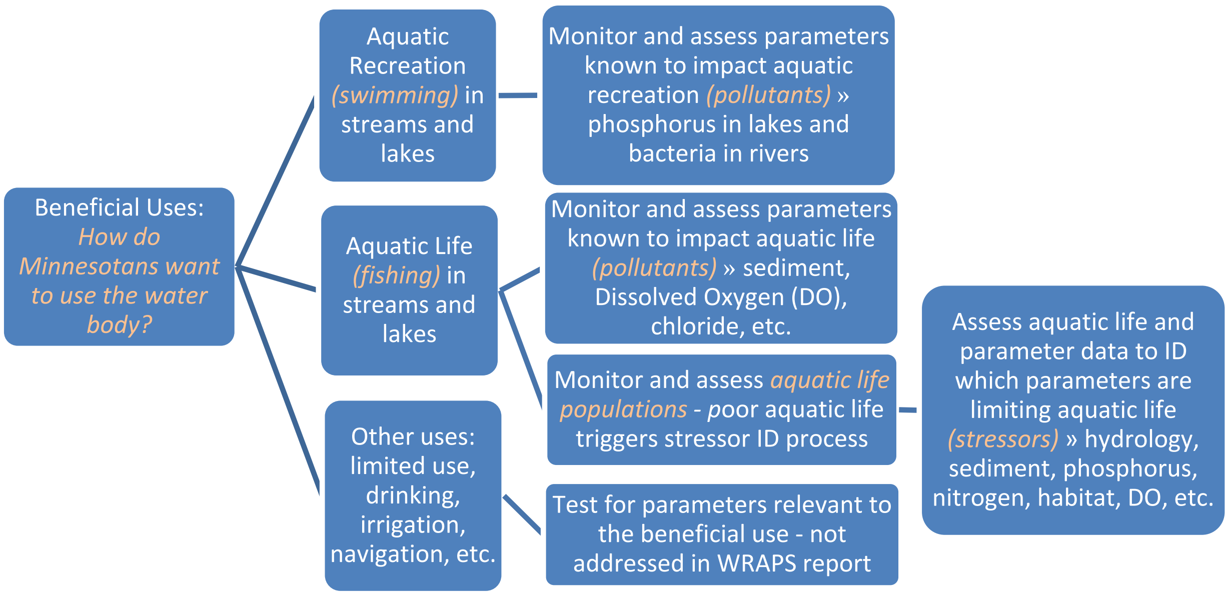
Stressor Identification

When streams are found to be bio-impaired, the cause of bio-impairment is studied and identified in a process called stressor identification (SID). SID identifies the parameters negatively impacting the AqL populations, referred to as “stressors”. Stressors can be pollutants like nitrate or sediment, or can be non-pollutants, like degraded habitat or high flow. 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 SID results but the full report is available at Blue Earth River Watershed Stressor ID (MPCA 2021a).

Summary of Beneficial Uses, Pollutants, and Stressors

Pollutants and stressors both affect beneficial uses and must be addressed to bring waters to a supporting status. Pollutants and stressors are identified through different processes. Pollutants are tested for directly and compared to the water quality standards. Stressors are assessed when AqL populations are determined to be impaired using the IBI score. The SID process is used to determine which parameters are impacting AqL populations. Often pollutants and stressors can be complex and interconnected. Furthermore, an identified stressor can be more of an effect than a cause, and will therefore have additional stressors and/or sources driving the problem. The difference between a pollutant and a stressor and a brief summary of how pollutants and stressors are identified is illustrated in Figure 6.

Figure 6: The process for identifying pollutants and stressors.



Monitoring Plan

Data from three water quality monitoring programs enable water quality assessment and create a long-term data set to track progress towards water quality goals. These programs will continue to collect and analyze data in the Blue Earth River Watershed as part of Minnesota's Water Quality Monitoring Strategy (MPCA 2021b). Data needs are considered by each program and additional monitoring is implemented when deemed necessary and feasible. Combined, these programs collect data at dozens of locations around the watershed (Figure 7). The parameters collected at each monitoring site can vary. These monitoring programs are summarized below.

Intensive Watershed Monitoring (IWM; MPCA 2012): Through the State of Minnesota's Watershed Approach, the MPCA collects water quality and biological data for two years every 10 years at established stream and lake monitoring stations within every major watershed in the State. The first round of IWM for the Blue Earth River Watershed was completed in 2017 and 2018. In addition to the chemistry and biological monitoring completed by the MPCA, water chemistry monitoring was completed through a Surface Water Assessment Grant (SWAG) with local partners. Lake samples were collected from June through September for both years. Stream samples were collected May through September in 2017 and June through August in 2018. These efforts are summarized in the Blue Earth River Watershed Monitoring and Assessment Report (MPCA 2020a).

The second cycle of monitoring and assessment will start in 2028. The MPCA, with assistance from LGUs, will re-visit and re-assess some of the cycle 1 monitoring stations, as well as consider monitoring new sites with demonstrated local or state importance. It is expected that funding for monitoring and analysis will be available through the MPCA, from the state Clean Water Fund.

Watershed Pollutant Load Monitoring Network (WPLMN; MPCA 2015b): The WPLMN, which includes state and federal agencies, Metropolitan Council Environmental Services, state universities, and local partners, collects data on water quality and flow in Minnesota to calculate pollutant loads in rivers and streams. Data are collected at 199 sites around the state. Each year, approximately 25 to 35 water quality samples are collected at each monitoring site, either year-round or seasonally, depending on the site. Water quality samples are collected near flow gaging stations, and typically analyzed for total suspended solids (TSS), total phosphorus (TP), nitrate-nitrogen (NO_3-N), Total Kjeldahl nitrogen (TKN), and dissolved orthophosphate (PO4). Samples are collected more frequently when water flow is moderate and high, when pollutant levels are typically elevated. Pollutant concentrations are generally more stable when water flows are low, and fewer samples are taken in those conditions. This staggered approach generally results in samples collected over the entire range of flows.

Data collected through WPLMN are used to assist in watershed modeling, determine pollutant source contributions, evaluate trends, develop reports, and measure water quality restoration efforts. In the Blue Earth River Watershed, four sites are used to collect data for the WPLMN program. An annual site collects data below the Rapidan Dam. Three seasonal sites collect data on the main stem of the Blue Earth River near the city of Winnebago and near the city of Blue Earth, and on the East Branch Blue Earth River near the city of Blue Earth.

The MPCA's Volunteer Water Monitoring Program (MPCA 2015c) relies on a network of volunteers who take stream and lake measurements regularly, with the data reported annually. Data collected through these efforts can provide a continuous record of water body transparency throughout much of the state. Volunteers monitor 9 lake and 13 stream locations within the Blue Earth River Watershed. Volunteer data are not as rigorous but can provide an excellent long-term data set.

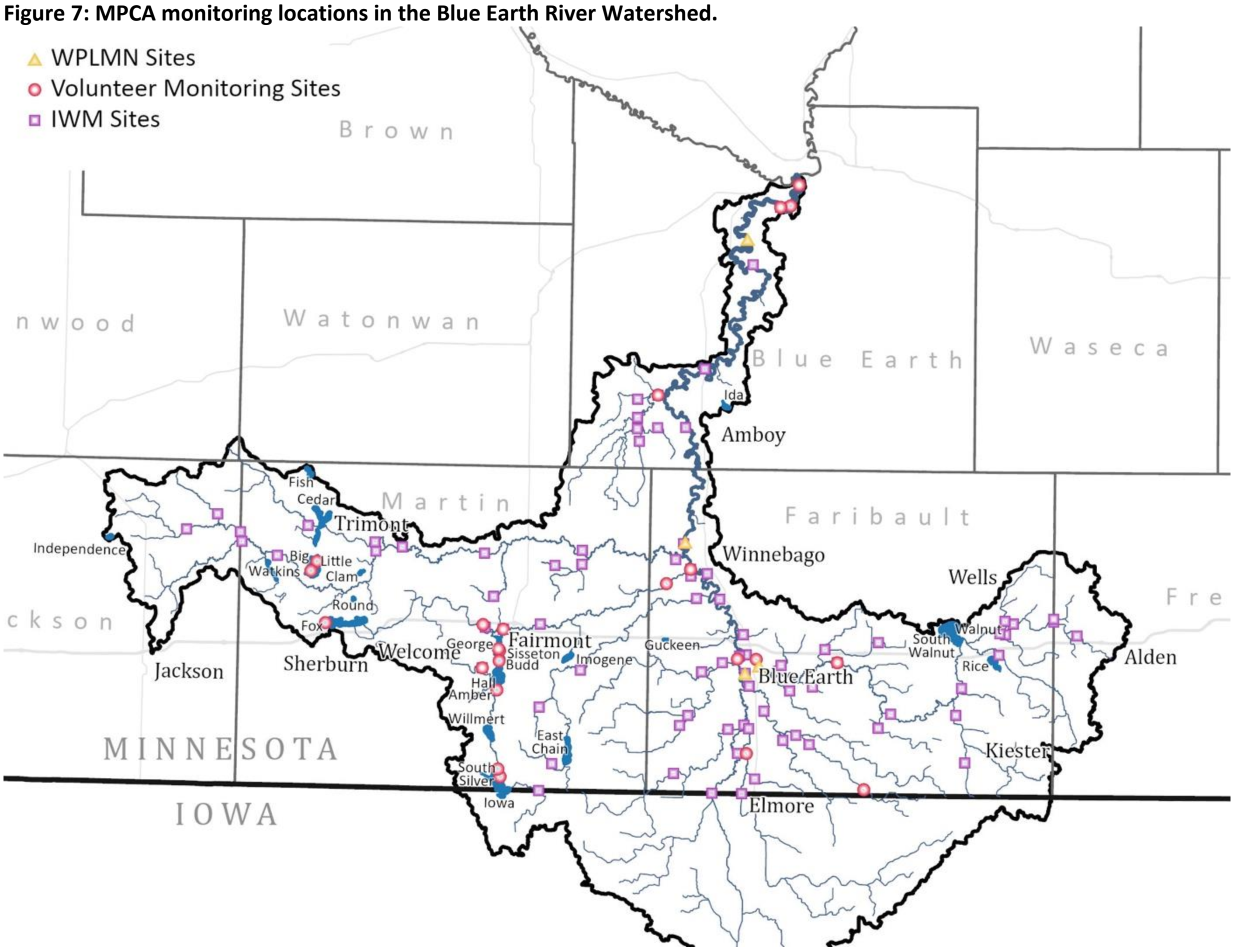
Other monitoring activities include:

The Minnesota Department of Agriculture (MDA) conducts MDA's pesticide water quality monitoring in groundwater and surface water with a variety of cooperators to analyze water for up to approximately 180 different pesticide compounds. The purpose is to determine the presence and concentration of pesticides and present long-term trend analysis. From 1991 to 2021, the MDA has collected over 600 pesticide water quality samples from eleven river and stream locations in the Blue Earth River Watershed.

The Minnesota Department of Natural Resources (DNR) and MPCA cooperatively support monitoring by MDA and Martin SWCD at two stations: Dutch Creek near Fairmont and Elm Creek near Huntley. Data collection includes pesticides in addition to more conventional water quality parameters. MDA monitoring reports are available on their website: MDA Water Monitoring Reports and Resources.

Discharges from permitted municipal and industrial wastewater sources are reported through discharge monitoring records; these records are used to evaluate compliance with National Pollutant Discharge Elimination System/State Disposal System (NPDES/SDS) permits. Summaries of discharge monitoring records are available through the MPCA Wastewater Data Browser.

Figure 7: MPCA monitoring locations in the Blue Earth River Watershed.



Implementation Tracking

Implementation tracking of BMPs is conducted by both BWSR (i.e., eLINK) and the United States Department of Agriculture. Both agencies track the locations of the BMP installations. Tillage transects and crop residue data are collected periodically and reported through the Minnesota Tillage Transect Survey Data Center. BMP tracking information is readily available through the MPCA's Healthier Watersheds webpage.

Computer Modeling

With the Watershed Approach, monitoring for pollutants and stressors is generally extensive, but not every stream or lake in the state 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, and soil type to estimate flow, sediment, and nutrient conditions within the watershed. Building a Picture of a Watershed (MPCA 2014a) explains the model's uses and development. Information on the HSPF development, calibration, and validation in the Blue Earth River Watershed are available in Model Resegmentation and Extension for Minnesota River Watershed Model (RESPEC 2014a), and Hydrology and Water-Quality Calibration and Validation of Minnesota River Watershed Model Applications (RESPEC 2014b). The Blue Earth River Watershed HSPF modeling was recalibrated to include the most recent data collected and now covers the time period 1996 through 2017. Loading information from this update was included in the sources work and is available upon request.

HSPF model output provides a reasonable estimate of pollutant concentrations across the watershed. The output can be used for source assessment, total maximum daily load (TMDL) calculations, and prioritizing and targeting conservation efforts. However, these modeled data are not used for impairment assessments since monitoring data are required for those assessments. Modeled pollutant concentrations are presented in Section 2.3 within the Sources subsection for each pollutant; modeled yields are presented in Appendix 4.4 under HSPF Yield Maps, and modeled landscape and practice changes (referred to as scenarios) are summarized in Section 3.1 and detailed in Appendix 4.4.

2. Water Quality Conditions

Water quality condition refers to a characterization of water bodies' ability to support fishable and swimmable water quality standards. This section summarizes condition information including water quality data and associated impairments. For water bodies not able to support fishable, swimmable standards, the pollutants and/or stressors causing these poor conditions are identified. This report covers only impairments to AqR and AqL. Several lakes and stream reaches are impaired for AqC with information available at the links below.

2.1 Conditions Overview

This section provides a general overview of watershed conditions and basic information to orient the reader to Section 2.2, where the status, sources, and goals are presented for each of the identified pollutants and stressors.

More information on the conditions of the Blue Earth River Watershed can be found at:

Blue Earth River Monitoring and Assessment Report (MPCA 2020a)

Blue Earth River Watershed Stressor ID (MPCA 2021a)

Blue Earth River Watershed Characterization Report (DNR 2021)

Watershed Health Assessment Framework (DNR 2019a)

Environmental Data Application (MPCA 2015d)

State-wide Mercury TMDL (MPCA 2015e)

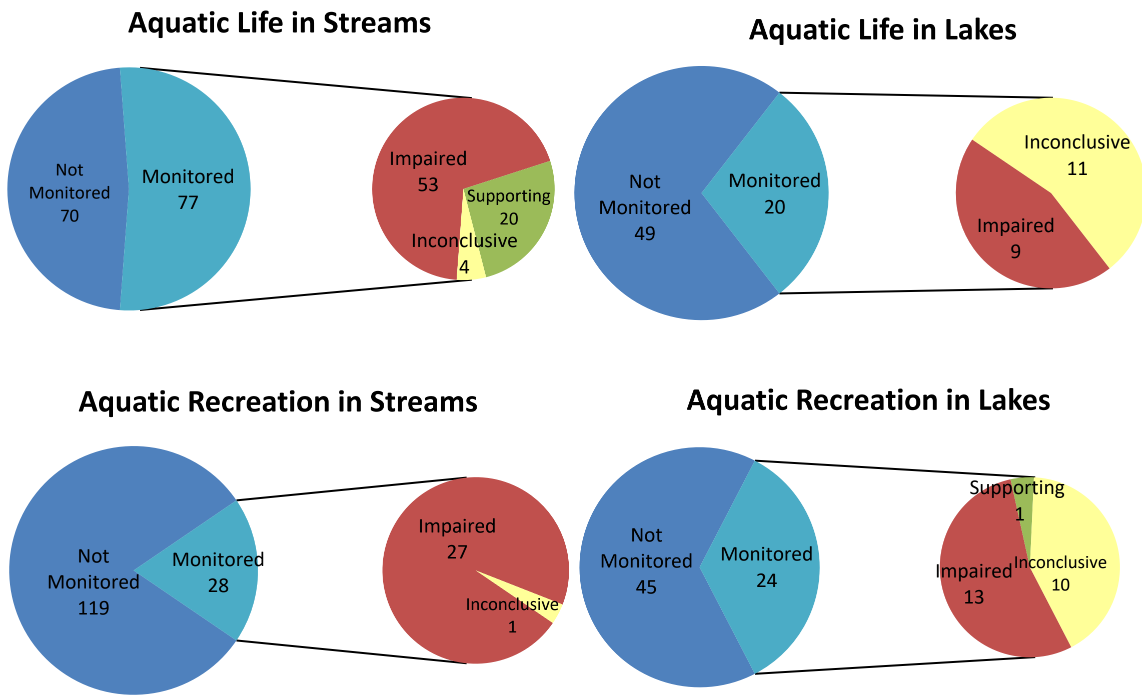
Fish Consumption Guidance (MDH 2019)

Blue Earth River Watershed, Climate Summary for Watersheds (DNR 2019b)

Status Overview

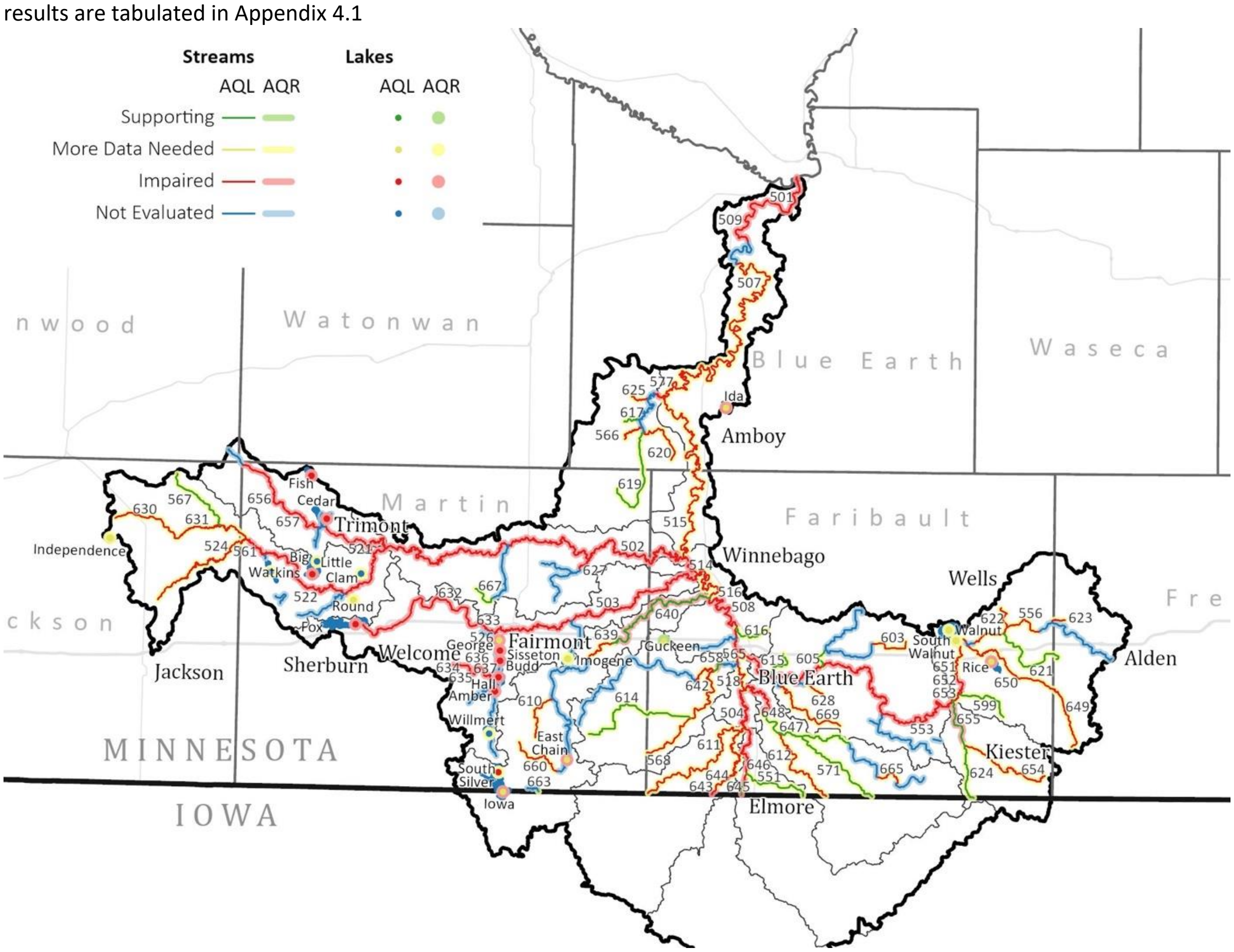
Of the 147 stream reaches in the Blue Earth River Watershed, monitoring was conducted in 2017 and 2018 on 77 reaches for AqL (fish and bugs) and 28 reaches for AqR (swimming). Of the 69 assessable lakes (generally publicly accessible lakes over 100 acres), monitoring was conducted on 20 lakes for AqL and 24 lakes for AqR. Generally, a large percentage of the water bodies were found to be impaired or the assessment results were inconclusive. A breakdown of the total number of water bodies, the monitored water bodies, and the assessment results are presented in Figure 8. See Appendix 4.1 for a comprehensive table of monitoring and assessment results by stream reach.

Figure 8: Aquatic life and recreation impairments in lakes and streams in the Blue Earth River Watershed.



Many of the monitored stream reaches and lakes have impaired AqR and/or AqL as illustrated in Figure 9 (red). In the Blue Earth River Watershed, 19 assessed stream reaches are fully supporting AqL; no assessed stream reaches are supporting AqR; no assessed lakes are supporting AqL; and 1 assessed lake is supporting AqR (Figure 9, green). Several reaches and lakes need more data to make a scientifically conclusive finding (Figure 9, yellow). The full accounting of specific pollutants and/or stressors that are causing the impairments by individual reach is provided in Appendix 4.1 and are discussed in Section 2.2.

Figure 9: Impairment status of streams in the Blue Earth River Watershed. In this image, the inside line color indicates the AqL assessment, and the outside line color indicates the AqR assessment. Lake assessment results are indicated by circles, where the inside circle color indicates AqL assessment, and the outside circle color indicates the AqR assessment. These results are tabulated in Appendix 4.1



Trends Overview

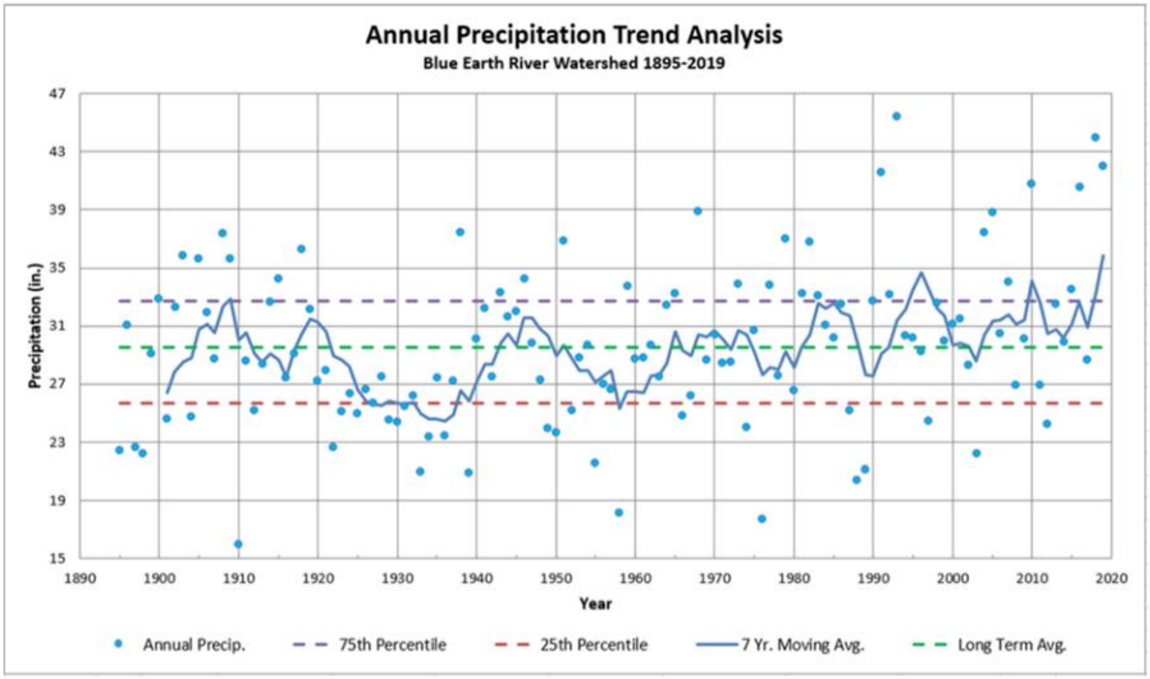
Since European settlement of the Blue Earth River Watershed, a substantial amount of change has occurred across the landscape with land use, farming practices, and human populations. Water quality trends (QWTREND, Seasonal Kendall) calculated in the Minnesota River Basin are discussed in the Minnesota River Basin Trends Report (MSU 2009). While this is an older report, the information focuses on the history, land use, demographics and agricultural practices that are still relevant in the Blue Earth River Watershed and its water quality.

Statistical trends in stream and lake water quality can be difficult to identify because substantial data sets are required for trend analysis. Furthermore, year-to-year climatic variability can obscure gradual trends.

Precipitation

Average annual precipitation from 1895 through 2019 for the Blue Earth River Watershed was 29.52 inches, with 75th and 25th percentile values of 32.75 inches and 25.66 inches, respectively (Figure 10). Average annual precipitation from 1895 through 1990 was 28.54 inches, and 32.78 inches from 1991 through 2019. The two periods represent a significant breakpoint in the relationship between precipitation and streamflow in the watershed. Since the 1991 breakpoint, only seven years have recorded below average annual rainfall totals. In recent decades, increasing precipitation trends coupled with land use changes that often expedite the timing and increase the magnitude of runoff have led to increasing streamflow trends (DNR 2021).

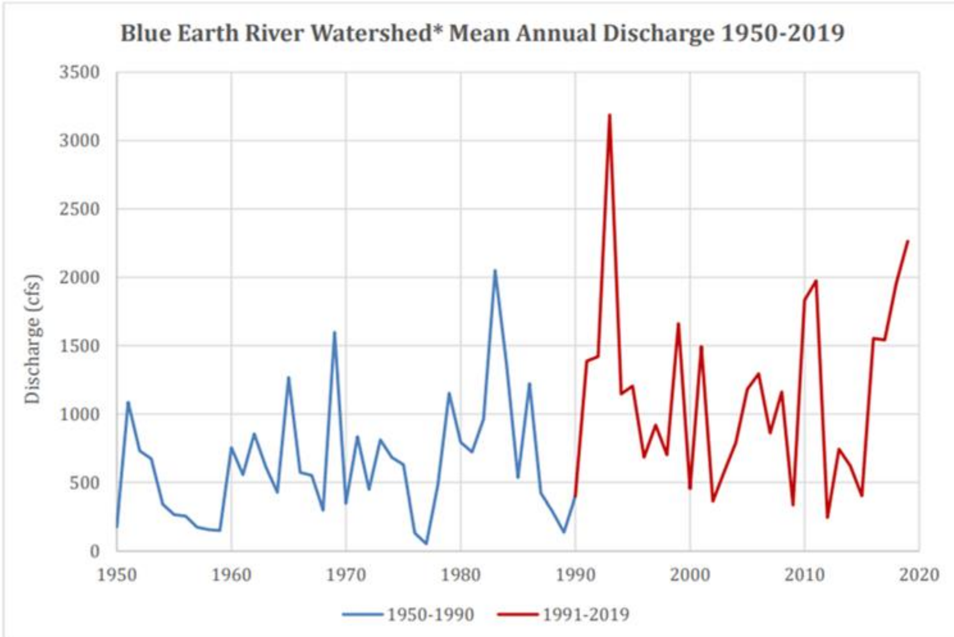
Figure 10: Precipitation trend analysis for the Blue Earth River Watershed. Annual precipitation totals with a seven-year moving average line and 25th, 50th, and 75th percentile lines (DNR 2021).



Streamflow

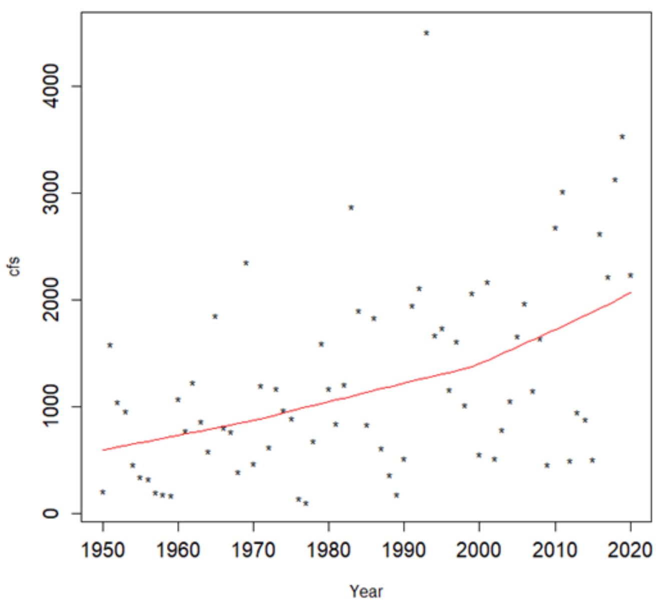
Long term mean annual flow data from USGS water data was reviewed and provided annual flow data starting in 1950. Mean annual discharge from 1950 through 2019 for the Blue Earth River Watershed was 856 cubic feet per second (cfs); mean annual discharge for 1950 through 1990 and 1991 through 2019 was 634 cfs and 1170 cfs, respectively—an increase of nearly 85%. All but 8 years were below the long-term average streamflow in the 1950 through 1990 time period, while 16 years from 1991 through 2019 were above average, most notably 1993, the highest average discharge year at 3,187 cfs (Figure 11) (DNR 2021).

Figure 11: Annual discharge analysis for the Blue Earth River Watershed 1950-2019. * Accounts for approximately 99% of the Blue Earth River Watershed covered under the USGS stream gage (05320000) station.



Utilizing data finalized through 2020, a trend analysis on mean annual flow data was completed for the 1950 through 2020 time period and there was found an increasing trend (Figure 12).

Figure 12: Mean annual flow for the Blue Earth River near Rapidan.



Utilizing the TSS, TP, and NO_3-N data from the WPLMN, two statistical analyses were completed for the Blue Earth River Watershed. Flow-corrected methods are designed to assess if human changes (e.g., implementation activities) on the land for a certain time period, in this case several years prior to the 2008 through 2019 time period, have had an impact on water quality or whether the change was caused by variability in precipitation and river flow. These flow-corrected methods can be interpreted as changes that would occur if flow had been the same year after year. A flow-corrected and nonflow-corrected analysis was performed by the MPCA using the Seasonal Kendall Test for trends with a confidence interval of 90%. The Seasonal Kendall is a nonparametric test that is robust to outliers, missing values, and values less than detection limits. The test can account for seasonal differences and is commonly used to analyze water quality trends (MPCA 2014e). The flow-corrected analysis showed no significant trend in the concentration data from 2008 to 2019 (Table 1), the period for which finalized data was available. The trend analysis will be updated each year as new water quality and flow information becomes available.

Table 1: Flow-corrected concentration trends from the WPLMN.

Flow-corrected trends WPLMN 2008-2019		
Stream Reach	Parameter	Significance
Blue Earth River nr Rapidan, MN	TN	Significance (Confidence Interval 90%)-> NO SIGNIFICANT TREND
Blue Earth River nr Rapidan, MN	TP	Significance (Confidence Interval 90%)-> NO SIGNIFICANT TREND
Blue Earth River nr Rapidan, MN	TSS	Significance (Confidence Interval 90%)-> NO SIGNIFICANT TREND

The nonflow-corrected concentrations show different results because precipitation and associated river flow have been increasing in the Blue Earth River Watershed since the 1950s with an inflection point around 2000. While concentrations do not appear to have an increasing trend in the flow-corrected analysis, nonflow-corrected analysis shows a significant increase with a confidence interval of 90% in concentrations for all parameters (Table 2). While the overall condition of water quality in the Blue Earth River Watershed is driven by land use changes, the results of the analysis for the three pollutants during the 2008 through 2019 time period have been driven largely by flow.

Table 2: Nonflow-corrected concentration trend assessment from the WPLMN.

Non flow-corrected trends WPLMN 2008-2019		
Stream Reach	Parameter	Significance
Blue Earth River nr Rapidan, MN	TN	Significance (Confidence Interval 90%)-> SIGNIFICANT INCREASING
Blue Earth River nr Rapidan, MN	TP	Significance (Confidence Interval 90%)-> SIGNIFICANT INCREASING
Blue Earth River nr Rapidan, MN	TSS	Significance (Confidence Interval 90%)-> SIGNIFICANT INCREASING

Pollutant Loads

Pollutant concentrations are direct measures of water quality that can indicate the probability of algae blooms, the health of the water for fish and other AqL, and the suitability of water for drinking. Pollutant loads describe the amount of nutrients moving downstream over a given period of time. Loads are a combination of concentration and river flow (River Nutrient Trends in Minnesota; MPCA 2020b). As seen in the Blue Earth River Watershed, while flow corrected concentrations have not statistically changed during the period of record, the increase in flow has produced an increase in pollutant load from the watershed.

Water Clarity

Water clarity measurements have been collected at different reaches in the Blue Earth River Watershed through the Volunteer Stream Monitoring Program and the Watershed Approach process. For streams, a seasonal Mann-Kendall test with a 95% confidence interval analysis was completed. Individual sites by reach and their trends are included in Table 3. In general streams in the upper reaches have been showing no trend or an improving trend while the outlet reach of the Blue Earth River has shown a degrading trend. This information can be used to identify areas to focus implementation efforts where a degrading trend is detected and determine what efforts have been taken in improving reaches for potential delisting opportunities.

Table 3: Stream transparency trends by reach in the Blue Earth River Watershed.

Transparency Trend Analysis for Blue Earth Reaches				
HUC	Water Body Name	Station ID	Years	Trend
7020009-501	Blue Earth River: Le Sueur R to Minnesota R	S000-134	1997-2013	Improving
7020009-501	Blue Earth River: Le Sueur R to Minnesota R	S005-389	2008-2020	Degrading
7020009-501	Blue Earth River: Le Sueur R to Minnesota R	S005-460	2008-2018	Degrading
7020009-502	Elm Creek: Cedar Cr to Blue Earth R	S003-025	2004-2020	Improving
7020009-503	Center Creek: Lily Cr to Blue Earth R	S000-291	1997-2009	Improving
7020009-503	Center Creek: Lily Cr to Blue Earth R	S006-073	2009-2019	No trend
7020009-507	Blue Earth River: Willow Cr to Watonwan R	S001-327	1999-2011	No trend
7020009-509	Blue Earth River: Rapidan Dam to Le Sueur R	S005-379	2004-2020	No trend
7020009-514	Blue Earth River: Center Cr to Elm Cr	S000-523	1999-2020	Degrading
7020009-515	Blue Earth River: Elm Cr to Willow Cr	S000-522	1998-2020	No trend
7020009-518	Blue Earth River: Coon Cr to Badger Cr	S003-378	2004-2020	Improving
7020009-521	Cedar Creek (Cedar Run Creek): Cedar Lk to Elm Cr	S000-671	2000-2019	No trend
7020009-522	Elm Creek: S Fk Elm Cr to Cedar Cr	S003-020	2000-2019	Improving
7020009-553	Blue Earth River, East Branch: Brush Cr to Blue Earth R	S002-470	2003-2020	Improving
7020009-565	Blue Earth River: Badger Cr to E Br Blue Earth R	S002-471	2003-2020	No trend
7020009-571	Judicial Ditch 13 Branch A: MN/IA border to JD 13	S003-445	2004-2020	Improving
7020009-627	Judicial Ditch 3: -94.351 43.739 to Elm Cr	S001-950	2002-2019	Improving
7020009-635	Dutch Creek: 94.507 43.626 to T102 R31W S24, north line	S003-000	2000-2020	Degrading
7020009-640	South Creek: -94.300 43.661 to Blue Earth R	S004-743	2007-2014	Improving
7020009-646	Blue Earth River, Middle Branch: -94.104 43.514 to W Br Blue Earth R	S005-423	2008-2020	No trend
7020009-648	Coon Creek: T102 R27W S33, south line to Blue Earth R	S000-533	2006-2019	No trend
7020009-650	Blue Earth River, East Branch: -93.663 43.624 to -93.73 43.654	S002-477	2003-2017	Improving

2.2 Sources Overview, Risks, Natural Conditions, and Goals

This section orients readers to the array of sources of pollutants and stressors in the Blue Earth River Watershed. Sources of pollutants and stressors can be grouped into either point sources (NOAA 2008), which discharge directly from a discrete point, or nonpoint sources (EPA 2018), which is runoff and drainage from diffuse areas. Examples of point sources are wastewater plants and industries, and examples of nonpoint sources are farm drainage and smaller city runoff. Generally, point sources are regulated to ensure any discharge supports water quality standards, while nonpoint sources are generally not, or are minimally regulated.

Within Section 2.3, detailed source assessment will be presented for each pollutant and stressor. These source assessments were developed after analyzing multiple lines of evidence (see Appendix 4.2). These lines of evidence include state and basin-level reports, model studies, TMDLs, and field-scale and watershed data. The WRAPS LWG was asked to review and use this information, applying their professional judgement and local knowledge, to ensure source assessments reflected recent conditions in the Blue Earth River Watershed. The Watershed Approach starts a new iteration every 10 years, each time striving for more refined and widespread analysis. Therefore, source assessments will be revisited and revised with each iteration to ensure that new data and science are incorporated.

Point Sources

Point sources are regulated through National Pollutant Discharge Elimination System (NPDES; EPA 2014a) permits. Depending on the type of point source, regulatory requirements vary. Some point sources are not allowed to discharge; some are allowed to discharge but must treat and measure discharged pollutants to ensure permit requirements are met; and some are allowed to discharge under special circumstances or required to use BMPs to reduce pollutants.

Municipal and Industrial Wastewater

Municipal and industrial wastewater point sources have discharge and monitoring requirements specified in the facility permits to ensure pollutant levels in their discharge support water quality goals. The industrial and municipal facilities (wastewater treatment plants (WWTPs)) that discharge to water bodies are listed in Table 4. Because these systems often require monitoring, their total contributions can be calculated. The estimated 2009 through 2018 contributions of these facilities to the total loads delivered by the Blue Earth River Watershed are: 0.73% of nitrogen, 1.6% of phosphorus, and 0.03% of sediment (see data and calculations in Appendix 4.2).

Table 4: Point sources in the Blue Earth River Watershed. Eight industries, 14 municipal wastewater treatment plants, and 10 nonmetallic mining operations comprise the point sources that discharge into the Blue Earth River Watershed.

Industrial Facility	County
CHS Mankato	Blue Earth
Darling Ingredients Inc – Blue Earth	Faribault
Fairmont Foods Inc	Martin
Fairmont WTP	Martin
Great River Energy – Lakefield Junction Station	Martin
Green Plains Fairmont LLC	Martin
Seneca Foods Corp – Blue Earth	Faribault
Valero Renewable Fuels Co LLC – Welcome Plant	Martin
Municipal Facility	**County**
Alden WWTP	Freeborn
Blue Earth WWTP	Faribault
Bricelyn WWTP	Faribault
Elmore WWTP	Faribault
Fairmont WWTP	Martin
Frost WWTP	Faribault
Granada WWTP	Martin
Kiester WWTP	Faribault
Northrop WWTP	Martin
Trimont WWTP	Martin
Vernon Center WWTP	Blue Earth
Walters WWTP	Faribault
Welcome WWTP	Martin
Winnebago WWTP	Faribault
Nonmetallic Mining	**County**
Cemstone Products Co	Martin
Cemstone Products Co	Faribault
Croell Inc	Faribault
Erosion Control Plus Inc	Martin
Faribault County Public Works	Faribault
Forrey Sand & Gravel Pit	Blue Earth
OMG Midwest	Martin
Ulland Brothers Inc	Faribault
Wells Concrete Products	Faribault

While the impact of these point sources on the total pollutant loads is minimal, they can be substantial sources at times of low flow. Refer to the TMDLs (links provided in Goals and Targets Overview section) for more information on the impact of point sources on individual impaired reaches.

Urban, Construction, and Industrial Stormwater

Stormwater systems in some communities, dependent on size and location, are regulated under the Municipal Separate Storm Sewer System (MS4) program, which requires the use of BMPs to reduce pollutants. The municipal stormwater permit holds permittees responsible for stormwater discharging from the conveyance system they own and/or operate. The conveyance system includes ditches, roads, storm sewers, stormwater ponds, etc. In the Blue Earth River Watershed, any stormwater conveyance in the cities of Fairmont (MS400239) and Mankato (MS400226) are regulated under MS4 rules. Stormwater conveyance located within platted or urbanized areas in the city of Skyline (MS400292) and South Bend Township (MS400299) are regulated under the MS4 General Permit, as are any Blue Earth County (MS400276) road or Minnesota State highway right of ways within the urbanized area around Mankato. A map of the MS4 regulated areas can be found at the link above. Under the NPDES stormwater program, permitted MS4 entities are required to obtain a permit, then develop and implement an MS4 Stormwater Pollution Prevention Program (SWPPP), which outlines a plan to reduce pollutant discharges, protect water quality, and satisfy water quality requirements in the Clean Water Act. An annual report is submitted to the MPCA each year by the permittee documenting progress on implementation of the SWPPP.

Construction stormwater is regulated by NPDES General Permit (MNR100001) for any construction activity disturbing a) one acre or more of soil, b) less than one acre of soil if that activity is part of a “larger common plan of development or sale” that is greater than one acre, or c) less than one acre of soil, but the MPCA determines that the activity poses a risk to water resources. Industrial stormwater is regulated by NPDES General Permit (MNR050000) or Nonmetallic Mining and Associated Activities General Permit (MNG490000) if the industrial activity has the potential for significant materials and activities to be exposed to stormwater discharges. The amount of land under Construction and Industrial Stormwater Permits in the Blue Earth River Watershed was divided by the total area of the watershed to determine the percent of permitted land. Results of this analysis show that approximately 0.05% of land in the Blue Earth River Watershed is currently under a Construction and Industrial Stormwater Permit suggesting these land uses are not a significant source of pollutants in the Blue Earth River Watershed.

Animal Feeding Operations

Livestock are potential sources of bacteria, phosphorus, and nitrogen to streams in the Blue Earth River Watershed, particularly when direct access is not restricted and/or where feeding structures are located adjacent to riparian areas.

Minn. R. ch. 7020 governs the permitting, standards for discharge, design, construction, operation, and closure of animal feeding operations (AFOs) throughout Minnesota. An AFO is a site where animals are confined for 45 days or more in a 12-month period and vegetative cover is not maintained.

Concentrated animal feeding operations (CAFOs) is an EPA definition that implies not only a certain number of animals but also specific animal types. CAFO size is based on number of animals (head count) and can include large, medium, and small CAFOs. For example, 2,500 head of swine weighing 55 pounds or more is considered a large CAFO and 1,000 head of cattle other than mature dairy or veal calves are a large CAFO. However, a site with 2,499 head of swine weighing 55 pounds or more, or a site with 999 head of cattle other than mature dairy would be considered a medium CAFO. The MPCA currently uses the federal definition of a CAFO in its permit requirements of animal feedlots along with the definition of animal unit (AU). In Minnesota, a NPDES permit is required for facilities that exceed any of the federal large CAFO threshold numbers and discharges to waters of the United States. SDS permits are required for any facility that has a capacity of 1,000 AU or more. Facilities required to obtain SDS permit coverage may choose to obtain NPDES coverage in lieu of the SDS permit. CAFOs with less than 1,000 AU capacity that do not discharge to waters of the United States are not required to obtain NPDES Permit coverage.

CAFO production areas need to be designed, constructed, operated, and maintained to contain all manure, manure-contaminated runoff, or process wastewater, and direct precipitation. CAFOs and AFOs with 1,000 or more AUs must be designed to contain all manure and manure contaminated runoff from precipitation events of less than a 25-year–24-hour storm event. Having and complying with an NPDES permit allows some enforcement protection if a facility discharges due to a 25-year–24-hour precipitation event (approximately 5.07" in 24 hours) and the discharge does not contribute to a water quality impairment. Large CAFOs permitted with an SDS permit, or those not covered by a permit, must contain all runoff, regardless of the precipitation event. Therefore, many large CAFOs in Minnesota have chosen to have an NPDES permit, even if discharges have not occurred in the past at the facility. A current manure management plan (MMP), which complies with Minn. R. 7020.2225, and the respective permit is required for all CAFOs and AFOs with 1,000 or more AUs. Additionally, MMP requirements for CAFOs are more stringent than for smaller feedlots. CAFOs are inspected by the MPCA in accordance with the MPCA NPDES Compliance Monitoring Strategy approved by the EPA. All CAFOs (NPDES permitted, SDS permitted, and not required to be permitted) are inspected by the MPCA on a routine basis with an appropriate mix of field inspections, offsite monitoring, and compliance assistance.

Feedlots under 1,000 AUs and those that are not federally defined large CAFOs do not operate with permits; however, the requirements under Minn. R. chs. 7020, 7050, and 7060 still apply. In Minnesota, feedlots with greater than 50 AUs, or greater than 10 AUs in shoreland areas, are required to register with the state. Facilities with fewer AUs are not required to register with the state. Feedlot registration enables the County and the MPCA to communicate directly with feedlot owners regarding all aspects of feedlot management including technical requirements, permitting, inspections and corrective action. Registration also helps ensure that surface waters are not contaminated by the runoff from feeding facilities, manure storage or stockpiles, and cropland with improperly applied manure. Livestock are also part of hobby farms, which are small-scale farms that are not large enough to require registration but may have small-scale feeding operations and associated manure application or stockpiles.

All counties in the Blue Earth River Watershed are delegated to administer feedlot-related activities such as permitting, inspections, and compliance/enforcement. Therefore, each county administers a county feedlot program based on the requirements of the Minn. R. 7020, Feedlot Rules. These counties have the responsibility for implementing state feedlot regulations for facilities with fewer than 1,000 AUs and do not meet the federal definition of a large CAFO that are not subject to state or federal operating permit requirements. Responsibilities include registration, permitting, education and assistance, and complaint follow-up.

The MPCA maintains a feedlot registration database for CAFOs and registered feedlots that contains information such as feedlot locations, animal numbers, and types of animals. The database includes the maximum number of animals that each registered feedlot can hold; therefore, the actual number of livestock in registered facilities is likely lower. Livestock in nonregistered, smaller operations (e.g., hobby farms) likely contribute pollutant loads to surface waters through watershed runoff from fields and direct deposition in surface waters. Note, smaller operations that don't require NPDES/SDS permits are not considered point sources in this analysis. The 2021 MPCA registered feedlot database indicates there are approximately 643 active feedlot facilities with 369,278 livestock AUs throughout the Blue

Earth River Watershed (Figure 13). On average, this translates to roughly 477 AUs per 1,000 acres. See the [Animal Unit Calculator](#) (MPCA 2016a) for conversions of animal numbers to units. An estimated 179,298 (49%) AUs reside in 153 CAFOs, which are regulated as point sources (list available in the Blue Earth River Watershed TMDL). Table 5 summarizes livestock type and numbers for the entire watershed.

Figure 13: Feedlots in the Blue Earth River Watershed. Map symbols denote feedlot size, location and primary animal type. The number of feedlot AUs per region, along with additional information, can indicate the likeliness that feedlot-produced manure is making substantial contributions of bacteria and nutrients to water bodies.

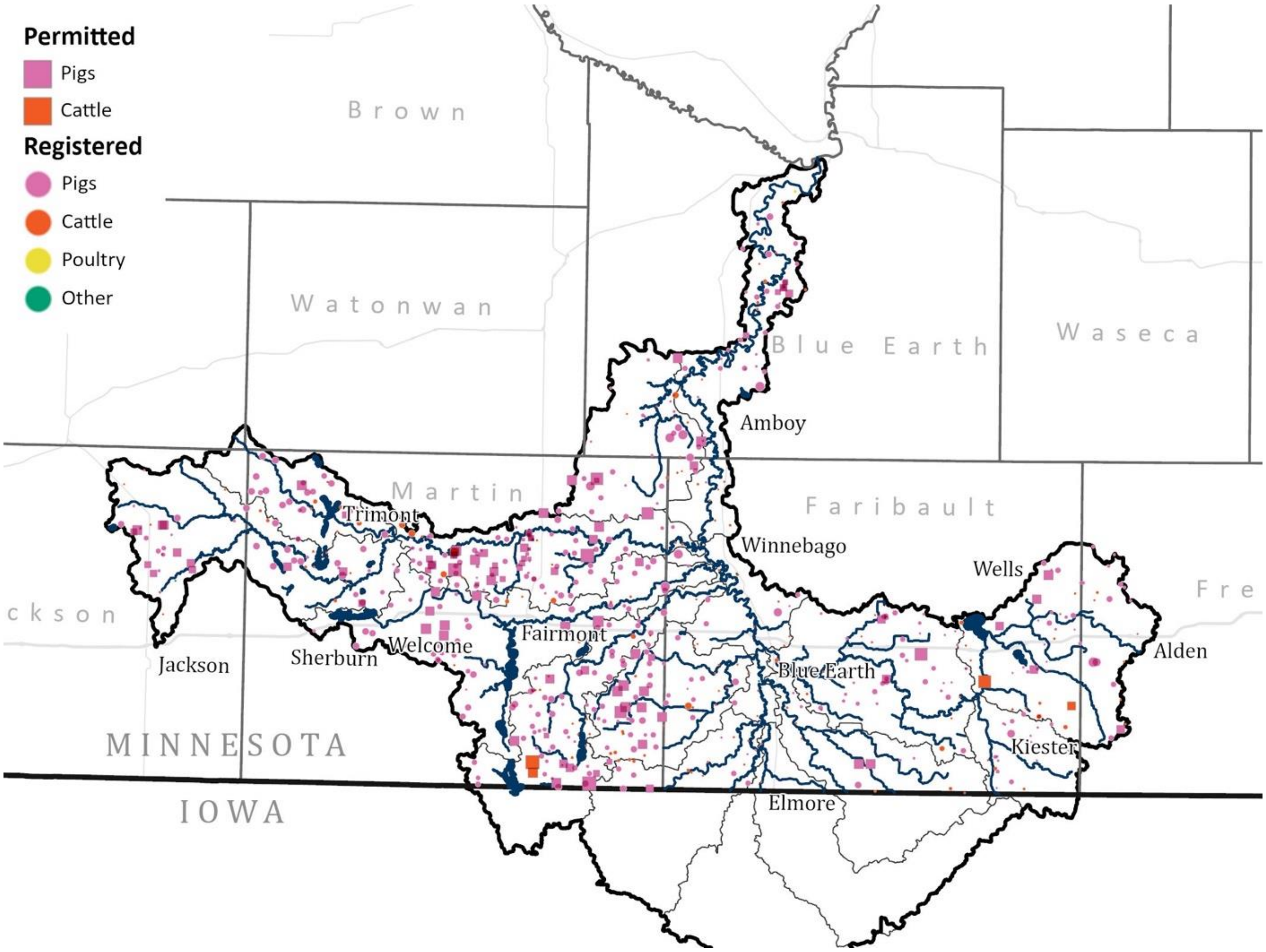


Table 5: Estimate of AUs in the Blue Earth River Watershed (2021).

	Pigs	Cattle	Poultry	Other
Total AUs	331,935	35,937	746	660
% of Total	89.9%	9.7%	0.2%	0.2%

Nonpoint Sources

With a generally low input of pollutants/stressors from point sources, nonpoint sources are the dominant source of pollutants/stressors in the Blue Earth River Watershed. Nonpoint sources of pollutants/stressors are products of the way that land is used and how well human impacts are managed/mitigated with BMPs. This section summarizes the types of nonpoint sources.

Nonpoint sources of pollutants/stressors typically travel from the land and watershed into the water body in response to precipitation. The pollutants/stressors can be of natural origin (like tree leaves breaking down), human-accelerated natural origin (like excessive streambank erosion from altered hydrology), or of human origin (like fertilizer and manure applied on fields and lawns). Once the area where precipitation falls cannot hold more water, water and the pollutants/stressors it carries will move via surface runoff, artificial drainage networks, or groundwater pathways to streams and lakes.

Farm and City Runoff

Typically, highly manipulated land uses contribute higher levels of pollutants/stressors compared to more naturalized areas. Grasslands and forests tend to have lower contributions of pollutants/stressors compared to many cultivated crop fields, urban developments, and over-grazed pastures.

While highly manipulated (urban and agricultural) land often does contribute higher levels of pollutants/stressors, the impacts can be reduced by adequately managing/mitigating with sufficient BMPs. As demonstrated by sustainable agriculture (USC 2018), farming and clean water do not have to be mutually exclusive. For instance, a farm that incorporates nutrient management practices, conservation tillage, cover crops, grassed waterways, and buffers will contribute substantially less pollutants/stressors than if those BMPs were not used. Likewise, city stormwater systems can be designed and built for zero or minimal runoff depending on the size and intensity of the rain event.

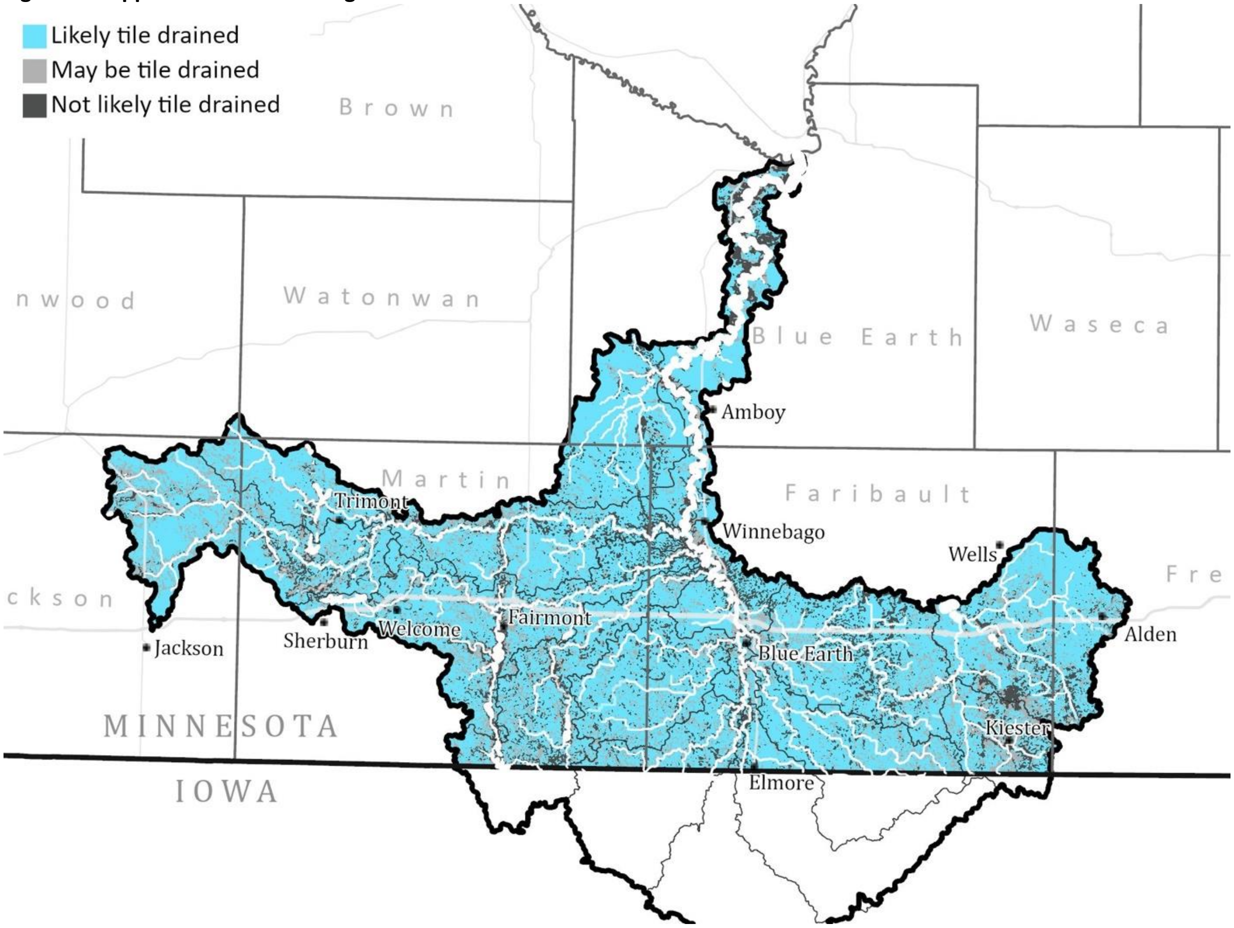
When land uses such as cultivated crops do not adhere to industry recommendations (for instance the over application of fertilizer/manure as documented in the Commercial Nitrogen and Manure Fertilizer… Management Practices (MDA 2014), contributions of pollutants and stressors can be further accelerated. While comparing converted prairie land to agricultural production, the MDA (2016), found much larger exports of nutrients, sediment, and water runoff on a corn plot compared to a prairie plot. The Blue Earth River Watershed is dominated by cultivated crop production (refer to background section), which has a large potential impact on water quality.

While some agricultural and urban runoff has been reduced using sufficient BMPs, substantial additional BMPs need to be adopted to achieve clean water. The MPCA Healthier Watersheds: Tracking the actions taken webpage shows that 741 agricultural related BMPs have been installed in the Blue Earth River Watershed from 2010 to 2021. The Agricultural Water Quality Certification Program (MDA 2022) has certified 46 producers farming 31,018 acres (4% of Blue Earth River Watershed in Minnesota) as of October, 2022. These farms are certified that impacts to water quality are adequately managed/mitigated. While these producers and others have incorporated sufficient BMPs to protect water quality, much of the cultivated crops, pastures, urban development, and residential landscape are not adequately managed/mitigated with BMPs.

Subsurface Drainage

In addition to surface runoff pathways, subsurface drainage pathways also deliver pollutants/stressors to water bodies. In urban settings, subsurface drainage occurs via storm sewers. Up to 7% of the Blue Earth River Watershed is potentially serviced by storm sewers, based on the land use statistics for the area of developed land. In farming settings, subsurface drainage occurs via subsurface tile drainage systems. Based on a GIS analysis, up to 85% of the Blue Earth River Watershed's area may be tile drained, with 70% of the area likely drained (Figure 14).

Figure 14: Approximate tile drainage in the Blue Earth River Watershed.



Tile drainage has been identified as a primary cause of stream flow changes in heavily tiled landscapes. Several research papers found that roughly 60% or more of increases in stream flow between mid- and late-20th century in heavily-tiled areas of the Midwest and Southern Minnesota are due to agricultural drainage changes: Twentieth Century Agricultural Drainage Creates More Erosive Rivers (Schottler et al. 2013), Temporal Changes in Stream Flow and Attribution of Changes (Gyawali, Greb, and Block 2015), and Quantifying the Relative Contribution of the Climate and Direct Human Impacts (Wang and Hejazi 2011). The rest of the increase in stream flow is attributed to crop and climate changes.

Other Feedlots, Manure Application, and Pastures

Only the largest feedlots are regulated as point sources (discussed in section above). The 2021 feedlot data shows there were 189,980 (52%) AUs in 490 feedlots that were not regulated as point sources (feedlots not meeting Large CAFO criteria). However, these facilities were still regulated and may only have discharge/runoff that meets a maximum pollutant concentration (using a designated estimation tool). Small animal operations (<10 AUs in shoreland or <50 AUs elsewhere) are not considered feedlots and are not regulated. AU counts associated with the nonregulated operations were not available but can be presumed to be relatively small.

Feedlots within close proximity to water bodies (referred to as shoreland) may pose a disproportionately high risk to water quality if runoff is not prevented or treated. In the Blue Earth River Watershed, 7,964 (2%) AUs in 40 feedlots are near shoreland, one of which is a CAFO. Of the feedlots in shoreland, 3,616

(1%) AUs in 26 feedlots have access to open lots. Open lots can be particularly high risk because manure is not contained within a structure and may more readily run off.

Because most feedlots are regulated to have minimal runoff, the largest water quality risk associated with feedlots is from the land-applied manure. Manure is a by-product of animal production and large numbers of animals create large quantities of manure. This manure is usually stockpiled and then spread over agricultural fields to help fertilize the soil. When stored and applied properly, this beneficial re-use of manure provides a natural source for crop nutrition. Manure, however, can pose water quality concerns when it is not applied properly or leaks or spills from nearby fields, storage pits, lagoons, tanks, etc. Animal waste contains high amounts of fecal bacteria, phosphorus, and nitrogen, and therefore when delivered to surface and groundwater can cause high bacteria levels, eutrophication, and oxygen demand (i.e., low oxygen levels) that negatively impacts human health, aquatic organisms, and AqR.

The Minnesota Feedlot rules include regulations regarding the requirements for MMPs and land application of manure. The MPCA has developed templates, guides, and standards for the development and implementation of MMPs, manure nutrient management, and application rates. MMPs are required when producers apply for a feedlot permit, or when a facility has 300 or more AUs and does not use a licensed commercial applicator. MMPs are designed to help ensure that application rates do not exceed crop nutrient needs, and that setbacks from waters and drain tile intakes are observed.

Based on the MPCA feedlot staff analysis of feedlot demographics, knowledge, and actual observations, there is some potential for late winter solid manure application (before the ground thaws) in the Blue Earth River Watershed. During this time the manure can be a source of nutrients and pathogens in rivers and streams, especially during precipitation events. For feedlots with NPDES permits, surface applied solid manure is prohibited during the month of March. Winter application of manure (December through February) for permitted sites requires fields are approved in their MMP and the feedlot owner/operator must follow a standard list of setbacks and BMPs.

Short term stockpile sites are defined in Minn. R. ch. 7020, and are considered temporary. Any stockpile kept for longer than a year must be registered with the MPCA and would be identified as part of a feedlot facility. Because of the temporary status of the short-term stockpile sites, and the fact they are usually very near or at the land application area, they are included with the land applied manure.

Winter application of surface applied liquid manure is prohibited except for emergency manure application as defined by the NPDES permit. “Winter application” refers to application of manure to frozen or snow-covered soils, except below the soil surface (Minn. R. 7001).

Incorporating manure is the preferred BMP for land application of manure and should result in less runoff losses. Manure from roughly 90% of the AUs in the watershed is likely injected and incorporated swine manure from facilities with more than 300 AUs (Table 5). Ten percent of the AUs in the watershed are cattle and poultry. This manure is generally handled as solid manure and may not be immediately incorporated. Nutrient loads modeled by HSPF are calibrated using monitored, in-stream water quality data at several points throughout the watershed and manure contributions to nutrient loads are therefore implicit.

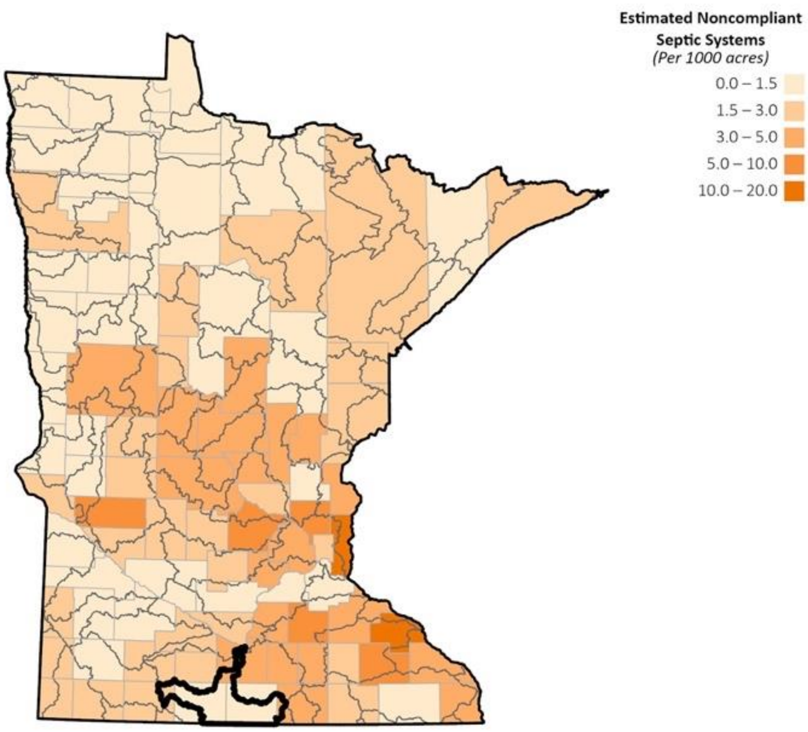
While the percent of land in grass and pasture is estimated at 3%, these pastures are often located directly adjacent to water bodies and therefore can disproportionately impact water bodies if not properly managed. Perennial vegetation, like that of pasture, typically provides an overall benefit to water quality compared to inadequately managed/mitigated urban and cultivated cropland uses. However, when pasture is overgrazed (indicated by too little vegetation), especially adjacent to a water body, these areas can be sources of pollutants/stressors. Furthermore, when cattle access streams, the delicate streambank habitat is trampled, the stream geomorphology (DNR 2017) is negatively impacted, and streambank erosion is accelerated.

Septic Systems and Unsewered Communities

Well-functioning individual and small community wastewater treatment systems generally pose little risk to waters. When these systems fail or do not offer adequate treatment, these systems can pose a risk to water quality.

Based on the estimates provided by counties, there are on average 1.7 failing septic systems (subsurface treatment systems, SSTS) per 1,000 acres in the Blue Earth River Watershed (Figure 15). At this density, failing septic systems are unlikely to contribute substantial amounts of pollutants/stressors to the total annual load. However, the impacts of failing SSTS on water quality may be pronounced in areas with high concentrations of failing SSTS or at times of low precipitation and/or flow.

Figure 15: Failing septic systems in the Blue Earth River Watershed.



Unsewered or undersewered communities (MPCA 2019) are clusters of five or more homes or businesses on small lots where individual or small community systems do not provide sufficient sewage treatment (including straight pipes). Many of these have been upgraded, but several unsewered or undersewered areas still exist in the Blue Earth River Watershed including the communities of Rapidan, South Bend, East Chain, Fox Lake, Imogene, Guckeen, Pilot Grove, Riverside Heights, Brush Creek, and Mansfield.

High Risk Areas

While some highly altered land uses can adequately manage pollutant contributions by adopting sufficient BMPs, some areas within a landscape are particularly sensitive from a water quality perspective. For instance, the area or buffer around water bodies is particularly sensitive. Crops or lawn turf directly adjacent to a stream or lake can cause more pollutants/stressors to enter water bodies, accelerate erosion, and destroy sensitive habitat. On the contrary, a high-quality vegetative buffer adjacent to a water body can help capture pollutants/stressors, stabilize the streambank, and provide habitat to sensitive aquatic species. Other particularly sensitive areas include flood plains, high slope areas, and areas with highly erodible soils.

Historical Changes

Understanding landscape conditions prior to European settlement, and changes between then and today, provides context for today's water quality conditions and sources. The landscape in the Blue Earth River Watershed has been highly manipulated since European settlement. In 1855, portions of the Blue Earth River Watershed were covered by prairie and dotted with prairie potholes (EPA 2015a) (Figure 16). These potholes and the rich, healthy, prairie soils provided water storage, nutrient recycling, and superior erosion protection across the landscape.

Figure 16: Pre-European settlement land cover in the Blue Earth River Watershed. The pre-European settlement land cover map depicts what the landscape likely looked like before widespread EuroAmerican settlement. This image is for illustrative purposes only, showing the large extent of prairies, wetlands and forested lands across the watershed. See Appendix 4.2 for data sources.

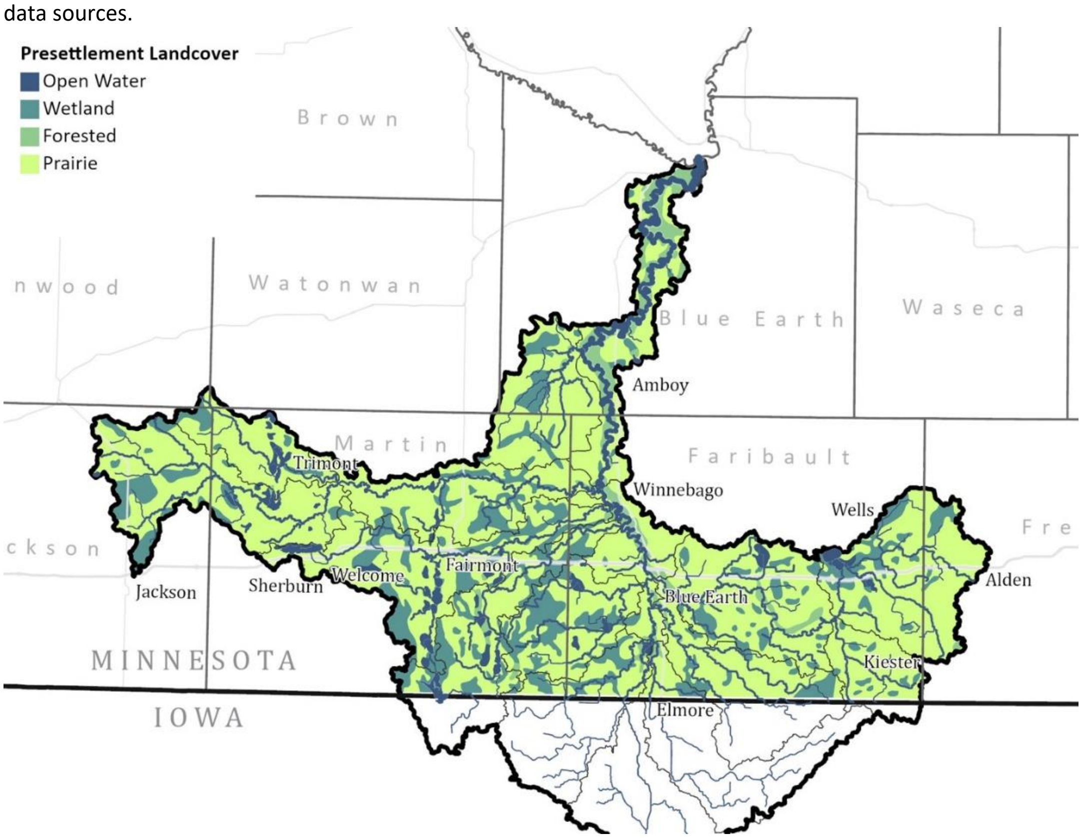


Figure 17 and Figure 18 compare the estimated streams, lakes, and wetlands of pre-European settlement to those of today. Before settlement, grasslands and wetlands provided water storage and kept most precipitation on the landscape to be used for vegetative growth and to recharge shallow groundwater, which resulted in relatively fewer streams (Figure 17). The areas covered by wetlands, lakes, and streams have changed substantially between the mid-19th century and today. Today, most of the grasslands have been converted to crops and cities, streams have been ditched or straightened, ditches have been added to the landscape, and prairie potholes have been drained or highly altered (Figure 18). This drainage network has replaced prairies and wetlands and created a "short-circuit" in hydrologic conditions that can increase the volume of water delivered and decrease the amount of time the water would remain on the landscape.

Figure 17: Pre-European settlement water bodies and waterways in the Blue Earth River Watershed. The Blue Earth River Watershed likely had substantial amounts of wetlands to hold, infiltrate, and evapotranspirate water. This image is for illustrative purposes only. See Appendix 4.2 for data sources.

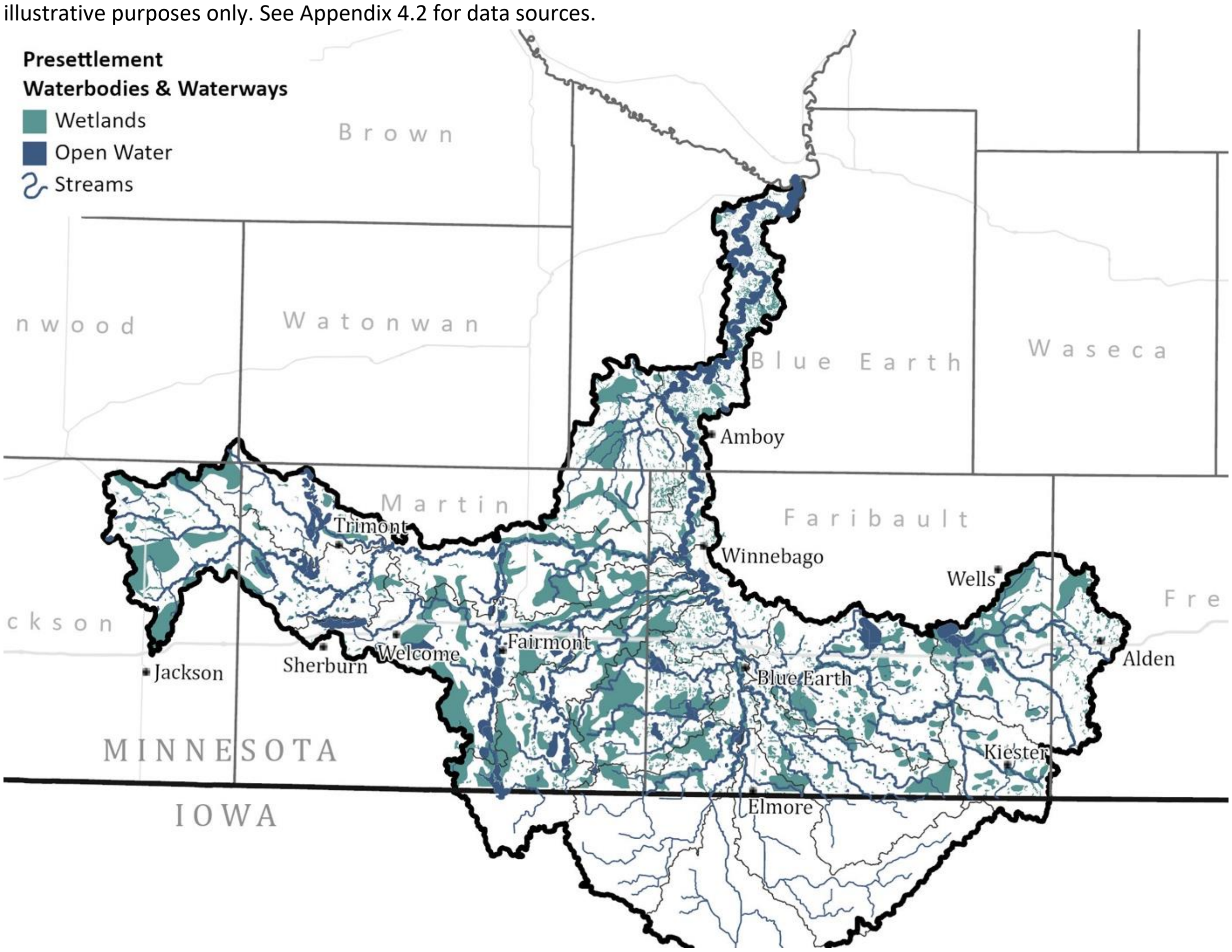
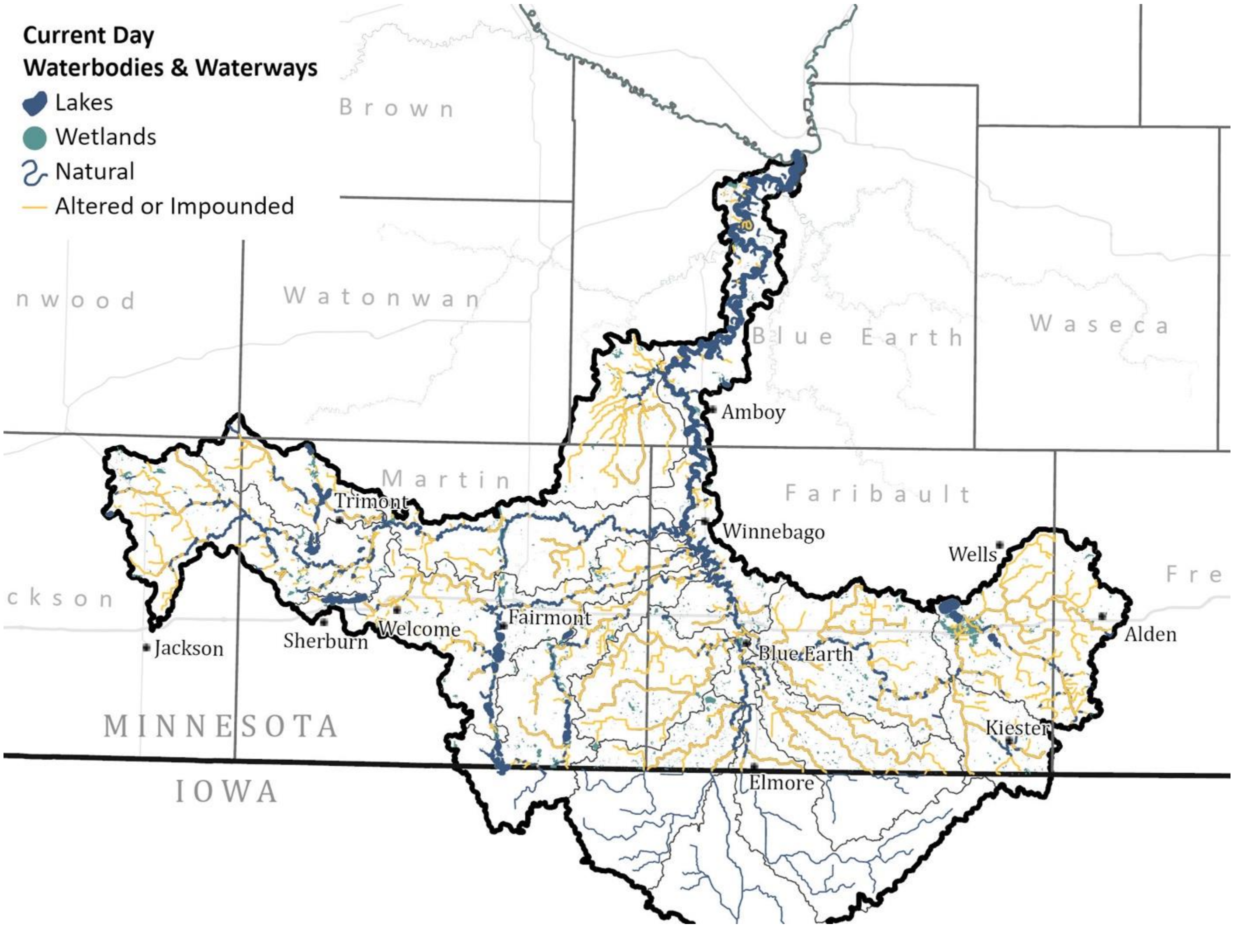


Figure 18: Current day water bodies and waterways in the Blue Earth River Watershed. Current day water bodies and waterways map illustrates the extent of altered waterways and loss of wetlands across the watershed. See Appendix 4.2 for data sources.



The diversity of vegetation and crops on the landscape continued to decline during the mid- to late-20th century. The diversity of crops–including substantial amounts of small grains and hay–were replaced by a dominance of corn and soybeans (Figure 19). Small grains provided earlier season growth with more root density and year-round soil coverage, increasing infiltration and reducing the potential for erosion. Increasing corn and soybean production also necessitated more artificial drainage due to the heavier and wetter soils in the Blue Earth Watershed. The changes in land use and crops have resulted in impacts to hydrology: less evapotranspiration (ET) in spring and more ET in mid-summer (Figure 20), resulting in more precipitation entering rivers in spring and less entering in mid-summer. The nearly total conversion of prairie/wetland complexes to agricultural and urban development have led to major changes to the hydrologic and nutrient cycling within the Blue Earth River Watershed. These changes have increased the volume and altered the timing of stream flows that have in turn increased nutrient and sediment loads to the watershed.

Figure 19: Harvested acres of corn, soybeans, hay, and small grains in Blue Earth County. The chart illustrates how small grains and hay were replaced through time by soybeans and corn.

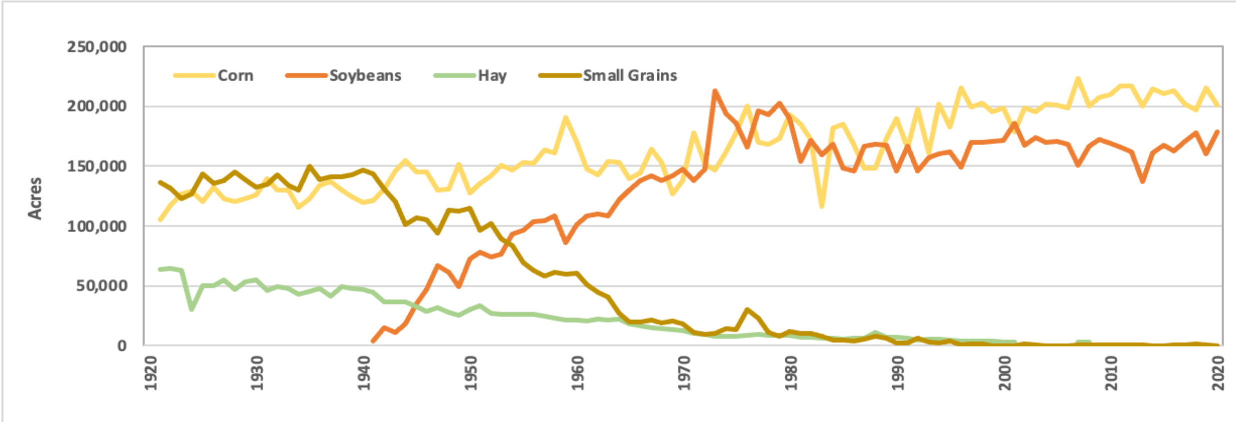
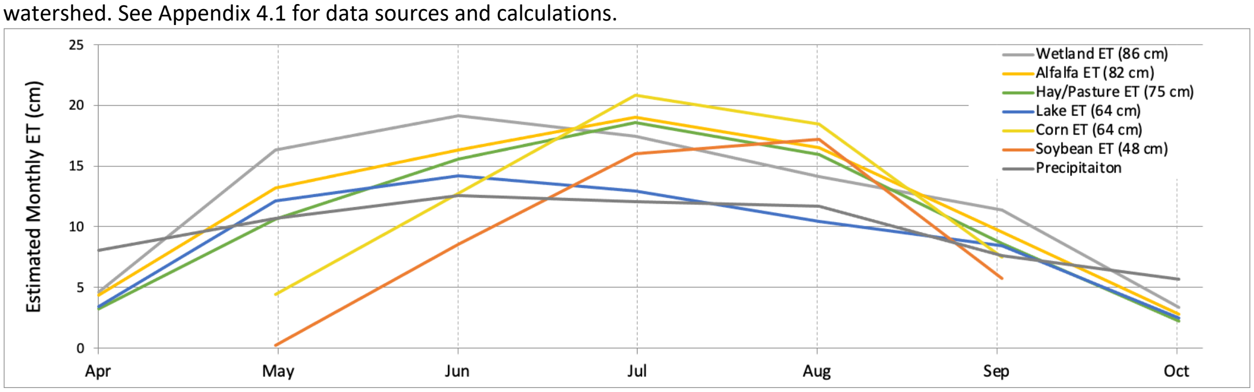


Figure 20: The total annual ET rates of replacement crops. Since European settlement, prairies and wetlands were replaced first by diverse crops and then by corn and soybeans. The total annual ET rates (indicated in the figure legend) of these replacement crops are smaller and the timing of ET through the year has shifted. These changes affect the hydrology of the watershed. See Appendix 4.1 for data sources and calculations.



Goals Overview

Water quality goals are intended to help both water bodies within the watershed and water bodies downstream of the watershed meet their designated uses. Goals for the Blue Earth River Watershed (Table 6) were set after analyzing the WPLMN data, HSPF model output, TMDL studies, and statewide reduction goals (summarized in Appendix 4.3). The selected watershed-wide goals integrate multiple levels of goals into one watershed-wide goal. Subwatershed goals (for individual stream reaches and lakes) are presented for water bodies when TMDL data are available. The TMDL studies include the Blue Earth River Watershed TMDL (developed concurrently with this WRAPS report; see MPCA Blue Earth River webpage (MPCA 2023b), Minnesota River and Greater Blue Earth River Basin TMDL for TSS (MPCA 2018a) and the Blue Earth River Basin Fecal Coliform TMDL (MPCA 2007).

The specific goal for every lake and stream reach is to meet water quality standards for all relevant parameters and to support downstream water quality goals. However, to better communicate water quality goals and to make the identification of strategies and adoption rates more straight-forward, the multiple levels of goals were integrated into one average or surrogate watershed-wide goal for the major watershed. Likewise, because water quality standards do not include a specific method to calculate a reduction, surrogate goals for individual streams and lakes were calculated from TMDL data. A summary of the WRAPS report calculation methods and results is in Appendix 4.2.

For parameters that are the effect of other pollutants/stressors (Fish IBI, Macroinvertebrate IBI, dissolved oxygen (DO), eutrophication, and temperature), a numeric goal for the identified pollutants/stressors was estimated. For instance, in the case of bio-impaired streams (where the AqL impairment [AqL] was due to a low fish or bug IBI score), the goal is to have the fish and/or bug populations meet the IBI score threshold. However, there is not a tool or model available to estimate the magnitude or change needed to meet this threshold. Therefore, numeric goals for the stressors causing the bio-impairments (altered hydrology, sediment, nitrogen, etc.) are the surrogate goal.

Within Section 2.3, goals for each pollutant and stressor are illustrated in a "goals map". The subwatershed area of each water body is colored according to its goal. The watershed-wide goal underlays subwatershed goals. The watershed-wide goal is also the default goal for any area that does not have sufficient data to calculate an individual subwatershed goal.

Interim water quality "10-year targets" and a proposed "Years to Reach Goal" were selected by consensus of the WRAPS LWG. The 10-year targets allow opportunities to adaptively manage implementation efforts, while the years to reach the goals set reasonable timelines to meet water quality goals.

With each iteration of the Watershed Approach, progress will be measured, goals will be reassessed, and new 10-year targets will be set. Future efforts should consider changes in water body conditions reflected by new data or due to changes in standards, state-wide goals, and calculation methods.

Table 6: Protection and restoration goals and 10-year targets for areas in the Blue Earth River Watershed.

Parameters (Pollutant/ Stressors)	**Watershed-Wide Goal** (Average/surrogate for Watershed)	**Range of Subwatershed Goals** (Estimated only when TMDL or MSHA data are available)	**10-year Target** (for 2033)	**Years to Reach Goal** (from 2023)
Habitat	65% increase in MSHA habitat score	Protect up to a 181% increase	10% ↑	50+
Altered Hydrology	25% reduction in peak and annual stream flow	Not estimated (TMDLs not completed on this parameter)	No increase	50+
	Increase dry season stream base flow where ID'd in SID by enough to support AqL		Increase	
Nitrogen	45% reduction in stream concentrations/loads	Not estimated (TMDLs not completed on this parameter)	5% ↓	50+
Sediment	60% reduction in stream concentrations/loads	Protect up to an 85% reduction	5% ↓	50+
Connectivity	Address human-caused issues (dams, culverts) as identified in SID and where practical/feasible	Not estimated (TMDLs not completed on this parameter)	Replace 10% of culverts	20
Phosphorus/ Eutrophication	47% reduction in stream concentrations/loads	Protect up to a 47% reduction	Streams 5% ↓ Lakes 10% ↓	50+
Bacteria	75% reduction in stream concentrations/loads	32-93% reduction	5% ↓	50+

Parameters (Pollutant/ Stressors)	**Watershed-Wide Goal** (Average/surrogate for Watershed)	**Range of Subwatershed Goals** (Estimated only when TMDL or MSHA data are available)	**10-year Target** (for 2033)	**Years to Reach Goal** (from 2023)
Parameters that are impacted/addressed by the above pollutants and stressors				
F-IBI and M-IBI	Each parameter's goal is to meet the water quality standard and support downstream goals. Because these parameters are a response to (caused by) the above pollutants/stressors, the above watershed-wide and subwatershed goals are indirect goals for these parameters and are more usable for selecting strategies than direct goals for these parameters.	Not estimated (TMDLs not completed on these parameters)	Meet other 10-year targets	Reassess at 10 Year Cycle
DO				Reassess at 10 Year Cycle

2.3 Identified Pollutants and Stressors

The Monitoring and Assessment Report (MPCA 2020a) and SID Report (MPCA 2021a) detail the pollutants and stressors identified as part of the Watershed Approach in the Blue Earth River Watershed.

This section summarizes information by parameter, describing and/or illustrating:

- Status: the streams and lakes known to be impacted or not impacted by the pollutants/stressors
- Sources: a detailed source assessment for the watershed
- Goals: estimated reductions or improvements necessary to meet water quality goals in and downstream of the Blue Earth River Watershed

Refer to the Conditions Overview Section 2.1 for a broad summary and methods relevant to multiple parameters. Refer to the Assessing Water Quality Section 1.3 for a summary of how water bodies are monitored and assessed, the SID process, and the difference between a pollutant and stressor.

The SID process was completed on 44 of the impaired reaches in the Blue Earth River Watershed. Two reaches (502 and 654) were dropped from the SID process due to insufficient data to make determinations on the stressors for these reaches. These reaches are added in the mapping exercise and considered inconclusive. The following figures and tables will highlight the 42 remaining reaches that went through the full SID process.

SID identified several candidate causes for biological impairments. Probable causes stressing AqL include issues with habitat, altered hydrology, NO_3-N, connectivity, TSS, DO, and eutrophication. Individual reaches were studied further to identify conditions that may be contributing to the biological impairments as not all stressors contribute equally to each impairment.

Data was collected to identify potential drivers of the identified stressors in each reach. Drivers help to narrow down the main cause of stress in the reaches. This information also helps define goals by identifying land use practices or activities that could be contributing to impairment and identifying implementation practices.

Tables for each parameter provide information on the reach name, reach identification number and whether the reach is affected by the particular pollutant and or stressor. SID tables also provide further information on the drivers of the particular stressor to help identify potential sources to be considered.

In some cases, there are not clearly identified stressors to the biology, yet potential contributors were highlighted. These areas of concern are highlighted as they may be impacting biological communities downstream and create negative impacts to local communities in the future.

Habitat

Habitat, as identified in this report, refers to the in- and adjacent-stream habitat. Important stream habitat components include stream size and channel dimensions, channel gradient (slope), channel substrate, habitat complexity, and in-stream and riparian zone vegetation. Degraded habitat reduces AqL's ability to feed, shelter, and reproduce, which results in altered behavior, increased mortality, and decreased populations.

Status

The SID process was fully conducted on 42 of the bio-impaired stream reaches. Degraded habitat was identified as a stressor in 28 of the stream reaches and inconclusive on the remaining 14 reaches (Figure 21). MPCA's Stream Habitat Assessment (MSHA) (MPCA 2017) scores in the Blue Earth River Watershed range from 16 to 67 with an average score of 42. The MSHA assessment considers floodplain, riparian, instream, and channel morphology attributes at biological monitoring locations on stream reaches. The habitat assessment results are illustrated in Figure 22 and tabulated in Table 7. The MSHA scores at biological sample locations (used in part with biological community attributes to assess habitat within a stream reach) are also illustrated. Generally, "good" habitat scores (>65) are necessary to support healthy, aquatic communities. While a point location may have a "good" MSHA score, SID results consider habitat throughout the stream reach, which can be considerably lower quality than a point location.

Figure 21: Stream habitat in the Blue Earth River Watershed. Stream habitat at point locations was scored using the MSHA habitat score; those scores are indicated by the colored squares. While a stream reach can be stressed by degraded habitat, point locations on that reach may have good habitat. Most locations in the watershed scored fair to poor stream habitat.

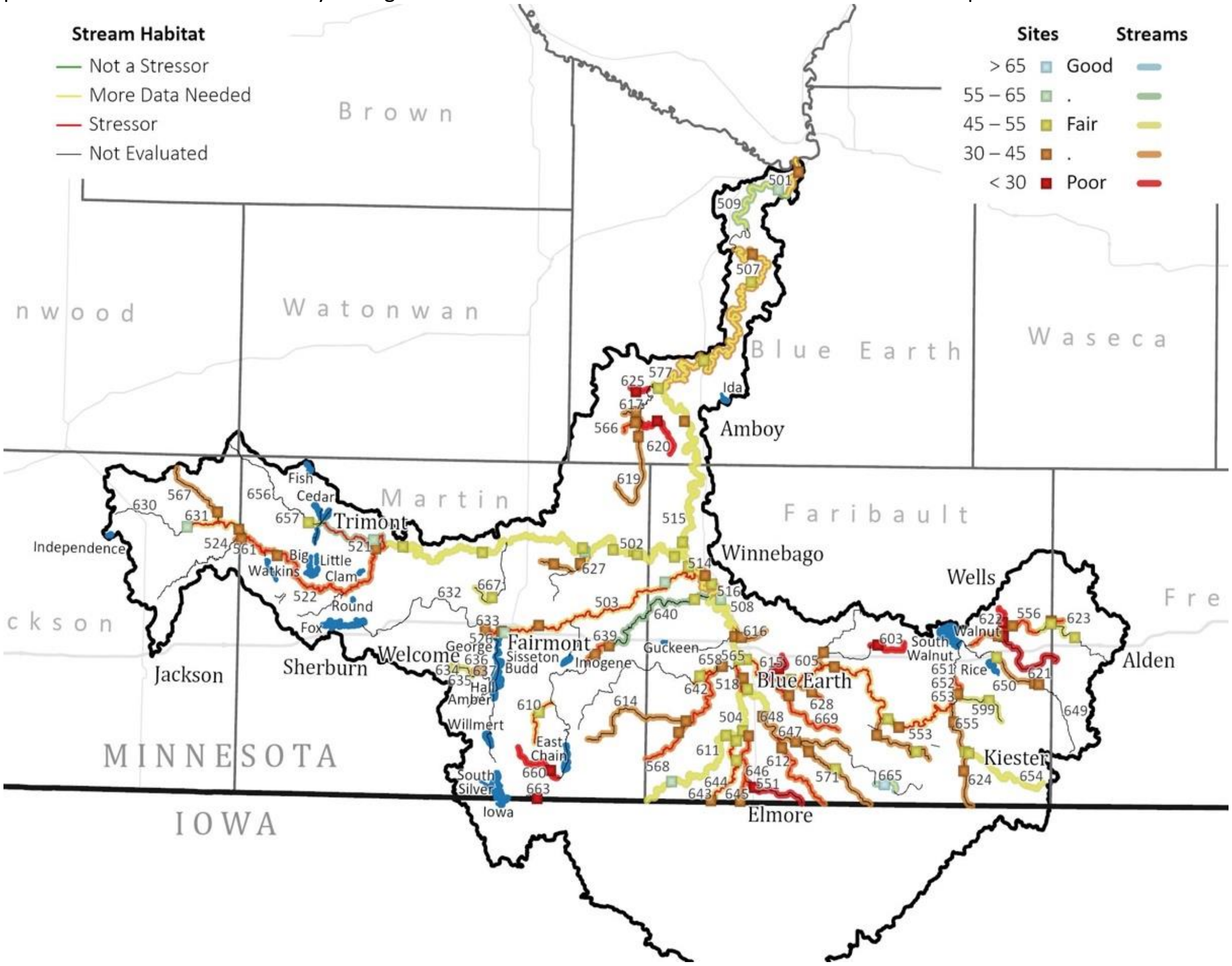


Figure 22: MPCA's Stream Habitat Assessment Score. MPCA's Stream Habitat Assessment score ranks habitat from good to poor.

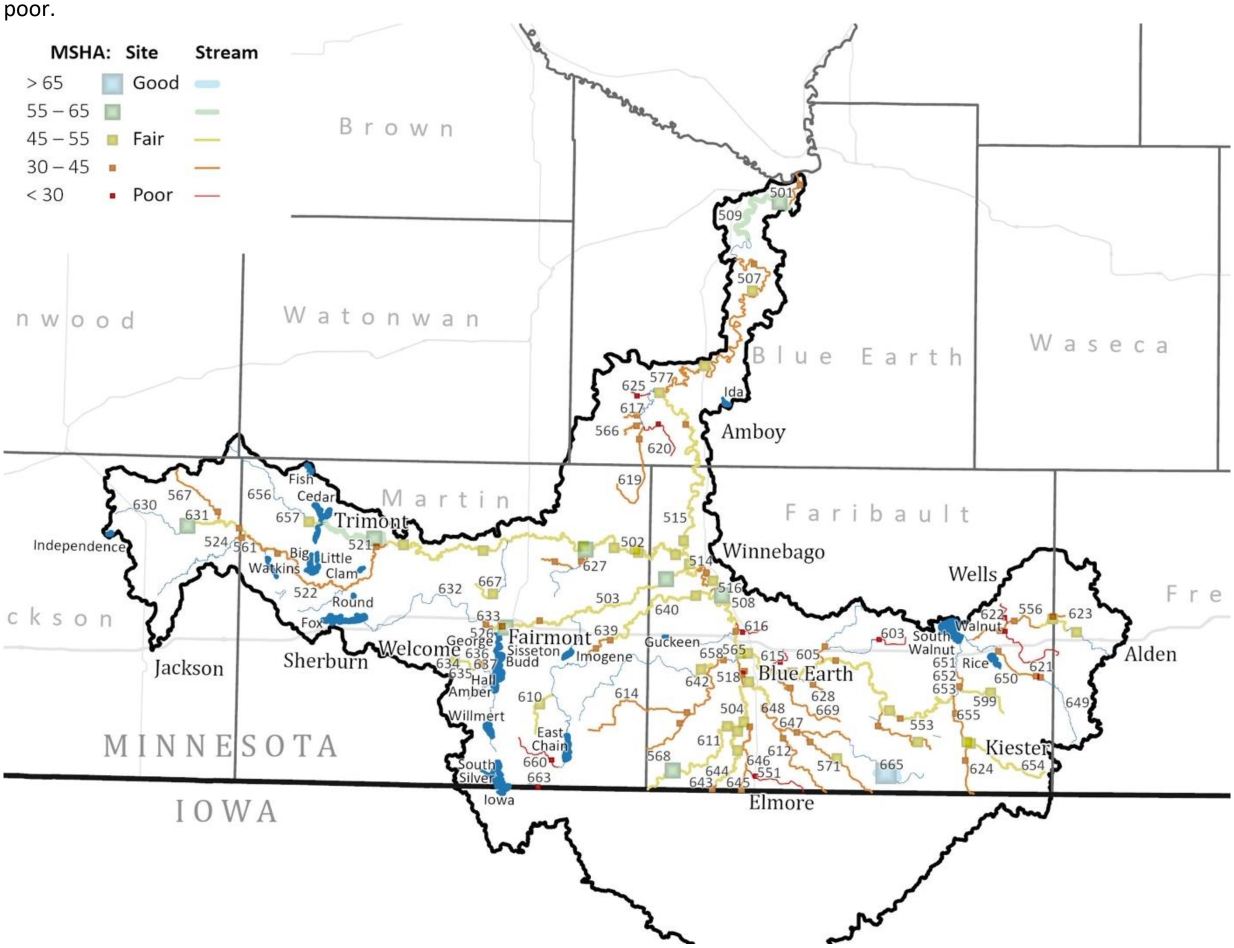


Table 7: Assessment results for degraded habitat as a stressor in Blue Earth River Watershed stream reaches.

Stream	Reach (AUID-3)	Habitat	Stream	Reach (AUID-3)	Habitat	Stream	Reach (AUID-3)	Habitat
Blue Earth River	501	?	County Ditch 25	603	x	South Creek	639	x
Elm Creek	502	?	County Ditch 5	605	-	South Creek	640	-
Center Creek	503	x	Judicial Ditch 98	610	x	Little Badger Creek	642	x
Blue Earth River	504	?	Judicial Ditch 7	611	?	Blue Earth River, West Branch	643	x
Blue Earth River	507	?	County Ditch 31	612	x	Blue Earth River, West Branch	644	x
Blue Earth River	508	?	Judicial Ditch 14	614	-	Blue Earth River, Middle Branch	645	-
Blue Earth River	509	?	County Ditch 14	615	-	Blue Earth River, Middle Branch	646	x

Stream	Reach (AUID-3)	Habitat
Blue Earth River	514	?
Blue Earth River	515	?
Blue Earth River	516	?
Blue Earth River	518	x
Cedar Creek (Cedar Run Creek)	521	x
Elm Creek	522	x
Elm Creek, South Fork	524	-
Center Creek	526	-
Unnamed ditch	551	-
Blue Earth River, East Branch	553	x
Foster Creek	556	x
Elm Creek, South Fork	561	x
Blue Earth River	565	?
Unnamed creek	566	x
Elm Creek, North Fork	567	-
Judicial Ditch 14 (Badger Creek)	568	x
Judicial Ditch 13 Branch A	571	-
Willow Creek	577	?
Unnamed ditch	599	-

Stream	Reach (AUID-3)	Habitat
County Ditch 17	616	-
Unnamed creek	617	-
Judicial Ditch 116	619	-
County Ditch 89/Judicial Ditch 24	620	x
Unnamed creek	621	-
Thisius Branch	622	x
Judicial Ditch 14	623	x
Unnamed creek	624	-
Unnamed creek	625	x
Judicial Ditch 3	627	?
County Ditch 26	628	x
Elm Creek	630	-
Elm Creek	631	x
Lily Creek	632	-
Lily Creek	633	x
Dutch Creek	634	-
Dutch Creek	635	-
Dutch Creek	636	x
Dutch Creek	637	-

Stream	Reach (AUID-3)	Habitat
Coon Creek	647	-
Coon Creek	648	?
Blue Earth River, East Branch	649	-
Blue Earth River, East Branch	650	-
Blue Earth River, East Branch	651	-
Blue Earth River, East Branch	652	x
Blue Earth River, East Branch	653	-
Brush Creek	654	?
Brush Creek	655	-
Cedar Creek (Cedar Run Creek)	656	-
Cedar Creek (Cedar Run Creek)	657	-
Badger Creek	658	-
Judicial Ditch 38	660	x
Unnamed creek	663	-
Judicial Ditch 13	665	?
County Ditch 72	667	-
County Ditch 8	669	x

x	= stressor	?	= inconclusive (need more data)
+	= not a stressor	-	= not assessed

Sources

The specific drivers of lack of habitat were assessed for the Blue Earth River Watershed in the SID report. Streambed sedimentation has led to a lack of pool/riffle habitat diversity, with bank erosion and lack of vegetation in the riparian corridor being driven by excessive flow alteration (altered hydrology). The drivers of lack of habitat in the Blue Earth River Watershed (Table 8) reflect complex, interconnected sources driven by three primary factors: altered hydrology, excess sediment, and heavily altered landscape which combine to limit habitat diversity. Within the confines of a channelized stream, the impacts of altered hydrology (excessive flow) are magnified because the stream cannot dissipate energy to the floodplain. Concurrently, degraded riparian vegetation lacks the strength to resist erosion and does not offer AqL adequate cover. The excessive streambank erosion in turn creates bedded sediment. All these factors compromise or destroy critical habitat components.

Table 8: Drivers of habitat stressors in the Blue Earth River Watershed.

		Habitat				
Stream Name	**WID**	**Channelized**	**Riparian**	**Streambed**	**Habitat diversity**	**Trampling**
Blue Earth River	501			o		
Center Creek	503		●	●	●	●
Blue Earth River	504		o			
Blue Earth River	507			o		
Blue Earth River	508		o			
Blue Earth River	509			o		
Blue Earth River	514		o			
Blue Earth River	515			o		
Blue Earth River	516		o	o	o	
Blue Earth River	518		●	●	●	
Cedar Run Creek	521			●	●	
Elm Creek	522		●	●		
Blue Earth River, East Branch	553			●	●	
Foster Creek	556	●	●	●	●	
South Fork	561	●	●	●		
Blue Earth River	565		o			
Unnamed Creek	566	●	●	●	●	
Badger Creek	568	●	●	●	●	
Judicial Ditch 7	611			o		
County Ditch 31	612	●	●	●	●	
County Ditch 89	620	●	●	●	●	
Thisius Branch	622	●	●	●	●	
Judicial Ditch 14	623	●	●	●	●	
Unnamed Creek	625			●	●	
Judicial Ditch 38	627					
County Ditch 26	628	●	●	●	●	
Elm Creek	631	●	●	●		
Lily Creek	633		●	●	●	
Dutch Creek	636	●	●	●	●	●
South Creek	639		●	●		
Little Badger Creek	642	●	●	●	●	●
West Branch	643	●	●	●	●	
West Branch	644	●	●	●	●	
Blue Earth River, Middle Branch	646	●	●	●	●	
Coon Creek	648					
Blue Earth River, East Branch	652	●	●	●	●	

		Habitat				
Stream Name	WID	Channelized	Riparian	Streambed	Habitat diversity	Trampling
Willow Creek	577			o		
County Ditch 25	603	●	●	●	●	
Judicial Ditch 98	610	●	●	●	●	

		Habitat				
Stream Name	WID	Channelized	Riparian	Streambed	Habitat diversity	Trampling
Judicial Ditch 38	660	●	●	●	●	
Judicial Ditch 13	665					
County Ditch 8	669	●	●	●	●	

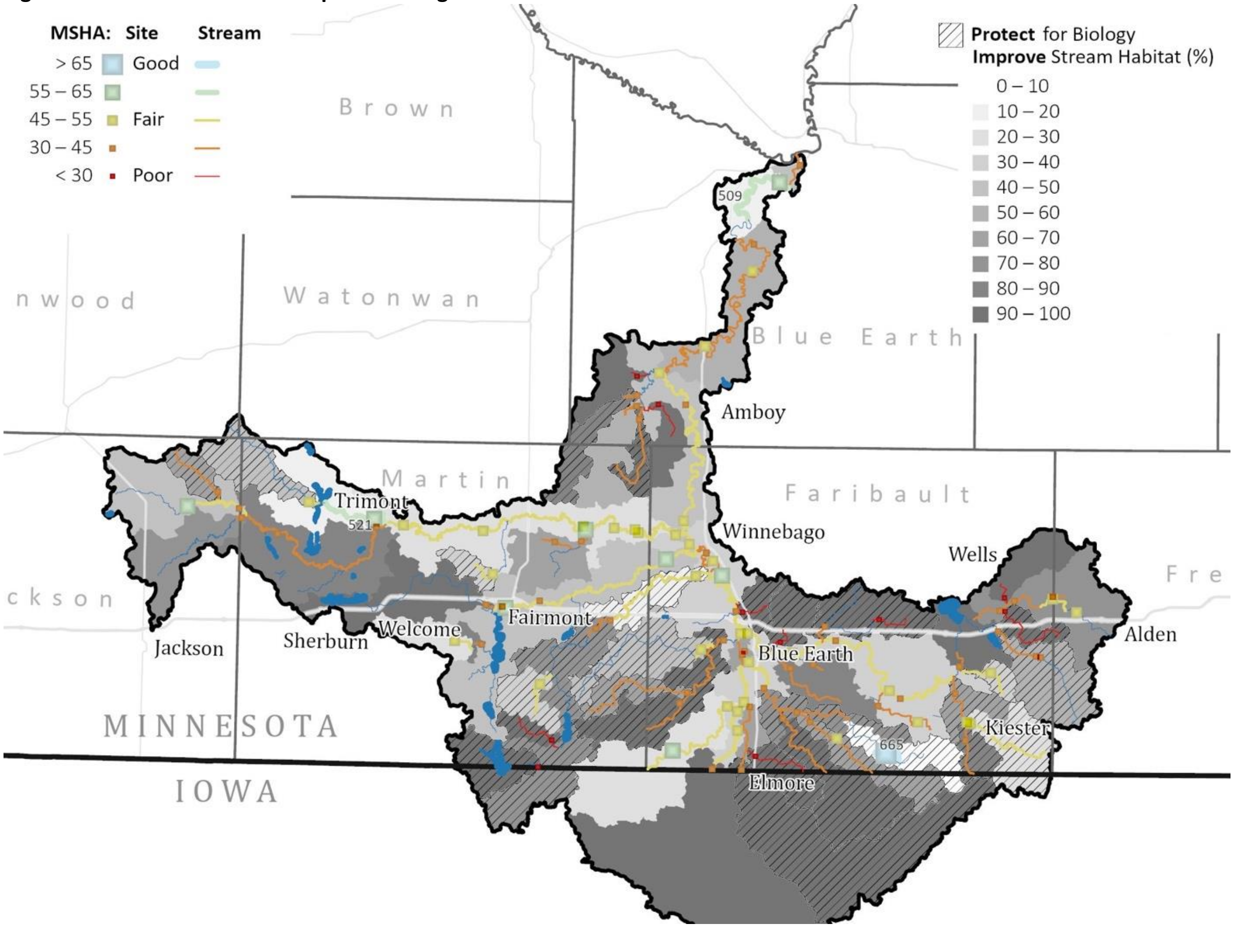
KEY	
	Stressor
	Inconclusive
	Not a Stressor
●	Driver/Pathway
o	Potential Driver/Pathway

Goal and 10-year Target

The watershed-wide goal for habitat in the Blue Earth River Watershed (Figure 23) is a 65% increase in the watershed average MSHA score, from 42 to 66 or greater. Subwatershed goals range based on the steam class; Class 2 stream reaches should have “good” habitat (MSHA score >66) and Class 2 modified (ditches) and Class 7 (limited use) stream reaches should have “fair” habitat (MSHA score >45). Individual site scores were averaged to create stream reach conditions. Goals were created based on the average reach score and shaded by the percent increase needed to improve the habitat score to meet the “good” IBI goal.

The 10-year target selected by the WRAPS LWG is a 10% increase in the MSHA scores. Since low habitat scores are mostly due to degraded riparian vegetation, channel instability, and excess sediment (the latter being accelerated by altered hydrology), these factors should be the focus of restoration and protection efforts to meet the goal and 10-year target. Strategies and methods to prioritize regions to address habitat are summarized in Section 3.

Figure 23: Habitat status and improvement goals in the Blue Earth River Watershed.



Altered Hydrology

Altered hydrology (USGS 2014b) in general refers to changes in hydrologic parameters including stream flow, precipitation, drainage, impervious surfaces, wetlands, stream paths, vegetation, soil conditions, etc. Altered hydrology as an identified stressor more specifically refers to changes in the amount and timing of stream flow. Both too much and too little stream flow directly harm AqL by creating excessive speeds in the water or reducing the amount of water. Altered hydrology also indirectly harms AqL because it increases the transport or exacerbates the conditions of other pollutants and stressors, including sediment from streambank erosion, nitrogen, and connectivity issues.

Status

The SID process was conducted on 42 of the bio-impaired stream reaches. Altered hydrology was identified as a stressor in all reaches. The altered hydrology assessment results are illustrated in Figure 24 and tabulated in Table 9.

Figure 24: Altered hydrology as a stressor in the Blue Earth River Watershed. Altered hydrology was identified as a stressor throughout the Blue Earth River Watershed. Red indicates a stressor (altered hydrology is problematic in that reach), and yellow indicates that more data is needed to assess altered hydrology as a stressor.

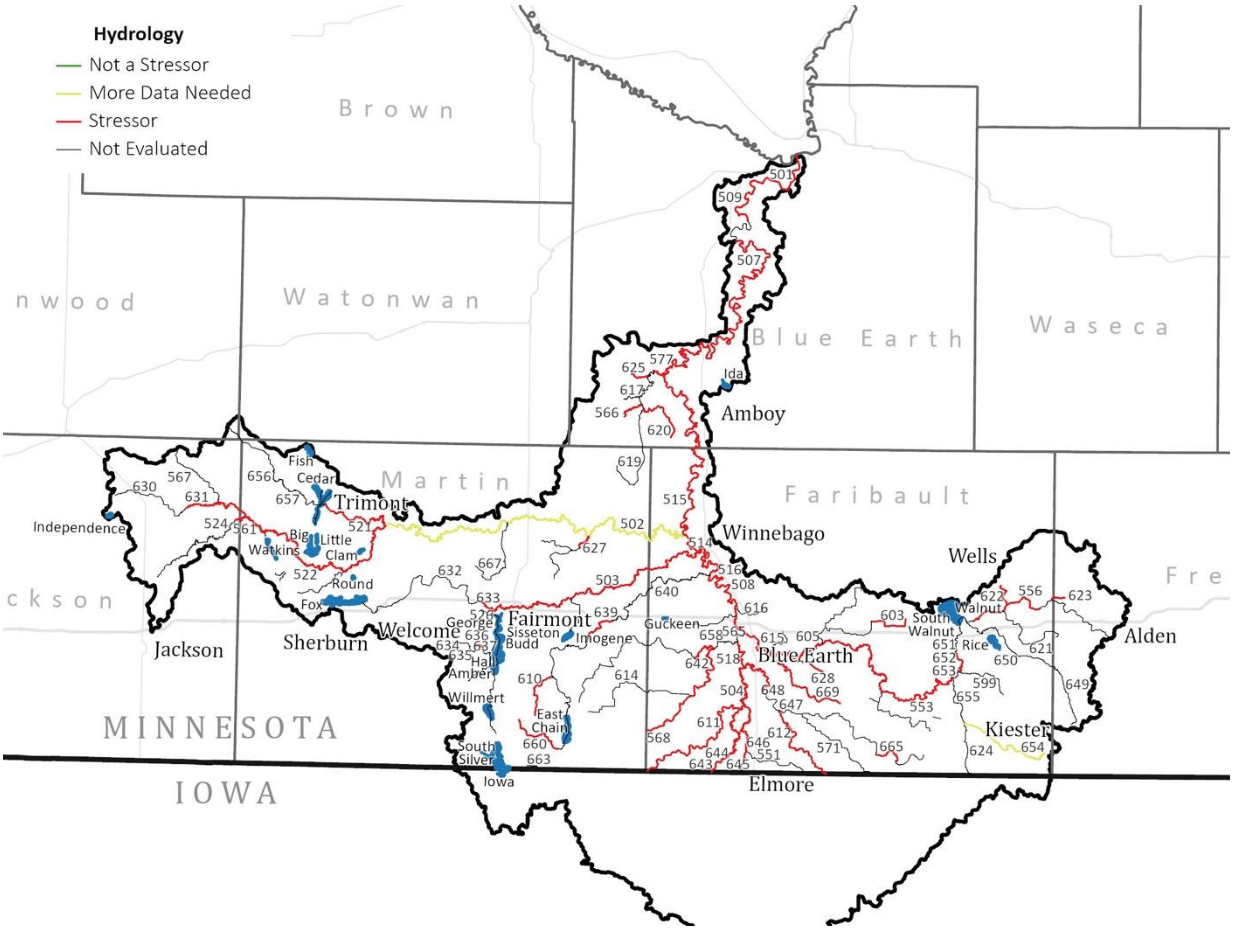


Table 9: Assessment results for altered hydrology as a stressor in Blue Earth River Watershed stream reaches.

Stream	Reach (AUID-3)	Hydrology	Stream	Reach (AUID-3)	Hydrology	Stream	Reach (AUID-3)	Hydrology
Blue Earth River	501	x	County Ditch 25	603	x	South Creek	639	x
Elm Creek	502	?	County Ditch 5	605	-	South Creek	640	-
Center Creek	503	x	Judicial Ditch 98	610	x	Little Badger Creek	642	x
Blue Earth River	504	x	Judicial Ditch 7	611	x	Blue Earth River, West Branch	643	x
Blue Earth River	507	x	County Ditch 31	612	x	Blue Earth River, West Branch	644	x
Blue Earth River	508	x	Judicial Ditch 14	614	-	Blue Earth River, Middle Branch	645	-
Blue Earth River	509	x	County Ditch 14	615	-	Blue Earth River, Middle Branch	646	x
Blue Earth River	514	x	County Ditch 17	616	-	Coon Creek	647	-
Blue Earth River	515	x	Unnamed creek	617	-	Coon Creek	648	x

Stream	Reach (AUID-3)	Hydrology
Blue Earth River	516	x
Blue Earth River	518	x
Cedar Creek (Cedar Run Creek)	521	x
Elm Creek	522	x
Elm Creek, South Fork	524	-
Center Creek	526	-
Unnamed ditch	551	-
Blue Earth River, East Branch	553	x
Foster Creek	556	x
Elm Creek, South Fork	561	x
Blue Earth River	565	x
Unnamed creek	566	x
Elm Creek, North Fork	567	-
Judicial Ditch 14 (Badger Creek)	568	x
Judicial Ditch 13 Branch A	571	-
Willow Creek	577	x
Unnamed ditch	599	-

Stream	Reach (AUID-3)	Hydrology
Judicial Ditch 116	619	-
County Ditch 89/Judicial Ditch 24	620	x
Unnamed creek	621	-
Thisius Branch	622	x
Judicial Ditch 14	623	x
Unnamed creek	624	-
Unnamed creek	625	x
Judicial Ditch 3	627	x
County Ditch 26	628	x
Elm Creek	630	-
Elm Creek	631	x
Lily Creek	632	-
Lily Creek	633	x
Dutch Creek	634	-
Dutch Creek	635	-
Dutch Creek	636	x
Dutch Creek	637	-

Stream	Reach (AUID-3)	Hydrology
Blue Earth River, East Branch	649	-
Blue Earth River, East Branch	650	-
Blue Earth River, East Branch	651	-
Blue Earth River, East Branch	652	x
Blue Earth River, East Branch	653	-
Brush Creek	654	?
Brush Creek	655	-
Cedar Creek (Cedar Run Creek)	656	-
Cedar Creek (Cedar Run Creek)	657	-
Badger Creek	658	-
Judicial Ditch 38	660	x
Unnamed creek	663	-
Judicial Ditch 13	665	x
County Ditch 72	667	-
County Ditch 8	669	x

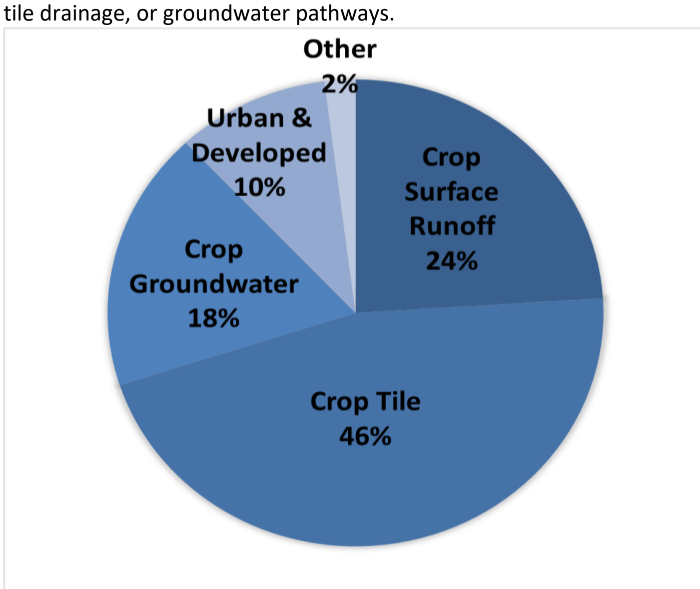
x	= stressor	?	= inconclusive (need more data)
+	= not a stressor	-	= not assessed

Sources

There are several causes of altered hydrology in the Blue Earth River Watershed. These causes range from landscape and climate changes, to crop and vegetative changes, to soil and drainage changes. While understanding what has caused altered hydrology is important to develop restoration strategies, numeric source assessment work focused on the land use and pathway that water travels after being received as precipitation. By understanding the relative magnitude of water coming from various land uses and pathways, the land uses most critical to mitigating altered hydrology are identified.

While most precipitation is returned to the atmosphere by ET, the remaining water travels to water bodies via different pathways. Pathways for water to travel to water bodies include surface runoff, groundwater flow, and artificial subsurface drainage such as drainage tile or storm sewer networks. Numeric estimates of the Blue Earth River Watershed land uses' contributions of water to water bodies were estimated using a water portioning calculator (Appendix 4.2) and vetted by the WRAPS LWG (Figure 25).

Figure 25: Estimates of relative hydrologic contributions in the Blue Earth River Watershed by land use. An estimated 88% of water that enters water bodies in the Blue Earth River Watershed is delivered from cultivated cropland through surface runoff, tile drainage, or groundwater pathways.



SID analyzed the specific altered hydrology issues of stressed stream reaches in the Blue Earth River Watershed. All of the 42 stream reaches were stressed by altered hydrology. These stressors are largely tied to past and present land use activities in the watershed. Watersheds that have a high degree of human alteration are most at risk for altered hydrology stress issues resulting from land use/tile drainage or channelization, and have been the primary driver of stream erosion and instability causing habitat loss and impacts to biology (Table 10). Agricultural land use with associated tile drainage and channelized (altered) streams was the most identified issue.

Table 10: Altered hydrology source assessment. The specific drivers of altered hydrology were assessed for the Blue Earth River Watershed in the SID report.

		Altered hydrology
Stream Name	**WID**	**Land use change, tile drainage and channelization**
Blue Earth River	501	●
Center Creek	503	●
Blue Earth River	504	●
Blue Earth River	507	●
Blue Earth River	508	●
Blue Earth River	509	●
Blue Earth River	514	●
Blue Earth River	515	●
Blue Earth River	516	●
Blue Earth River	518	●

		Altered hydrology
Stream Name	**WID**	**Land use change, tile drainage and channelization**
Judicial Ditch 7	611	●
County Ditch 31	612	●
County Ditch 89	620	●
Thisius Branch	622	●
Judicial Ditch 14	623	●
Unnamed Creek	625	●
Judicial Ditch 38	627	●
County Ditch 26	628	●
Elm Creek	631	●
Lily Creek	633	●

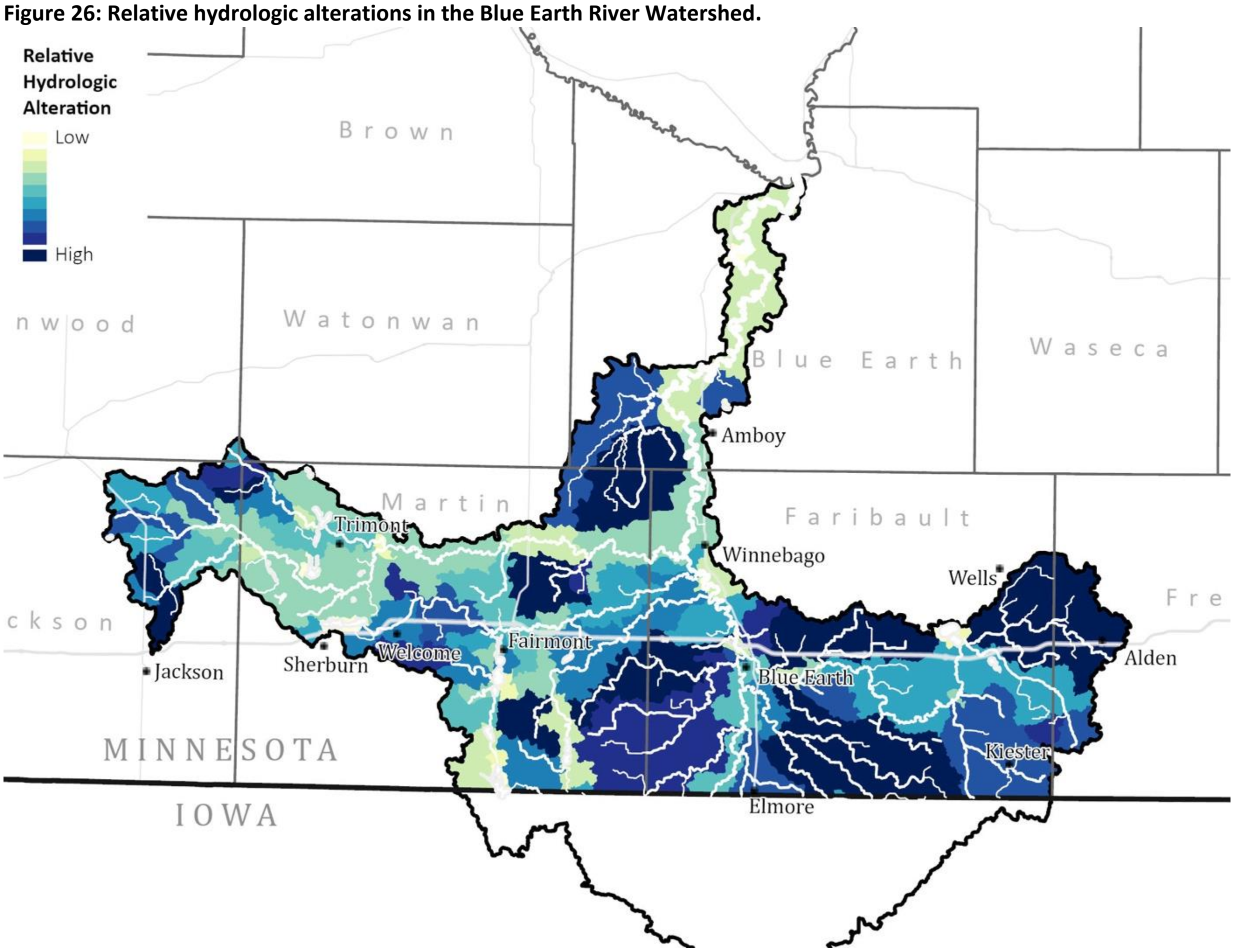
		Altered hydrology
Stream Name	**WID**	**Land use change, tile drainage and channelization**
Cedar Run Creek	521	●
Elm Creek	522	●
Blue Earth River, East Branch	553	●
Foster Creek	556	●
South Fork	561	●
Blue Earth River	565	●
Unnamed Creek	566	●
Badger Creek	568	●
Willow Creek	577	●
County Ditch 25	603	●
Judicial Ditch 98	610	●

		Altered hydrology
Stream Name	**WID**	**Land use change, tile drainage and channelization**
Dutch Creek	636	●
South Creek	639	●
Little Badger Creek	642	●
West Branch	643	●
West Branch	644	●
Blue Earth River, Middle Branch	646	●
Coon Creek	648	●
Blue Earth River, East Branch	652	●
Judicial Ditch 38	660	●
Judicial Ditch 13	665	●
County Ditch 8	669	●

KEY	
	Stressor
(light grey)	Inconclusive
(dark grey)	Not a Stressor
●	Driver/Pathway
o	Potential Driver/Pathway

Areas of the watershed with higher levels of hydrologic alteration were estimated using GIS (Figure 26). Hydrologic factors considered in the presented analysis include the estimated percentage of land area that is tile drained, the percentage of stream length that is channelized/artificially straightened, the percentage of wetlands that were drained, the percentage of land in nonperennial vegetation, the percentage of land covered in impervious surfaces, and the number of road crossings per stream length. See Appendix 4.4 for maps of the individual hydrologic factors and weights.

Figure 26: Relative hydrologic alterations in the Blue Earth River Watershed.



Goal and 10-year Target

The watershed-wide goals for altered hydrology in the Blue Earth River Watershed are a 25% decrease in average annual flow (from 823,000 to 617,000 acre-feet) and 25% decrease in peak river flow and an 25% increase in dry season base flow sufficient to support AqL (Figure 27). This goal considered multiple lines of evidence including the Sediment Reduction Strategy for the MN River Basin (MPCA 2015f), and data and goals for altered hydrology from other southwestern Minnesota watersheds. This goal is revisable and will be revisited in the next iteration of the Watershed Approach.

The 10-year target selected by the WRAPS LWG is no increase in annual and peak river flow and an increase in dry season base flow. The LWG felt that trying to set a reduction goal in the watershed would be extremely difficult with the changes in timing and intensity of rain events and the increasing number of drainage improvement projects that are proposed and installed. There was much discussion that there is the potential for more water to leave these systems in the future.

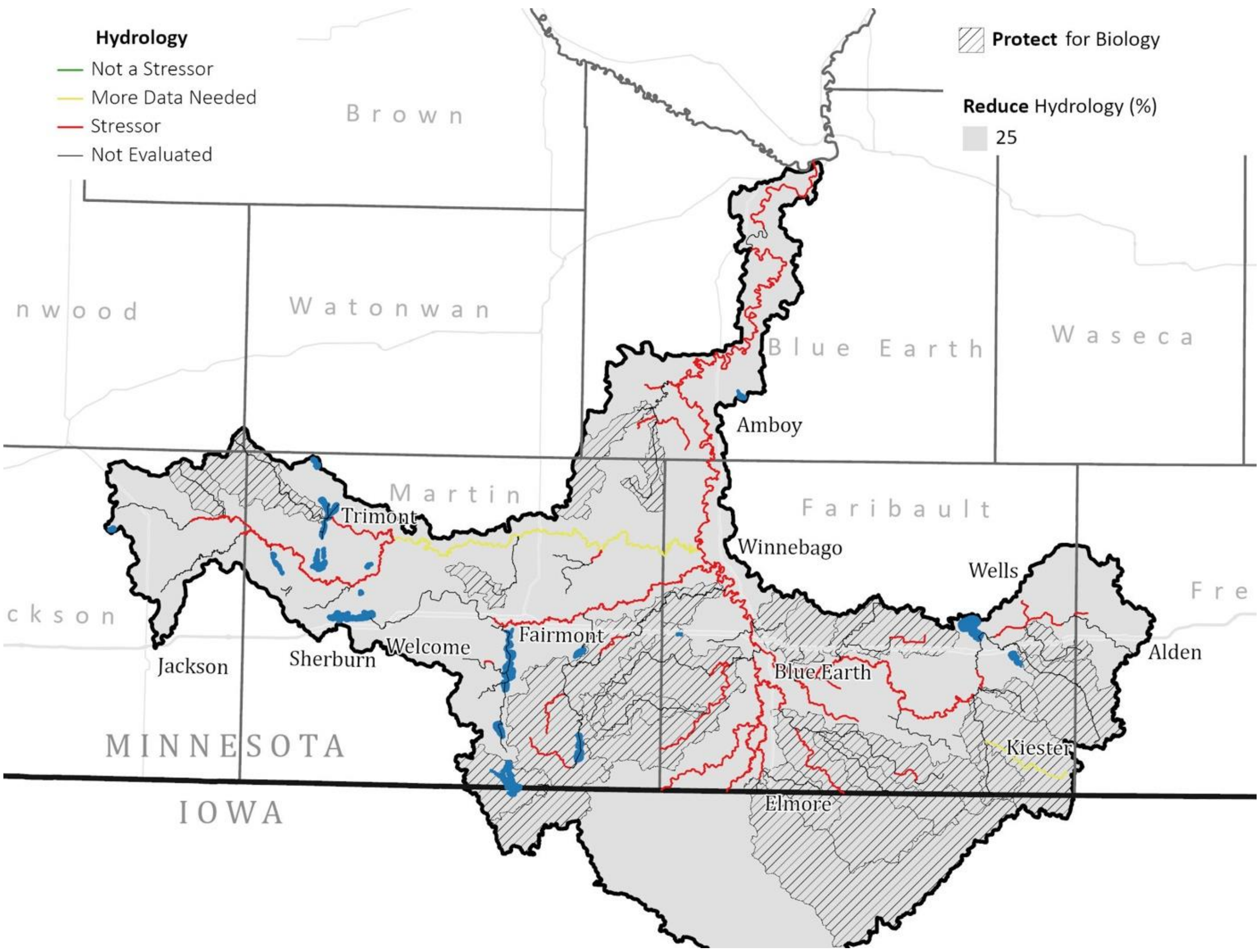
Increased flows and altered hydrology are often identified as a source of water quality impairments and stressors to aquatic biology. Drainage improvement projects represent an opportunity to incorporate water storage practices and other BMPs that can help offset total and peak flow increases. Drainage improvement projects require preliminary and final engineering reports that are submitted to DNR. The DNR provides advisory letters in response to the engineering reports to identify additional areas of investigation and any relevant DNR regulatory requirements. The MPCA coordinates with DNR in the development of the response letters to identify concerns related to water quality and aquatic biology.

Earlier coordination with drainage proposers could provide potential siting of water storage practices and funding.

The goals will be to continue to work with drainage authorities to design and implement water storage practices in drainage improvement projects that do not increase the volume of water coming from the projects in the improved systems. Local partners will also continue to work with landowners to promote and install practices that infiltrate and store more water in the soil profile.

Decreases in the total annual flow should focus on decreasing peak flows, shifting flow timing to the dry season, and maintaining the dynamic properties of the natural hydrograph, which are important for channel geomorphology, vegetation, and AqL. Strategies to accomplish these tasks must increase ET, store, and infiltrate water on the landscape to increase groundwater contributions (base flow) to streams during dry periods. Strategies and methods to prioritize regions to address altered hydrology are summarized in Section 3.

Figure 27: Watershed-wide altered hydrology goals in the Blue Earth River Watershed.



Nitrogen

Nitrogen can be present in water bodies in several forms including ammonia, nitrite, and nitrate. The process in which nitrogen changes from one form to another is called the nitrogen cycle (Britannica 2019). Nitrate is typically the nitrogen form of concern in water. However, all nitrogen forms are connected, and all forms pose risks. Therefore, the different nitrogen forms are addressed together in this report as the sum of the forms, or the total nitrogen (TN).

Excessive nitrogen can be toxic to fish and bugs; even at small concentrations nitrogen can limit sensitive species. The eutrophication causing the Gulf Hypoxic Zone (NOAA 2022) is due to excessive nutrient contributions from the Mississippi River Basin. Nitrogen is also a human health concern, as excessive nitrate consumption via drinking water can cause blue baby syndrome (MDH 2018) and has been linked to other health effects in adults. Due to this health risk, excessive nitrogen in drinking water can necessitate expensive treatments in both public and private drinking water systems. The MDH provides information on private wells and treatment options at Nitrate in Drinking Water.

Status

The SID process was conducted on 42 of the bio-impaired stream reaches. Nitrogen as a stressor was identified in 26, and inconclusive in 16. Figure 28 illustrates the stream reaches assessed for nitrogen, and Table 11 tabulates those results. Nitrogen, as measured by nitrate concentration, was one of the more common stressors in the Blue Earth River Watershed in regard to macroinvertebrate stressors. High concentrations of nitrate indicate a strong correlation in the drop of nitrate sensitive species. Many of the small headwater streams are supplied primarily through tile water and were considered vulnerable to nitrate overloading. Nitrogen in groundwater, while outside the scope of the WRAPS report, is a related concern as nitrogen in groundwater originates from the same sources.

Reach 503 Center Creek (Lily Creek to Blue Earth River) is impaired by ammonia. Data has been collected and the reach will be investigated further in the Cycle II watershed work to identify potential sources of the impairment. Future work will investigate potential delisting through source identification and implementation activities.

Figure 28: Nitrogen as a stressor in the Blue Earth River Watershed. Nitrogen as a stressor is common in the Blue Earth River Watershed. Stream reaches assessed for nitrogen and the assessment results are indicated by color. Red indicates TN was identified as a stressor (TN is problematic in that reach), yellow indicates that more data is needed.

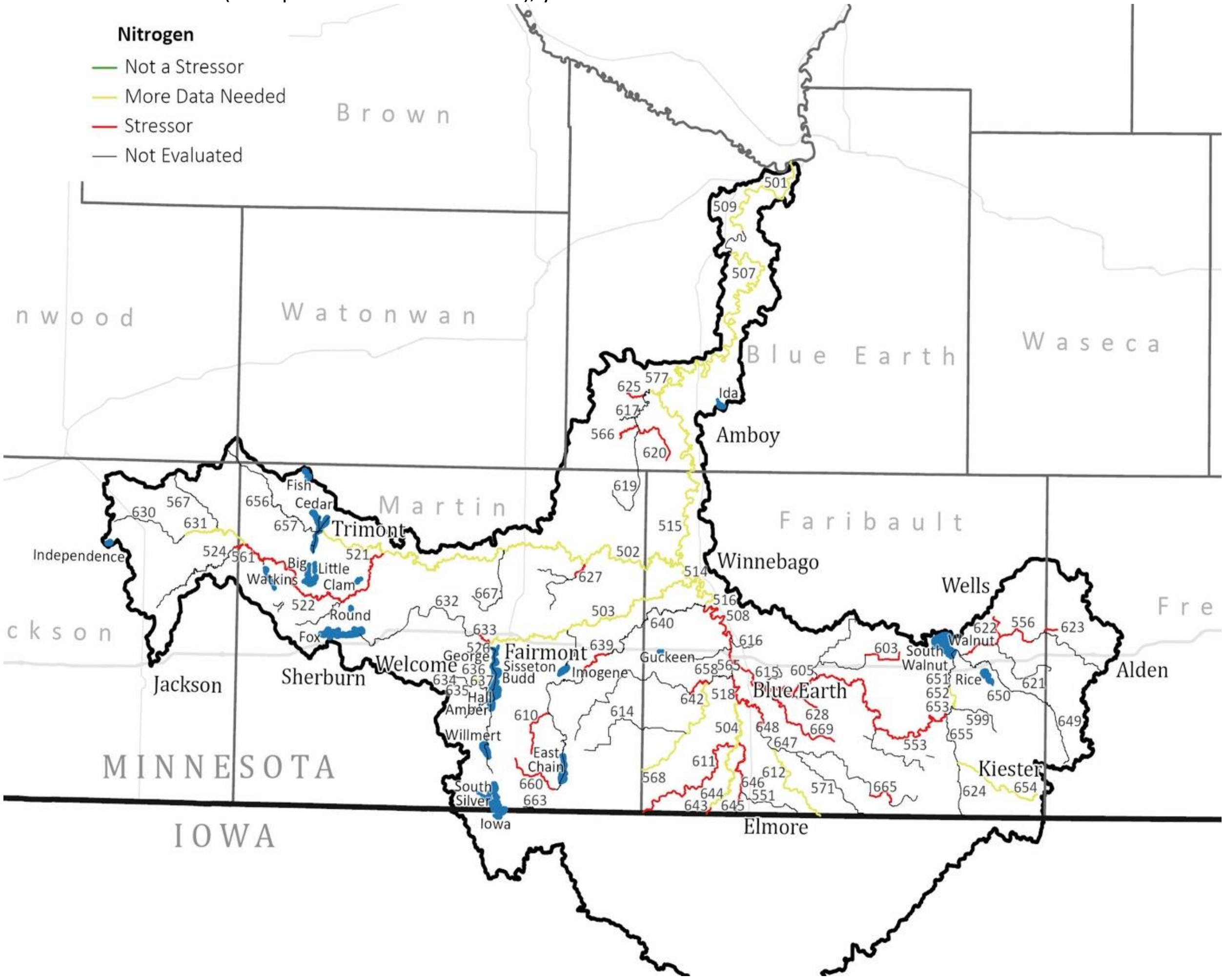


Table 11: SID results for Nitrogen (measured as nitrate) as a stressor in Blue Earth River Watershed stream reaches.

Stream	Reach (AUID-3)	Nitrogen
Blue Earth River	501	?
Elm Creek	502	?
Center Creek	503	?
Blue Earth River	504	?
Blue Earth River	507	?
Blue Earth River	508	x
Blue Earth River	509	?
County Ditch 25	603	x
County Ditch 5	605	-
Judicial Ditch 98	610	x
Judicial Ditch 7	611	x
County Ditch 31	612	?
Judicial Ditch 14	614	-
County Ditch 14	615	-
South Creek	639	x
South Creek	640	-
Little Badger Creek	642	x
Blue Earth River, West Branch	643	x
Blue Earth River, West Branch	644	?
Blue Earth River, Middle Branch	645	-
Blue Earth River, Middle Branch	646	x

Stream	Reach (AUID-3)	Nitrogen
Blue Earth River	514	?
Blue Earth River	515	?
Blue Earth River	516	?
Blue Earth River	518	x
Cedar Creek (Cedar Run Creek)	521	?
Elm Creek	522	x
Elm Creek, South Fork	524	-
Center Creek	526	-
Unnamed ditch	551	-
Blue Earth River, East Branch	553	x
Foster Creek	556	x
Elm Creek, South Fork	561	x
Blue Earth River	565	x
Unnamed creek	566	x
Elm Creek, North Fork	567	-
Judicial Ditch 14 (Badger Creek)	568	?
Judicial Ditch 13 Branch A	571	-
Willow Creek	577	?
Unnamed ditch	599	-

Stream	Reach (AUID-3)	Nitrogen
County Ditch 17	616	-
Unnamed creek	617	-
Judicial Ditch 116	619	-
County Ditch 89/ Judicial Ditch 24	620	x
Unnamed creek	621	-
Thisius Branch	622	x
Judicial Ditch 14	623	x
Unnamed creek	624	-
Unnamed creek	625	x
Judicial Ditch 3	627	x
County Ditch 26	628	x
Elm Creek	630	-
Elm Creek	631	?
Lily Creek	632	-
Lily Creek	633	x
Dutch Creek	634	-
Dutch Creek	635	-
Dutch Creek	636	?
Dutch Creek	637	-

Stream	Reach (AUID-3)	Nitrogen
Coon Creek	647	-
Coon Creek	648	x
Blue Earth River, East Branch	649	-
Blue Earth River, East Branch	650	-
Blue Earth River, East Branch	651	-
Blue Earth River, East Branch	652	?
Blue Earth River, East Branch	653	-
Brush Creek	654	?
Brush Creek	655	-
Cedar Creek (Cedar Run Creek)	656	-
Cedar Creek (Cedar Run Creek)	657	-
Badger Creek	658	-
Judicial Ditch 38	660	x
Unnamed creek	663	-
Judicial Ditch 13	665	x
County Ditch 72	667	-
County Ditch 8	669	x

x	= stressor	?	= inconclusive (need more data)
+	= not a stressor	-	= not assessed

An HSPF model was developed for the Blue Earth River Watershed. The model's estimated FWMCs for the years 1996 through 2017 are illustrated in Figure 29. This model output can be used to estimate conditions in stream reaches that have not been monitored, and estimates broadly that the western portion of the watershed ranges from 12 to 20 mg/L while the eastern and lower portions of the watershed range from 20 to 28 mg/L.

From a state-wide perspective, the Blue Earth River Watershed has a high yield and flow-weighted mean concentration (FWMC) of nitrogen (Figure 30). From 2007 through 2018, the FWMC of nitrogen in the Blue Earth River Watershed was 11 mg/L with an average yield of 24.6 lbs/acre based on WPLMN data.

Figure 29: Total Nitrogen FWMC based on HSPF model. The presented model output represents years 1996-2017.

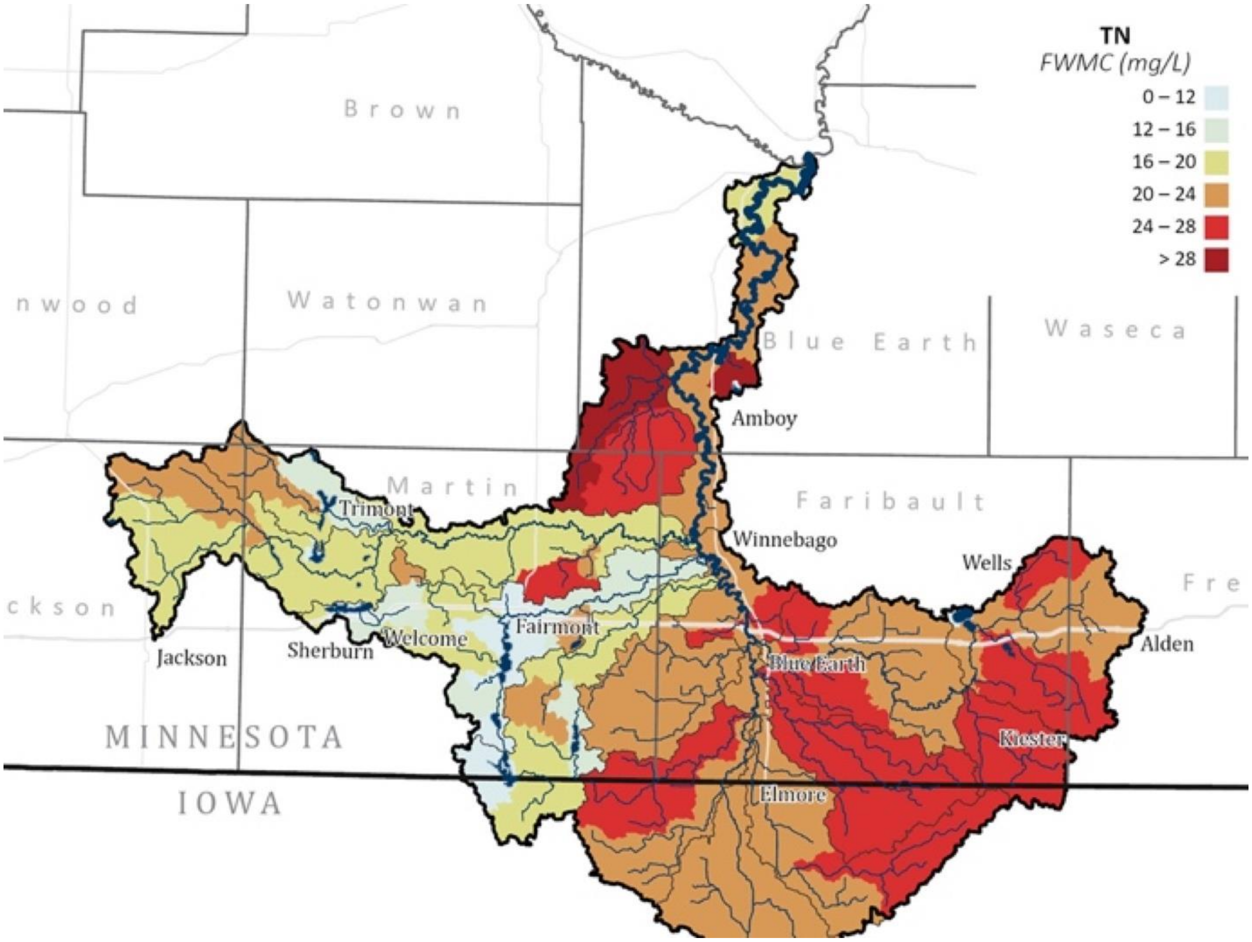
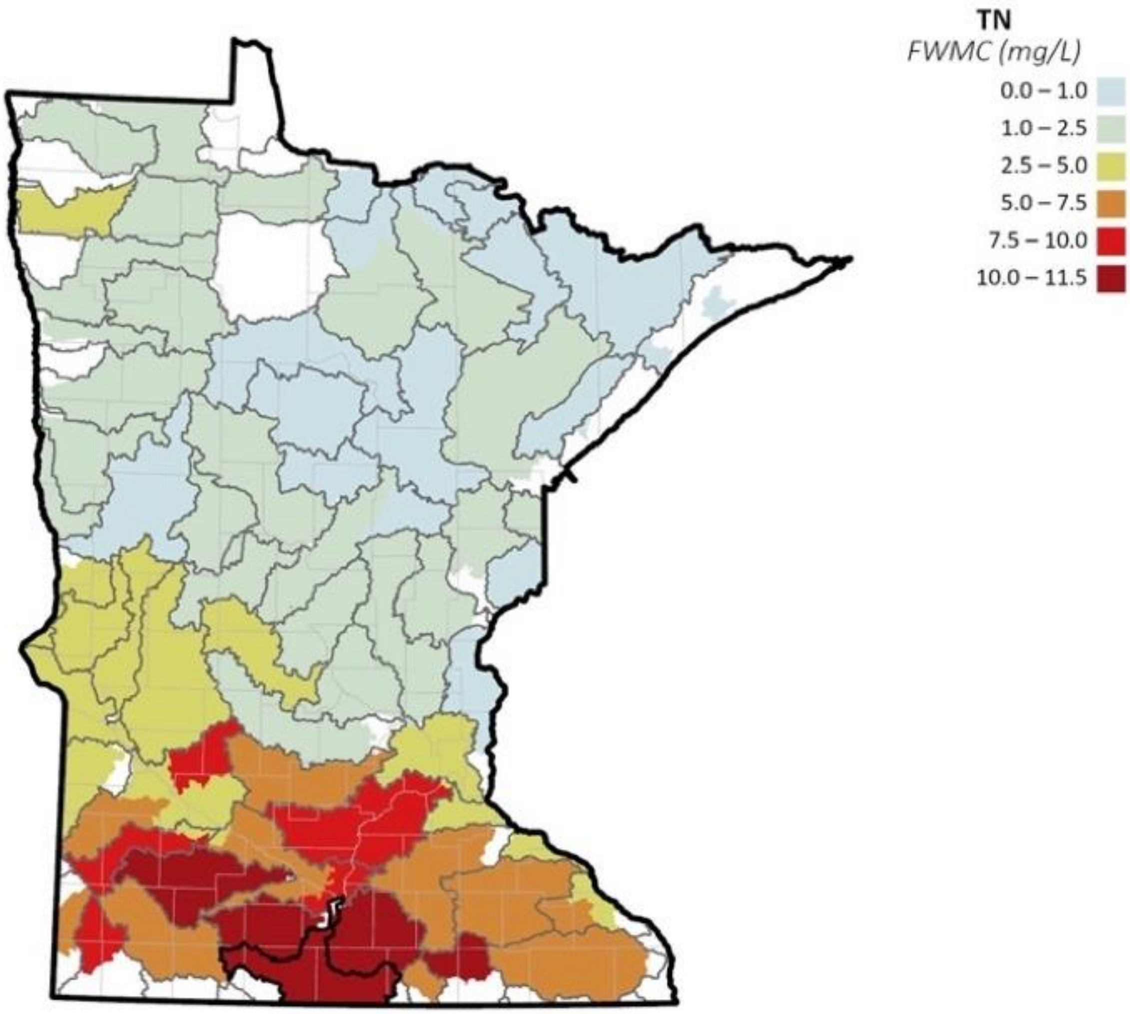
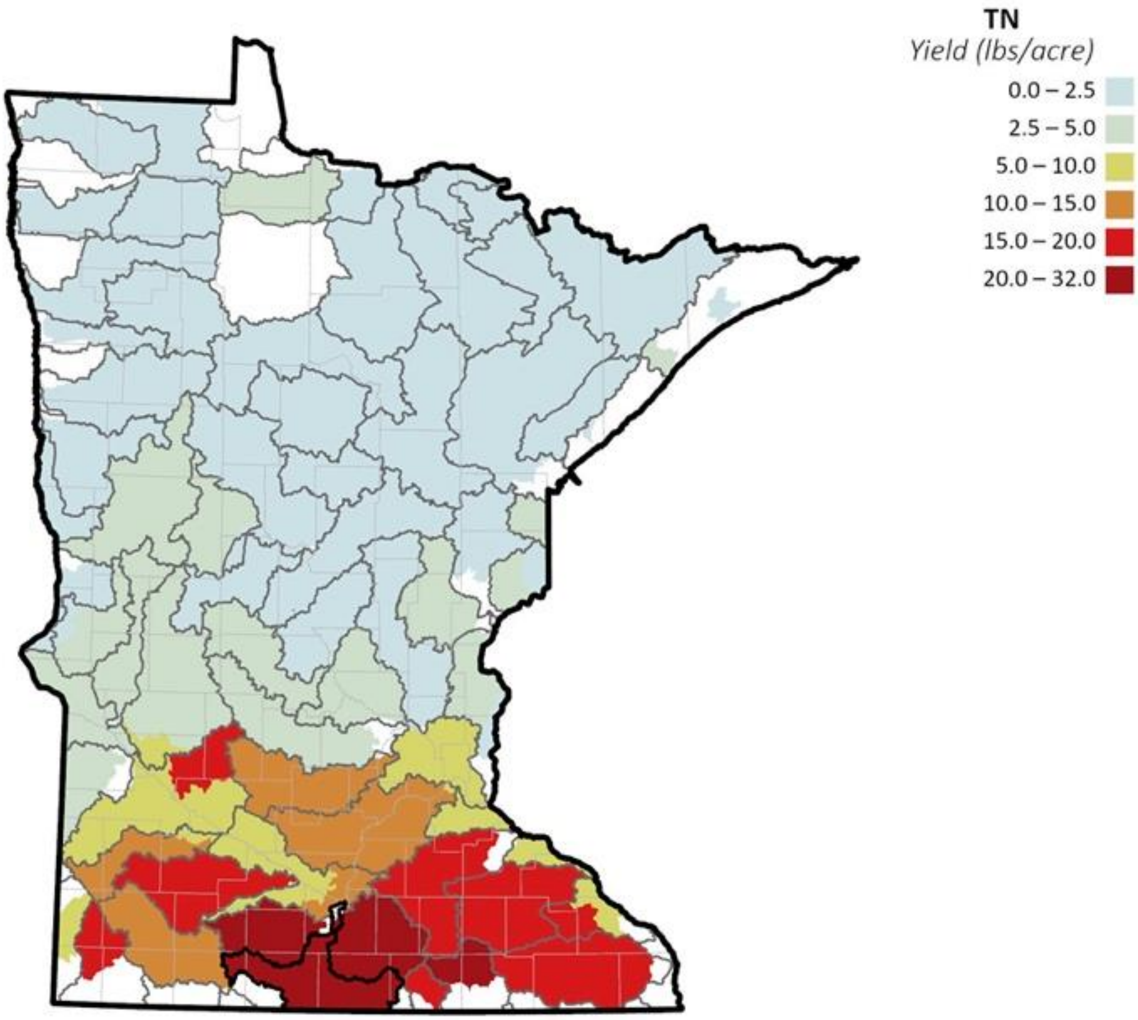


Figure 30: Total Nitrogen concentrations and yields in the state (WPLMN). The Blue Earth River Watershed has a high FWMC and yield of TN compared to the rest of the state. Data are from the WPLMN.





Nitrogen from the Blue Earth River Watershed is driving groundwater nitrogen issues within and downstream of the watershed. The Blue Earth River is a source of drinking water for the city of Mankato. Two municipal wells are Ranney wells, which are wells that extract water from an aquifer with direct connection to a surface water source. These two wells pull water that is influenced by the Blue Earth River and the Minnesota River through the surficial sands to supply the well with water. Nitrate concentrations in the Mankato Ranney Wells often exceed the drinking water standard of 10 mg/L, necessitating costly treatment or dilution. For more information, see the Source Water Assessment Area discussion in Appendix 4.4.

Sources

In the Blue Earth River Watershed, most nitrogen that reaches water bodies is from nonpoint sources. Point source contributions for the years of 2009 through 2018 are estimated to total less than 0.75% of the Blue Earth River Watershed's nitrogen load (Appendix 4.2). A numeric estimate of the Blue Earth River Watershed's nitrogen sources (land use and pathways) is presented in Figure 31; refer to the Sources Overview in Section 2.2 for more details.

Crop drainage and crop groundwater (shallow groundwater from nontiled fields) dominate nitrogen contributions to water bodies. Nitrogen contributions from cropland originate from fertilizers, manure, plant mater decomposition (referred to as mineralization), and legumes. Over-application of fertilizer and manure increases the potential nitrogen loss from cropland.

SID provides information on the drivers for the nitrogen-stressed stream reaches (Table 12). The SID report (MPCA 2021a) notes high concentrations of nitrate tolerant species and review of the chemistry data shows many exceedances of the drinking water standard and the draft toxicity criteria in the Aquatic Life Water Quality Standards Draft Technical Support Document for Nitrate (MPCA 2022c). SID source assessment results indicate cropland use and tile drainage are contributing nitrogen in all of the reaches. Point sources may be contributing nitrogen in nine reaches and further investigation will be conducted to determine whether municipalities are adding to the stressors on individual reaches.

Figure 31: Nitrogen source assessment in the Blue Earth River Watershed.

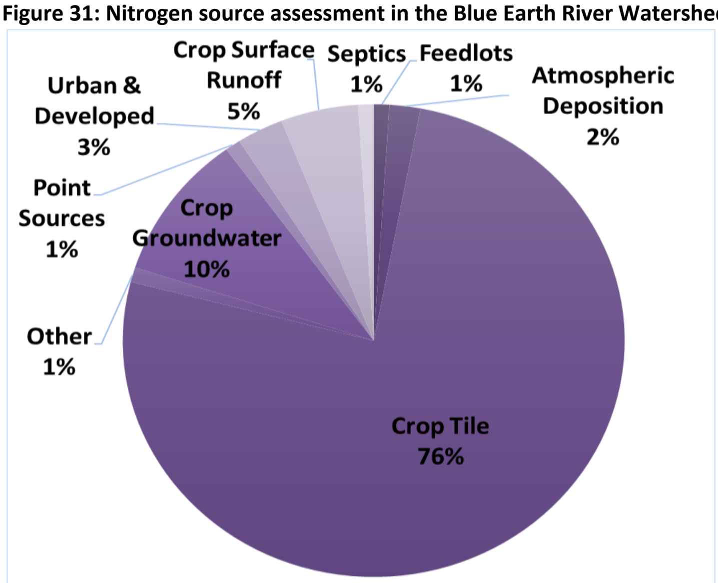


Table 12: Nitrogen source assessment in the Blue Earth River Watershed. The specific drivers of nitrogen for bio-impaired stream reaches were investigated in the SID report. Land use application, upstream water bodies, and point sources were drivers. Tile drainage and cropland use were the most commonly identified issues.

		Nitrate					Nitrate		
Stream Name	WID	Land Use (application)	Upstream water body	Point Source	Stream Name	WID	Land Use (application)	Upstream water body	Point Source
Blue Earth River	501		o	o	Judicial Ditch 7	611	●		
Center Creek	503	o	o	o	County Ditch 31	612	o		
Blue Earth River	504	o			County Ditch 89	620	●		
Blue Earth River	507	o			Thisius Branch	622	●		

		Nitrate					Nitrate		
Stream Name	**WID**	**Land Use (application)**	**Upstream water body**	**Point Source**	**Stream Name**	**WID**	**Land Use (application)**	**Upstream water body**	**Point Source**
Blue Earth River	508	●		o	Judicial Ditch 14	623	●		
Blue Earth River	509	o		o	Unnamed Creek	625	●		
Blue Earth River	514	o			Judicial Ditch 38	627	●		
Blue Earth River	515	o		o	County Ditch 26	628	●		
Blue Earth River	516	o			Elm Creek	631	o		
Blue Earth River	518	●		o	Lily Creek	633	●	●	o
Cedar Run Creek	521	o	o		Dutch Creek	636	o		o
Elm Creek	522	●	●		South Creek	639	●	●	
Blue Earth River, East Branch	553	●	●		Little Badger Creek	642	●		
Foster Creek	556	●			West Branch	643	●		o
South Fork	561	●			West Branch	644	o		
Blue Earth River	565	●		o	Blue Earth River, Middle Branch	646	●		o
Unnamed Creek	566	●			Coon Creek	648	●		
Badger Creek	568	o			Blue Earth River, East Branch	652	o		
Willow Creek	577	o	o		Judicial Ditch 38	660	●		
County Ditch 25	603	●			Judicial Ditch 13	665	●		
Judicial Ditch 98	610	●			County Ditch 8	669	●		

KEY	
	Stressor
	Inconclusive
	Not a Stressor
●	Driver/Pathway
o	Potential Driver/Pathway

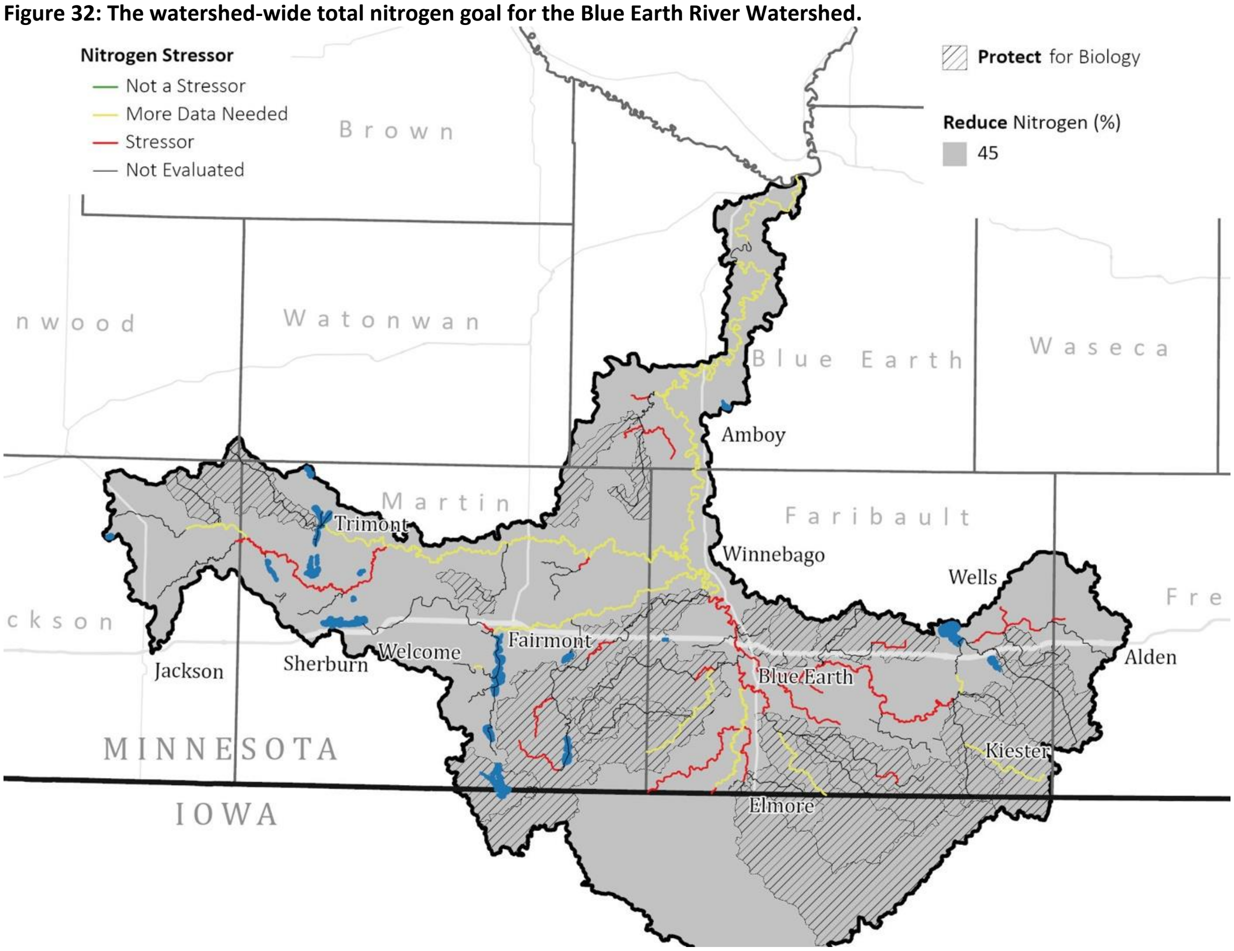
Goal and 10-year Target

The watershed-wide goal for nitrogen is a 45% reduction of stream concentration/loads for nitrogen (Figure 32). Two resources were considered to set the watershed-wide reduction goal: Aquatic Life

Water Quality Standards Draft Technical Document (MPCA 2022c; draft chronic values based on four-day duration of 8 mg/L Class for class 2B and 2Bd waters and 5 mg/L Class 2A streams) and the Minnesota Nutrient Reduction Strategy (MPCA 2014b), which calls for a 45% reduction (with an interim 20% reduction by 2025) from the Minnesota portion of the Mississippi River Basin as a whole.

The 10-year target selected by the WRAPS LWG is a 5% decrease in total nitrogen. These goals are revisable and will be revisited in the next iteration of the Watershed Approach. Strategies to meet the goals and 10-year targets and methods to prioritize regions for nitrogen reductions are summarized in Section 3.

Figure 32: The watershed-wide total nitrogen goal for the Blue Earth River Watershed.



Connectivity

Connectivity, as identified in this report, refers to the longitudinal connectivity of a stream, or the upstream to downstream connectedness of a stream. A lack of connectivity is typically due to dams, waterfalls, perched culverts, and improperly sized bridges and culverts. A lack of connectivity can obstruct the movement of migratory fish and bugs, causing a negative change in the population and community structure.

The Rapidan Dam creates a permanent fish barrier to the entire upper Blue Earth and Watonwan watersheds. This barrier eliminates the potential migration of fish from the Minnesota River system to the upper reaches of the Blue Earth, potentially reducing species diversity.

Status

The SID process was conducted on 42 of the bio-impaired stream reaches. Lack of connectivity as a stressor was identified in 40 reaches and ruled out in 2 stream reaches. Figure 33 illustrates the stream reaches assessed for connectivity and Table 13 tabulates those results.

Figure 33: Connectivity as a stressor in the Blue Earth River Watershed. Red indicates lack of connectivity is a stressor (connectivity is problematic in that reach), green indicates connectivity was not a stressor, and yellow indicates two reaches dropped from SID assessment.

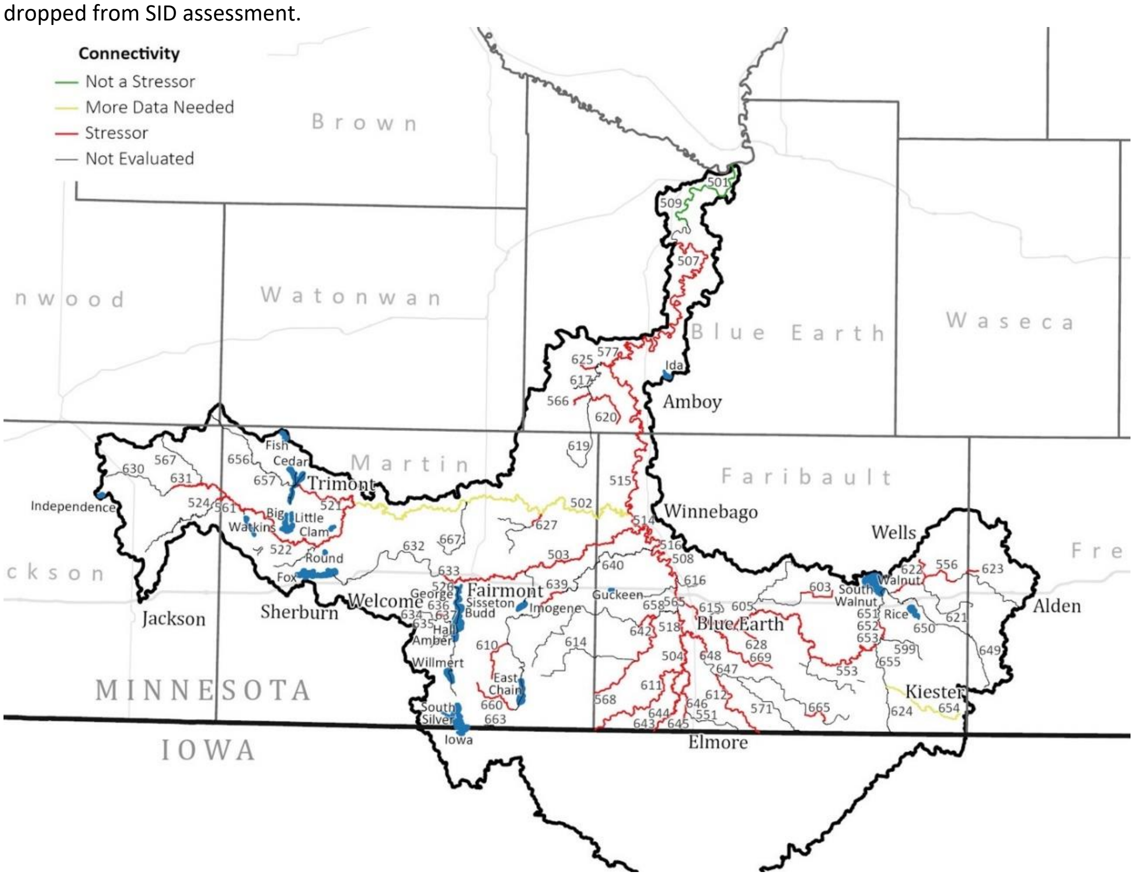


Table 13: Assessment results for lack of connectivity as a stressor in Blue Earth River Watershed stream reaches.

Stream	Reach (AUID-3)	Connectivity	Stream	Reach (AUID-3)	Connectivity	Stream	Reach (AUID-3)	Connectivity
Blue Earth River	501	+	County Ditch 25	603	x	South Creek	639	x
Elm Creek	502	?	County Ditch 5	605	-	South Creek	640	-
Center Creek	503	x	Judicial Ditch 98	610	x	Little Badger Creek	642	x
Blue Earth River	504	x	Judicial Ditch 7	611	x	Blue Earth River, West Branch	643	x
Blue Earth River	507	x	County Ditch 31	612	x	Blue Earth River, West Branch	644	x
Blue Earth River	508	x	Judicial Ditch 14	614	-	Blue Earth River, Middle Branch	645	-
Blue Earth River	509	+	County Ditch 14	615	-	Blue Earth River, Middle Branch	646	x

Stream	Reach (AUID-3)	Connectivity	Stream	Reach (AUID-3)	Connectivity	Stream	Reach (AUID-3)	Connectivity
Blue Earth River	514	x	County Ditch 17	616	-	Coon Creek	647	-
Blue Earth River	515	x	Unnamed creek	617	-	Coon Creek	648	x
Blue Earth River	516	x	Judicial Ditch 116	619	-	Blue Earth River, East Branch	649	-
Blue Earth River	518	x	County Ditch 89/Judicial Ditch 24	620	x	Blue Earth River, East Branch	650	-
Cedar Creek (Cedar Run Creek)	521	x	Unnamed creek	621	-	Blue Earth River, East Branch	651	-
Elm Creek	522	x	Thisius Branch	622	x	Blue Earth River, East Branch	652	x
Elm Creek, South Fork	524	-	Judicial Ditch 14	623	x	Blue Earth River, East Branch	653	-
Center Creek	526	-	Unnamed creek	624	-	Brush Creek	654	?
Unnamed ditch	551	-	Unnamed creek	625	x	Brush Creek	655	-
Blue Earth River, East Branch	553	x	Judicial Ditch 3	627	x	Cedar Creek (Cedar Run Creek)	656	-
Foster Creek	556	x	County Ditch 26	628	x	Cedar Creek (Cedar Run Creek)	657	-
Elm Creek, South Fork	561	x	Elm Creek	630	-	Badger Creek	658	-
Blue Earth River	565	x	Elm Creek	631	x	Judicial Ditch 38	660	x
Unnamed creek	566	x	Lily Creek	632	-	Unnamed creek	663	-
Elm Creek, North Fork	567	-	Lily Creek	633	x	Judicial Ditch 13	665	x
Judicial Ditch 14 (Badger Creek)	568	x	Dutch Creek	634	-	County Ditch 72	667	-
Judicial Ditch 13 Branch A	571	-	Dutch Creek	635	-	County Ditch 8	669	x
Willow Creek	577	x	Dutch Creek	636	x			
Unnamed ditch	599	-	Dutch Creek	637	-			

x	= stressor	?	= inconclusive (need more data)
+	= not a stressor	-	= not assessed

Sources

The Rapidan Dam is the main issue of connectivity on the Blue Earth River, according to the SID report (Table 14). The dam eliminates the passage of fish from downstream reaches to the upper parts of the watershed. Headwater reaches above the dam may be impacted by other connectivity issues both human made and natural. The DNR conducted a desktop analysis and found 22 potential barriers to fish migration in the Blue Earth River Watershed including 8 lake outlet structures, 8 waterfalls, and 5 perched culverts (DNR 2021). Field investigation would be needed to identify the total number of barriers within the watershed.

Table 14: Drivers of connectivity issues in the Blue Earth River Watershed.

		Connectivity	
Stream Name	**WID**	**Natural**	**Human Made**
Blue Earth River	501		
Center Creek	503		●
Blue Earth River	504		●
Blue Earth River	507	●	●
Blue Earth River	508		●
Blue Earth River	509		
Blue Earth River	514		●
Blue Earth River	515	●	●
Blue Earth River	516		●
Blue Earth River	518		●
Cedar Run Creek	521		●
Elm Creek	522		●
Blue Earth River, East Branch	553		●
Foster Creek	556		●
South Fork	561		●
Blue Earth River	565		●
Unnamed Creek	566	o	●
Badger Creek	568		●
Willow Creek	577	o	●
County Ditch 25	603		●
Judicial Ditch 98	610		●
Judicial Ditch 7	611	o	●
County Ditch 31	612		●
County Ditch 89	620	o	●
Thisius Branch	622		●
Judicial Ditch 14	623		●
Unnamed Creek	625	o	●
Judicial Ditch 38	627	●	●
County Ditch 26	628		●
Elm Creek	631		●
Lily Creek	633		●
Dutch Creek	636		●
South Creek	639		●
Little Badger Creek	642		●
West Branch	643	o	●
West Branch	644	o	●
Blue Earth River, Middle Branch	646	●	●
Coon Creek	648		●
Blue Earth River, East Branch	652		●
Judicial Ditch 38	660	o	●
Judicial Ditch 13	665		●
County Ditch 8	669		●

KEY	
	Stressor
	Inconclusive
	Not a Stressor
●	Driver/Pathway
o	Potential Driver/ Pathway

Goal and 10-year Target

The goal for connectivity for the Blue Earth River Watershed is to mitigate or remove connectivity issues where relevant and feasible. More investigation into the possible number of fish barriers needs to be considered with the local partners, the MPCA, and the DNR. Part of the goal would be to identify and map culverts that are limiting fish passage and work with County Highway staff to develop culvert replacement designs that allow fish passage. The 10-year target selected by the WRAPS LWG is to replace 10% of culverts verified through field work that are stressing AqL. Connectivity issues should be assessed to determine if they are the main stressor to the reach prior to investing in upgrades. Upgrades or mitigation may not be cost effective if other stressors (altered hydrology, nutrients, habitat, etc.) are having larger impacts on the aquatic communities.

This goal is revisable and will be revisited in the next iteration of the Watershed Approach. Strategies and methods to prioritize regions to address connectivity are summarized in Section 3.

Sediment

TSS are material suspended in the water. This material is often primarily sediment, but also includes algae and other solids. Suspended sediment and stream bed sediment are closely related because they have many of the same sources. Due to the inter-related nature of these parameters, they are grouped together in this report. Furthermore, sediment is the focus of this section of the report, and issues related to the algae-portion of TSS are due to phosphorus (eutrophication) and are addressed in that section of this report.

TSS directly affects AqL by: reducing visibility, which reduces feeding; clogging gills, which reduces respiration; and smothering substrate, which limits reproduction. Excessive TSS indirectly affects AqL by reducing the penetration of sunlight, limiting plant growth, and increasing water temperatures.

Status

Of the 73 stream reaches monitored to assess if TSS was a pollutant, 28 were impaired, none were supporting, and 45 were inconclusive. Of the 42 bio-impaired stream reaches, TSS as a stressor was identified in 24, ruled out in 1, and inconclusive in 17. Figure 34 illustrates the stream reaches that were assessed for TSS and Table 15 tabulates those results.

Figure 34: Sediment as a stressor and/or pollutant in the Blue Earth River Watershed. Most bio-impaired and assessed stream reaches show issues with TSS, as indicated by color. Red indicates an impairment or a stressor (TSS is problematic in that reach), green indicates TSS is supporting the standard or not a stressor (TSS is not problematic in that reach), and yellow indicates more data is needed. The results for the pollutant assessment overlay the results for the stressor assessment, with the pollutant results in the inside and stressor results showing around the outside.

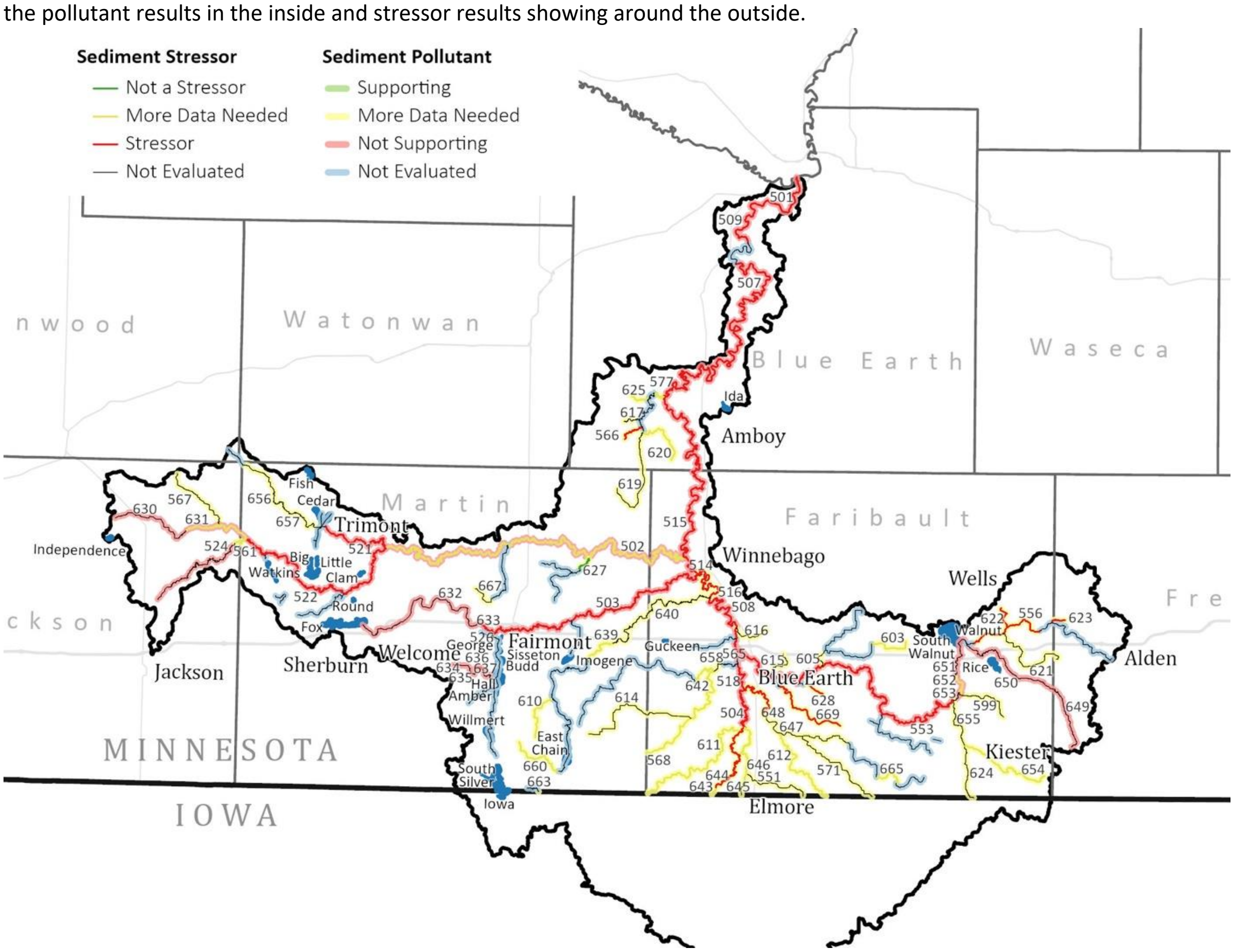


Table 15: Assessment results for TSS as a pollutant and/or stressor in Blue Earth River Watershed stream reaches.

Stream	Reach (AUID-3)	TSS as a Stressor	TSS as a Pollutant
Blue Earth River	501	x	x
Elm Creek	502	?	x
Center Creek	503	x	x
Blue Earth River	504	x	x
Blue Earth River	507	x	x
Blue Earth River	508	x	x
Blue Earth River	509	x	x
Blue Earth River	514	x	x
Blue Earth River	515	x	x
Blue Earth River	516	x	-
Blue Earth River	518	x	x
Cedar Creek (Cedar Run Creek)	521	x	x
Elm Creek	522	x	x
Elm Creek, South Fork	524	-	x
Center Creek	526	-	-
Unnamed ditch	551	-	?
Blue Earth River, East Branch	553	x	x
Foster Creek	556	x	?
County Ditch 25	603	?	?
County Ditch 5	605	-	?
Judicial Ditch 98	610	?	?
Judicial Ditch 7	611	?	?
County Ditch 31	612	?	?
Judicial Ditch 14	614	-	?
County Ditch 14	615	-	?
County Ditch 17	616	-	?
Unnamed creek	617	-	?
Judicial Ditch 116	619	-	?
County Ditch 89/Judicial Ditch 24	620	?	?
Unnamed creek	621	-	?
Thisius Branch	622	x	?
Judicial Ditch 14	623	x	?
Unnamed creek	624	-	?
Unnamed creek	625	?	?
Judicial Ditch 3	627	+	?
County Ditch 26	628	x	?
South Creek	639	?	?
South Creek	640	-	?
Little Badger Creek	642	?	?
Blue Earth River, West Branch	643	?	?
Blue Earth River, West Branch	644	x	?
Blue Earth River, Middle Branch	645	-	?
Blue Earth River, Middle Branch	646	?	?
Coon Creek	647	-	?
Coon Creek	648	x	?
Blue Earth River, East Branch	649	-	x
Blue Earth River, East Branch	650	-	x
Blue Earth River, East Branch	651	-	x
Blue Earth River, East Branch	652	?	x
Blue Earth River, East Branch	653	-	x
Brush Creek	654	?	?
Brush Creek	655	-	?
Cedar Creek (Cedar Run Creek)	656	-	?
Cedar Creek (Cedar Run Creek)	657	-	-

Stream	Reach (AUID-3)	TSS as a Stressor	TSS as a Pollutant
Elm Creek, South Fork	561	?	?
Blue Earth River	565	x	x
Unnamed creek	566	x	?
Elm Creek, North Fork	567	-	?
Judicial Ditch 14 (Badger Creek)	568	?	?
Judicial Ditch 13 Branch A	571	-	?
Willow Creek	577	?	?
Unnamed ditch	599	-	?

Stream	Reach (AUID-3)	TSS as a Stressor	TSS as a Pollutant
Elm Creek	630	-	x
Elm Creek	631	?	x
Lily Creek	632	-	x
Lily Creek	633	x	x
Dutch Creek	634	-	x
Dutch Creek	635	-	x
Dutch Creek	636	x	x
Dutch Creek	637	-	x

Stream	Reach (AUID-3)	TSS as a Stressor	TSS as a Pollutant
Badger Creek	658	-	?
Judicial Ditch 38	660	?	?
Unnamed creek	663	-	?
Judicial Ditch 13	665	?	?
County Ditch 72	667	-	?
County Ditch 8	669	x	?

x	= stressor	?	= inconclusive (need more data)
+	= not a stressor	-	= not assessed

From a state-wide perspective, the Blue Earth River Watershed has a high TSS yield and FWMC (Figure 35). From 2007 through 2018, the average TSS FWMC in the Blue Earth River Watershed was 202 mg/L based on the WPLMN data. This average concentration is over three times the water quality standard, which allows for TSS not to exceed 65 mg/L in more than 10% of the samples in the assessment period of April through September. Using this same data, the average yield of sediment form the Blue Earth River Watershed is 449 lbs/acre, which is quite high when compared to the rest of the state of Minnesota.

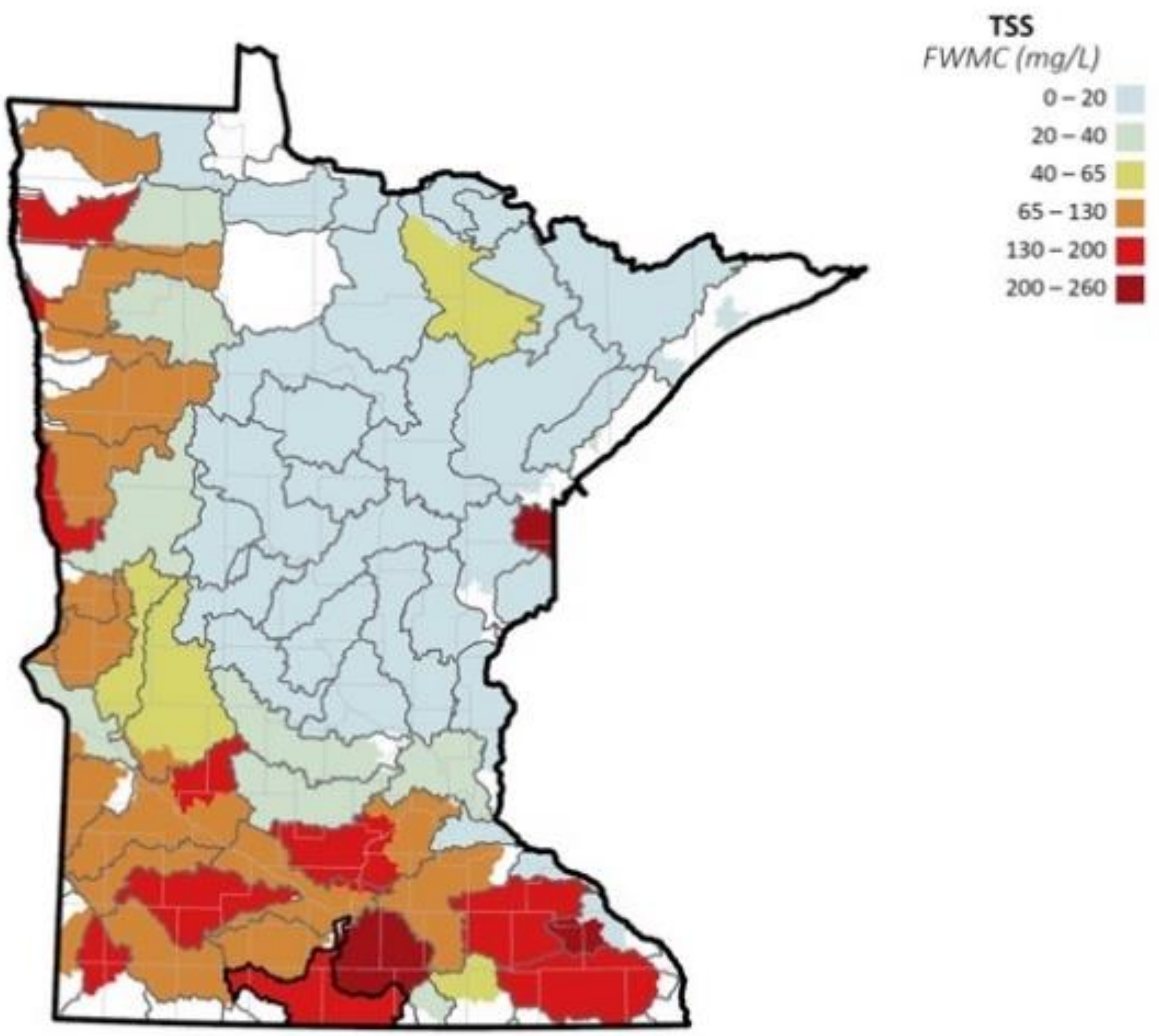
HSPF modeling was developed for the Blue Earth River Watershed. The model's estimated FWMCs for the years 1996 through 2017 are illustrated in Figure 36. This model output can be used to estimate conditions in stream reaches that have not been monitored. The modeling shows that FWMC increases greatly from the upland reaches to the knick zone. The highest concentrations of sediment are coming from the incised areas of the watershed. This information can be used to identify reaches that should be further investigated to understand sediment sources and develop implementation activities to reduce loading.

Sources

The primary sources of sediment can be broken into three groups: upland, channel, and ravine. Other sources have minimal contributions; point source contributions for the years of 2009 through 2018 are estimated to be approximately 0.03% of the Blue Earth River Watershed's sediment load (data and calculations in Appendix 4.2).

Upland erosion includes farm field surface and gully erosion, sediment that is washed away from roads and developed areas, and surface erosion from other areas. Upland sediment contributions typically happen when bare soils erode during rains or snowmelt.

Figure 35: WPLMN TSS FWMC and yield in the Blue Earth River Watershed. The Blue Earth River Watershed has a high annual sediment yield (the total amount leaving the watershed), losing over 250-500 pounds per acre on average. The in-stream FWMC of TSS over the same period ranged from 130-200 mg/L.



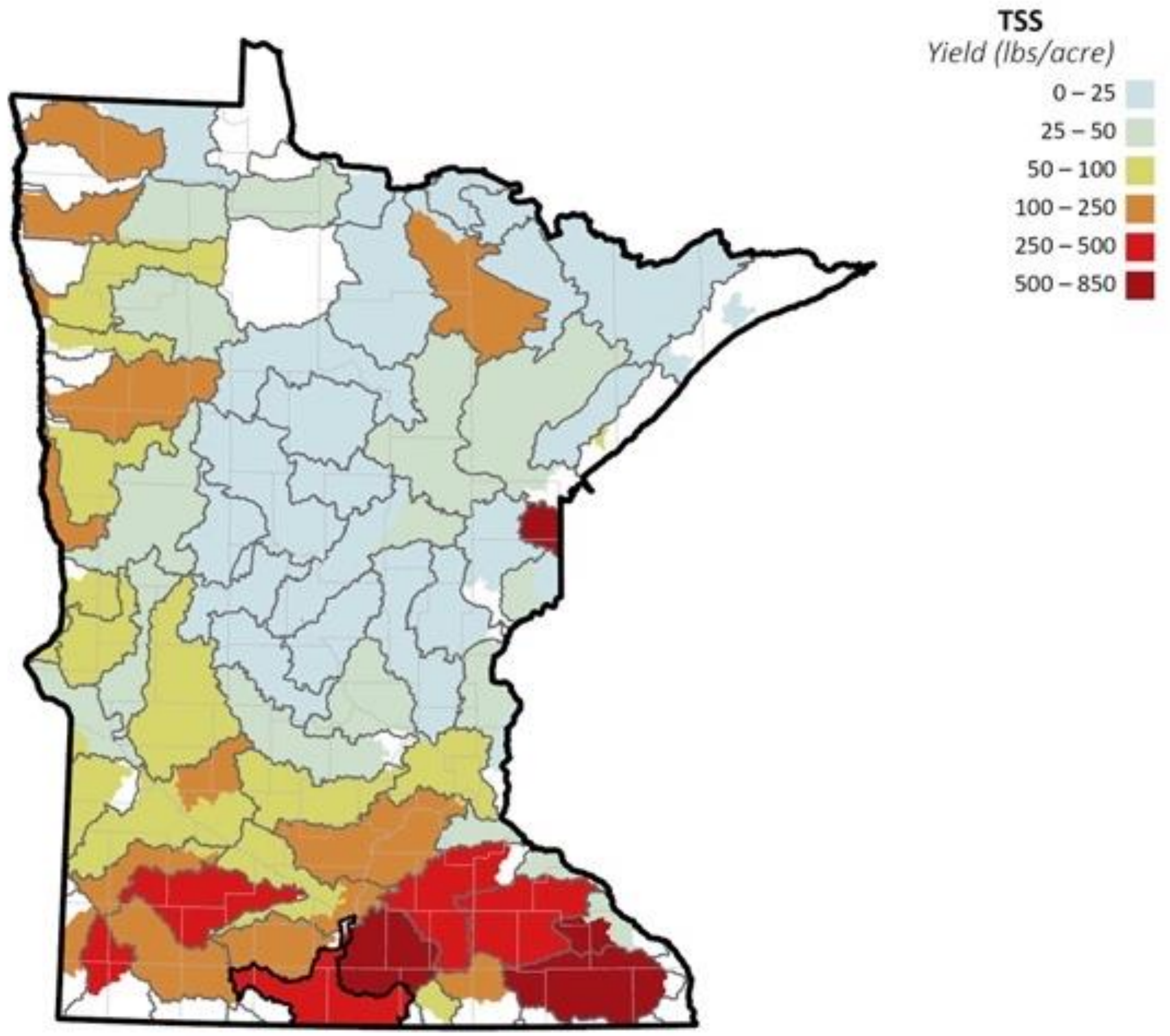
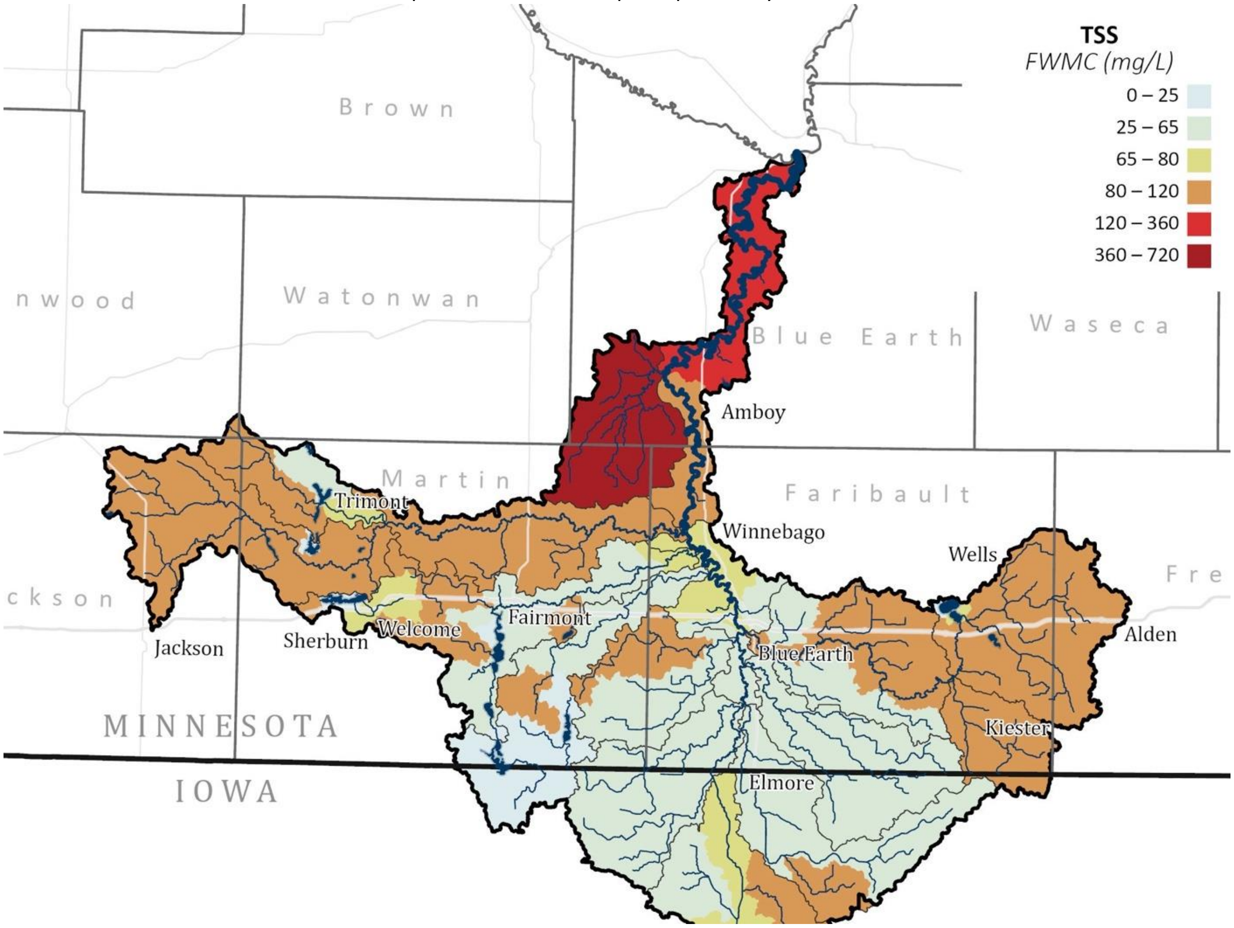

TSS
Yield (lbs/acre)
0 – 25
25 – 50
50 – 100
100 – 250
250 – 500
500 – 850

Figure 36: Total Suspended Solids (TSS) FWMC sediment concentrations based on HSPF model. HSPF model output indicate that the FWMC sediment concentrations vary through the watershed. The highest modeled concentrations were found in the lower reaches of the Blue Earth River. The presented model output represents years 1996-2017.



Channel sediment contributions are dominated by streambank, ditch bank, and bluff erosion, but also include channel bed and other material in or directly adjacent to the water body. While some amount of channel migration and associated bank/bluff erosion is natural, altered hydrology has increased stream flow, contributing to excessive bank/bluff erosion. The DNR (DNR 2010) discusses the multiple causes of streambank erosion, including how altered hydrology influences streambank erosion.

Ravines occur in locations where a flow path drops elevation drastically. In the Blue Earth River Watershed, a more rapid elevation change occurs near the outlet, making ravines more common in this area of the watershed. While some erosion of ravines is natural, the natural erosion rate is greatly accelerated when the land use above the ravine delivers more water than a natural condition, including when drainage waters from farms and cities are routed down the ravine. In this way, altered hydrology can cause excessive ravine erosion.

While some streambank erosion is part of the natural channel evolution process, streambank erosion due to unstable streams is common in the Blue Earth River Watershed as discussed in the Blue Earth River Watershed Characterization Report (DNR 2021). According to this report, stream instability can occur from degraded riparian vegetation and altered hydrology (higher flows due to losses in water storage and ET, and decreased channel residence times due to stream straightening). Sites with good riparian vegetation and intact floodplain areas appeared more resilient than those without dense, deep-rooted vegetation.

A numeric estimate of the Blue Earth River Watershed's sediment sources is presented in Figure 37; refer to the Sources Overview (Section 4.2) for more details. Streambank erosion and cultivated crop surface runoff are the dominant sources of sediment throughout the Blue Earth River Watershed.

SID provides information on the drivers for the TSS-stressed stream reaches (Table 16). All but 1 of the 24 TSS-stressed reaches were due to flow alterations that are increasing erosion that has created biological and habitat issues related to sediment. Most of these streams were shown to have stream bank erosion as a common stressor and were impacted by altered hydrology, including flow alteration and altered channels.

Figure 37: Total Suspended Solids (TSS) source assessment in the Blue Earth River Watershed.
The TSS source assessment in the Blue Earth River Watershed estimates that the largest sources of sediment are from streambank erosion and crop surface runoff.

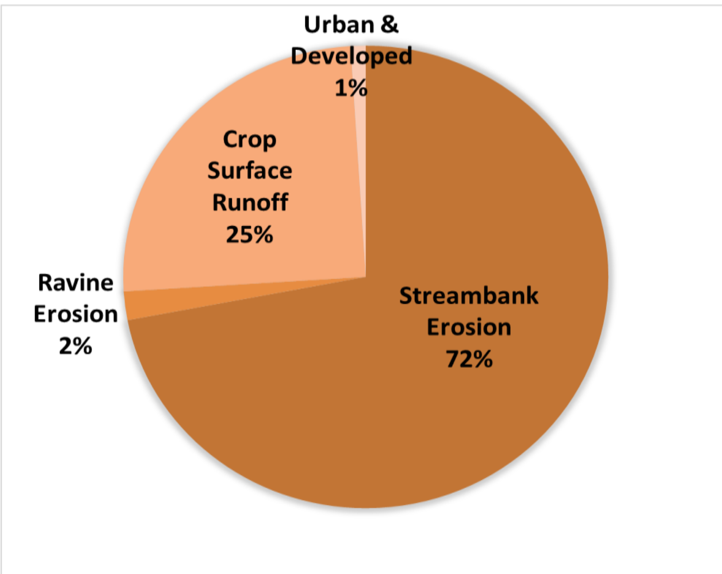


Table 16: TSS drivers for sediment-stressed stream reaches in the Blue Earth River Watershed. TSS contributions were assessed for sediment-stressed stream reaches in the Blue Earth River Watershed in the SID report. Flow alteration and streambank erosion were commonly identified stressors.

		TSS			
Stream Name	WID	Suspended Algae	Flow Alterations	Streambank Erosion	Pasture
Blue Earth River	501		●	●	
Center Creek	503		●	●	●
Blue Earth River	504		●	●	
Blue Earth River	507		●	●	
Blue Earth River	508		●	●	

		TSS			
Stream Name	WID	Suspended Algae	Flow Alterations	Streambank Erosion	Pasture
Judicial Ditch 7	611		o		
County Ditch 31	612		o		
County Ditch 89	620		o		
Thisius Branch	622		●	●	
Judicial Ditch 14	623		●	●	

Stream Name	WID	TSS: Suspended Algae	TSS: Flow Alterations	TSS: Streambank Erosion	TSS: Pasture
Blue Earth River	509		●	●	
Blue Earth River	514		●	●	
Blue Earth River	515		●	●	
Blue Earth River	516		●	●	
Blue Earth River	518		●	●	
Cedar Run Creek	521		●	●	
Elm Creek	522		●	●	●
Blue Earth River, East Branch	553		●	●	
Foster Creek	556		●	●	
South Fork	561		o	o	o
Blue Earth River	565		●	●	
Unnamed Creek	566		●	●	
Badger Creek	568		o		
Willow Creek	577		o		
County Ditch 25	603		o	o	
Judicial Ditch 98	610	o	o		

Stream Name	WID	TSS: Suspended Algae	TSS: Flow Alterations	TSS: Streambank Erosion	TSS: Pasture
Unnamed Creek	625		o		
Judicial Ditch 38	627				
County Ditch 26	628	●	●		
Elm Creek	631				o
Lily Creek	633			●	●
Dutch Creek	636		●	●	●
South Creek	639	o	o		
Little Badger Creek	642		o		
West Branch	643				
West Branch	644	●		●	
Blue Earth River, Middle Branch	646		o	o	
Coon Creek	648		●	●	
Blue Earth River, East Branch	652		o		o
Judicial Ditch 38	660		o		
Judicial Ditch 13	665		o		
County Ditch 8	669	●	●	●	

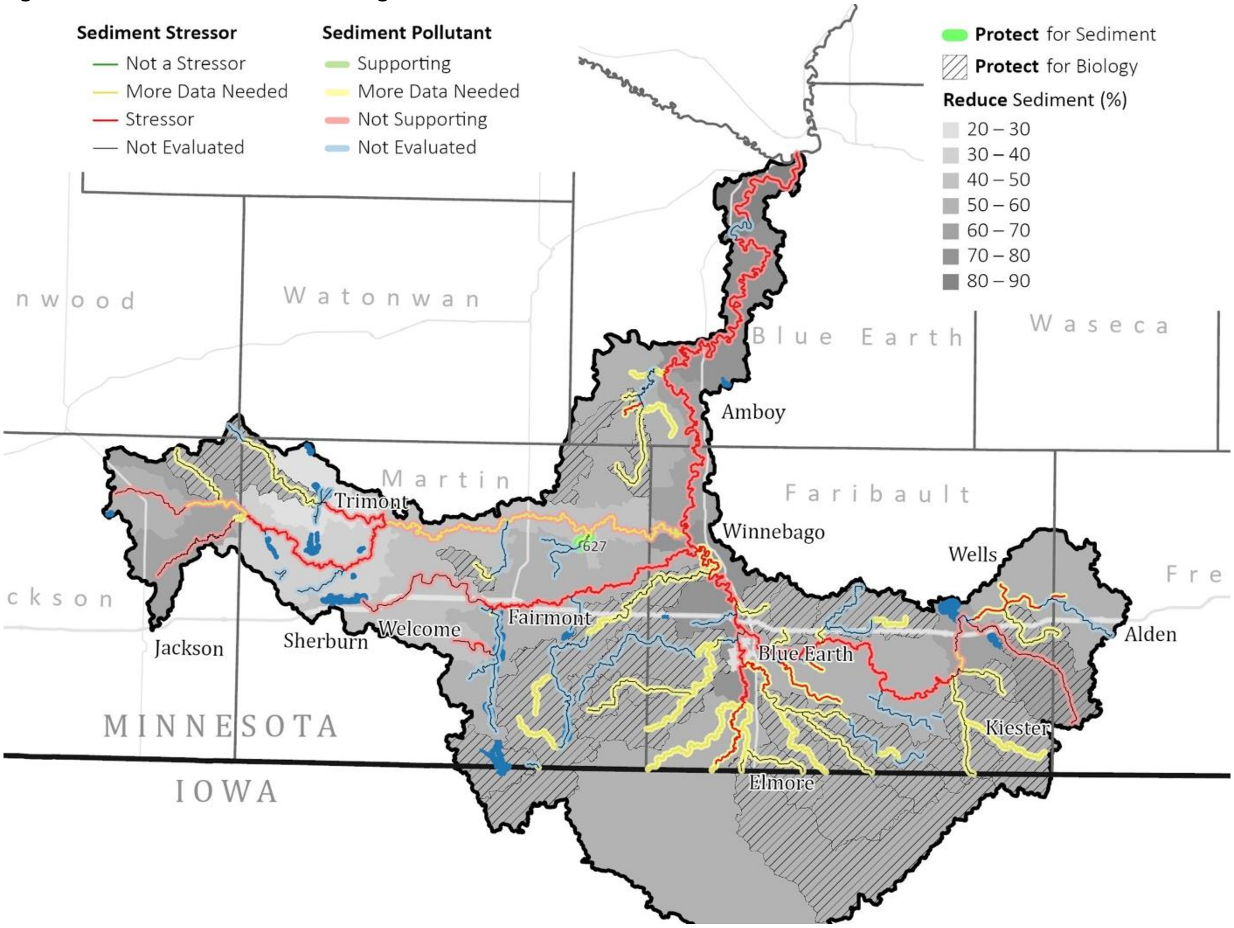
KEY	
	Stressor
	Inconclusive
	Not a Stressor
●	Driver/Pathway
o	Potential Driver/Pathway

Goal and 10-year Target

The watershed-wide sediment goal for the Blue Earth River Watershed (Figure 38) is a 60% reduction in stream TSS FWMC to reach a FWMC of 65 mg/L. Subwatershed goals were calculated where TMDL data were available and ranged from a 24% reduction goal for the Cedar Creek (521) to an 85% reduction needed at the outlet of the Blue Earth River (501). Subwatershed goals are illustrated below and are tabulated in Appendix 4.3. The selected watershed-wide goal provides consistency with the Sediment Reduction Strategy (MPCA 2015f), which identifies a baseline 2000 through 2010 FWMC of 116 mg/L and calls for a 25% reduction by 2020, 50% reduction by 2030, and 80% reduction by 2040 from the Minnesota River.

The 10-year target selected by the WRAPS LWG is a 5% reduction in TSS. These goals are revisable and will be revisited in the next iteration of the Watershed Approach. Strategies to meet the goals and 10-year targets and methods to prioritize regions for sediment reductions are summarized in Section 3.

Figure 38: Watershed-wide sediment goal for the Blue Earth River Watershed.



Dissolved Oxygen

Dissolved oxygen is oxygen gas within water. Low or highly fluctuating concentrations of DO can have detrimental effects on many fish and bug species. Low DO concentrations impact AqL by limiting respiration, which contributes to stress, disease, and can result in reduced growth or death.

Status

Of the 67 stream reaches monitored to assess if DO meets standards, 3 were impaired, 1 was supporting, and 63 were inconclusive. Of the 42 bio-impaired stream reaches, DO as a stressor was identified in 19, ruled out in 2, and inconclusive in 21. Figure 39 illustrates the stream reaches assessed for DO and Table 17 tabulates those results. Reach 627, while listed as impaired, was found to be meeting DO as a stressor. This reach will be examined further in the next round of watershed condition monitoring to identify if the reach can potentially be delisted.

Figure 39: DO as a pollutant and/or stressor in the Blue Earth River Watershed. Stream reaches assessed for low DO and the assessment results are indicated by color. Red indicates an impairment or a stressor (low DO is problematic in that reach), and green indicates DO is supporting the standard or not a stressor (DO is not problematic in that reach). The results for the pollutant assessment overlay the results for the stressor assessment, with the pollutant results showing in the inside and stressor results showing around the outside.

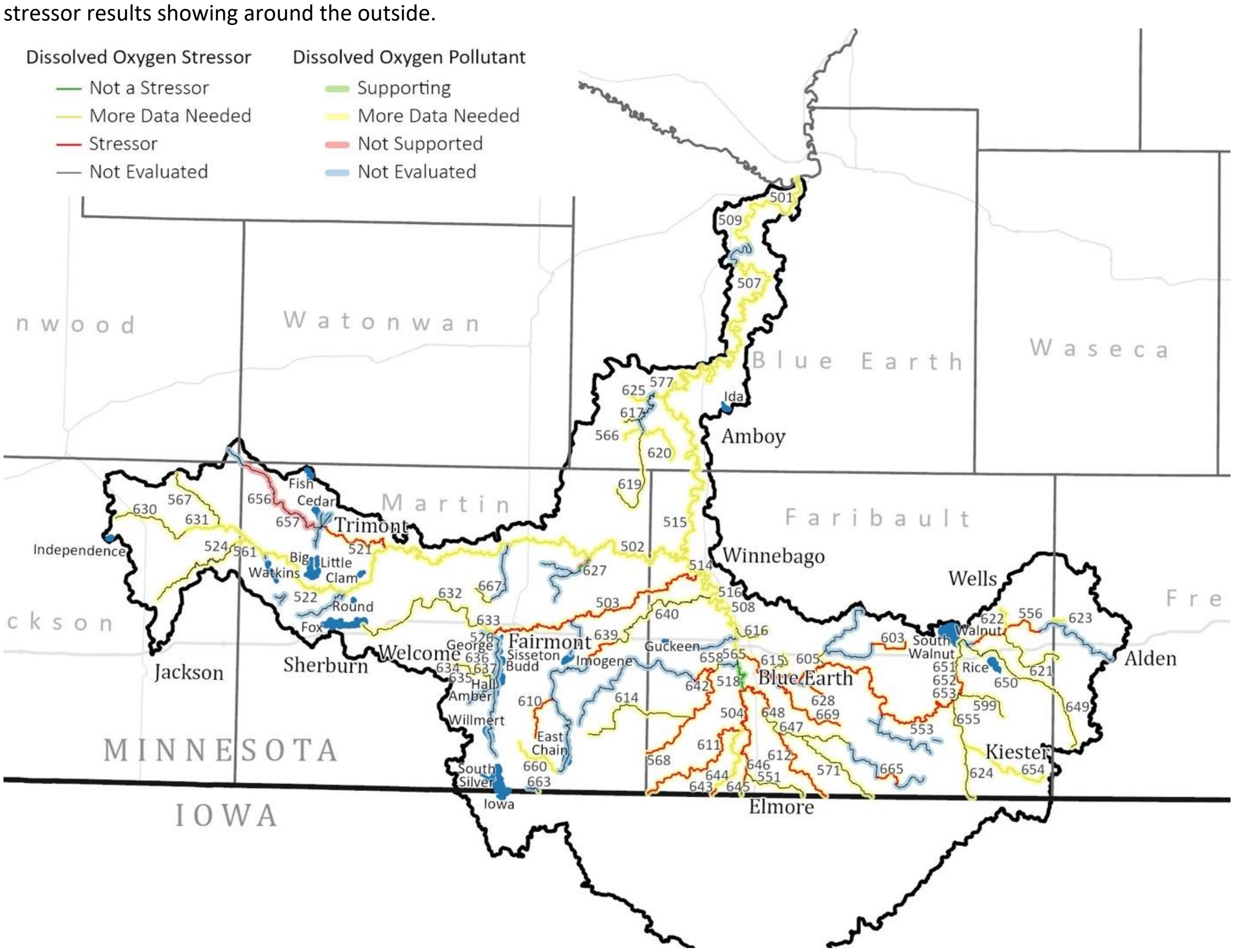


Table 17: Assessment results for DO as a pollutant and/or stressor in Blue Earth River Watershed stream reaches.

Stream	Reach (AUID-3)	DO as a Stressor	DO as a Pollutant
Blue Earth River	501	?	?
Elm Creek	502	?	?
Center Creek	503	x	?
Blue Earth River	504	x	?
Blue Earth River	507	?	?
County Ditch 25	603	x	?
County Ditch 5	605	-	?
Judicial Ditch 98	610	x	?
Judicial Ditch 7	611	x	?
County Ditch 31	612	x	?
South Creek	639	x	?
South Creek	640	-	?
Little Badger Creek	642	x	?
Blue Earth River, West Branch	643	x	?
Blue Earth River, West Branch	644	?	?

Stream	Reach (AUID-3)	DO as a Stressor	DO as a Pollutant
Blue Earth River	508	?	?
Blue Earth River	509	?	?
Blue Earth River	514	?	?
Blue Earth River	515	?	?
Blue Earth River	516	?	-
Blue Earth River	518	+	+
Cedar Creek (Cedar Run Creek)	521	x	?
Elm Creek	522	?	?
Elm Creek, South Fork	524	-	-
Center Creek	526	-	?
Unnamed ditch	551	-	?
Blue Earth River, East Branch	553	x	?
Foster Creek	556	x	?
Elm Creek, South Fork	561	?	?
Blue Earth River	565	?	?
Unnamed creek	566	?	?

Stream	Reach (AUID-3)	DO as a Stressor	DO as a Pollutant
Judicial Ditch 14	614	-	?
County Ditch 14	615	-	?
County Ditch 17	616	-	?
Unnamed creek	617	-	?
Judicial Ditch 116	619	-	?
County Ditch 89/ Judicial Ditch 24	620	?	?
Unnamed creek	621	-	?
Thisius Branch	622	?	?
Judicial Ditch 14	623	?	?
Unnamed creek	624	-	?
Unnamed creek	625	?	?
Judicial Ditch 3	627	+	x
County Ditch 26	628	x	?
Elm Creek	630	-	-
Elm Creek	631	?	?
Lily Creek	632	-	-

Stream	Reach (AUID-3)	DO as a Stressor	DO as a Pollutant
Blue Earth River, Middle Branch	645	-	?
Blue Earth River, Middle Branch	646	x	?
Coon Creek	647	-	?
Coon Creek	648	x	?
Blue Earth River, East Branch	649	-	-
Blue Earth River, East Branch	650	-	?
Blue Earth River, East Branch	651	-	-
Blue Earth River, East Branch	652	x	?
Blue Earth River, East Branch	653	-	-
Brush Creek	654	?	?
Brush Creek	655	-	?
Cedar Creek (Cedar Run Creek)	656	-	x
Cedar Creek (Cedar Run Creek)	657	-	x
Badger Creek	658	-	?
Judicial Ditch 38	660	?	?
Unnamed creek	663	-	?

Stream	Reach (AUID-3)	DO as a Stressor	DO as a Pollutant
Elm Creek, North Fork	567	-	?
Judicial Ditch 14 (Badger Creek)	568	x	?
Judicial Ditch 13 Branch A	571	-	?
Willow Creek	577	?	?
Unnamed ditch	599	-	?
Lily Creek	633	?	?
Dutch Creek	634	-	-
Dutch Creek	635	-	?
Dutch Creek	636	?	?
Dutch Creek	637	-	-
Judicial Ditch 13	665	x	?
County Ditch 72	667	-	?
County Ditch 8	669	x	?

x	= stressor	?	= inconclusive (need more data)
+	= not a stressor	-	= not assessed

Sources

Low DO in water bodies is caused by excessive oxygen use, which is often caused by the decomposition of algae and plants, whose growth is fueled by excess phosphorus and/or too little re-oxygenation, which is often caused by minimal turbulence due to low flow or high water temperatures. Low DO levels can be exacerbated in over-widened channels because these streams move more slowly and have more direct sun-warming. Likewise, channels with degraded riparian vegetation lack cover and are susceptible to excessive warming. SID analysis showed that low DO was a driver in many of the biological impairments (Table 18). When combined with eutrophic conditions, the impaired reaches tended to show the effects of low DO that lead to biological populations that are tolerant to low DO conditions.

Table 18: Drivers of DO stressors in the Blue Earth River Watershed.

		Dissolved Oxygen		
Stream Name	WID	Dissolved Oxygen	Lack of flow	Wetland/Lake influence
Blue Earth River	501	o		
Center Creek	503			●
Blue Earth River	504	●		
Judicial Ditch 7	611	●		
County Ditch 31	612	●		
County Ditch 89	620	o		

		Dissolved Oxygen		
Stream Name	WID	Dissolved Oxygen	Lack of flow	Wetland/Lake influence
Blue Earth River	507	o		
Blue Earth River	508			
Blue Earth River	509	o		
Blue Earth River	514			
Blue Earth River	515	o		
Blue Earth River	516			
Blue Earth River	518			
Cedar Run Creek	521			
Elm Creek	522			
Blue Earth River, East Branch	553	●		
Foster Creek	556	●		
South Fork	561	o		
Blue Earth River	565		o	
Unnamed Creek	566	o		
Badger Creek	568	●		
Willow Creek	577	o		
County Ditch 25	603	●		
Judicial Ditch 98	610	●		

		Dissolved Oxygen		
Stream Name	WID	Dissolved Oxygen	Lack of flow	Wetland/Lake influence
Thisius Branch	622	o		
Judicial Ditch 14	623	o		
Unnamed Creek	625	o		
Judicial Ditch 38	627			
County Ditch 26	628	●		
Elm Creek	631	o		
Lily Creek	633	o	o	
Dutch Creek	636	o		
South Creek	639	●		●
Little Badger Creek	642	●		
West Branch	643	●		
West Branch	644	o		
Blue Earth River, Middle Branch	646	●		
Coon Creek	648	●		
Blue Earth River, East Branch	652	●	●	
Judicial Ditch 38	660		o	
Judicial Ditch 13	665	●		
County Ditch 8	669	●		

KEY	
	Stressor
	Inconclusive
	Not a Stressor
●	Driver/Pathway
o	Potential Driver/Pathway

Goal and 10-year Target

Because DO is primarily a response to other stressors, the effective watershed-wide goal and 10-year target for DO are to meet the altered hydrology, phosphorus, and habitat goals. The reach-specific goal for DO is to reach the minimum standard of 5 mg/L and for diurnal DO flux to be less than 4.5 mg/L. This goal is revisable and will be revisited in the next iteration of the Watershed Approach. Strategies and methods to prioritize regions to address altered hydrology, phosphorus, and habitat are summarized in Section 3.

Phosphorus

Phosphorus is a nutrient that fuels algae and plant growth. While not directly harmful to AqL, excess phosphorus can lead to excessive algae growth and eutrophication (Nature 2013). These responses to excess phosphorus affect AqL by changing food chain dynamics, affecting fish growth and development, and decreasing DO when algae/plant growth decomposes. Phosphorus also affects AqR in lakes by fueling algae growth, at times making waters undesirable or even dangerous to swim in due to the potential presence of toxic blue-green algae.

Monitoring for phosphorus includes a measure of all phosphorus found in a sample including dissolved and particulate forms and is considered as TP. In order to identify phosphorus as a pollutant in a stream, not only does the water body need to exceed the phosphorus concentration standard, it must also exceed levels set for the response variable conditions for the water body. These include chlorophyll-*a*, five-day biochemical oxygen demand (BOD_5), DO flux, or pH levels. One or more of these eutrophic conditions must be observed in addition to high phosphorus concentrations in order for the stream to be listed as impaired. For a lake to be considered impaired, the average phosphorus concentration must exceed the water quality standard and either chlorophyll-a concentration or Secchi disk transparency must also violate response variable benchmarks. A high phosphorus concentration does not always result in eutrophic conditions. While a watershed with high phosphorus concentrations may not have eutrophic response, a downstream receiving water body may show a eutrophic response. Therefore, regardless of whether eutrophication is locally present, high phosphorus concentrations remain concerning.

Status

Of the 24 lakes that were monitored to determine if phosphorus is a pollutant, 13 were impaired, 1 was supporting, and 10 were inconclusive. Of the 66 streams reaches assessed for eutrophication, 1 reach was supporting, 1 reach was impaired, and 64 reaches were inconclusive. Most of the inconclusive reaches did not have data from the response variables to confirm or deny impairment. Of the 42 bio-impaired stream reaches, phosphorus was identified as a stressor in 17, ruled out as a stressor in 7, and inconclusive in 18. Figure 40 illustrates the stream reaches and lakes that were assessed for phosphorus. Table 19 tabulates stream status results and Table 20 tabulates lake status results.

Figure 40: Total Phosphorus as a stressor and/or pollutant in the Blue Earth River Watershed.

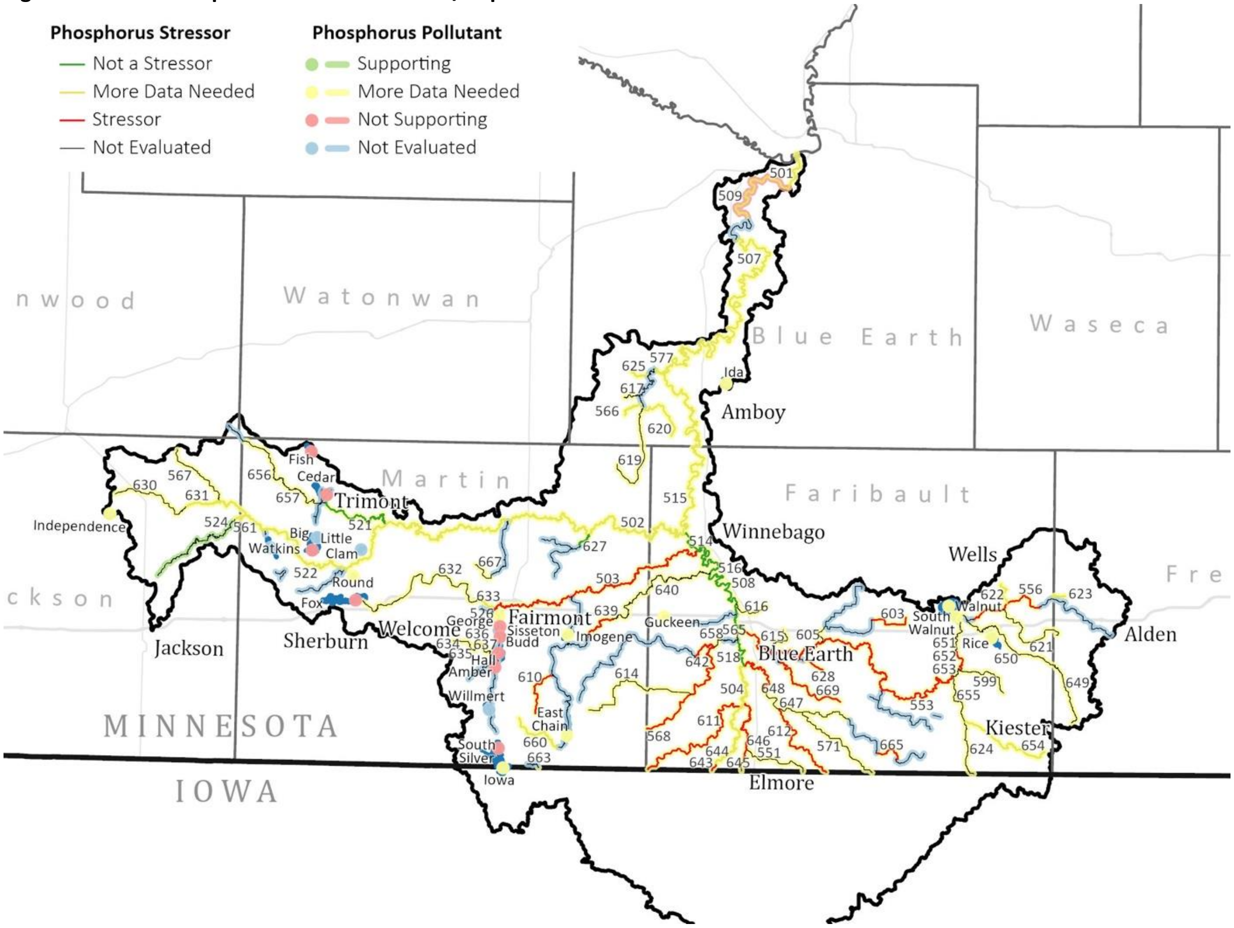


Table 19: Assessment results for Eutrophication as a pollutant in Blue Earth River Watershed stream reaches.

Stream	Reach (AUID-3)	Eutrophication as a Stressor	Eutrophication as a Pollutant	Stream	Reach (AUID-3)	Eutrophication as a Stressor	Eutrophication as a Pollutant	Stream	Reach (AUID-3)	Eutrophication as a Stressor	Eutrophication as a Pollutant
Blue Earth River	501	?	?	County Ditch 25	603	x	?	South Creek	639	x	?
Elm Creek	502	?	?	County Ditch 5	605	-	?	South Creek	640	-	?
Center Creek	503	x	?	Judicial Ditch 98	610	x	?	Little Badger Creek	642	x	?
Blue Earth River	504	?	?	Judicial Ditch 7	611	x	?	Blue Earth River, West Branch	643	x	?
Blue Earth River	507	?	?	County Ditch 31	612	x	?	Blue Earth River, West Branch	644	?	?

Stream	Reach (AUID-3)	Eutrophication as a Stressor	Eutrophication as a Pollutant
Blue Earth River	508	+	?
Blue Earth River	509	?	x
Blue Earth River	514	+	?
Blue Earth River	515	?	?
Blue Earth River	516	+	-
Blue Earth River	518	+	?
Cedar Creek (Cedar Run Creek)	521	+	?
Elm Creek	522	?	?
Elm Creek, South Fork	524	-	+
Center Creek	526	-	-
Unnamed ditch	551	-	?
Blue Earth River, East Branch	553	x	?
Foster Creek	556	x	?
Elm Creek, South Fork	561	?	?

Stream	Reach (AUID-3)	Eutrophication as a Stressor	Eutrophication as a Pollutant
Judicial Ditch 14	614	-	?
County Ditch 14	615	-	?
County Ditch 17	616	-	?
Unnamed creek	617	-	?
Judicial Ditch 116	619	-	?
County Ditch 89/Judicial Ditch 24	620	?	?
Unnamed creek	621	-	?
Thisius Branch	622	?	?
Judicial Ditch 14	623	?	?
Unnamed creek	624	-	?
Unnamed creek	625	?	?
Judicial Ditch 3	627	+	?
County Ditch 26	628	x	?
Elm Creek	630	-	-

Stream	Reach (AUID-3)	Eutrophication as a Stressor	Eutrophication as a Pollutant
Blue Earth River, Middle Branch	645	-	?
Blue Earth River, Middle Branch	646	x	?
Coon Creek	647	-	?
Coon Creek	648	x	?
Blue Earth River, East Branch	649	-	-
Blue Earth River, East Branch	650	-	?
Blue Earth River, East Branch	651	-	-
Blue Earth River, East Branch	652	x	?
Blue Earth River, East Branch	653	-	-
Brush Creek	654	?	?
Brush Creek	655	-	?
Cedar Creek (Cedar Run Creek)	656	-	?
Cedar Creek (Cedar Run Creek)	657	-	-
Badger Creek	658	-	?

Stream	Reach (AUID-3)	Eutrophication as a Stressor	Eutrophication as a Pollutant
Blue Earth River	565	+	?
Unnamed creek	566	?	?
Elm Creek, North Fork	567	-	?
Judicial Ditch 14 (Badger Creek)	568	x	?
Judicial Ditch 13 Branch A	571	-	?
Willow Creek	577	?	?
Unnamed ditch	599	-	?
Elm Creek	631	?	?
Lily Creek	632	-	-
Lily Creek	633	?	?
Dutch Creek	634	-	-
Dutch Creek	635	-	?
Dutch Creek	636	?	?
Dutch Creek	637	-	-
Judicial Ditch 38	660	?	?
Unnamed creek	663	-	?
Judicial Ditch 13	665	x	?
County Ditch 72	667	-	?
County Ditch 8	669	x	?

x	= stressor	?	= inconclusive (need more data)
+	= not a stressor	-	= not assessed

Table 20: Aquatic recreation assessment results for lakes and individual trends in the Blue Earth River Watershed.

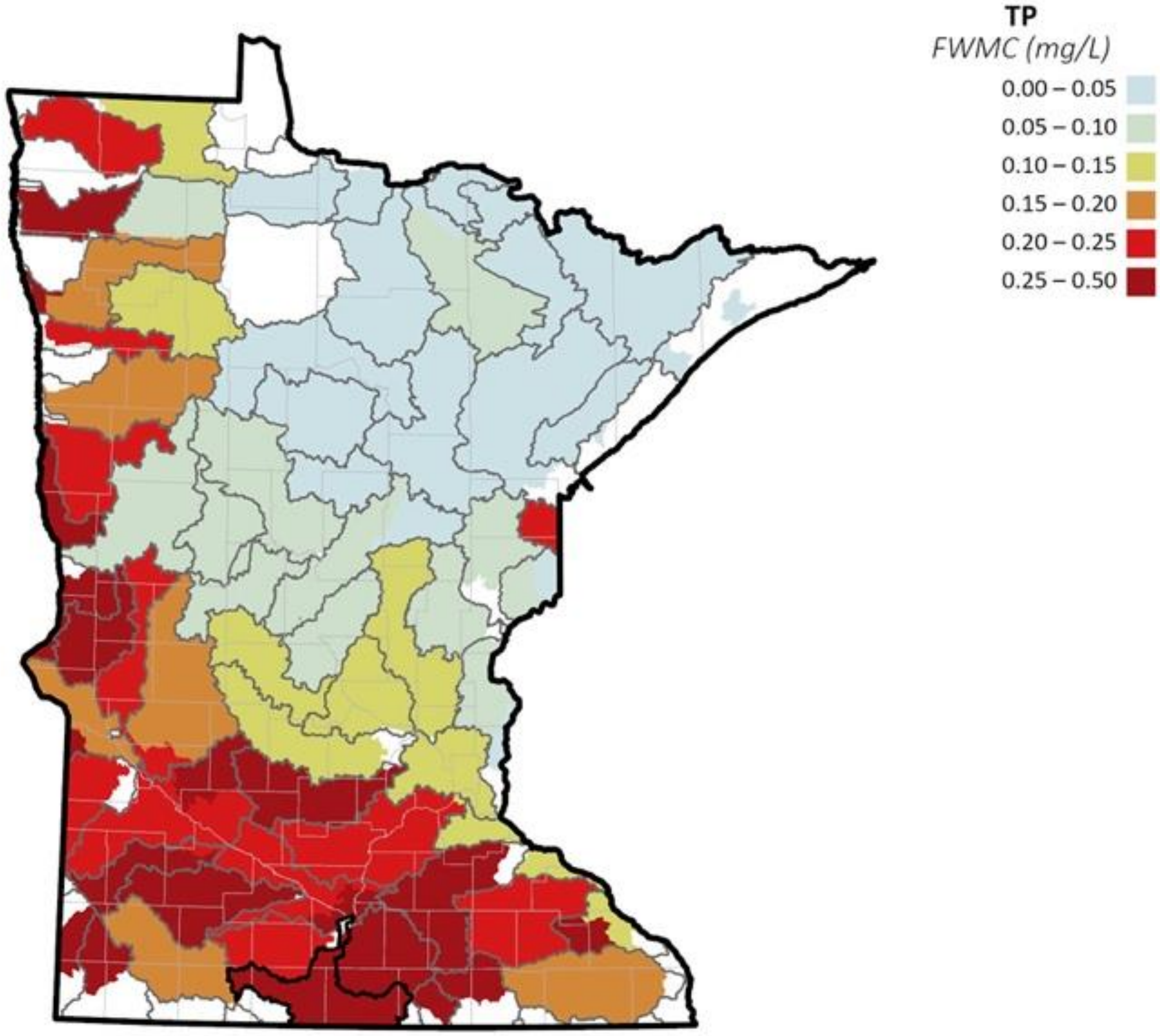
Lake ID	Lake Name	Aquatic Rec. (Phosphorus)	Trend
07-0090-00	Ida	x	?
22-0007-00	Rice	x	?
22-0022-00	South Walnut	?	?
22-0023-00	Walnut	?	?
22-0088-00	Unnamed	+	?
32-0017-00	Independence	?	?
46-0010-00	East Chain	x	?
46-0012-00	Imogene	?	?
46-0014-01	Willmert (Main Bay)	?	?

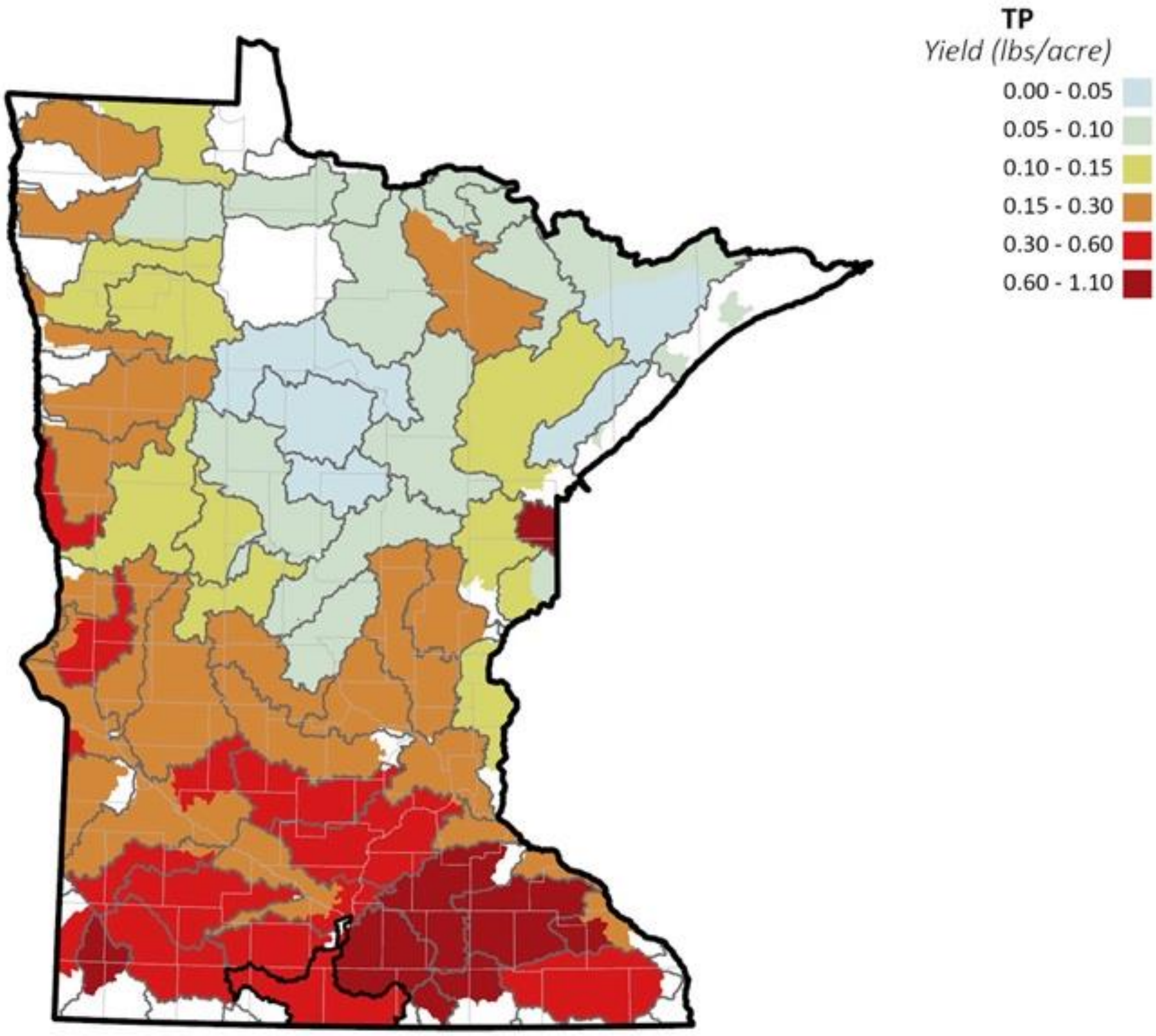
Lake ID	Lake Name	Aquatic Rec. (Phosphorus)	Trend
46-0020-00	South Silver	?	NT
46-0024-00	George	x	NT
46-0025-00	Sisseton	x	NT
46-0030-00	Budd	x	NT
46-0031-00	Hall	x	NT
46-0034-00	Amber	x	NT
46-0049-00	Iowa	x	?
46-0109-00	Fox	x	NT
46-0111-00	Clam	?	?
46-0116-00	Round	?	?
46-0121-00	Cedar	x	?
46-0130-00	Little Twin	?	?
46-0132-00	Watkins	?	?
46-0133-00	Big Twin	x	?
46-0145-00	Fish	x	?

x	= impaired	?	= inconclusive (need more data)
+	= not impaired	NT	= no trend

From a statewide perspective, the Blue Earth River Watershed's phosphorus concentrations and yields are high (Figure 41). From 2007 through 2018, the average annual TP FWMC in the Blue Earth River was estimated at 0.28 mg/L. Despite a lack of eutrophic response variable data collection (as represented in the conditions discussed above), the Blue Earth River is supplying excessive phosphorus to downstream waters that are impaired (e.g., Lake Pepin).

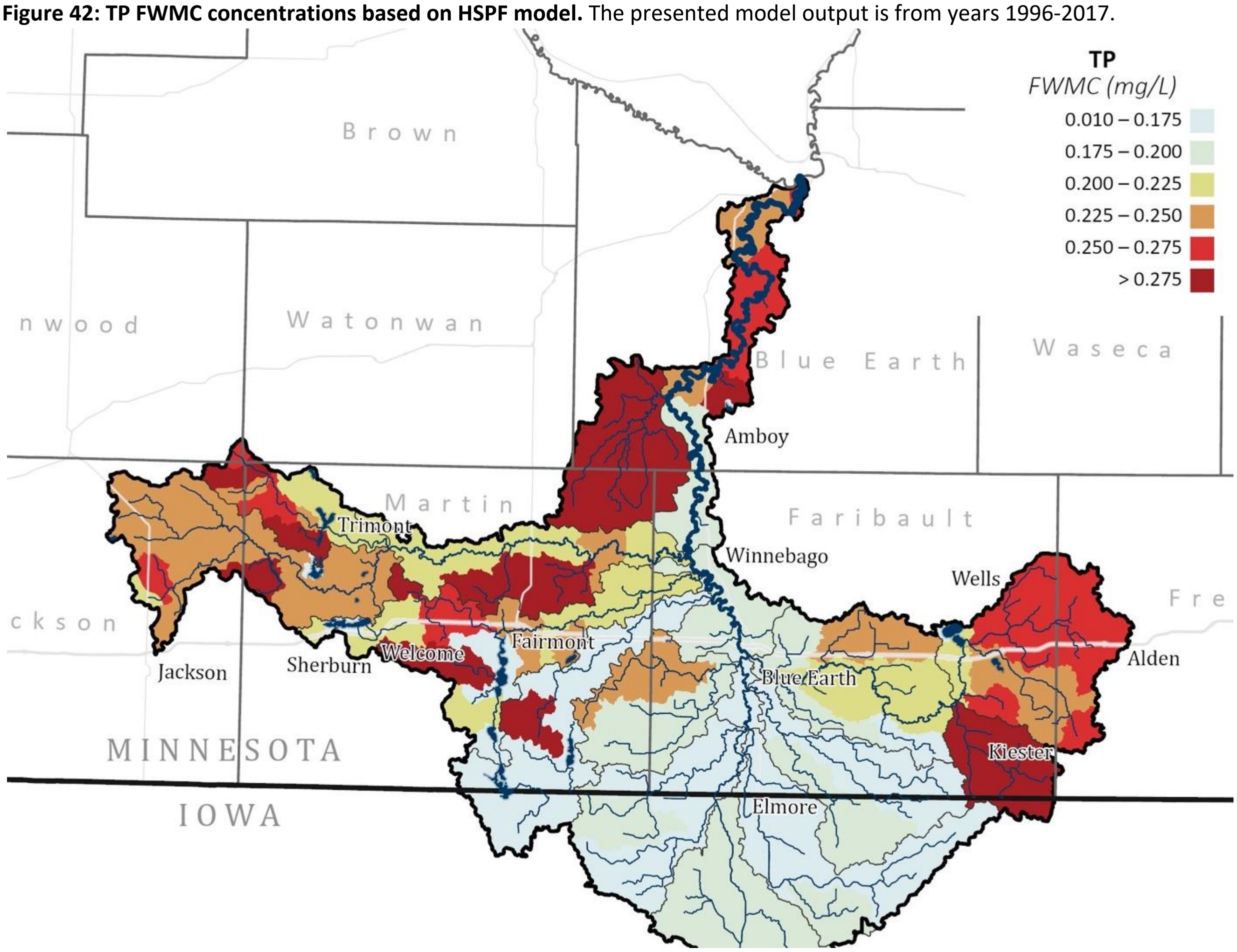
Figure 41: TP FWMC and yield in the Blue Earth River Watershed. The Blue Earth River Watershed has a high FWMC and yield of TP compared to the rest of the state. Data are from the WPLMN.




TP
Yield (lbs/acre)
0.00 - 0.05
0.05 - 0.10
0.10 - 0.15
0.15 - 0.30
0.30 - 0.60
0.60 - 1.10

The HSPF model's estimated TP FWMCs for the years 1996 through 2017 are illustrated in Figure 42. HSPF model output indicate that the FWMC phosphorus concentrations vary widely across the watershed. The highest modeled concentrations were found in the eastern and lower portions of the watershed. This model output can be used to estimate conditions in stream reaches that have not been monitored and identify areas for further monitoring and investigation. Higher loading areas identified can be used to prioritize further monitoring and/or implementation needs.

Figure 42: TP FWMC concentrations based on HSPF model. The presented model output is from years 1996-2017.



Sources

Phosphorus sources are dominated by nonpoint sources in the Blue Earth River Watershed. Point source contributions for the years of 2009 through 2018 are estimated to total less than 2% of the Blue Earth River Watershed's phosphorus load (Appendix 4.2). Although point sources are a small portion of the annual TP load, wastewater discharges can be significant drivers of river eutrophication during low flow conditions. Eighteen WWTP permits in the watershed include annual TP effluent limits. Permits for eight of the WWTPs include (or are recommended to include) summer only TP limits based on river eutrophication criteria. WWTPs in the watershed have made and will continue to make significant investments in TP reduction to help improve water quality.

A numeric estimate of the Blue Earth River Watershed's phosphorus sources is presented in Figure 43; refer to the Sources Overview (Section 2.2) for more details. Crop surface runoff is the largest source followed by streambank erosion and drainage tile. Much of the phosphorus leaving agricultural fields is from applied fertilizer and manure, and some is from phosphorus native to the soil. Excess phosphorus loading to individual stream reaches from crop surface runoff was identified as the main driver of phosphorus stressors in the Blue Earth River Watershed (Table 21).

Internal lake phosphorus loads are not explicitly accounted for in the source assessment. Internal lake loads are a product of excessive, legacy phosphorus contributions from the lake's watershed, and little of the internal load is natural. When planning for lake restoration, knowing the magnitude of internal load is important in developing the specific strategies to address the impairment. Planners should consult the TMDL or additional lake modeling or studies to estimate the internal load accordingly.

Figure 43: Phosphorus source assessment for the Blue Earth River Watershed.

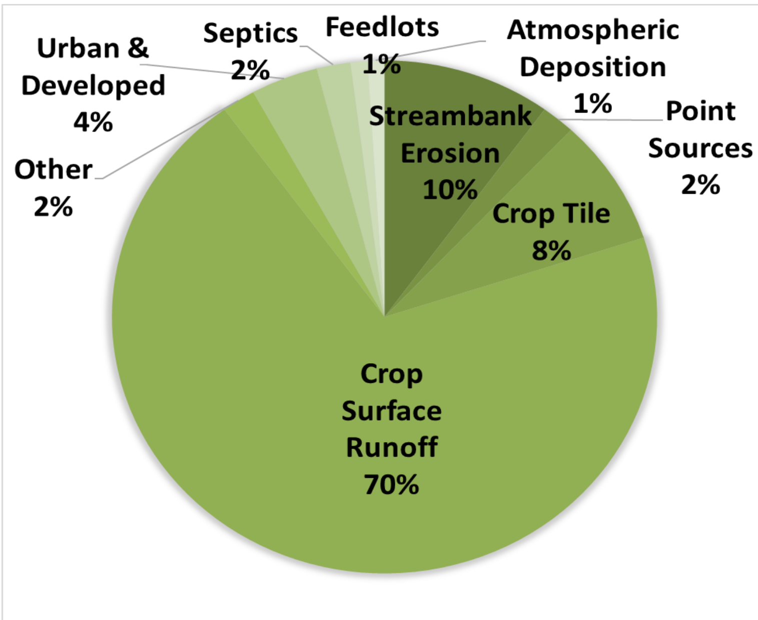


Table 21: Drivers of eutrophication stressors in the Blue Earth River Watershed.

Stream Name	WID	Eutrophication: Wetland/Lake influence	Eutrophication: Excess Phosphorus
Blue Earth River	501		o
Center Creek	503	•	•
Blue Earth River	504		o
Blue Earth River	507		o
Blue Earth River	508		•
Blue Earth River	509		o
Judicial Ditch 7	611		o
County Ditch 31	612		o
County Ditch 89	620		o
Thisius Branch	622		o
Judicial Ditch 14	623		o
Unnamed Creek	625		o

Stream Name	WID	Eutrophication: Wetland/Lake influence	Eutrophication: Excess Phosphorus
Blue Earth River	514	Not a Stressor	Not a Stressor
Blue Earth River	515	Inconclusive	Inconclusive, o
Blue Earth River	516	Not a Stressor	Not a Stressor
Blue Earth River	518	Not a Stressor	Not a Stressor, o
Cedar Run Creek	521	Not a Stressor	Not a Stressor
Elm Creek	522	Inconclusive	Inconclusive, o
Blue Earth River, East Branch	553	Stressor	Stressor, ●
Foster Creek	556	Stressor	Stressor, ●
South Fork	561	Inconclusive	Inconclusive, o
Blue Earth River	565	Not a Stressor	Not a Stressor, o
Unnamed Creek	566	Inconclusive	Inconclusive, o
Badger Creek	568	Stressor	Stressor, ●
Willow Creek	577	Inconclusive	Inconclusive, o
County Ditch 25	603	Not a Stressor	Not a Stressor, o
Judicial Ditch 98	610	Not a Stressor	Not a Stressor, o

Stream Name	WID	Eutrophication: Wetland/Lake influence	Eutrophication: Excess Phosphorus
Judicial Ditch 38	627	Not a Stressor	Not a Stressor
County Ditch 26	628	Stressor	Stressor, ●
Elm Creek	631	Inconclusive	Inconclusive, o
Lily Creek	633	Inconclusive	Inconclusive, o
Dutch Creek	636	Inconclusive	Inconclusive, o
South Creek	639	Stressor, ●	Stressor, ●
Little Badger Creek	642	Stressor	Stressor, ●
West Branch	643	Stressor	Stressor, ●
West Branch	644	Inconclusive	Inconclusive, o
Blue Earth River, Middle Branch	646	Stressor	Stressor, ●
Coon Creek	648	Stressor	Stressor, ●
Blue Earth River, East Branch	652	Stressor	Stressor, ●
Judicial Ditch 38	660	Inconclusive	Inconclusive
Judicial Ditch 13	665	Stressor	Stressor, ●
County Ditch 8	669	Stressor	Stressor, ●

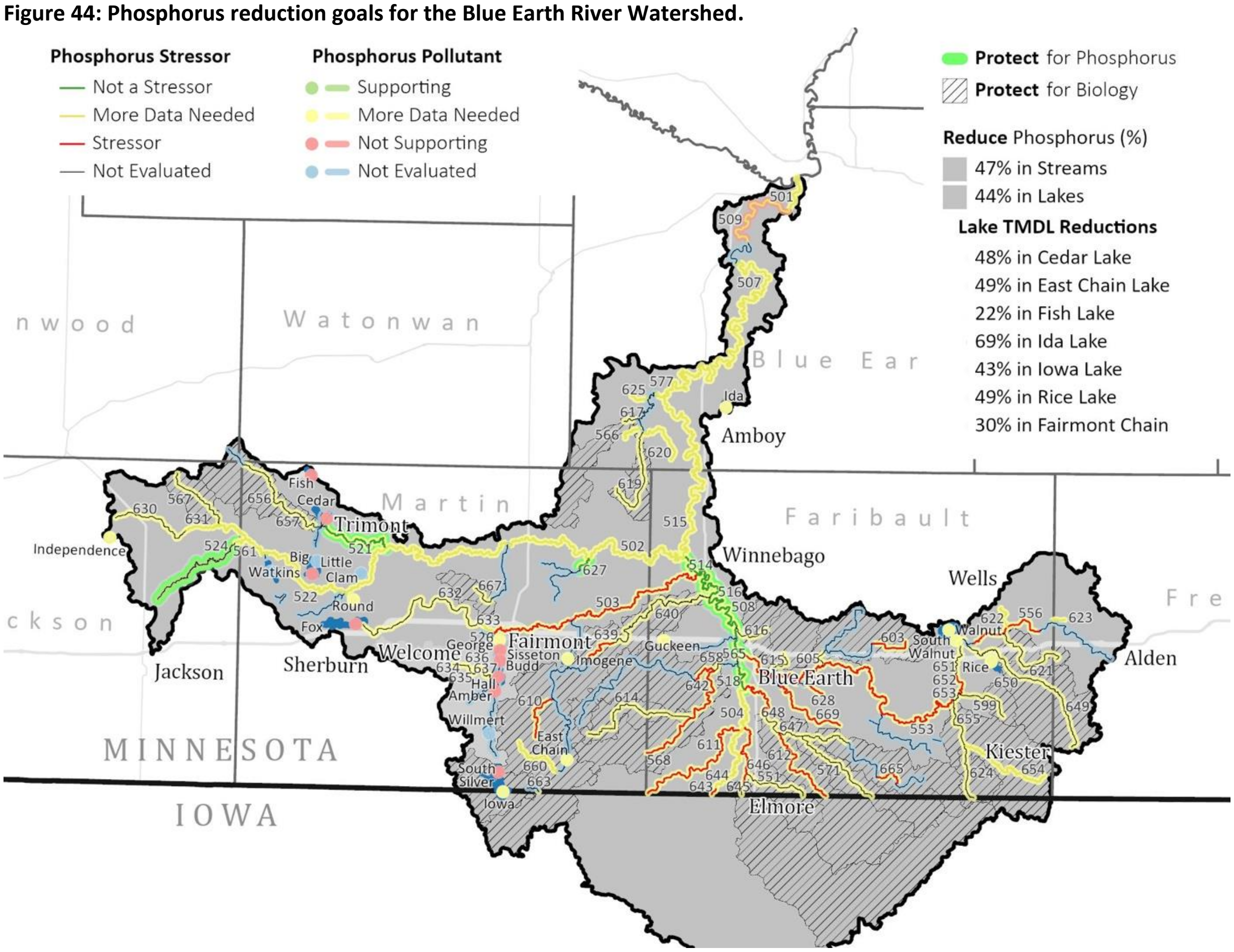
KEY	
(white)	Stressor
(light gray)	Inconclusive
(dark gray)	Not a Stressor
●	Driver/Pathway
o	Potential Driver/Pathway

Goal and 10-year Target

The watershed-wide average goal for phosphorus in the Blue Earth River Watershed is a 47% reduction in stream concentrations/loads and a 44% reduction for lake concentrations (Figure 44). The watershed-wide goal was set after reviewing phosphorus data from lakes and streams in the watershed, TMDL information, model output, and the Minnesota Nutrient Reduction Strategy (MPCA 2014b) goals. The Blue Earth River Watershed Lake Water Quality Improvement Study (MPCA, 2023a) was developed to provide additional information for local consideration for implementation activities. Streams should achieve a maximum FWMC of 0.15 mg/L, and lakes should achieve a maximum summer mean of 0.09 mg/L. Lake phosphorus reduction goals were calculated in the Blue Earth River Watershed TMDL (MPCA 2023b) and vary from a 31% reduction in Fish Lake to a 61% reduction in Rice Lake. Refer to the TMDL summary in Appendix 4.3 for a tabulated summary of lake reduction goals.

The 10-year target selected by the WRAPS LWG is a 5% phosphorus reduction in streams and a 10% phosphorus reduction in lakes. Strategies to meet the goals and 10-year targets and methods to prioritize regions for phosphorus reductions are summarized in Section 3. These goals are revisable and will be revisited in the next iteration of the Watershed Approach.

Figure 44: Phosphorus reduction goals for the Blue Earth River Watershed.



Fecal Bacteria

Fecal coliform and *E. coli*, referred to in this report as bacteria, are indicators of animal or human fecal matter, which may contain pathogens. Fecal matter can make AqR unsafe because contact with fecal matter can lead to potentially severe illnesses. Fecal bacteria are living organisms, unlike most other measured water quality parameters. Because bacteria can reproduce or die-off in the environment, this parameter's dynamics can be more challenging to understand.

Status

Of the 30 stream reaches monitored to assess for bacteria, 29 were impaired and one was inconclusive. Figure 45 illustrates the stream reaches assessed for bacteria, and Table 22 tabulates those results.

Bacteria and pathogens will always be present in surface waters and in general bacteria will die off and decompose as part of the natural process. Bacteria found at high enough levels can be an indicator of potential health risks and can cause sickness of even death. All of the monthly geometric mean concentrations on all impaired reaches exceed the 126 org/100 mL standard, and 7% to 27% of the individual samples at each site exceed the 1,260 org/100 mL standard. Monitoring data indicate that *E. coli* concentrations can be elevated under mid to very high flows suggesting that a range of source type contributions exists.

Figure 45: Assessed stream reaches for fecal bacteria in the Blue Earth River Watershed. Stream reaches assessed for fecal bacteria and the assessment results are indicated by color. Red indicates an impairment (bacteria is problematic in that reach).

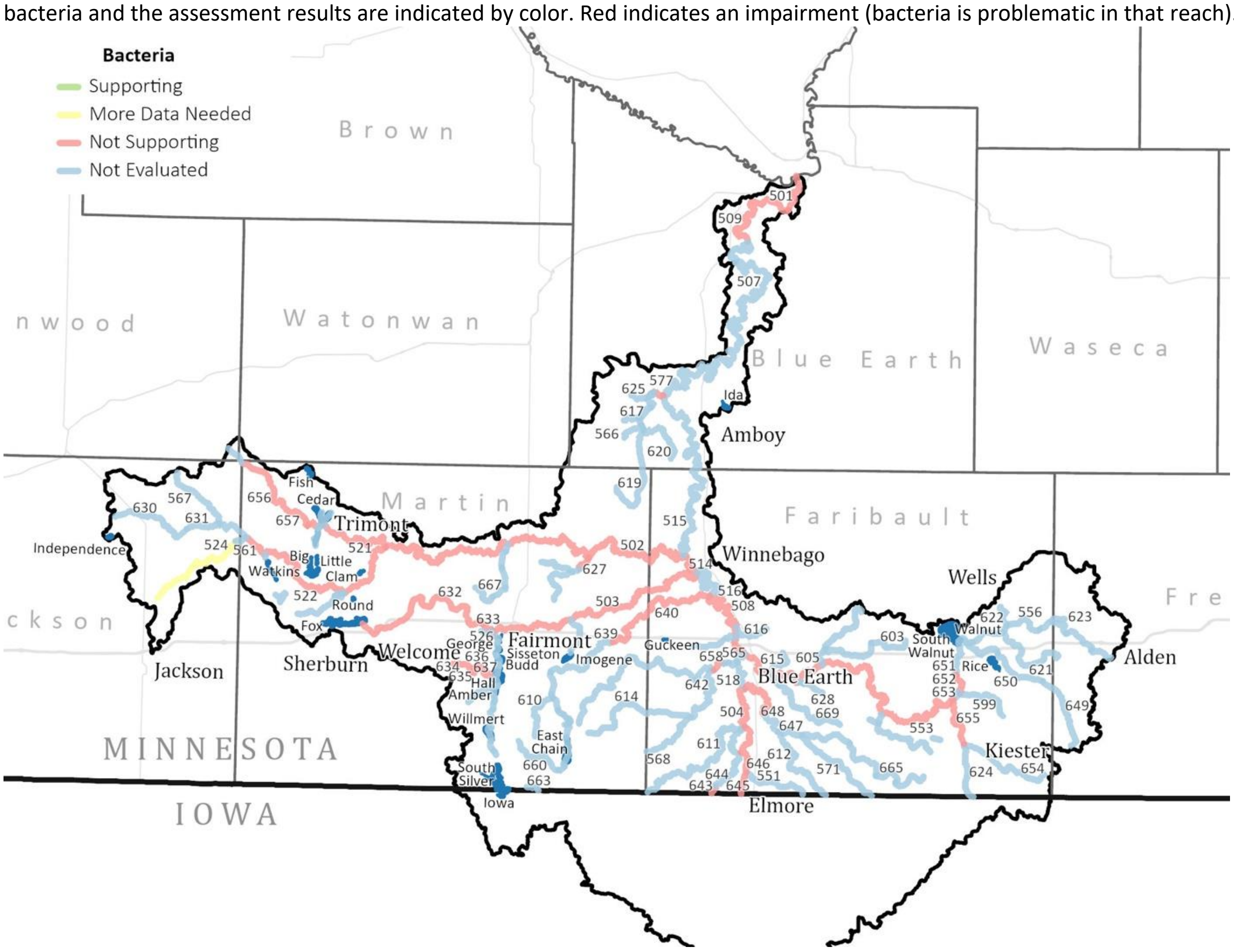


Table 22: Assessment results for bacteria as a pollutant in the Blue Earth River Watershed.

		Bacteria
Stream	Reach (AUID-3)	Bacteria Class 2 Assessment
Blue Earth River	501	x
Elm Creek	502	x
Center Creek	503	x
Blue Earth River	504	x
Blue Earth River	508	x
Blue Earth River	509	x
Blue Earth River	514	x
Cedar Creek (Cedar Run Creek)	521	x
Elm Creek	522	x
Elm Creek, South Fork	524	?
Center Creek	526	x
Blue Earth River, East Branch	553	x
Willow Creek	577	x
Judicial Ditch 3	627	x
Lily Creek	632	x
Lily Creek	633	x
Dutch Creek	634	x
Dutch Creek	635	x
Dutch Creek	636	x
Dutch Creek	637	x
South Creek	640	x
Blue Earth River, West Branch	643	x
Blue Earth River, Middle Branch	645	x
Blue Earth River, Middle Branch	646	x
Coon Creek	648	x
Blue Earth River, East Branch	652	x
Brush Creek	655	x
Cedar Creek (Cedar Run Creek)	656	x
Cedar Creek (Cedar Run Creek)	657	x
Badger Creek	658	x

x	= stressor	?	= inconclusive (need more data)
+	= not a stressor	-	= not assessed

Unlike nutrients and sediment, statewide bacteria monitoring is not done by the WPLMN; therefore, statewide results are not readily available for comparison. Furthermore, HSPF does not model bacteria, so model results are also not available.

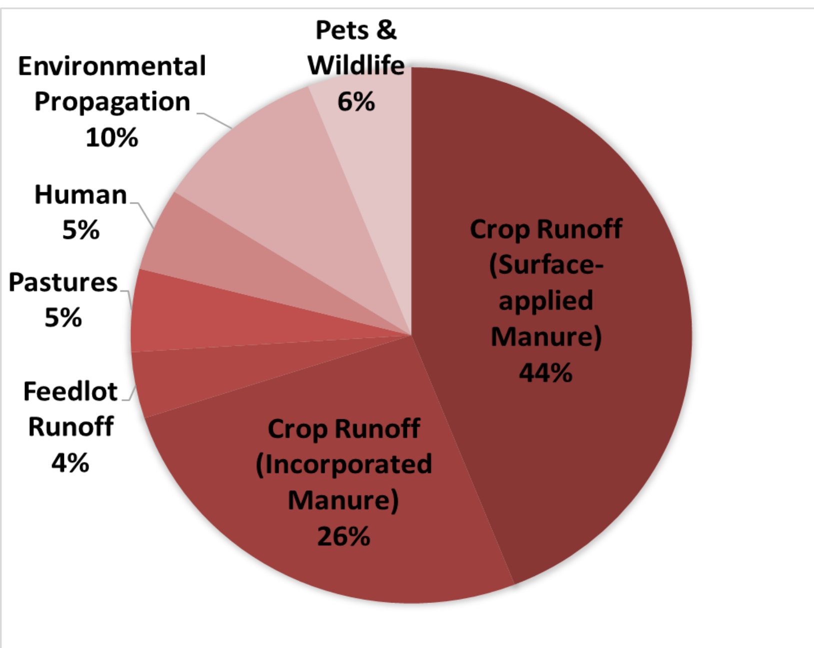
Sources

Specific source assessment of fecal bacteria is difficult due to fecal bacteria's ability to persist, reproduce, and migrate in unpredictable ways. Emmons & Olivier Resources (2009) conducted a Literature Summary of Bacteria for the MPCA. The literature review summarized factors that have either a strong or weak positive relationship to fecal bacterial contamination in streams (Table 23).

Table 23: Factors associated with bacterial presence in surface waters.

Strong relationship to fecal bacterial contamination in water	**Weak** relationship to fecal bacterial contamination in water
• High storm flow (the single most important factor in multiple studies) • % rural or agricultural areas greater than % forested areas in the landscape (entire watershed area) • % urban areas greater than % forested riparian areas in the landscape • High water temperature • Higher % impervious surfaces • Livestock present • Suspended solids	• High nutrients • Loss of riparian wetlands • Shallow depth (bacteria decrease with depth) • Amount of sunlight (increased UV-A deactivates bacteria) • Sediment type (higher organic matter, clay content and moisture; finer-grained) • Soil characteristics (higher temperature, nutrients, organic matter content, humidity, moisture and biota; lower pH) • Stream ditching (present or when increased) • Epilithic periphyton present • Presence of waterfowl or other wildlife • Conductivity

Figure 46: Bacteria source assessment in the Blue Earth River Watershed. Source assessment work estimates that runoff from crops where manure is applied is the largest bacteria source in the Blue Earth River Watershed.



Bacteria are able to survive and reproduce in streams (Chandrasekaran et al., 2015). This study traced substantial numbers of bacteria to cattle sources, while no samples could be traced to human sources. The authors postulated that bacteria could be reproducing in the study region, but the amount of sampled bacteria that was from in-stream reproduction versus recent bacteria contamination was not determined. In order to acknowledge this source type, but without certainty, the WRAPS LWG assigned 10% of the watershed's bacteria population to environmental propagation; however, it should be noted that this value is currently not well-understood.

A numeric estimate of the Blue Earth River Watershed's fecal bacteria sources is presented in Figure 46. This source assessment was estimated by the WRAPS LWG with the use of a bacteria calculator (Appendix 4.2). The single largest fecal bacteria source is from crop runoff from surface-applied manure.

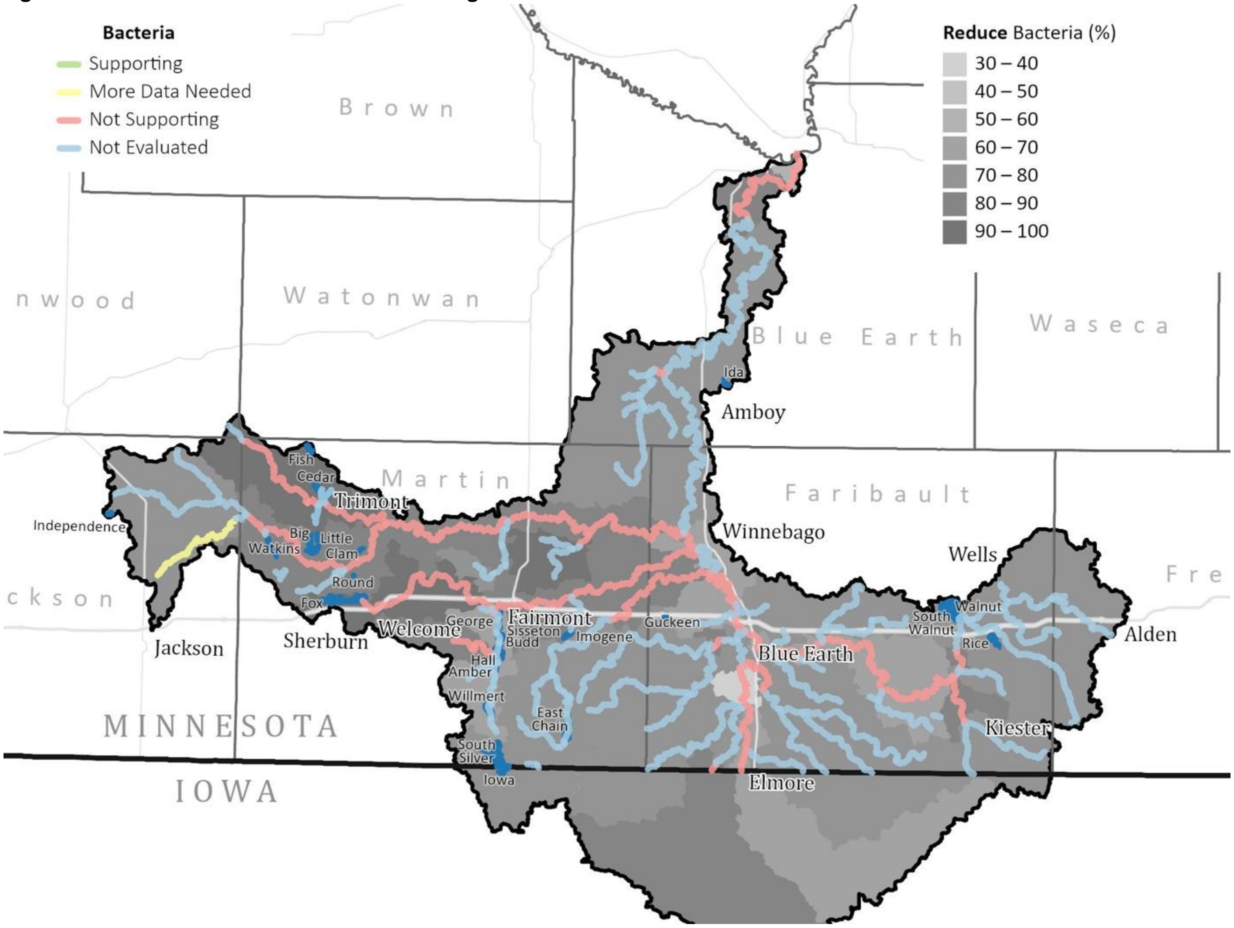
Most of the manure that is applied to fields originates from feedlot operations. Refer to the Sources Overview in Section 2.2 for more information on feedlots in the Blue Earth River Watershed.

Goal and 10-year Target

The watershed-wide goal for bacteria in the Blue Earth River Watershed is 75% reduction (Figure 47) to a mean monthly geomean of 126 cfu/mL in stream bacteria. The map uses a gray scale with darker shaded areas indicating the need for higher reductions. The 10-year target selected by the WRAPS LWG is a 5% reduction in stream bacteria. The subwatershed goals range from a 32% reduction on the West Branch Blue Earth (Reach 504) to a 93% reduction in Judicial Ditch 3 (Reach 627). No assessed reaches met the bacteria water quality standards. Refer to the TMDL summary in Appendix 4.3 for a table of subwatershed reductions goals.

These goals are revisable and will be revisited in the next iteration of the Watershed Approach. Strategies to meet the goals and 10-year targets and methods to prioritize regions for bacteria reductions are summarized in Section 3.

Figure 47: Watershed-wide bacteria reduction goals in the Blue Earth River Watershed.



3. Restoration and Protection

This section presents a summary of scientifically and socially supported strategies to restore and protect waters, Strategies Tables to address restoration and protection goals in the Blue Earth River Watershed, and a Priorities Table with tools to identify watershed priority waters. The content in these tables was developed by using input from the WRAPS LWG. The Strategies Tables provide high-level information on the changes necessary to restore and protect waters within the Blue Earth River Watershed. The Priorities Table provides subwatersheds that are high priority using various water quality and multiple benefits prioritizing criteria. These two high-level tools, along with civic engagement project findings, will provide a helpful starting point for local water resource planning.

Strategies

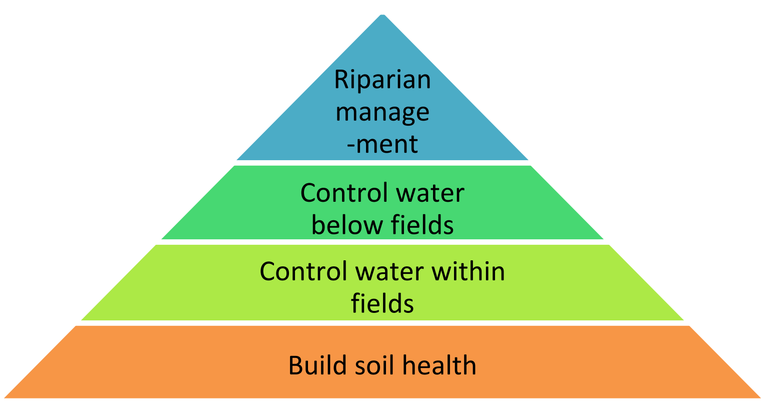
3.1 Scientifically-Supported Strategies

This section summarizes studies and data on land management and BMP effects on water quality. Supplementary and detailed information relevant to this section is included in Appendix 4.4.

To address the widespread water quality impairments, comprehensive and layered BMP suites are likely necessary. This comprehensive and layered BMP adoption represents a paradigm shift in land management, particularly in the agricultural lands that dominate the Blue Earth River Watershed. However, these same principles should be applied to all land uses.

A conceptual model displaying this layered approach is presented by Tomer et al. (2013); Figure 48. The Tomer model to address water quality in agricultural watersheds uses 1) soil health principles as a base: nutrient management, reduced tillage, crop rotation, etc., 2) in-field water control: grassed waterways, controlled drainage, filter strips, etc., 3) below-field water controls: wetlands, impounds, etc., and 4) riparian management: buffers, stabilization, restoration, etc.

Figure 48: Conceptual model to address water quality in agricultural watersheds (Tomer et al. 2013).



Another model to address widespread nutrient problems is presented in the Minnesota Nutrient Reduction Strategy (MPCA 2014b), which calls for four major steps involving millions of acres statewide: 1) increase fertilizer use efficiencies, 2) increase and target living cover, 3) increase field erosion control, and 4) increase drainage water retention.

A third example of a comprehensive, layered approach is being demonstrated with a "Treatment Train" approach in the Elm Creek Watershed (ENRTF 2013), which has demonstrated layered strategies including: 1) upland: cover crops and nutrient management, 2) tile treatment: treatment wetlands and controlled drainage, and 3) in-stream: woody debris and stream geomorphology restoration.

Point Sources

The wastewater sector has made huge improvements in phosphorus reduction over the last two decades, and ammonia concentrations are also largely under control, but nitrate concentrations mostly are not. There are opportunities for progress in wastewater TN management and treatment. The MPCA is currently working on refining a wastewater nitrogen reduction strategy which will likely include site specific water quality based effluent limits for dischargers that cause or contribute to exceedances of the future NO_3-N aquatic toxicity standards (after adoption). The goal of this work is to address facilities with disproportionately high effluent concentrations and reduce loading from these sources. Requirements for local development of Nitrogen Management Plans for those facilities will almost certainly be part of the strategy.

The Blue Earth WWTP is one example that is effectively denitrifying its effluent. For the May 2014 to January 2023 time period, NO_2+NO_3-N concentrations average 9.3 mg/L and TKN concentrations average 1.9 mg/L. This compares to other Class A major municipal WWTP average TN concentrations of 21 mg/L Wastewater Data Browser | Tableau Public.

Agricultural BMPs

Since the Blue Earth River Watershed land use and pollutant sources are generally dominated by agriculture, reducing pollutant/stressor contributions from agricultural sources is critical to water resources restoration. A comprehensive resource for agricultural BMPs is the Agricultural BMP Handbook for Minnesota (MDA 2017). Hundreds of field studies of agricultural BMPs are summarized in the handbook. Additional field data has been compiled by Iowa and Minnesota for review in their respective state nutrient reduction strategies. This information is included in Appendix 4.4.

Urban and Residential BMPs

The Minnesota Stormwater Manual (MPCA 2014c) is a comprehensive resource for urban and residential BMPs. This resource is in electronic format and includes links to studies, calculators, special considerations for Minnesota, and links regarding industrial and stormwater programs. In addition to stormwater, failing and unmaintained septic systems can pollute waters. Information and BMPs for Septic Systems is provided by EPA (2014b).

Stream and Ravine Erosion Control

By-and-large, wide-scale stabilization of eroding streambanks and ravines is cost-prohibitive. Instead, first addressing altered hydrology (e.g., excessive, concentrated flows) within the landscape can help decrease wide-scale stream and ravine erosion problems as discussed in *the* Minnesota River Valley Ravine Stabilization Charrette (E&O 2011) and the Minnesota River Basin Sediment Reduction Strategy (MPCA 2015f). Improving activities directly adjacent the stream/ravine (e.g., buffers) can also decrease erosion as summarized in The River Restoration Toolbox (IA DNR 2018). In some cases, high value property may need to be protected, or a ravine/streambank may be experiencing such severe erosion that stabilizing the streambank or ravine is deemed necessary.

Lake Watershed Improvement

Strategies to protect and restore lakes include both strategies to minimize pollutant contributions from the watershed and strategies to implement adjacent to and in the lake (refer to summary in Appendix 4.4). Strategies to minimize pollutant contributions from the watershed focus mostly on agricultural and/or stormwater BMPs, depending on the land use and pollutant sources in the watershed. The DNR (2014) supplies detailed information on strategies to implement adjacent and in the lake via Shoreland Management guidance.

Culverts, Bridges, and Connectivity Barriers

Strategies to address connectivity barriers include correctly sizing, removing, or otherwise mitigating the connectivity barriers, and need to be assessed on a case-by-case basis. Bridges and culverts should be sized using flow regime and stream properties using a resource such as Hillman (2015). The effects of dams and impoundments can be mitigated to minimize impacts to AqL. Overall system health should be considered; restoring connectivity may not be cost effective if other stressors are creating significant impacts to aquatic communities.

Computer Model Results

Computer models provide a scientifically-based estimate of the pollutant reduction effectiveness of land management and BMPs. Models represent complex natural phenomena with equations and numeric estimates of natural features, which can vary substantially between models. Because of these varying assumptions and estimates, each model has its strengths and weaknesses, and can provide differing results. For these reasons, multiple model results were used as multiple lines of evidence when establishing the strategies tables. N-BMP, P-BMP, HSPF, and other scenarios are summarized in the Model Summary Table in Appendix 4.4.

3.2 Socially-Supported Strategies

Most of the changes that need to occur to improve and protect water resources are voluntary; therefore, communities and individuals ultimately hold the power to restore and protect waters in the Blue Earth River Watershed. For this reason, the Clean Water Council (MPCA 2022d) recommended that agencies integrate civic engagement in watershed projects (MPCA 2022e).

A growing body of evidence detailed in Pathways for Getting to Better Water Quality: The Citizen Effect (Morton and Brown 2011) suggests that to achieve clean water in the voluntary-adoption system in place, a citizen-based approach is likely the most feasible means to success. Specifically, the transition to more sustainable practices must be developed, demonstrated, and spread by trusted leaders within the community. When leaders embrace a transition, communities are more likely to accept and adopt the transition. When leaders and communities develop solutions, they are likely to intertwine financial security and environmental stewardship instead of viewing them as conflicting goals. In this way, the community is more likely to improve water quality while securing sustainable farms and cities for future generations. If this pathway to water body improvement is to be embraced, one of the most important uses for limited resources is to further develop and support local leaders to take on this challenging work.

Project Development and Activities

The broad goal of the Blue Earth River Watershed Civic Engagement was to share research findings to help citizens better understand watershed issues, to clarify restoration and protection strategies, and promote BMPs to facilitate increased conservation adoption. Numerous activities were undertaken to achieve the goals of the project. Existing partnerships and community initiatives were leveraged to optimize resources. Activities are summarized below.

County and SWCD staff from Blue Earth, Freeborn, Faribault, Jackson, and Martin counties developed many events throughout the Blue Earth River Watershed, particularly focusing on growing community capacity to increase adoption of soil health practices and other key restoration strategies. Many of the activities planned by the group were not held due to restrictions from the pandemic. Targeted audiences included farmer networks, elected officials, lake associations, and women in agriculture groups. A website and [GIS Story Map] were developed to help share water quality and other watershed information with the general public. This work was integrated into the strategies table and is aligned with the citizen-based approach to develop, demonstrate, and spread information about BMPs by trusted leaders within the community.

Soil Health Events

Increasing soil health practice adoption was a major civic engagement strategy across the watershed. Soil health practices, including cover crops, reduced tillage, reduced use of chemical fertilizers and pesticides, and integrating livestock onto cover cropped lands, were promoted through a series of soil health events. Numerous collaborative soil health education events occurred across the watershed, planned and hosted by county, SWCD and Natural Resources Conservation Service (NRCS) staff.

- ***I-90 Soil Health Tours***

  The Blue Earth Civic Engagement (BECE) technical team members collaborated with other regional partners to create series of "I-90 Soil Health Tours," an annual speaker series that occurs over several days and held at multiple locations across the region.

  The I-90 Soil Health Field Tour (2020) focused on economics and soil health and included landowners who farm in the Blue Earth River Watershed. Speakers included a nationally renowned speaker on economics, Rick Clark, along with local Faribault County farmers (Andy Linder and Matt Alford).

  The I-90 Soil Health Tour (2022) focused on local cover crop and no till/strip till operations. The tour featured speakers Mitchell Hora, Dean Sponheim, Anne Sawyer, and AJ Krusemark, and drew farmers, government agencies, and agronomists to events in Albert Lea and Fairmont.

- ***Cover Crops 101 Program***

  Faribault SWCD hosted a cover crops 101 meeting in Blue Earth to provide information on getting started with cover crops, and to introduce landowners to other farmers and companies utilizing cover crops in their operations.

- ***Cover Crop Promotion Program***

  Faribault SWCD developed and coordinated a cover crop promotion program to encourage hesitant but interested landowners to try cover crops on a small piece of their land. The project offered landowners that had never tried a cover crop reimbursement for the cost of cover crop seed (maximum of $500 per producer).

- ***Seneca Foods Collaboration***
  Faribault SWCD worked with Seneca Foods to co-host a cover crop field day targeted to the growers of the facility. The workshop focused on soil health and cover crop BMPs. This meeting has had long term results and has resulted in cover crops being planted on several fields.

- ***Tillage Inventory***

  Freeborn County conducted a Tillage Transect Survey using previous transect points to track changes over time. Data was collected and summarized and was utilized in the WRAPS process and to develop implementation strategies.

Elected Official Meetings

The BECE team planned and hosted three elected official meetings to share WRAPS findings, targeted to county elected officials across the watershed. The goal of the first elected officials meeting (March 2018) was to introduce the WRAPS process, to provide a hands-on overview about the approach for monitoring and assessment, and to clarify how this information will be used throughout the WRAPS process. The second elected officials meeting (March 2019) focused on sharing WRAPS research findings. The DNR and MPCA staff gave presentations about the chemical, biological, and geomorphic research used during the monitoring and assessment portion of the WRAPS/TMDL process. The first two meetings were designed with a series of informational stations hosted by researchers that were available to explain general information about the health of area rivers and lakes and research findings including the status of water quality, fish, and macroinvertebrate communities. Watershed staff hosted a third meeting (August 2019), a river float led by the MPCA and DNR researchers that was open to all elected officials. During the float, researchers highlighted resource concerns, provided additional information, and gave elected officials the opportunity to personally experience the river and learn about watershed conditions first hand.

Women in Agriculture

Faribault and Martin County SWCDs planned and hosted two Women in Agriculture Days. The first event targeted women landowners, called 'Women Caring for the Land'. Presenters included staff from NRCS, Faribault County Drainage, and an attorney. The second event focused on farm policy, regulations, and transition planning as well as soil health and conservation farming. Presenters included staff from BWSR, a Seed Salesperson and producer, and the Minnesota State Southern Agricultural Center of Excellence.

Fairmont Lakes Coalition Building

Martin County SWCD continued to work with the Fairmont Lakes Association and hosted public meetings to gather information for the WRAPS process. The MPCA monitoring approach for the lakes was presented. The SWCD worked with a SWCD Board and county commissioner liaison to use information from the Lake Group to inform county water planning work. Watershed approach information was presented to the County Board.

Website and Virtual Tour

A website and virtual tour was created to provide information about the Blue Earth River Watershed to help share water quality information and restoration and protection strategies with watershed residents and the general public. The website includes a series of GIS Story Maps so citizens can explore the watershed and serves as a repository of watershed information for future planning and civic engagement. It can be visited at the website: bewatershed.org.

Watershed Outreach and Media

Partner staff reached out watershed-wide using a variety of media outlets. Martin County has a Conservation Update article, which reaches 12,000 citizens. Many counties post conservation updates and outstanding conservationist awards on their SWCD websites. Counties also used social media posts about the watershed work as well as outreach thorough local radio outlets and mailed flyers.

3.3 Selected Restoration and Protection Strategies

The presented strategies tables show the types of practices and associated adoption rates estimated to meet: A) the full water quality goals (Appendix 4.3) and B) 10-year water quality targets (Table 6) for the Blue Earth River Watershed. The strategies need to be refined in local planning processes to determine specific locations and means to get these types of strategies "on the ground."

Strategies Table A (Table 24) summarizes the water quality conditions, goals, and high-level strategies and adoption rates at the watershed scale. The basis for these strategies was derived from the Model Summary presented in Appendix 4.4 and best professional judgement. Recommending specific suites of practices capable of cumulatively achieving all water quality goals is not practical. Challenges including the vast amount of change needed to meet water quality goals and the needed changes in technologies, programs, markets, and other whole-scale drivers will likely result in this work taking decades. Instead, high-level, narrative strategies and adoption rates were deemed more practical.

Strategies Table B (Table 25) presents strategies and numeric adoption rates estimated to meet the 10-year water quality targets. These strategies were proposed and ranked (highest to lowest adoption) by the WRAPS LWG. The numeric adoption rates were then calculated to meet the 10-year water quality targets, using the developed source assessment, with a spreadsheet tool (notes and assumptions in Appendix 4.2) and reviewed to ensure consistency with computer model information (Model Summary in Appendix 4.4). This strategies table is intended to be more helpful for local planning efforts, which typically work on a 10-year revision schedule.

The presented strategies need to be implemented across the watershed, in all subwatersheds with impaired water bodies or supporting water bodies with declining trends (any area shown in gray in the goals maps presented in Section 2.2). However, the adoption rates in any one region will not necessarily match the watershed-wide adoption rates due to regional differences. Furthermore, not all strategies are appropriate for all locations. The strategies and regional adoption rates need to be customized during local planning efforts.

Protection Considerations

Water bodies that meet water quality standards should be protected to maintain or improve water quality. Furthermore, water bodies that have not been assessed should not be allowed to degrade. The strategies presented in Table 24 and Table 25 – set at the major watershed scale – are intended to not only restore but also protect waters in the Blue Earth River Watershed. Similar to customizing regional adoption rates of the watershed-wide strategies, strategies and adoption rates should reflect the relative amount of protection needed and any site-specific considerations.

The highest priority aspects of water quality protection in the Blue Earth River Watershed include:

- Mitigate alterations to hydrology by adding storage, infiltration, and ET. Effectively, this means improving soil health so that there is more organic matter in the soil to hold water; mitigating on-site when possible, such as adding a wetland/pond to intercept and infiltrate water from a new tile drainage project; and adding more living vegetation to the landscape in early summer and late fall by using cover crops, diversifying crops, and restoring stream buffers, wetlands, and grasslands.
- Maintain and spread the good practices happening on the landscape. Keep practices and BMPs in place, and work to spread their adoption.
- Maintain perennial vegetation on the landscape, especially adjacent to water bodies, in areas with high slopes, and in areas with highly-erodible soils.

Additional concerns in the watershed relate to groundwater and drinking water protection. The main supply of drinking water to the residents and businesses in the Blue Earth River Watershed is groundwater – either from private or community wells.

Two communities in particular, Mankato and Fairmont, have vulnerable drinking water systems that have a connection with and influence from surface water in the watershed. The MDH has developed Source Water Assessments (SWA) for each of the communities designed to protect the public water source from point and nonpoint pollution including nitrates and other contaminants (Appendix 4.4). The City of Mankato obtains water for some of its public water supply from two shallow wells that draw water from the Minnesota and Blue Earth Rivers. The City of Fairmont draws water from Budd Lake for its public water supply. Contaminants on the surface can move into the drinking water aquifers more quickly in these areas, and the SWA reports provide information on how to protect these resources from potential contamination sources.

Most of the smaller communities in the Blue Earth River Watershed have low to very low vulnerability to contamination, which means that in those areas the deep aquifers are fairly well protected. There is also the potential for contamination through unused and abandoned wells. Ensuring abundant and high-quality supplies of groundwater is critical, especially in light of altered hydrology and the impacts on groundwater recharge.

Climate protection co-benefit of strategies

Many agricultural BMPs, which reduce the load of nutrients and sediment to receiving waters also act to decrease emissions of greenhouse gases (GHGs) to the air. Agriculture, forestry and land use is the third largest emitting sector of GHGs in Minnesota. Important sources of GHGs from crop production include the application of manure and nitrogen fertilizer to cropland, soil organic carbon oxidation resulting from cropland tillage, and carbon dioxide (CO_2) emissions from fossil fuel used to power agricultural machinery or in the production of agricultural chemicals. Reduction in the application of nitrogen to cropland through optimized fertilizer application rates, timing, and placement is a source reduction strategy; conservation cover, riparian buffers, vegetative filter strips, field borders, and cover crops reduce GHG emissions as compared to cropland with conventional tillage.

The USDA NRCS has developed a ranking tool for cropland BMPs that can be used by local units of government to consider ancillary GHG effects when selecting BMPs for nutrient and sediment control.

Practices with a high potential for GHG avoidance include: conservation cover, forage and biomass planting, no-till and strip-till tillage, multi-story cropping, nutrient management, silvopasture establishment, other tree and shrub establishment, and shelterbelt establishment. Practices with a medium-high potential to mitigate GHG emissions include: contour buffer strips, riparian forest buffers, vegetative buffers, and shelterbelt renovation. A longer, more detailed assessment of cropland BMP effects on GHG emission can be found at NRCS, *et al*. COMET-Planner: Carbon and Greenhouse Gas Evaluation for NRDC Conservation Practice Planning.

Table 24: Strategies Table A.

This portion of the strategies table summarizes the conditions, goals, 10-year targets, proposed years to reach the goals, and the strategies and estimated adoption rates needed to achieve the goals. The strategies and estimated adoption rates are presented in narrative form. The high-level strategies and rough estimate adoption rates are intentionally used to reflect the variety of practices, corresponding differences in practice efficiencies, and uncertainty in the exact practices and adoption rates that will be needed to achieve water quality goals throughout the watershed. These strategies and adoption rates were estimated after reviewing multiple model results (available in Appendix 4.4), the identified sources of pollutants and stressors in the Blue Earth River Watershed, and the SID and Geomorphology/Hydrology reports. Strategies, practices, and specific adoption rates, to meet the 10-year targets are identified in Table 25.

Parameter	**Identified Conditions**	**Water Quality Goal** (summarized)	**Basin-wide Goal** (average/surrogate for watershed)	**10-yr Target** (meet by 2033)	**Years to Reach Goal** (from 2023)	**Restoration and Protection Strategies** See key in Appendix 4.4 for BMPs associated with strategies Estimated Adoption Rates: All= >90% Most= >60% Many/much= >30% Some= >10% Few= <10% Adoption rates indicate the final landscape outcome and include any practices already in place.
Degraded Habitat	▪28 stream reaches stressed ▪Likely stressor of lake AqL	AqL populations are not stressed by degraded or lack of habitat.	65% increase in MSHA habitat score	10% ↑	50+	All streams and ditches have a restored riparian area/shoreland. Most ditches reduce impacts. Many stream/ditch channels, banks, and floodplains are improved. Few marginally productive/high risk land uses are converted for critical habitat (wetlands, CRP, etc.). Most lake and wetland shorelands are restored/protected. Altered hydrology and sediment are addressed
Phosphorus/ Eutrophication	▪18 stream reaches and 13 lakes stressed/impaired ▪7 stream reaches and 1 lake not stressed/supporting ▪Reductions needed to meet downstream goals	Summer lake mean TP concentration is less than 0.09 mg/L and AqL populations are not stressed by eutrophication. Support statewide and downstream reduction goals.	45% reduction in lake and stream concentrations/loads	Lakes 10% ↓ Streams 5% ↓	Lakes Streams 50+	All croplands improve soil health by decreasing fertilizer use, adding cover crops, decreasing tillage, and/or diversifying crops. Most croplands reduce and treat cropland surface runoff. All streams and ditches have riparian buffer. All residential/urban areas reduce and treat runoff. Some stream/ditch channels, banks, and floodplains are improved. All WWTPs and septic systems are providing adequate treatment.
Sediment	▪37 stream reaches stressed/impaired ▪1 stream reach not stressed/supporting ▪Sediment reductions needed to meet downstream needs ▪Contributing to other stressor (habitat)	90% of stream concentrations are below 65 mg/L. AqL populations are not stressed by sediment.	60% reduction from high flows 90% reduction to meet TSS standard	5% ↓	50+	All croplands improve soil health by adding cover crops, decreasing tillage, and/or diversifying crops. Most croplands reduce and treat cropland surface runoff. All streams and ditches have riparian buffer. All residential/urban areas reduce and treat runoff. Some stream/ditch channels, banks, and floodplains are improved. Impacts from most ditches are reduced.
Nitrogen/Ammonia	▪26 stream reaches stressed/impaired ▪17 stream reaches not impaired ▪Reductions needed to meet downstream goals	AqL populations are not stressed by nitrogen. Support statewide and downstream reduction goals.	45% reduction in river concentrations/loads	5% ↓	50+	All croplands improve soil health by decreasing fertilizer use, adding cover crops, decreasing tillage, and/or diversifying crops. Most croplands reduce and treat cropland tile drainage. All streams and ditches have riparian buffer. All residential/urban areas reduce and treat runoff. All WWTPs and septic systems are providing adequate treatment.
Altered Hydrology	▪41 stream reaches stressed ▪Source of other stressors (sediment, degraded habitat)	AqL populations are not stressed by altered hydrology (too high or too low river flow). Hydrology is not creating problems with other parameters (habitat, sediment, nitrogen, phosphorus, etc.).	25% reduction in peak and annual river flow	No Increase	50+	All croplands improve soil health by adding cover crops, decreasing tillage, and/or diversifying crops. Most croplands reduce and treat surface runoff and reduce and treat tile drainage. Few (marginally productive/high risk) areas are converted for critical habitat (wetlands, CRP, etc.). All residential/urban areas reduce and treat runoff. Some stream/ditch channels, banks, and floodplains are improved.
			increase dry season river base flow by enough to support AqL	small increase	50+	
Connect-ivity	▪39 stream reaches stressed ▪2 stream reaches not stressed	AqL populations are not stressed by human-caused connectivity barriers.	Address human-caused barriers as identified in SID and where practical	5 barriers removed	20	Fish barriers are addressed.

Parameter	Identified Conditions	**Water Quality Goal** (summarized)	**Basin-wide Goal** (average/surrogate for watershed)	**10-yr Target** (meet by 2033)	**Years to Reach Goal** (from 2023)	**Restoration and Protection Strategies** See key in Appendix 4.4 for BMPs associated with strategies Estimated Adoption Rates: All= >90% Most= >60% Many/much= >30% Some= >10% Few= <10% Adoption rates indicate the final landscape outcome and include any practices already in place.
Bacteria	▪29 stream reaches impaired	Average monthly geomean of stream samples is below 126 cfu/100mL to support AqR or 630 to support limited use (Class 7) streams.	75% reduction in river concentrations/loads	5% ↓	50+	All WWTPs and septic systems are providing adequate treatment. All feedlot-produced manure is applied to cropland using improved application practices. All croplands improve soil health by adding cover crops, decreasing tillage, and/or diversifying crops. Most manured croplands reduce and treat cropland surface runoff. All feedlots optimize manure storage and siting. All pastures improve livestock and manure management by improving grazing practices and restricting livestock access to water bodies. Some livestock are integrated onto the landscape.
Parameters that are impacted/addressed by the above pollutants and stressors						
F-IBI	▪33 stream reaches impaired ▪32 stream reaches supporting	AqL populations (scored with the IBI) meet thresholds based on stream class/use.	Each parameter's goal is to meet the water quality standard and support downstream goals. Because these parameters are a response to (caused by) the above pollutants/stressors, the above watershed-wide goals are the (indirect) goals for these parameters.	meet other 10-year targets	50+	The above strategies are implemented.
M-IBI	▪23 stream reaches impaired ▪38 stream reaches supporting					
DO	▪22 stream reaches stressed/impaired ▪2 stream reaches not stressed/supporting	Stream concentrations are above 5 mg/L and DO flux is not excessive.			50+	

Table 25: Strategies Table B (1 of 2).

This table presents a suite of strategies and practices that are cumulatively capable of meeting the 10-year targets for the Blue Earth River Watershed. The strategies are presented by land use and provide target adoption rates by both watershed area and the equivalent number of acres. This level of new adoption progresses the landscape and water bodies towards clean water consistent with the total years to achieve watershed restoration as presented in Table 24. Adoption rates are for new projects and assume existing practices will be maintained. Information on the conditions, goals, and total timelines is presented in Table 24. Refer to the narrative in Section 3.3 for more information. See Appendix 4.4 for information on practices and relevant NRCS practice codes.

Land use/ Source Type	Blue Earth River WRAPS and associated BMPs estimated to meet 10-year targets at specified adoption rates	Adoption Rate		Effectiveness of practice on parameter per acre comparison							
		Portion of Watershed Area	Watershed Acres	Sediment	Flow	Nitrogen	Phosphorus	Bacteria	Habitat‡	Connectivity	Chloride
Cultivated Crops	Add cover crops for living cover in fall/spring: cover crops on corn/beans, cover crops on early-harvest (canning) crops	7%	54,400	X	x	X	X	x	-		
	Decrease tillage: conservation tillage, no-till, strip till, ridge till	5%	38,900	x	-	-	x	x			
	Decrease fertilizer use: nutrient management, reduced rates, targeted/measured application	2%	15,500			x	-				
	Reduce and treat cropland surface runoff*: water and sediment control basins, retention ponds, treatment wetlands, stormwater control structures, field buffers	1%	7,800	X	-	-	X	x			
	Diversify crops: conversion to small grains, perennial crops, and well-managed pasture	1%	7,800	x	x	X	x	x	-		
	Replace or buffer open tile intakes*: blind, rock, sand filter intakes, vegetative buffer	0.5%	3,900	X			X	X			
	Reduce and treat cropland tile drainage*: Bioreactors, treatment wetlands, saturated buffers, limit new tiles	1%	7,800		-	X	-				
	Convert/protect land for critical habitat (replacing marginally productive and high risk cropped areas): Restore wetlands, conservation cover/CRP, prairie, habitat management, native shrub hedgerows	0.3%	1,900	X	X	X	X	X	-		

Land use/ Source Type	Blue Earth River WRAPS and associated BMPs estimated to meet 10-year targets at specified adoption rates	Adoption Rate		Effectiveness of practice on parameter per acre comparison							
		Portion of Watershed Area	Watershed Acres	Sediment	Flow	Nitrogen	Phosphorus	Bacteria	Habitat‡	Connectivity	Chloride
	Mitigate new ag drainage projects by adding basin/wetland storage (wetland trading program)	All new projects		n/a							
	Maintain existing BMPs, CRP, RIM	All current BMPs		n/a							
	Improved programs and program funding: Federal farm program changes, more reduced tillage programs, create programs for new crops, more funding in Ag Water Quality certification program, implement a wetland trading program, flexible funding and insurance coverage for innovative conservation practices, new 30-to-50-year easement programs	sufficient to achieve the above physical strategies		n/a							
	Education: nutrient management education for agronomists and landowners, cover crop, altered hydrology, and bioreactor education										
	Field trials and monitoring: field trials of cover crops/other conservation practices, tile monitoring to identify volume of water and pollutants										
	Market development: second crop (cover crops), small grains, perennials										
Feedlots	Optimize siting of manure storage: rainwater diversion (prevent from entering manure storage system) to water source, feedlot manure storage addition, add farm infrastructure to achieve storage/runoff reduction goals (machinery, buildings, roads)	sufficient to reduce current contributions by 25%				√	√	√			
	Reduce/treat feedlot runoff: targeting smaller and unpermitted facilities					√	√	√			

Land use/ Source Type	Blue Earth River WRAPS and associated BMPs estimated to meet 10-year targets at specified adoption rates	Adoption Rate		Effectiveness of practice on parameter per acre comparison							
		Portion of Watershed Area	Watershed Acres	Sediment	Flow	Nitrogen	Phosphorus	Bacteria	Habitat‡	Connectivity	Chloride
	Optimize feedlot siting: increase distance between livestock and water, move feedlots out of sensitive areas					√	√	√			
	Smaller facilities and transition to more grazing: encourage small scale facilities and more conservation and cover crop grazing					√	√	√			
	Education and outreach to encourage producers to graze livestock, use one-on-one consultant, educate neighbors and community	sufficient to achieve the above physical strategies		n/a							
Manure Application	Improve manure application: improve placement/setbacks, no application draining to open intakes, equipment upgrades to variable applicators	0.5%	3,900		-	x	x	X			
Manure Application	Outreach, education, and support: education on value of manure and better manure use, provide a manure testing incentive, provide variable rate applicator support	sufficient to achieve the above physical strategies		n/a							
Pastures	Improve pasture/grazing management: managed/rotational grazing, graze cover crops, remote watering facilities and fencing	0.1%	800	X			X	X			
Pastures	Restrict livestock access to water bodies: exclusions/fencing, watering facilities	0.1%	800	X			X	X			
Pastures	Networks and support: create support systems to encourage innovative pasture conservation, work with groups like Cattleman's Association	sufficient to achieve the above physical strategies		n/a							

Strategies Table B (page 2 of 2)

This table presents a suite of strategies and practices that are cumulatively capable of meeting the 10-year targets for the Blue Earth River Watersheds. The strategies are presented by land use and provide target adoption rates by both watershed area and the equivalent number of acres. This level of new adoption progresses the landscape and water bodies towards clean water consistent with the total years to achieve watershed restoration as presented in Table 24. Adoption rates are for new projects and assume existing practices will be maintained. Information on the conditions, goals, and total timelines is presented in Table 24. Refer to the narrative in Section 3.3 for more information. See Appendix 4.4 for information on practices and relevant NRCS practice codes.

Land use/ Source Type	Blue Earth River WRAPS and associated BMPs estimated to meet 10-year targets at specified adoption rates	Adoption Rate	Pollutants/ Stressor addressed by strategy							
			Sediment	Flow	Nitrogen	Phosphorus	Bacteria	Habitat‡	Connectivity	Chloride
Stream, ditches, and riparian	Stream channel, bank, and habitat projects: stream stabilization, re-connect/ restore flood plains, re-meander channelized stream reaches, and/or stream habitat improvement and management on selected locations within assessed stream miles	5% of streams/diches (40 miles)	√	√	√	√	√	√	√	
	Reduce ditch impacts: reduce ditch clean-outs, ditch improvements projects include additional water storage practices to mitigate impacts, 2-stage ditches	100% of ditches	√	√	√	√	√	√		
	Address fish barriers: replace/properly size culverts and bridges (perched culverts and velocity barriers)	5% of culverts replaced							√	
	Enhance/improve buffers: improve required buffers with native plants	100% of stream/ditches have required buffer and 10% are planted to natives	√	√	√	√	√	√		
	Education and outreach: topics to include stream functionality/stability, fish barriers, watershed health; use existing public events for outreach, education field days	sufficient to achieve the above physical strategies	n/a							
	Programs and funding: increased guidance, funding, and flexibility									
	Collaboration: work with drainage authority and engineers to incorporate water storage in ditch projects									
	Rules: create and enforce a maximum drainage coefficient									

Land use/ Source Type	Blue Earth River WRAPS and associated BMPs estimated to meet 10-year targets at specified adoption rates	Adoption Rate	Pollutants/ Stressor addressed by strategy							
			Sediment	Flow	Nitrogen	Phosphorus	Bacteria	Habitat‡	Connectivity	Chloride
Lakes, wetlands, and shoreland	Restore/protect shoreland: stabilize/restore shoreline with native vegetation and/or increase distance (buffer) between water body and impacts at selected locations within assessed lakes	5 lakes	√			√		√		
	Manage in-lake/wetland: drawdowns, wetland enhancements	5 lakes/wetlands	√			√		√		
	Remove dams/outlet structures	2 lakes						√	√	
	Prevent AIS spread: add new check points to prevent aquatic invasive species spread †	4 new check points	n/a							
	Education: topics to include AIS prevention, lake dams, economic benefits of restoration	sufficient to achieve the above physical strategies	n/a							
	Funding: create funding source for dam removal									
	Regulations/zoning: enforce shoreland ordinance									
	Collaboration: lake associations and sportsman's clubs									
Forest and prairies	Protect and enhance: areas in natural land uses, increase native populations †	n/a	√	√	√	√	√	√		
City and residential	Increase stormwater treatment and storage: stormwater ponds, swales, rain gardens/barrels, wetlands, applicable parties follow SWPPPs	sufficient adoption to reduce current contributions by 20%	√	√	√	√	√			
	Improve vegetation: add and diversify trees, native landscaping, rain gardens		√	√	√	√	√	√		
	Improve road management: road salt management/education, street sweeping, smart snow stockpiling, utilize Statewide Chloride Management Plan		√	√	√	√	√			√
	Nutrient management: proper/reduced use of lawn fertilizer, pet waste management				√	√	√			
	Water softener upgrades	5% of softeners upgraded								√

Land use/ Source Type	Blue Earth River WRAPS and associated BMPs estimated to meet 10-year targets at specified adoption rates	Adoption Rate	Pollutants/ Stressor addressed by strategy							
			Sediment	Flow	Nitrogen	Phosphorus	Bacteria	Habitat‡	Connectivity	Chloride
	Education and advertising: urban BMPs and water softener upgrades through radio, newspapers, fliers; educational events at businesses that sell plants; marking storm drains	sufficient to achieve the above physical strategies	n/a							
	Funding: funding for educational events, cost-share for urban/residential BMPs									
	Ordinance: require stormwater management									
	Leadership/oversight: create an urban BMP committee to lead educational events, identify ordinance needs, locate proposed project sites, oversee project completion									
Septics/ SSTS	Eliminate unsewered areas and straight pipes: systems discharging to streams/land surfaces are redirected per SSTS rules	100% eliminated			√	√	√			
	Maintenance and replacement: scheduled maintenance and replace failing systems	As needed, roughly 30%			√	√	√			
	Funding: cost-share available, including targeted to low-income households	sufficient to achieve the above physical strategies	n/a							
Point Sources	Facility upgrades: when required by permit	Follow permit requirements			√	√	√			√
	Regulations: follow permitting process		n/a							

3.4 Priorities

The priorities section summarizes selected priority areas from the Cycle I planning work with local partners and from the various assessment and SID efforts. This section helps to identify and justify priority areas or issues for water quality restoration and protection and to summarize other priority areas for multi-benefits (in addition to water quality) that are important to local staff and citizens. The chart provides areas to focus planning efforts in the Blue Earth River Watershed and gives examples of areas to be considered.

Table 26: Priorities Table

	"Priority Area" Prioritizing Criteria	Specific Examples	Applicable WRAPS/other data sources	Other considerations
Surface Water Quality (WRAPS) Driven Priority Areas These priority areas are directly from the WRAPS report and focus on water quality restoration or protection	"**Tipping Point: Barely Impaired"** Water bodies that are impaired but have a relatively smaller reduction or improvement goal.	**Cedar Creek (Cedar Run Creek) reach 521 and Elm Creek reach 522** need relatively smaller reductions to meet TSS standards in the major watershed. Two reaches show fish and bug communities that are nearly impaired, **Unnamed Creek reach 624** (MN/IA border to Brush Cr) **and Brush Creek reach 655.** Shallow lakes with enough data to be considered nearly/barely impaired, within 15% of the standard, in the Blue Earth River Watershed include: **Fox, Imogene, Willmert and Amber.**	Use the goals maps in Section 2.2 (which illustrate the TMDL Summary table in the Appendix) to identify which impaired water bodies require the least reduction. On the goals map, the lighter the gray shading, the less reduction that is required. AqL IBI scores are available in the Monitoring and Assessment report. Those that are closer to the threshold are likely more attainable/restorable. Additional details are provided in the SID and the DNR Hydro/geomorph reports.	Compared to "dirtier" subwatersheds, fewer changes are needed to address parameters and can be "easier" to achieve restoration goals. These prioritizing criteria can be especially important if the primary goal of the funding entity is to achieve restoration of impaired water bodies. Prioritization of biological impairments can be found in Appendix 7 of the Monitoring and Assessment Report.
	"Protection of Supporting Waters" or "Reverse Degrading Trends" Water bodies that are currently meeting the water quality standard (beneficial use or for any parameter) or any water body (assessed or not)	**Unnamed (22008800) "Guckeen"** is the only assessed lake supporting AqR. Twenty stream reaches were found to support both fish and invertebrate populations.	The "green" water bodies in the status maps and assessment tables throughout Section 2.2 show the supporting water bodies. While a stream reach may be impaired for a beneficial use, some parameters may be supporting. Refer to Monitoring and Assessment Table in Appendix 4.1.	Additional useful prioritizing criteria for protection include: hydrologic alteration, trends, HSPF-modeled yields, phosphorus sensitivity, local pollutant sources, etc. The MPCA Lakes Phosphorus Sensitivity Analysis can be used to prioritize lakes that are estimated to be the most sensitive to additional phosphorus inputs.

	"Priority Area" Prioritizing Criteria	Specific Examples	Applicable WRAPS/other data sources	Other considerations
	should have an improving or stable trend in water quality.			
	"Dirtiest Watersheds or Waters" Watersheds with high pollutant/stressor yields or water bodies that have higher amounts of pollutants/stressors using either: 1) estimated reductions/TMDL based on observed concentrations, or 2) model data (yields or concentrations), 3) total number of identified parameters not supporting water quality goals.	**Blue Earth River (Le Sueur to MN River) reach 501** needs the highest estimated TSS reduction. This is the outlet reach that also includes loading from the Watonwan and Le Sueur River. **Center Creek reach 503** has the most identified parameters not meeting standards/stressing AqL. HSPF modeling maps were created to aid in identifying potentially higher loading areas for TN, TP, and TSS.	1) The goals maps (Section 2.2 - Goals Subsections) illustrate areas that need pollutant reductions - the darker the gray shading, the more reduction needed from this contributing area. The larger the needed reduction, the "dirtier" the water body (reductions also in the TMDL summary in Appendix 4.3). 2) Data are available online and additional interpretation are available in the SID and the DNR hydro/geomorph reports. 3) HSPF-modeled concentrations are in the status subsections in Section 2.2 and yield maps are presented in Appendix 4.2.	1) Subwatershed goals maps can be used to estimate the dirtiest areas but are only presented when there is TMDL data and only apply to TSS, TP, and bacteria. 2) Observed data should be corroborated by that parameter being assessed as a pollutant or stressor 3) Model data is an estimate and may not represent real world conditions and may be limited by model mechanics or assumptions. Coupling model data with additional prioritizing criteria (versus being a single driver in selecting a priority area) is recommended.
	"Connectivity/Fish Passage Barriers" stream reaches where connectivity was identified as a	**All reaches, excluding the outlet below Rapidan Dam, have an impact on the upper reaches of the Blue Earth River. DNR's Blue Earth Watershed**	Streams stressed by connectivity barriers were identified in the SID report and summarized in the WRAPS. A more comprehensive inventory of fish passage barriers is presented in	Work with county and township officials to opportunistically eliminate other small barriers when culverts are replaced.

	"Priority Area" Prioritizing Criteria	Specific Examples	Applicable WRAPS/other data sources	Other considerations
	stressor or other known fish passage barriers.	**Characterization Report identifies 22 potential barriers for fish migration.**	the DNR Watershed Characterization Report.	
	"Highly Hydrologically Altered" Subwatersheds or water bodes identified as highly hydrologically altered.	**Headwaters portions of the East Branch Blue Earth River, Willow Creek, and Coon Creek** are among the areas in the watershed that were estimated to have the highest level of altered hydrology through GIS analysis and SID observations.	A GIS analysis of altered hydrology is presented in Section 2.3 in the Altered Hydrology section. Areas with a higher score indicate more alteration. 1855 land survey or other past landscape imagery/analysis can identify drained lakes/wetlands.	Altered hydrology is a commonly identified stressor in the Blue Earth River Watershed and a driver of most other stressors like sediment, habitat, and nitrogen.
	"Measurable waters" Water bodies with ample monitoring data to establish baseline conditions prior to work being done and future monitoring data can be used to track changes in water quality.	WPLMN sites exist in four locations in the Blue Earth River Watershed: **Blue Earth River nr Rapidan, MN, East Branch Blue Earth River at Blue Earth, CSAH16 Blue Earth River nr Winnebago and CSAH12 Blue Earth River nr Blue Earth, CR6.** Smaller scale locally sampled sites exist in **Elm Creek and Dutch Creek Watersheds**. Stream reaches with AqL (IWM) monitoring locations provide a record to compare after implementing projects. In particular, areas that may show a quick response in AqL (IBI) scores are those associated with connectivity barriers.	The monitoring locations are illustrated on a map in Section 1.3. The three different types of monitoring locations provide different types of data. Review the data online (link at beginning of Section 2) to determine which parameter could be tracked to compare the conditions before and after BMPs are implemented.	Lakes with small watersheds will probably be the easiest to show changes in. Depending on the kind of work to be done, biological data may change. Solid, long-term data is taken at WPLMN sites, but the watersheds of these sites are very large and substantial change is likely necessary before changes will be seen.
	"Impaired Waters" Water bodies that have a 303d listed impairment.	**61 stream reaches and 14 lakes** are impaired for one or more beneficial uses.	The status overview map in Section 2.1 shows the impairments by beneficial use, and the status maps throughout Section 2.2 illustrate the parameters causing the beneficial use impairment (by water body). The assessment table in Appendix 4.1 tabulates all the beneficial use impairments and parameters causing the impairments.	Use the strategies table (referring to the effectiveness column) to identify which practices could be the most effective on the parameter causing the impairment, applying local knowledge of local sources and opportunities. Use additional prioritizing criteria to strengthen

	"Priority Area" Prioritizing Criteria	Specific Examples	Applicable WRAPS/other data sources	Other considerations
				the case for selecting a specific impaired water.
Multiple Benefit and Locally Surface Water Quality (WRAPS) Driven Priority Areas These priority areas are directly from the WRAPS report and focus on water quality restoration or protection driven priority areas: these priorities are not strictly associated with the water quality assessments in the WRAPS, but would offer benefits to water quality in addition to the primary priority area criteria	**"Drinking water and groundwater"** Areas contributing water or risks to drinking and groundwater resources.	**Fairmont Chain of Lakes drinking water source for the city of Fairmont and city of Mankato Wellhead protection** have been identified to be high priority for protecting groundwater due to the soils, geology, and other attributes. Several small community Drinking Water Supply Management Areas (DWSMA) are included in the Blue Earth River Watershed.	Nitrogen concentration/load observed and modeled data and soils data (course textured and tile drained) can estimate higher yielding areas. MDH also provides information for targeting for drinking water source restoration and protection. A narrative is included in the Appendix 4.4 or contact MDH for more info.	The Blue Earth River, which recharges the surficial sands aquifer used for Mankato's drinking water source, which often has excessive N contributions.
	"Wildlife habitat, prairie and wetland restoration" Areas that provide critical habitat and water quality improvement.	Native plant communities **adjacent to the Blue Earth River, tributaries and lakes. Near and within the Guckeen WMA (JD4).** Lakes of high biological significance**: South Lower's Lake, South Walnut Lake, and Walnut Lake.** Rare and unique species and habitats **along the main and east branches of the Blue Earth River, Elm Creek, Center Creek, and South Creek.**	Wetland Management Areas, National Wetland Inventory/Restorable Wetlands, and River Corridors are all data sets useful for identifying and prioritizing habitat. DNR Fisheries Lakes of Biological Significance (2015 GIS layer) identifies high quality lakes based on unique in-lake habitat features.	Blue Earth River Watershed Characterization Report (DNR 2021).
	"Popular recreational water bodies" Water bodies that are commonly used for recreation.	**Fairmont Chain of Lakes, Fox, Big Twin, South Silver.**	Civic engagement and the day-to-day work of local partners has identified several priority areas based on local values and special uses.	City of Fairmont stormwater plan, Blue Earth River Watershed Lake Water Quality Improvement Study (MPCA 2023a).
	"Water bodies seeing increased development" Recreational water bodies.	**Fox, Big Twin, South Silver.**	Civic engagement and the day-to-day work of local partners has identified several priority areas based on local values and special uses.	County and City Planning and Zoning reports, Local Water Plans.

	“**Priority Area**” Prioritizing Criteria	Specific Examples	Applicable WRAPS/other data sources	Other considerations
	"Public Ditches"	**Brush Creek 319-** Faribault County SWCD and Drainage Authority work in designing practices and storage within an improvement project.	Civic engagement and the day-to-day work of local partners has identified several priority areas based on local values and special uses.	Develop new partnerships and practices in ditch improvement to incorporate water storage and erosion control.
	"Stream Restoration" and "Erosion Control"	**Brush Creek, South Creek, Dutch Creek, Center Creek.** Potential for restoration due to watershed characteristics and flood plain connection. **East of Creek Lake**, lower reaches have increased streambank erosion.	Utilize geomorphic study work from the DNR to identify potential stream restoration work that could be developed as part of other conservation activities and drainage work.	

4. Appendix

4.1 Appendix 1 - Watershed Conditions and Background – Related Appendices

Stream Monitoring and Assessment Results

The monitoring and assessment table includes each reach in the Blue Earth River Watershed that is currently listed as impaired or was monitored and assessed in the most current watershed assessment time period. The table lists each of the individual reaches, the pollutants and stressors assessment results from each reach, and the bacterial assessment. Lake assessments includes the AqR and AqL summary by lake assessed.

A summary of the watershed water quality information collected by the WPLMN program for the watershed approach work is included.

AUID-3	Stream	Reach Description	Stream Class	Beneficial Use and Associated Biology, Stessor, and Pollutant Assessment															
				Aquatic Life														Aq Rec	
					Bio		Stressors							Pollutants					Po l.
				Assessment*	Fish IBI	Macro IBI	Hydrology	Nitrogen	Habitat	Connectivity	DO	Eutroph (P)	TSS	TSS	DO	Eutrophication	Ammonia	Assessment*	Bacteria
07020009-501	Blue Earth River	Le Sueur R to Minnesota R	2Bg, 3C	x	x	?	x	?	?	+	?	?	x	x	?	?	+	x	x
07020009-502	Elm Creek	Cedar Cr to Blue Earth R	2Bg, 3C	x	x	x	?	?	?	?	?	?	?	x	?	?	+	x	x
07020009-503	Center Creek	Lily Cr to Blue Earth R	2Bg, 3C	x	x	x	x	?	x	x	x	x	x	x	?	?	x	x	x
07020009-504	Blue Earth River	W Br Blue Earth R to Coon Cr	2Bg, 3C	x	x	+	x	?	?	x	x	?	x	x	?	?	+	x	x
07020009-507	Blue Earth River	Willow Cr to Watonwan R	2Bg, 3C	x	x	+	x	?	?	x	?	?	x	x	?	?	?	-	-
07020009-508	Blue Earth River	E Br Blue Earth R to South Cr	2Bg, 3C	x	x	+	x	x	?	x	?	+	x	x	?	?	+	x	x
07020009-509	Blue Earth River	Rapidan Dam to Le Sueur R	2Bg, 3C	x	x	+	x	?	?	+	?	?	x	x	?	x	?	x	x
07020009-514	Blue Earth River	Center Cr to Elm Cr	2Bg, 3C	x	x	+	x	?	?	x	?	+	x	x	?	?	+	x	x
07020009-515	Blue Earth River	Elm Cr to Willow Cr	2Bg, 3C	x	x	+	x	?	?	x	?	?	x	x	?	?	?	-	-
07020009-516	Blue Earth River	South Cr to Center Cr	2Bg, 3C	x	x	+	x	?	?	x	?	+	x	-	-	-	?	-	-
07020009-518	Blue Earth River	Coon Cr to Badger Cr	2Bg, 3C	x	x	+	x	x	x	x	+	+	x	x	+	?	?	-	-
07020009-521	Cedar Creek (Cedar Run Creek)	Cedar Lk to Elm Cr	2Bg, 3C	x	+	x	x	?	x	x	x	+	x	x	?	?	+	x	x
07020009-522	Elm Creek	S Fk Elm Cr to Cedar Cr	2Bg, 3C	x	x	x	x	x	x	x	?	?	x	x	?	?	+	x	x
07020009-524	Elm Creek, South Fork	T103 R34W S30, west line to T103 R34W S1, north line	2Bg, 3C	x	-	-	-	-	-	-	-	-	-	x	-	+	-	?	?
07020009-526	Center Creek	George Lk to Lily Cr	2Bg, 3C	-	-	-	-	-	-	-	-	-	-	-	?	-	?	x	x

7020009-551	Unnamed ditch	Headwaters to Blue Earth R	2Bm, 3C	+	+	+	-	-	-	-	-	-	-	?	?	?	?	-	-
07020009-553	Blue Earth River, East Branch	Brush Cr to Blue Earth R	2Bg, 3C	x	x	+	x	x	x	x	x	x	x	x	?	?	+	x	x
07020009-556	Foster Creek	T103 R24W S35, east line to T102 R24W S6, west line	2Bm, 3C	x	+	x	x	x	x	x	x	x	x	?	?	?	?	-	-
07020009-561	Elm Creek, South Fork	T104 R34W S36, south line to Elm Cr	2Bg, 3C	x	x	x	x	x	x	x	?	?	?	?	?	?	?	-	-
07020009-565	Blue Earth River	Badger Cr to E Br Blue Earth R	2Bg, 3C	x	x	+	x	x	?	x	?	+	x	x	?	?	?	-	-
07020009-566	Unnamed creek	Unnamed cr to Willow Cr	2Bg, 3C	x	+	x	x	x	x	x	?	?	x	?	?	?	?	-	-
07020009-567	Elm Creek, North Fork	Headwaters to Elm Cr	2Bm, 3C	+	+	-	-	-	-	-	-	-	-	?	?	?	?	-	-
07020009-568	Judicial Ditch 14 (Badger Creek)	T101 R28W S18, west line to Little Badge Cr	2Bm, 3C	x	+	x	x	?	x	x	x	x	?	?	?	?	?	-	-
07020009-571	Judicial Ditch 13 Branch A	MN/IA border to JD 13	2Bm, 3C	+	+	+	-	-	-	-	-	-	-	?	?	?	?	-	-
07020009-577	Willow Creek	Unnamed cr to Blue Earth R	2Bg, 3C	x	x	+	x	?	?	x	?	?	?	?	?	?	+	x	x
07020009-599	Unnamed ditch	Unnamed cr to E Br Blue Earth R	2Bm, 3C	+	+	+	-	-	-	-	-	-	-	?	?	?	?	-	-
07020009-603	County Ditch 25	Headwaters to CD 5	2Bm, 3C	x	x	x	x	x	x	x	x	x	?	?	?	?	?	-	-
07020009-605	County Ditch 5	JD 6 to E Br Blue Earth R	2Bm, 3C	+	+	+	-	-	-	-	-	-	-	?	?	?	?	-	-
07020009-610	Judicial Ditch 98	Headwaters to Sager Lk	2Bm, 3C	x	+	x	x	x	x	x	x	x	?	?	?	?	?	-	-
07020009-611	Judicial Ditch 7	MN/IA border to W Br Blue Earth R	2Bm, 3C	x	x	x	x	x	?	x	x	x	?	?	?	?	?	-	-
07020009-612	County Ditch 31	MN/IA border to Coon Cr	2Bm, 3C	x	x	x	x	?	x	x	x	x	?	?	?	?	?	-	-
07020009-614	Judicial Ditch 14	Headwaters to JD 14	2Bm, 3C	+	+	+	-	-	-	-	-	-	-	?	?	?	?	-	-
07020009-615	County Ditch 14	CD 14 to E Br Blue Earth R	2Bm, 3C	+	+	+	-	-	-	-	-	-	-	?	?	?	-	-	-
07020009-616	County Ditch 17	Headwaters to Blue Earth R	2Bm, 3C	+	+	+	-	-	-	-	-	-	-	?	?	?	?	-	-

07020009-617	Unnamed creek	Unnamed cr to WIllow Cr	2Bg, 3C	+	+	+	-	-	-	-	-	-	-	?	?	?	?	-	-
07020009-619	Judicial Ditch 116	Headwaters to Willow Cr	2Bm, 3C	+	+	+	-	-	-	-	-	-	-	?	?	?	?	-	-
07020009-620	County Ditch 89/Judicial Ditch 24	Headwaters to Willow Cr	2Bm, 3C	x	x	+	x	x	x	x	?	?	?	?	?	?	?	-	-
07020009-621	Unnamed creek	Headwaters to Foster Cr	2Bm, 3C	+	+	+	-	-	-	-	-	-	-	?	?	?	?	-	-
07020009-622	Thisius Branch	CD 1 to Foster Cr	2Bm, 3C	x	x	x	x	x	x	x	?	?	x	?	?	?	?	-	-
07020009-623	Judicial Ditch 14	Unnamed cr to Foster Cr	2Bm, 3C	x	+	x	x	x	x	x	?	?	x	?	?	?	?	-	-
07020009-624	Unnamed creek	MN/IA border to Brush Cr	2Bm, 3C	+	+	+	-	-	-	-	-	-	-	?	?	?	?	-	-
07020009-625	Unnamed creek	Unnamed cr to Willow Cr	2Bg, 3C	x	x	x	x	x	x	x	?	?	?	?	?	?	?	-	-
07020009-627	Judicial Ditch 3	-94.351 43.739 to Elm Cr	2Bg, 3C	x	x	+	x	x	?	x	+	+	+	?	x	?	?	x	x
07020009-628	County Ditch 26	Headwaters to CSAH 13	2Bm, 3C	x	+	x	x	x	x	x	x	x	x	?	?	?	?	-	-
07020009-630	Elm Creek	Headwaters to 570th Ave	2Bg, 3C	x	-	-	-	-	-	-	-	-	-	x	-	-	-	-	-
07020009-631	Elm Creek	570th Ave to S Fk Elm Cr	2Bg, 3C	x	x	?	x	?	x	x	?	?	?	x	?	?	?	-	-
07020009-632	Lily Creek	Headwaters (Fox Lk 46-0109-00) to N Bixby Rd	2Bg, 3C	x	-	-	-	-	-	-	-	-	-	x	-	-	-	x	x
07020009-633	Lily Creek	N Bixby Rd to Center Cr	2Bg, 3C	x	x	x	x	x	x	x	?	?	x	x	?	?	?	x	x
07020009-634	Dutch Creek	Headwaters to -94.507 43.626	2Bm, 3C	x	-	-	-	-	-	-	-	-	-	x	-	-	-	x	x
07020009-635	Dutch Creek	94.507 43.626 to T102 R31W S24, north line	2Bg, 3C	x	-	-	-	-	-	-	-	-	-	x	?	?	?	x	x
07020009-636	Dutch Creek	T102 R31W S13, south line to T102 R31W S18, south line	2Bm, 3C	x	x	+	x	?	x	x	?	?	x	x	?	?	?	x	x
07020009-637	Dutch Creek	T102 R30W S19, north line to Hall Lk	2Bg, 3C	x	-	-	-	-	-	-	-	-	-	x	-	-	-	x	x
07020009-639	South Creek	-94.337 43.642 to -94.300 43.661	2Bm, 3C	x	+	x	x	x	x	x	x	x	?	?	?	?	?	-	-
07020009-640	South Creek	-94.300 43.661 to Blue Earth R	2Bg, 3C	+	+	+	-	-	-	-	-	-	-	?	?	?	+	x	x
07020009-642	Little Badger Creek	345th Ave to Badger Cr	2Bg, 3C	x	x	x	x	x	x	x	x	x	?	?	?	?	?	-	-

07020009-643	Blue Earth River, West Branch	MN/IA border to 15th St	2Bm, 3C	x	x	+	x	x	x	x	x	x	?	?	?	?	+	x	x
07020009-644	Blue Earth River, West Branch	15th St to Blue Earth R	2Bg, 3C	x	x	+	x	?	x	x	?	?	x	?	?	?	?	-	-
07020009-645	Blue Earth River, Middle Branch	MN/IA border to -94.104 43.514	2Bm, 3C	+	+	+	-	-	-	-	-	-	-	?	?	?	+	x	x
07020009-646	Blue Earth River, Middle Branch	-94.104 43.514 to W Br Blue Earth R	2Bg, 3C	x	x	+	x	x	x	x	x	x	?	?	?	?	+	x	x
07020009-647	Coon Creek	Headwaters to T101 R27W S4, north line	2Bm, 3C	+	+	+	-	-	-	-	-	-	-	?	?	?	?	-	-
07020009-648	Coon Creek	T102 R27W S33, south line to Blue Earth R	2Bg, 3C	x	x	x	x	x	?	x	x	x	x	?	?	?	+	x	x
07020009-649	Blue Earth River, East Branch	Headwaters to -93.663 43.624	2Bg, 3C	x	-	-	-	-	-	-	-	-	-	x	-	-	-	-	-
07020009-650	Blue Earth River, East Branch	-93.663 43.624 to -93.73 43.654	2Bm, 3C	x	+	+	-	-	-	-	-	-	-	x	?	?	?	-	-
07020009-651	Blue Earth River, East Branch	-93.73 43.654 to T102 R25W S14, south line	2Bg, 3C	x	-	-	-	-	-	-	-	-	-	x	-	-	-	-	-
07020009-652	Blue Earth River, East Branch	T102 R25W S23, north line to Unnamed ditch	2Bm, 3C	x	+	x	x	?	x	x	x	x	?	x	?	?	+	x	x
07020009-653	Blue Earth River, East Branch	Unnamed ditch to Brush Cr	2Bg, 3C	x	-	-	-	-	-	-	-	-	-	x	-	-	-	-	-
07020009-654	Brush Creek	Headwaters to Unnamed cr	2Bg, 3C	x	x	+	?	?	?	?	?	?	?	?	?	?	?	-	-
07020009-655	Brush Creek	Unnamed cr to E Br Blue Earth R	2Bm, 3C	+	+	+	-	-	-	-	-	-	-	?	?	?	+	x	x
07020009-656	Cedar Creek (Cedar Run Creek)	T104 R33W S6, west line to 60th Ave	2Bg, 3C	x	-	-	-	-	-	-	-	-	-	?	x	?	?	x	x
07020009-657	Cedar Creek (Cedar Run Creek)	60th Ave to Cedar Lk	2Bm, 3C	x	+	+	-	-	-	-	-	-	-	-	x	-	-	x	x
07020009-658	Badger Creek	Little Badger Cr to -94.136 43.64	2Bm, 3C	+	+	+	-	-	-	-	-	-	-	?	?	?	+	x	x
07020009-660	Judicial Ditch 38	Headwaters to 245th Ave	2Bm, 3C	x	x	-	x	x	x	x	?	?	?	?	?	?	?	-	-

07020009-663	Unnamed creek	T101 R30W S35, west line to MN/IA border	2Bm, 3C	+	+	+	-	-	-	-	-	-	-	?	?	?	?	-	-
07020009-665	Judicial Ditch 13	20th St to 480th Ave	2Bg, 3C	x	+	x	x	x	?	x	x	x	?	?	?	?	?	-	-
07020009-667	County Ditch 72	Unnamed ditch to 196th Ave	2Bm, 3C	+	+	+	-	-	-	-	-	-	-	?	?	?	?	-	-
07020009-669	County Ditch 8	Headwaters to -94.054 43.618	2Bm, 3C	x	+	x	x	x	x	x	x	x	x	?	?	?	?	-	-

Beneficial Use Assessment*

x	= Impaired
?	= Inconclusive (need more data)
+	= Supporting
-	= Not applicable

Parameter/Stressor Assessment

x	= Failing standard/ Stressing
?	= Inconclusive (need more data)
+	= Supporting Standard/ Not Stressing
-	= Not monitored / assessed

* Beneficial use assessment considers the status of multiple parameters and professional judgement

Lake Monitoring and Assessment Results

Lake ID	Lake Name	Aquatic Rec. (Phosphorus)	Aquatic Life (Fish IBI)
07-0090-00	Ida	x	?
22-0007-00	Rice	x	?
22-0022-00	South Walnut	?	?
22-0023-00	Walnut	?	?
22-0088-00	Unnamed	+	?
32-0017-00	Independence	?	?
46-0010-00	East Chain	x	?
46-0012-00	Imogene	?	?
46-0014-01	Willmert (Main Bay)	?	
46-0020-00	South Silver	?	x
46-0024-00	George	x	?
46-0025-00	Sisseton	x	x

Lake ID	Lake Name	Aquatic Rec. (Phosphorus)	Aquatic Life (Fish IBI)
46-0030-00	Budd	x	x
46-0031-00	Hall	x	x
46-0034-00	Amber	x	x
46-0049-00	Iowa	x	?
46-0109-00	Fox	x	x
46-0111-00	Clam	?	
46-0116-00	Round	?	?
46-0121-00	Cedar	x	x
46-0130-00	Little Twin	?	
46-0132-00	Watkins	?	
46-0133-00	Big Twin	x	x
46-0145-00	Fish	x	x

Beneficial Use Assessment*

x = Impaired
? = Inconclusive (need more data)
+ = Supporting
- = Not applicable

Parameter/Stressor Assessment

x = Failing standard/ Stressing
? = Inconclusive (need more data)
+ = Supporting Standard/ Not Stressing
- = Not monitored / assessed

* Beneficial use assessment considers the status of multiple parameters and professional judgement

WPLMN Data Summary

Site	Year	Parameter	Mass (kg)	Mass (lbs)	Mass (tons)	Vol (acre/ft)	FWMC (mg/L)	YIELD lbs/acre
Blue Earth River w/o Watonwan	2010	DOP	192,969	425,419		1,470,390	0.106	0.422
Blue Earth River w/o Watonwan	2011	DOP	141,025	310,904		1,130,326	0.101	0.309
Blue Earth River w/o Watonwan	2012	DOP	14,673	32,348		176,250	0.067	0.032
Blue Earth River w/o Watonwan	2013	DOP	59,283	130,695		544,290	0.088	0.130
Blue Earth River w/o Watonwan	2014	DOP	60,290	132,915		464,860	0.105	0.132
Blue Earth River w/o Watonwan	2015	DOP	22,204	48,951		409,643	0.044	0.049
Blue Earth River w/o Watonwan	2016	DOP	123,320	271,871		1,419,830	0.070	0.270
Blue Earth River w/o Watonwan	2017	DOP	31,519	69,487		751,563	0.034	0.069
Blue Earth River w/o Watonwan	2018	DOP	180,778	398,543		1,661,310	0.088	0.395
Blue Earth River w/o Watonwan	2007	TP	379,268	836,134		850,473	0.362	0.830
Blue Earth River w/o Watonwan	2008	TP	217,450	479,390		599,289	0.294	0.476

Site	Year	Parameter	Mass (kg)	Mass (lbs)	Mass (tons)	Vol (acre/ft)	FWMC (mg/L)	YIELD lbs/acre
Blue Earth River w/o Watonwan	2009	TP	67,675	149,196		398,540	0.138	0.148
Blue Earth River w/o Watonwan	2010	TP	588,316	1,297,001		1,470,390	0.324	1.287
Blue Earth River w/o Watonwan	2011	TP	328,908	725,111		1,130,326	0.236	0.720
Blue Earth River w/o Watonwan	2012	TP	70,667	155,792		176,250	0.325	0.155
Blue Earth River w/o Watonwan	2013	TP	189,454	417,670		544,290	0.282	0.414
Blue Earth River w/o Watonwan	2014	TP	249,595	550,257		464,860	0.435	0.546
Blue Earth River w/o Watonwan	2015	TP	93,096	205,239		409,643	0.184	0.204
Blue Earth River w/o Watonwan	2016	TP	476,654	1,050,831		1,419,830	0.272	1.043
Blue Earth River w/o Watonwan	2017	TP	185,405	408,744		751,563	0.200	0.406
Blue Earth River w/o Watonwan	2018	TP	589,291	1,299,151		1,661,310	0.288	1.289
Sum of the 10-year load 2009-2018			2,839,061	6,258,994				
Average for the period of record			286,315	631,210				
Average annual FWMC							**0.278**	**0.626**
Multiyear FWMC 2009-2018							**0.273**	
Blue Earth River w/o Watonwan	2007	NO2+NO3	8,621,909	19,007,861		850,473	8.2	18.9
Blue Earth River w/o Watonwan	2008	NO2+NO3	7,220,358	15,918,001		599,289	9.8	15.8
Blue Earth River w/o Watonwan	2009	NO2+NO3	2,952,699	6,509,520		398,540	6.0	6.5
Blue Earth River w/o Watonwan	2010	NO2+NO3	12,967,859	28,588,942		1,470,390	7.1	28.4
Blue Earth River w/o Watonwan	2011	NO2+NO3	9,785,927	21,574,055		1,130,326	7.0	21.4
Blue Earth River w/o Watonwan	2012	NO2+NO3	1,826,755	4,027,264		176,250	8.4	4.0
Blue Earth River w/o Watonwan	2013	NO2+NO3	8,949,953	19,731,066		544,290	13.3	19.6
Blue Earth River w/o Watonwan	2014	NO2+NO3	5,098,880	11,240,991		464,860	8.9	11.2
Blue Earth River w/o Watonwan	2015	NO2+NO3	7,182,338	15,834,182		409,643	14.2	15.7
Blue Earth River w/o Watonwan	2016	NO2+NO3	25,461,252	56,131,876		1,419,830	14.5	55.7
Blue Earth River w/o Watonwan	2017	NO2+NO3	9,728,057	21,446,474		751,563	10.5	21.3
Blue Earth River w/o Watonwan	2018	NO2+NO3	16,902,443	37,263,126		1,661,310	8.2	37.0
Blue Earth River w/o Watonwan	2007	TKN	1,450,183	3,197,073		850,473	1.4	3.2
Blue Earth River w/o Watonwan	2008	TKN	750,960	1,655,566		599,289	1.0	1.6
Blue Earth River w/o Watonwan	2009	TKN	462,512	1,019,654		398,540	0.9	1.0
Blue Earth River w/o Watonwan	2010	TKN	2,239,704	4,937,651		1,470,390	1.2	4.9
Blue Earth River w/o Watonwan	2011	TKN	1,005,076	2,215,791		1,130,326	0.7	2.2
Blue Earth River w/o Watonwan	2012	TKN	561,882	1,238,725		176,250	2.6	1.2
Blue Earth River w/o Watonwan	2013	TKN	1,482,318	3,267,918		544,290	2.2	3.2
Blue Earth River w/o Watonwan	2014	TKN	1,241,792	2,737,655		464,860	2.2	2.7
Blue Earth River w/o Watonwan	2015	TKN	789,624	1,740,805		409,643	1.6	1.7
Blue Earth River w/o Watonwan	2016	TKN	2,945,948	6,494,637		1,419,830	1.7	6.4

Site	Year	Parameter	Mass (kg)	Mass (lbs)	Mass (tons)	Vol (acre/ft)	FWMC (mg/L)	YIELD lbs/acre
Blue Earth River w/o Watonwan	2017	TKN	1,390,069	3,064,546		751,563	1.5	3.0
Blue Earth River w/o Watonwan	2018	TKN	4,059,288	8,949,106		1,661,310	2.0	8.9
Blue Earth River w/o Watonwan	2007	TN	10,072,092	22,205,162		850,473	9.6	22.0
Blue Earth River w/o Watonwan	2008	TN	7,971,318	17,573,748		599,289	10.8	17.4
Blue Earth River w/o Watonwan	2009	TN	3,415,211	7,529,251		398,540	6.9	7.5
Blue Earth River w/o Watonwan	2010	TN	15,207,563	33,526,937		1,470,390	8.4	33.3
Blue Earth River w/o Watonwan	2011	TN	10,791,003	23,790,089		1,130,326	7.7	23.6
Blue Earth River w/o Watonwan	2012	TN	2,388,637	5,266,043		176,250	11.0	5.2
Blue Earth River w/o Watonwan	2013	TN	10,432,271	22,999,221		544,290	15.5	22.8
Blue Earth River w/o Watonwan	2014	TN	6,340,672	13,978,789		464,860	11.1	13.9
Blue Earth River w/o Watonwan	2015	TN	7,971,962	17,575,168		409,643	15.8	17.4
Blue Earth River w/o Watonwan	2016	TN	28,407,200	62,627,156		1,419,830	16.2	62.1
Blue Earth River w/o Watonwan	2017	TN	11,118,126	24,511,272		751,563	12.0	24.3
Blue Earth River w/o Watonwan	2018	TN	20,961,731	46,212,706		1,661,310	10.2	45.9
Sum of the 10-year load 2009-2018			117,034,376	258,016,633				
Average for period of record			11,256,482	24,816,295				
Average annual FWMC							**11.3**	**24.6**
Multiyear FWMC (2009-2018)							**11.3**	
Blue Earth River w/o Watonwan	2007	TSS	234,079,466	516,051,591	258,026	850,473	223	512
Blue Earth River w/o Watonwan	2008	TSS	247,846,272	546,401,891	273,201	599,289	335	542
Blue Earth River w/o Watonwan	2009	TSS	40,018,564	88,224,926	44,112	398,540	81	88
Blue Earth River w/o Watonwan	2010	TSS	465,411,055	1,026,045,212	513,023	1,470,390	257	1,018
Blue Earth River w/o Watonwan	2011	TSS	257,431,658	567,533,833	283,767	1,130,326	185	563
Blue Earth River w/o Watonwan	2012	TSS	42,484,652	93,661,664	46,831	176,250	195	93
Blue Earth River w/o Watonwan	2013	TSS	102,542,580	226,065,372	113,033	544,290	153	224
Blue Earth River w/o Watonwan	2014	TSS	184,600,593	406,970,467	203,485	464,860	322	404
Blue Earth River w/o Watonwan	2015	TSS	66,832,897	147,339,805	73,670	409,643	132	146
Blue Earth River w/o Watonwan	2016	TSS	318,521,191	702,211,818	351,106	1,419,830	182	697
Blue Earth River w/o Watonwan	2017	TSS	124,670,235	274,848,000	137,424	751,563	134	273
Blue Earth River w/o Watonwan	2018	TSS	377,741,197	832,768,243	416,384	1,661,310	184	826
Sum of the 10-year load (2009-2018)			1,980,254,622	4,365,669,340	2,182,835			
Average for Period of Record			205,181,697	452,343,568	226,172			
Average annual FWMC							**199**	
Multiyear FWMC (2009-2018)							**191**	

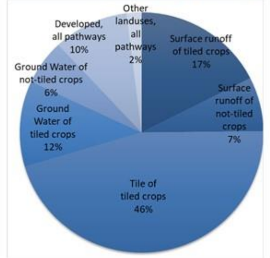
4.2 Appendix 2: Source Assessment – Related Appendices

This section summarizes information used to develop source assessments and provide information to the LWG to identify potential sources within the Blue Earth River Watershed. The multiple lines of evidence table is a summary of existing source related research from within the Blue Earth River Watershed and comparable watersheds. This information was used as a basis for developing the watershed wide goals and reductions with the LWG.

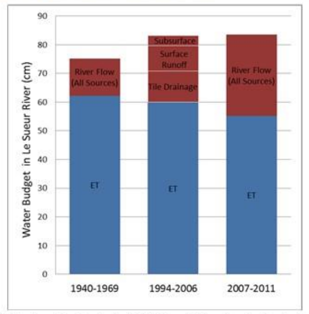
Multiple Lines of Evidence

Specific Source Assessment Analyses (including source and applicable area) | **HSPF Source Assessment for Blue Earth (model years 1996-2017)** | **2012-2017 Discovery Farms Data for the tiled farms (BE1, RE1)** | **2009-2018 Watershed Pollutant Load Monitoring Network Data** | **CSSR: Collaborative for Sediment Source Reduction Greater Blue Earth River Basin 2016**

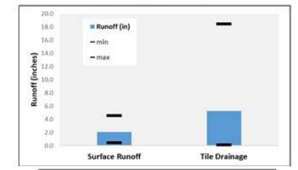
Q

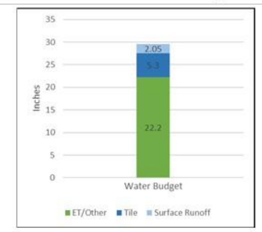


water portioning calculator (boettcher), assumes 68% of watershed tiled

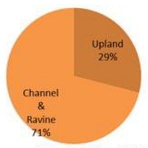


Middle bar of water budget: SWAT modeling of water budget by Folle

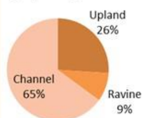




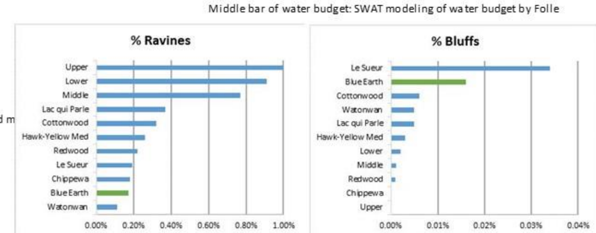
TSS



finger-printing, MN River US from mid m

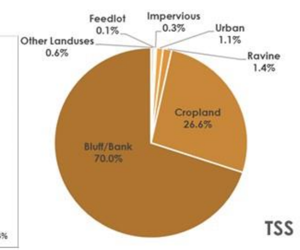


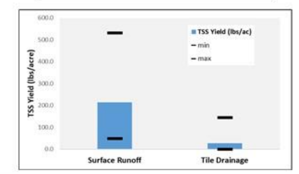
Gran Sediment Budget for Le Sueur River

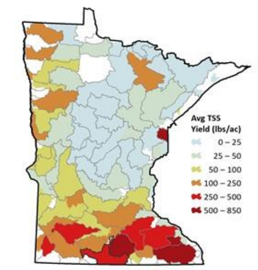


Mulla estimate of bluff and ravine areas per major watershed

MN River Basin Near Stream Sediment Sources (Mulla, 2010)







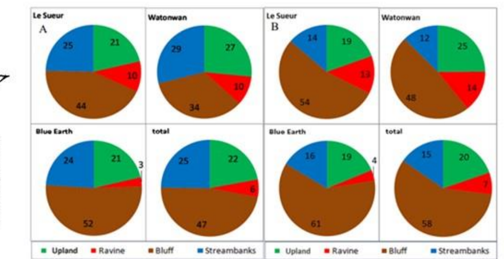
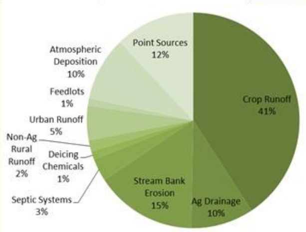


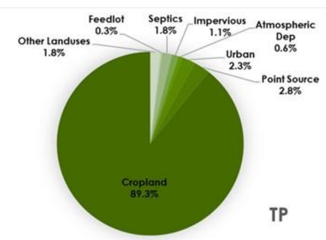
Figure 5.9: Pie charts from Scenario 4. On the left (A) are four pie charts showing the break-down of sediment sources in each major watershed, without considering sediment sinks. On the right (B) are four charts illustrating the effects of including both sources and sinks. Here, lake deposition was removed from upland source contributions and floodplain deposition was removed from streambank contributions.

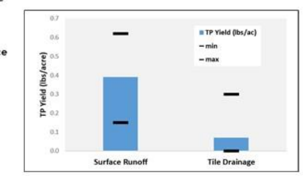
P

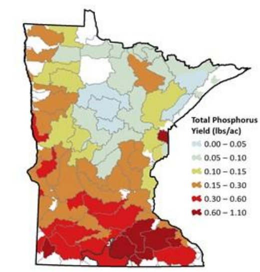


Detailed Assessments of Phosphorus Sources to Minnesota Watersheds

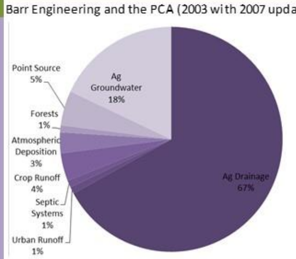
Barr Engineering and the PCA (2003 with 2007 update)



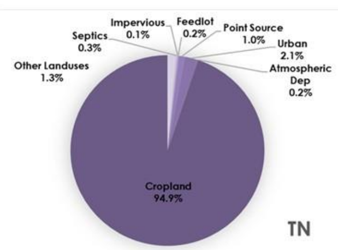


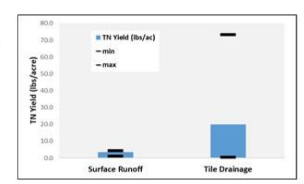


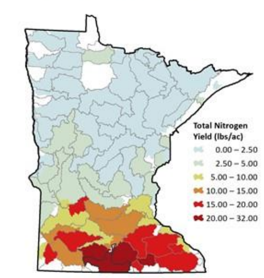
TN



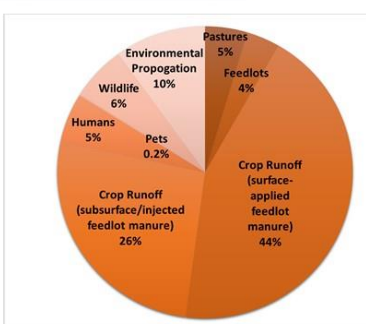
Nitrogen in Minnesota Surface Waters, 2013







Bacteria

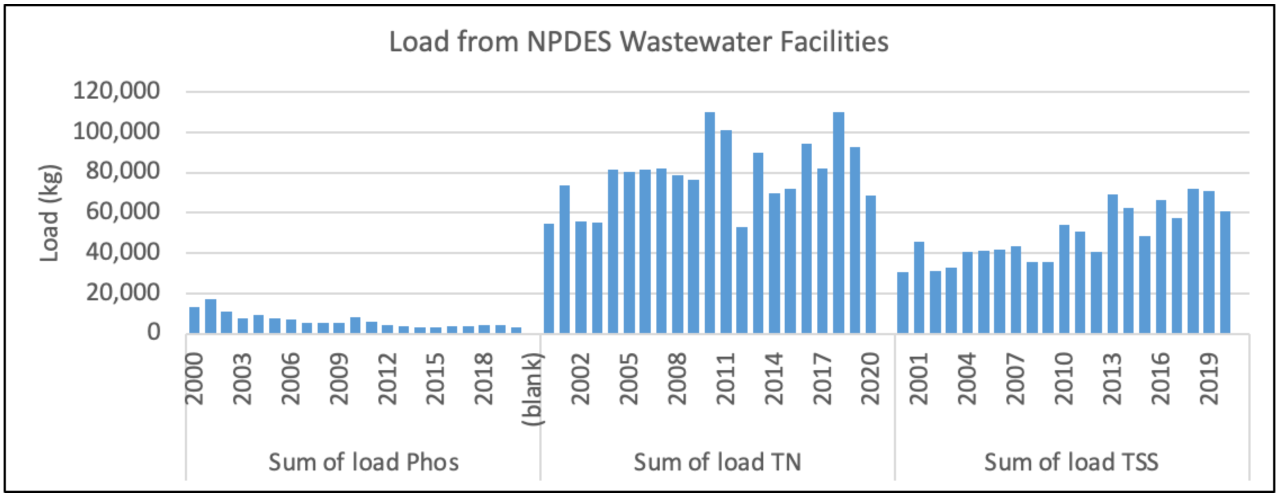


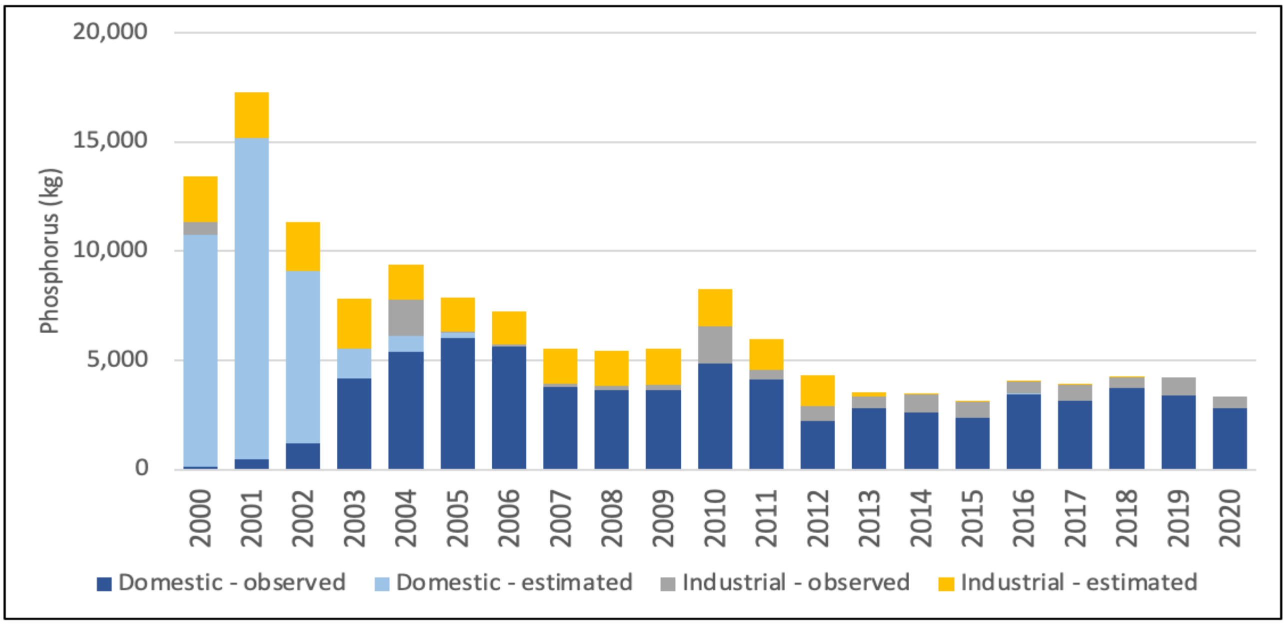
Bacteria Calculator, Boettcher

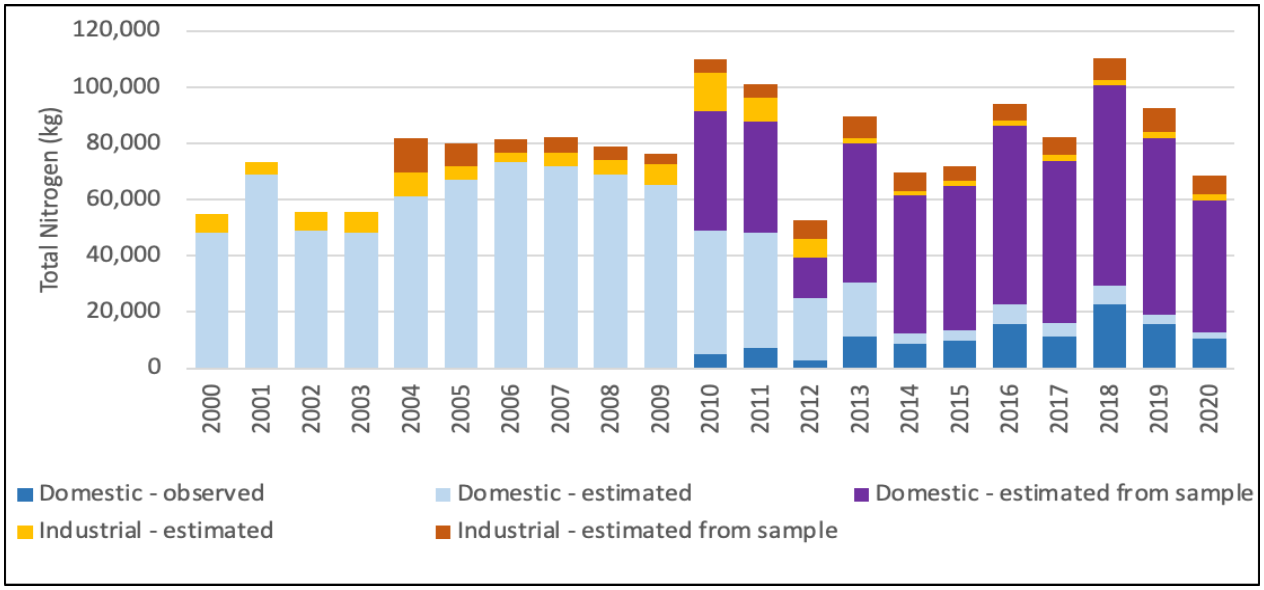
Strong relationship to fecal bacterial contamination in water	**Weak** relationship to fecal bacterial contamination in water
• High storm flow (the single most important factor in multiple studies) • % rural or agricultural areas greater than % forested areas in the landscape (entire watershed area) • % urban areas greater than % forested riparian areas in the landscape • High water temperature • Higher % impervious surfaces • Livestock present • Suspended solids	• High nutrients • Loss of riparian wetlands • Shallow depth (bacteria decrease with depth) • Amount of sunlight (increased UV-A deactivates bacteria) • Sediment type (higher organic matter, clay content and moisture; finer-grained) • Soil characteristics (higher temperature, nutrients, organic matter content, humidity, moisture and biota; lower pH) • Stream ditching (present or when increased) • Epilithic periphyton (plants and microbes that grow on stones in a stream) present • Presence of waterfowl or other wildlife • Conductivity

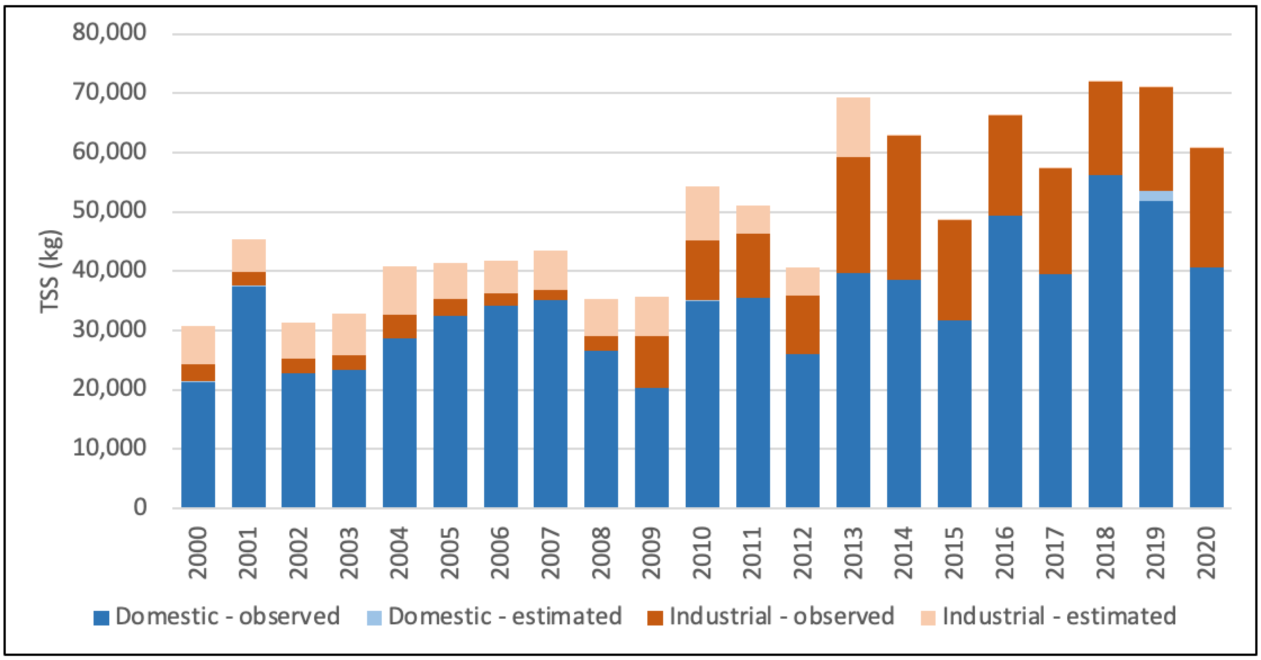
PCA/Emmons & Oliver literature summary of bacteria coorelation

Point Source Data Summary









Point Source Contribution to Total Watershed Load Calculation

2009-2018 Load	WPLMN	Point Sources	% Point Sources
TP (kg)	2,839,061	46,359	1.63%
TN (kg)	117,034,376	858,078	0.73%
TSS (kg)	1,980,254,622	558,142	0.03%

Regulated Facilities that do not Discharge to Surface Waters

Nondischarging	County
Avery Weigh-Tronix LLC	Martin
Greenfield Global Winnebago LLC	Faribault
Magellan Pipeline Co LP	Blue Earth
Milk Specialties Co – Site 1	Blue Earth
Milk Specialties Co – Site 2	Blue Earth
Milk Specialties Co	Martin

Presettlement Landscape Map Data Sources

This map graphic (Figure 16 and Figure 17) is an approximation of the pre-European settlement landscape. It is not intended for numerical analysis, but rather offers a small-scale illustration (or paints the picture) of the pre-European settlement, which was predominantly prairie with water bodies and wetlands (prairie wetlands, some streams, and some forested riparian areas). The pre-settlement landscape was estimated using the following data sources:

1. A digitized copy of the streams from the U.S. General Land Office Survey maps and notes (from 1848 through 1907; MnGeo 2011). Note that this digitization was intended to generally represent the features as captured in the U.S. General Land Office Survey maps and notes as documented 110 to 169 years ago. It cannot be used to calculate miles or to do analysis at a close-up scale. The image of this data layer may be used at a faraway scale, but is not visible at the scale presented.

2. Drained wetlands were pulled from the National Wetland Inventory (USFSW 2016) and Restorable Wetlands were pulled from the Restorable Wetland Inventory (USFWS 2009).

3. Additional wetland areas were pulled from Marschner's analysis. The Original Vegetation of Minnesota: data was first compiled in 1930 by F. J. Marschner (of the Office of Agricultural Economics, USDA) from the data created by the U.S. General Land Office Survey notes. In 1974, the Marschner's data was interpreted and mapped by M.L. Heinselman and others at the U.S. Forest Service (North Central Forest Experiment Station in St. Paul). This map was then digitized and modified by the DNR Natural Heritage and Nongame Research Program in the 1980s and later. The original map was done at 1:500,000 and then attributes and geography generalized for display, at approximately 1:1 million, at which the presented map is approximately shown. The purpose of the data is to analyze presettlement vegetation patterns to determine natural community potential, productivity indexes and patterns of natural disturbance.

Phosphorus from Agricultural versus Native Land Use

The amount of phosphorus (P) native to the soil does not necessarily indicate the likeliness of P to runoff (or export). Instead, we can compare P export of native prairie to P export from cultivated crops to deduce the relative amount of P export due to agricultural activities. Several ranges of grassland and prairie P export are available in the literature. The MPCA's Detailed P Assessment (completed by Barr Engineering) cited a large range of P export from grasslands and restored prairies ranging from 0.05 to 0.22 lb/ac/yr. In a more recent study of native prairie in the neighboring Cottonwood River Watershed, native prairie P export rates ranged from 0.02 to 0.09 lb/ac/yr (report reference provided in Sources Overview section). Discovery Farms field data has measured Minnesota cultivated crop P export rates of roughly 0.5 lb/ac (data utilized included in Lines of Evidence table). Furthermore, we know that typical cultivated crop P application rates on Minnesota River Basin farms are typically in the 10s of lb/ac/yr and that at the major watershed scale, P export is roughly 0.5 lb/ac/yr. This means that farm P export is roughly 10 times greater than native P export; roughly 10 to 20 times more P is applied to a typical farm field than is exported from a farm field, and roughly, the export rate of a farm field is about the same as the P export from the major watershed. Deducing from these ratios, agricultural activities (on what were natively prairie lands) are likely accounting for the majority of P export from farm fields. Although, the particular aspect of the agricultural activities (e.g., fertilizer application, tillage, change in vegetation, change in organic material, etc.) that causes the P export cannot be determined from this. However, based on the ratio of applied P to exported P, fertilizer and manure application are likely causes of this increased P export.

Interpretation of the Feedlot Statistics

This interpretation was provided by the MPCA feedlot staff (MPCA Feedlot Communications, 2020).

Surface applied manure generally tends to come from smaller feedlots or “smaller” dairies or poultry facilities.

Facilities with <300 AU generally have limited manure storage so manure application occurs on a more frequent basis and facilities are not required to have a MMP or test their soils for P.

Facilities with <100 AU have fewer restrictions under the feedlot rules.

Poultry litter does not follow the general rule of being spread close to the facility as it is generally brokered out to area crop farmers who are willing to pay for the manure. Because of the higher nutrient value and ease at which it can be hauled in a semi, poultry manure is more “mobile” than other manures. Implications of this include:

- Most of the manure is surface applied.
- Generally, manure from these facilities is sold to nonlivestock farmers.
- Barns are cleaned out when barns are emptied of mature birds which tends to lead to a significant amount of temporary manure stockpiles in fields which can have their own issues (they must meet setback requirements but generally do not have runoff controls like permanent stockpile sites) since they are exposed to weather extremes.

Most feedlots must keep records of manure application. The MPCA and/or delegated counties have the authority to request these records but due to a lack of staffing generally do not request them. The NPDES permitted sites have to submit annual reports with their manure records but lack of staffing does not allow comprehensive tracking of the acres.

ET Rate Data and Calculation

The presented ET rates are from the following sources/methodologies:

ET rate	Formula/specifics	Reference	Applicable Data
Wetland	$ET_W = 0.9* ET_{pan}$	Wallace, Nivala, and Parkin (2005)	Waseca station pan ET 1989-2008 average
Lake	$ET_L = 0.7* ET_{pan}$	Dadaser-Celik and Heinz (2008)	
Crops	Crop ET, Climate II	NRCS (1977)	Table from source

The NRCS crop ET source, despite the source age, was selected because it provided the highest estimates of crop ET. To illustrate this point, the seasonal corn ET rates, as determined from several sources, are presented below:

Methodology, data	Source	May-September Corn ET
1. Irrigation table	NRCS (1977)	64 cm
2. SWAT modeling in the Lake Pepin Full Cost Accounting	Dalzell et al. (2012)	54 cm
3. MN Irrigation Scheduling Checkbook, Waseca station temp	NDSU (2012)	42 cm
4. MN Crop Coefficient Curve for Pan ET, Waseca station pan ET	Seeley and Spoden (1982)	39 cm

Using the highest crop ET rates for comparison was desired for multiple reasons: 1) pan coefficients were developed using older data sets and it is likely that corn, with higher crop densities and larger plant sizes, uses more water today than it did when the coefficients were determined, 2) using lower crop ET rates may appear to exaggerate the difference between crop and noncrop ET rates, and 3) errors associated with pan ET rates could result in exaggerated differences between estimated wetland/lake ET and crop ET.

Bacteria Sources Calculator

The bacteria sources calculator was created by MPCA staff based on information from the Greater Blue Earth Fecal TMDL. The calculator was designed to utilize information collected at the watershed scale to account for land use practices, feedlot program data and septic information. The calculator was used to provide a method to calculate bacteria loading based on the Blue Earth River Watershed for the LWG to consider for source and reduction assumptions.

Bacteria Source Estimates Calculator

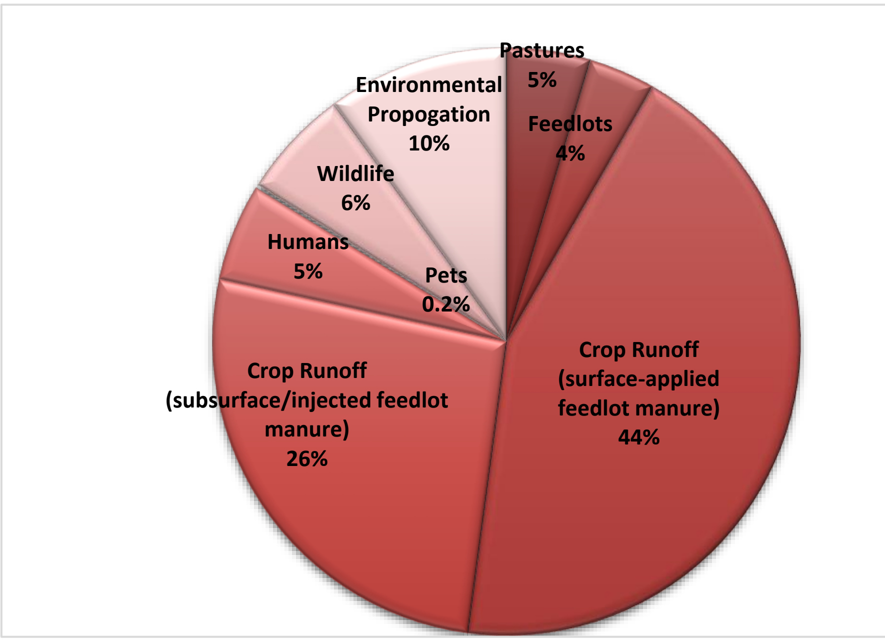
Watershed	Blue Earth
Total area (ac)	777,242
Total Pasture (ac)	3,000
Pasture <1,000ft of water body (ac)	1,500
Total AUs	369,277
% feedlot AUs whose manure stockpiles w/o runoff controls	5
number of pasture acres per 1 grazed AU	2
% Feedlot manure applied Surface	10
% Feedlot manure applied Subsurface	90
Pasture >1,000 ft (ac)	1,500
pasture <1,000ft AUs	750
pasture >1,000ft AUs	750
Feedlot AUs	367,777
Feedlot inadequate runoff AUs	18,389
Feedlot surface applied AUs	36,778
Feedlot subsurface applied AUs	330,999
Human population	34,000
number of failing septics per 1,000 acres	1.7
number of people per failing septic	2.3
# humans comparable to 1 AU	7
# acres per 1 wildlife AU of total watershed	250
humans per pet (one pet for every x humans)	3
# pets comparable to 1 AU	30
% of total load due to environmental propagation	10
people using failing septics	3039
% of human wastewater inadequately treated (on failing septics)	9
% of human wastewater is adequately treated	91
Human – inadequate treatment AUs	434
Human – adequate treatment AUs	4,423
Pet AUs	378

Watershed	Blue Earth
Wildlife AUs	3,109
% Wet conditions (time with active runoff)	5
% Dry conditions (no active runoff)	95

Total Livestock AUs data includes pastured animals.

Each AU produces 1 unit of manure/bacteria.

Calculator by J Boettcher (2016)



Estimate of bacteria sources based on calculator assumptions for the Blue Earth River Watershed.

	Condition	Pastures adjacent waterways	Other pastures	Pastures	Feedlots	Crop Runoff (surface-applied feedlot manure)	Crop Runoff (subsurface/injected feedlot manure)	Humans	Pets	Wildlife	Environmental Propagation	Human – adequately treated wastewater	Human – inadequately treated wastewater	SUM of Crop applied manure
Delivery ratio (assumed)	wet	5.0%	1.0%		0.5%	3.0%	0.2%		1.0%	3.0%		0.05%	2.0%	
Production x Delivery ratio x % of time		1.9	0.4		4.6	55.2	33.1		0.2	4.7		0.1	0.4	
Delivery ratio (assumed)	dry	0.5%	0.0%		0.0%	0.0%	0.0%		0.0%	0.1%		0.05%	1.0%	
Production x Delivery ratio x % of time		3.6	0.0		0.0	0.0	0.0		0.0	3.0		2.1	4.1	
Total Delivered Units		5.4	0.4	5.8	4.6	55.2	33.1	6.8	0.2	7.6	13	2.2	4.6	88.3
Total Delivered Percentage		4.3%	0.3%	4.6%	3.7%	43.8%	26.3%	5.4%	0.2%	6.1%	10.0%	1.8%	3.6%	70.1%

Water Yield Portioning Calculator

The calculator was created by MPCA staff and designed to utilize information collected at the watershed scale to account for land use practices. The calculator was used to provide a method to calculate water yield based on the Blue Earth River Watershed for the LWG to consider for source and reduction assumptions.

Key

- this color = known for watershed
- this color = assumption, based on other available data where possible
- this color = calculated using knows and assumptions
- <no color> = known value/used to check calculations, value = 0 or 1

Landuse	% of crops	% of watershed
tiled ag	80%	68.0%
not tiled ag	20%	17.0%
all ag	100%	85%

Estimate tiled ag % on local knowledge, tiled acres GIS estimate, or can estimated % of shed using purple cells in check section

Ratios of Water Yields				
The per acre tile water yield ratio for a tiled:not tiled field is	1.0	:	0	untiled field has no tile water path
Assume the surface runoff water yield ratio for a tiled:not tiled field is	0.60	:	1.0	see check numbers below (yellow)
Assume that in a tiled field, the tile:surface water yield ratio is	2.6	:	1.0	see check numbers below (blue)
Assume that the GW:total ratio of river water for watershed = that of ag ar	**0.20**	:	1.0	see check numbers below (light blue)
Assume that the per acre GW yield ratio for a tiled:not tiled field is	1.0	:	**2.1**	see check logic below (light pink)
Assume that the per acre yield for all flowpaths ratio for a tiled:not tiled fi	**1.40**	:	1.0	see check logic below (pink)

% of water yields by flow path between tiled and untiled land	% of ag water tile yields	% of ag water surface	% of ag water GW yields	% of total water from	% of total watershed
tiled land	100%	70.6%	66%	85%	75%
not tiled land	0%	29%	34%	15%	13%
all ag land	100%	100%	100%	100%	88%

number should be similar to landuse, likely adjusted up from landused due to ag's higher water yield t

Flow contributions by flow path toward total watershed contributions	tiled ag	not tiled ag	all ag land
% from tile	46%	0%	46%
% from surface	18%	7%	25%
% from GW	12%	6%	18%
% from all ag paths	75%	13%	88%

Use Solver to look at effects of inputs/assumptions (peach cells), especially cells B11:D13, by setting J18=J9

70.6%

Data and Estimates for Checks in Calculator-recalc values when updated info is available		
Watershed Yield (in) (WPLMN data)	9.9	
Change in River flow due to drainage (in) (estimated from Schottler, etc.)	2.7	reported for BE in Schottler et al 2013
Average Surface Runoff from Not-tiled sites (in) (Discovery Farms)	3.5	
Average Surface+Tile from Tiled sites (in) (DiscoveryFarms)	7.3	tiled farms represented by BE1-F, BE1-T, RE1-T
Average Surface+Tile yield ratio for tiled:not tiled (ratio) (Discover Farms)	2.1	
Average surface runoff ratio for a tiled:not tiled (ratio) (Discovery Farms)	0.6	
Average Tile Runoff from Tiled sites (in) (Discovery Farms)	5.3	
Average Surface Runoff from Tiled sites (in) (Discovery Farms)	2.1	
Average Tile:Surface water yield ratio in a tiled field (ratio) (Discovery Farm	2.6	
Estimated Tile Runoff from Tile Drained Areas (in)	4.0	Assume Schottler's number is all tile from the watershed, use this and est tile %
Estimated Surface Yield from Tile Drained Areas (in)	3.3	Above number and disc farm
Estimated tile:surface ratio for a tiled field	1.19	Above 2 numbers
baseflow estimate/justification - whole watershed	0.20	river yield across SW MN ranges from 4-11 inches (roughly same area covered by discover farms). Average could be roughly 8.5. So if we have 8.5 in rivers and 7.5 coming from farm tile + surface runoff (with 82% of land in ag), we could estimate that pr
Tile predominately drains ground water, thus the contribution to GW on a t	0.15	
Schottler's analysis says 20% increase in flow is 80% due to tile drainage changes		
Estimate of % ground water (See Folle & HSPF model on sources overview)	0.2	
Tiled all paths	8.4295	see calc
not tiled all paths	6	estimated based on prof judgement. Assumes 3 surface and 3 gw
	1.404917	

Surface runoff of tiled crops	18%
Surface runoff of not-tiled crops	7%
Tile of tiled crops	46%
Ground Water of tiled crops	12%
Ground Water of not-tiled crops	6%
Developed, all pathways	**10%**
Other landuses, all pathways	2%
	100%

11.22.21

Updated ag landuse to 85%

Updated Watershed yield to 9.9 in for 2007-2018

5.3.22

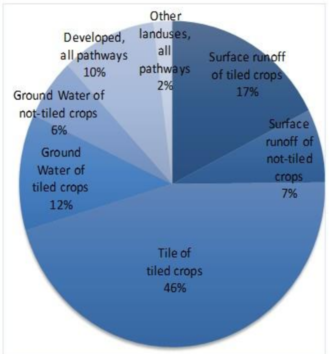
Updated Discovery Farms data cells B26, B29, B30, B31

7.8.22

Updated F3 based on GIS analysis

8.2.22

Updated B24 based on Schottler et al 2013; updated B32; B33



Stressor Identification Source Assessment for Bio-impaired Reaches

	Eutrophication					Nitrate			TSS						Habitat						Connect-ivity		Altered Hydrology				Chloride		Ammonia	
AUID	Wetland Influence	Excess Phosphorous	Algae/Plant Shift	Unidentified	Additional Monitoring?	Tile Drainage/Land Use	Point Sources	Additional Monitoring?	Flow Alteration/Connectivity	Streambank Erosion	Altered	Urbanization	Local Land Use or Pasture	Additional Monitoring?	Flow Alteration/Connectivity	Pasturing/ Lack of Riparian	Altered	Bedded Sediment	Erosion	Lack of Cover/Other Habitats	Dams/Impoundments	Road Crossings/Culverts	Water Withdrawal	Altered	Tile Drainage/Landuse	Additional Monitoring?	Wastewater or Industrial	Additional Monitoring?	Wastewater or Industrial	Additional Monitoring?
501		x	?		x	x		x		x								x	x	?					x	x				
505		x			x	x					x					x	x	x		x				x	x	x				
510		x	?		x	x	x	x		x	x					x		x	x	x					x	x	x	x	x	
511		x			x	x		x		x	x							x	x	x					x	x				
516		x	x		?	x	x		x	x	x				x	x	x	x	x	x		?		x	x	x	x	x	x	x
517		x			x	x			x	x			x		x	x		x	x	x					x					
523		x			x	x		x		x								?	x	x		?			x	x				
524		x	?		x	x			x	x						x		x	x	x		?			x					
526		x	?		x	x	x		x	?	x			x	x	x	x	x	?	x		?		x	x		x	x	x	
540		?			x	x			x	?	x						x	x	?			?		x	x	x				
547		x			x	x		x	x	x				x	x			x	x		?	?			x					
549		x			x	x			x		x		x	x	x	x	x		x	x				x	x					
552			x		x	x		x			x	?		x		x	x	?		x		?		x	x	x				
557		x			x	x		x	x	x	x				x		x	x	x			?		x	x					
559		x	?		x	x				x	x					x	x		x	x				x	x	x				
561				x	x	x			x	x	?		x	x	x	x	?	x	x	x		?		x	x	?				
563		x			x	x	x	x		x								x	x						x	x	x		x	
564		?	?		x	x			x	x	x			x	x	x	x	x	x			?		x	x	x				
565		x			x	x			x	x	x			x	x		x		x			?	x	x	x					
566	?	?	x		x	x	x		x	x					x	x		x	x					x	x		x		x	
567				x	x	x			x	x	x				x	x	x	x	x	x				x	x					
568		?			x	x			x	x			x	x	x	x		x	x		x	?			x					
569		x			x	x		x	x	x	x			x	x	x	x	x	x	x		?		x	x					
571		x	x		x	x			x	x			x	x	x	x		x	x	x		?			x					
574		x	x		x	x		x	x	x	x			x	x	x	x	x	x	x	x	?		x	x					
577		x			x	x			x	x	x			x	x	x	x	x	x			?		x	x					
579				x	x	x	x		x	x	x			x	x	x	x	x	x	x	x	?		x	x		x		x	
580		x	x		x	x	x	x	x		x			x	x		x	x		x		?		x	x	?	x		x	
581		x			x	x		x	x	x	x			x	x	x	x	?	x	x		x		x	x					
583		x	?		x	x			x	x	x			x	x	x	x	x	x	x				x	x					

4.3 Appendix 3: Water Quality Goals– Related Appendices

This information summarizes reduction needs for streams and lakes in the Blue Earth River Watershed, and is used to create the local partner goals maps and inform the watershed-wide goals to summarize all TMDLs for the WRAPS reporting.

TMDL Summary

	Bacteria			TSS	
AUID	Months with Data (in which std applies)	Maximum Monthly Geomean (TMDL report calc method)		Months with Data (in which std applies)	Calculated Percentile Reductions (TMDL/HSPF calc method)
07020009-501	Jun-Aug	52%		Apr-Sept	85%
07020009-502	Jun-Aug	80%		Apr-Sept	46%
07020009-503	Jun-Aug	87%		Apr-Sept	53%
07020009-504	Jun-Aug	32%		Apr-Sept	74%[a]
07020009-507				Apr-Sept	80%[a]
07020009-508	Jun-Aug	67%		Apr-Sept	72%[a]
07020009-509	Jun-Aug	80%		Apr-Sept	83%
07020009-514	Jun-Aug	68%		Apr-Sept	71%[a]
07020009-515				Apr-Sept	66%
07020009-518				Apr-Sept	30%
07020009-521	Jun-Aug	92%		Apr-Sept	24%[a]
07020009-522	Jun-Aug	81%		Apr-Sept	31%
07020009-524				Apr-Sept	64%[a]
07020009-526	Jun-Aug	64%			
07020009-553	Jun-Aug	60%		Apr-Sept	54%
07020009-565				Apr-Sept	73%[a]
07020009-577	Jun-Aug	77%			
07020009-627	Jun-Aug	93%			
07020009-630				Apr-Sept	60%[a]
07020009-631				Apr-Sept	62%[a]
07020009-632	Jun-Aug	91%		Apr-Sept	41%[a]
07020009-633	Jun-Aug	91%		Apr-Sept	41%[a]

07020009-634	Jun-Aug	86%	Apr-Sept	41%[b]
07020009-635	Jun-Aug	86%	Apr-Sept	41%[b]
07020009-636	Jun-Aug	86%	Apr-Sept	41%[b]
07020009-637	Jun-Aug	86%	Apr-Sept	41%[b]
07020009-640	Jun-Aug	81%		
07020009-643	Jun-Aug	85%		
07020009-645	Jun-Aug	68%		
07020009-646	Jun-Aug	61%		
07020009-648	Jun-Aug	76%		
07020009-649			Apr-Sept	65%[a]
07020009-650			Apr-Sept	65%[a]
07020009-651			Apr-Sept	65%[a]
07020009-652	Jun-Aug	85%	Apr-Sept	65%[a]
07020009-653			Apr-Sept	65%[a]
07020009-655	Jun-Aug	85%		
07020009-656	Jun-Aug	90%		
07020009-657	Jun-Aug	90%		
07020009-658	Jun-Aug	83%		

a. Sample size in TMDL period (2006–2015) less than 10%. Reductions calculated with HSPF loading information.

b. This impairment was originally listed in 2004 based on turbidity data; however, the TSS data presented in this report do not show impairment. The MPCA will reevaluate the reach in the next impairment assessment for this watershed. Reductions were calculated with HSPF loading estimates.

TMDL Summary – Lakes

Lake Name	ID	Data Months Years	Modeled Inflow Load Reduction (TMDL Report Method)
Cedar	46-0121-00	June – Sept. 2008-09, 2017-18	51%
East Chain	46-0010-00	June – Sept. 2017-18	58%
Fish	46-0145-00	June – Sept. 2017-18	31%
George	46-0024-00	June – Sept. 2002, 2004, 2017-18,2020	38%[a]
Ida	07-0090-00	June – Sept. 1997, 2017-18	42%
Iowa	46-0049-00	June – Sept. 2008-09, 2017-18	50%
Rice	22-0007-00	June – Sept. 2017-18	61%

a. Lake George is part of the Fairmont Chain of Lakes TMDL includes Amber, Hall, Budd and Sisseton Lakes.

Minnesota State Nutrient Reduction Strategy

The State of Minnesota developed the NRS to provide guidance on reducing nutrient loading to the waters of the State to help meet water quality goals. This report uses the information from the NRS to develop local goals for nutrient reduction. The full report can be found at the links below.

https://www.pca.state.mn.us/sites/default/files/wq-s1-80.pdf

https://www.pca.state.mn.us/air-water-land-climate/reducing-nutrients-in-waters

Recent guidance for the Minnesota NRS Goals was completed in 2022 at the link here: https://www.pca.state.mn.us/sites/default/files/wq-s1-86.pdf

This guidance document was created to provide updated nutrient load reduction estimates from individual watersheds to reduce Minnesota's contribution to restore and protect downstream waters such as the Gulf of Mexico, Lake Winnipeg, and the Great Lakes. The document also provides information on how to estimate BMP activities that will achieve specific watershed nutrient load reductions for nitrogen and phosphorus.

Major basin	Milestone 2014 to 2025	Final Goal 2025 to 2040
Mississippi River (Also includes Cedar, Des Moines, and Missouri Rivers)	**12%** reduction in phosphorus from the baseline loads	Achieve **45%** total reduction from 1980-1996 baseline and meet in-state lake and river water quality standards
	20% reduction in nitrogen	Achieve **45%** total reduction from 1980-1996 baseline

Description	Mississippi River Upper Mississippi, Minnesota, St. Croix Cedar, Des Moines, Missouri	
	TP	TN
Recent sum of modeled loads at state line (MT)	3,478	87,271
Final goal at state line (MT)	2,544	50,089
% load reduction still needed to meet final goals	26.9%	42.6%

HUC-8 Name	HUC-8 Number	Recent avg TN load at HUC-8 outlet (MT/yr)	Final goal TN load at HUC-8 outlet (MT/yr)	TN Load reduction at HUC-8 outlet to meet final goal (MT/yr)	Percent Reduction Target (from recent total HUC-8 loads)
Blue Earth	7020009	5,934	3,213	2,721	45.90%

HUC-8 Name	HUC-8 Number	Recent avg TP load at HUC-8 outlet (MT/yr)	Final goal TP load at HUC-8 outlet (MT/yr)	TP Load reduction at HUC-8 outlet to meet final goal (MT/yr)	Percent Reduction Target (from recent total HUC-8 loads)
Blue Earth	7020009	176.7	125.9	50.8	28.70%

4.4 Appendix 4: Strategies and Priorities – Related Appendices

Lake Restoration and Protection Strategies

This is a summary of strategies and not an exhaustive list. Not all strategies are applicable or appropriate for all lakes or regions. See the Minnesota State and Regional Government Review of Internal Phosphorus Load Control guide for more information.

Watershed Strategies – These strategies reduce phosphorus from being delivered to a lake and are the basis for any restoration work.

- **Manage nutrients** – Carefully planning for and applying phosphorus fertilizers decreases the total amount of phosphorus runoff from cities and fields.
    - Examples: crop nutrient management, city rules on phosphorus fertilizer use, etc.
- **Reduce erosion** – Preventing erosion keeps sediment (and attached phosphorus) in place.
    - Examples: construction controls, vegetation (see below).
- **Increase vegetation** – More vegetative cover on the ground uses more water and phosphorus and decreases the total amount of runoff coming from fields and cities.
    - Examples: cover crops, grass buffers, wetlands, prairie gardens/restorations, channel vegetation, etc.
- **Install/restore basins** – Capturing runoff and decreasing peak flows in a basin allows the sediment (and attached phosphorus) to settle out.
    - Examples: water and sediment control basins, wetlands, etc.
- **Improve soil health** – Soils that are healthy need less fertilizer and hold more water.
    - Examples: reduce/no-till fields, diversified plants in fields and yards.

Lake Shore-specific Strategies – These strategies are a subset of watershed strategies that can be directly implemented by lake-shore residents.

- **Eco-friendly landscaping** – Poor landscape design and impervious surfaces increase runoff and loading of nutrients into lakes.
    - Examples: aeration, rain barrels or cisterns, rain gardens, permeable pavers, sprinkler and drainage systems, septic systems maintenance, etc.
- **Manage upland buffer zone vegetation** – Upland buffer zone vegetation selection can greatly affect nutrient absorbance, watering needs, erosion potential, need for drainage, etc.
    - Examples: properly landscape, maintain canopy and address terrestrial invasive species that may prevent re-generation of native trees, proper turf grass and no mow lawns in highly utilized areas and planting native grasses and forbs with deep root systems in

    - underutilized areas of lawn, reduce watering needs, controlled fertilization and grass clippings.

- **Naturalize transition buffer zone** – A natural transition buffer zone increases absorption of nutrients and decreases erosion potential of the water-shore interface.
    - Examples: balance natural landscaping by minimizing recreational impact area, utilize natural materials for erosion control bioengineering using wood or biodegradable materials in combination with stabilizing native vegetation to restore a shoreline, minimize beach blankets, draw down water levels for consecutive seasons to allow existing seed banks to develop deep rooted native vegetation or plant diverse mixes of grasses, sedges, forbs, shrubs and trees to create a complex root mass to hold the bank soils, preserve and restore native emergent aquatic vegetation sedges, rushes, forbs, shrubs and trees, do not remove natural wood features that supply cover and food sources for aquatic species and invertebrates while serving as a wave break along the shoreline.
- **Preserve aquatic buffer zone** – The aquatic buffer zone is difficult to restore, so the best approach is preservation and providing best opportunity for aquatic plants through watershed improvements to increase water quality. Draw down water levels to allow natural seed banks of emergent and aquatic vegetation to establish naturally, supplement more plant diversity with lower water levels as restoration of emergent and aquatic vegetation have higher success rates.
    - Examples: reduce recreational impact area, minimize control of aquatic plants, reduce dock footprint, preserve and/or restore native emergent and floating-leaf aquatic plants.

In-Lake Strategies – These strategies use, remove, or seal internal phosphorus (from within the lake). These strategies are only effective if external phosphorus sources are first minimized to the point that water quality of incoming water is not the limiting factor in order to meet water quality standards. Incorporating Lake Shore specific strategies is also essential for long term success.

- **Biomanipulation** – changing the fish population. Rough fish are generally bottom feeders and through feeding activity re-suspend sediments and decrease water clarity; thus, removing rough fish through mechanical or biological methods can improve water clarity, increase aquatic vegetation, and improve water quality overall.
    - Examples: commercial netting (not a standalone tool, implement in conjunction with other fisheries management methods to augment reduced populations for a short-term period allowing desirable fish populations to develop adequate size to manage rough fish populations), balanced fish management increasing fish species diversity for a balanced fish population and introducing large predator fish populations, preserve and restore diverse spawning, cover, and feeding habitat that favors specific fish species that maintain a diverse fish population, reclamation (kill all fish and start over) inlets for rough fish should be considered when planning reclamation to prevent immediate re-

introduction. In-lake shore strategies are essential to incorporate to develop habitat for desirable species of fish once the rough fish population is removed.

- **Invasive species control of plants and/or animals** – Invasive species alter the ecology of a lake and can decrease diversity of habitat. Removing native vegetation or incorporating nonnative vegetation into landscaping can allow for invasive species to establish and spread taking over larger blocks of native species that maintain the natural systems health. Therefore, reducing disturbance to near shore habitat is important.
  - Examples: prevention, early detection, lake vegetation management plan (LVMP).
- **Chemical treatment to seal sediments** – Re-suspension of nutrients through wind action can cause internal nutrient loading.
  - Examples: alum treatments. Consider the long-term effectiveness in shallow lakes that experience wind driven turning, where stratification of the lake does not occur. Incorporating establishment of lake shore habitat is important to absorb phosphorus in the lake as part of a long-term approach to phosphorus level management.
- **Dredging** – Sedimentation after years of poor watershed practices increases nutrient laden sediments and decreases depth. Dredging should only be considered when the source of the sediment and the banks of the lake are stable to prevent sediment from redepositing. Dredging can: create channels for access, increase habitat diversity, and accommodate recreational use.

Strategies Table Menu/Key – This table provides available strategies and BMPs by land use for planning simplification. The table was utilized for LWG planning to identify practices with the most potential for implementation

Improve cropland soil health

Decrease fertilizer use
- Nutrient Management (590)
- Fertilizer rates match U of MN rec's (without gov't funding)
- Eliminate fall-applied anhydrous ammonia
- Precision nutrient timing & management (beyond 590 standard)

Add cover crops for living cover in fall/spring
- Cover Crops with Corn & Soybeans (340)
- Cover crops after early-harvest crops (340)

Decrease tillage (to increase residue)
- Conservation tillage - >30% residue cover (345, 346, 329B)
- No-till/ridge till/strip till (329, 329A)
- Contour tillage/farming (330)

Diversify Crops
- Conservation Crop Rotation - add small grains (328)
- Conservation Crop Rotation - add perennials (328)
- Perennial crops for regular harvest
- Convert cropland to (properly managed) pasture

Decrease pesticide use
- Integrated Pest Management (595)

Reduce and treat cropland surface runoff
(note: most soil health strategies also treat and reduce cropland contributions)
- Water and Sediment Control Basin (638)
- Sediment Basin (350)
- Terrace (600)
- Grassed waterway (412)
- Filter Strips (386)
- Contour Buffer Strips (332)
- Stripcropping (585)
- Field Border (393, 327) (also see buffers under stream/ditch strategies)
- Grade stabilization structure

Reduce and treat cropland tile drainage
(note: most soil health strategies also treat and reduce cropland contributions)
- Tile line bioreactors (747)
- Wetland Restoration or Creation for treatment (657, 658)
- Controlled tile drainage water management (554)
- Saturated buffers (604)
- Tile water storage with re-use on crops (636)

Replace open tile inlets
- Alternative tile intake - perforated riser pipe (171M)
- Alternative tile inlet - blind, rock, sand filter (606, 170M, 172M, 173M)

Decrease irrigation water use
- Irrigation Water Management (449)

Improve forestry management
- Forest erosion control on harvested lands
- Roads and trails improvement
- Reforestation on non-forested land and after cutting
- Forestry management - comprehensive (147M)
- Maintain existing forest cover

Improve livestock & manure management

Improve pasture/grazing management
- Conventional pasture to prescribed rotational grazing (528)
- Pasture improvement/vegetation diversification (101)
- Use alternative grazing areas/graze cover crops

Restrict livestock access to water bodies
- Livestock access control (472)
- Livestock stream crossing
- Livestock watering facilities

Reduce/treat feedlot runoff
- Feedlot runoff reduction/treatment (635, 784)

Optimize manure storage
- Rain water diversion
- Use deep bedding (for less runoff from storage piles)
- Feedlot manure/runoff storage addition (313, 784)

Optimize feedlot siting
- Move feedlots out of sensitve areas
- Increase distance between livestock and water

Integrate livestock onto landscape
- Transition confined livestock to grazed

Reduce total number of livestock
- Produce higher value livestock to reduce total number produced

Improve manure application
- Precision/variable rate manure application (590)
- Improved application location (590)
- Improved application timing (590)
- Manure incorporation (within 24 hrs)

Reduce and treat urban and residental runoff
- Stormwater practices to meet TMDL & permit conditions
- Constructed Stormwater Pond (urban) (155M)
- Constructed Wetland (urban) (658)
- Infiltration Basin (urban) (803M)
- Bioretention/Biofiltration (urban) (712M)
- Enhanced Road Salt Management
- Permeable surfaces and pavements (800M, 804M)
- Supplemental Street Sweeping
- Chemical Treatment of stormwater
- Sand Filter
- City/shared rentention and infiltration areas: stormwater ponds, swales, rain gardens, wetlands, etc.
- Improve soil health: reduce nutrient use, diversify lawns, add trees/shrubs/prairie/forest, no-till and cover
- Improve street construction and management: permeable pavement on new construction, improved
- Resident-scale water management: rain gardens, barrels, pet waste, lawn diversification
- Well head sealing and vegetative protection

Reduce Point Source Contributions
- Treatment plant upgrades (to achieve ....)
- Wastewater phosphorus reductions
- Wastewater nitrate reductions
- Wastewater bacteria reductions
- Consolidation of treatment facilities/close high input facility
- Conveyance system improvements (reduce/eliminate stormwater infiltration and emergency releases)

Convert/protect (marginal/high risk) land for critical habitat (can be applied to any landuse)
- Conservation Cover Perennials (327, 327M, 342, 612)
- Wetland Restoration for habitat (657)
- Wetland Creation for habitat (658)
- Wetland Wildlife Habitat Management (644)
- Upland Wildlife Habitat Management (645, 643)
- Restore drained lake beds
- Early Successional Habitat

Restore & protect lakes, wetlands, and shoreland

Manage in-water
- Internal load control (dredging, alum (563M), rough fish control, etc.)
- Drawdown and hypolimnetic withdrawal
- AIS (fish) management
- AIS (vegetation) management
- Watercraft restrictions

Restore/protect shoreline
- Stabilize/restore shoreline (580)
- Stabilize/restore shoreline with vegetation (580)
- Increase distance (buffer) between waterbody and impacts

Restore & protect streams, ditches, and riparian

Install/expand riparian buffers
- Riparian Buffers, 16+ ft (perennials replace tilled) (390, 391, 327)
- Riparian Buffers, 50+ ft (perennials replace tilled) (390, 391, 327)
- Riparian Buffers, 100+ ft wide (perennials replace tilled) (390, 391, 327)
- Riparian Buffers, 50+ ft wide (replacing *pasture*) (390, 391, 327)
- Riparian grass/forb planting (390)
- Riparian tree planings (612)

Reduce ditch impacts
- Reduce ditch clean-outs
- Grade stabilization structure - in ditch (410)
- Side inlet improvement (410)
- Structure for Water Control (587)

Address fish barriers
- Remove dams
- Replace/properly size culverts and bridges
- Replace/redesign perched culverts

Improve stream/ditch channel, banks, and habitat
- Re-meander channelized stream reaches (582)
- Two stage ditch (582)
- Restore riffle substrate
- Stream Channel Stabilization (584)
- Stream habitat improvement and management (395)
- Re-connect/restore floodplain
- Ravine stabilization (410)
- Lined Waterway or Outlet (468)
- Upland storage and vegetative treatment (in area just before ravine)
- Streambanks/bluffs stabilized/restored (580)

Reduce Septic System Contributions
- Septic system upgrades (126M)
- Sanitary sewer system extended to septic system community
- Improved septic land application

Model Summary Table

	Summary and Notes	Scenario	Modeled BMPs/Landscape	Reduction in Parameter: Sediment	Reduction in Parameter: Phosphorus	Reduction in Parameter: Nitrogen	Cost
N-BMP Spreadsheet Tool Minnesota Watershed Nitrogen Reduction Planning Tool (Lazarus et al., 2014)	The BMPs outlined here were developed using the N-BMP spreadsheet tool with inputs specifically for the Blue Earth River Watershed for average weather conditions. The first/top scenario achieves a 6.3% N reduction from all crop lands (enough to meet the 10-year target by making changes to crop land uses alone). The second/bottom scenario achieves a 48.9% N reduction from all crop lands (enough to meet the full goal by making changes to crop land uses alone). Parameter load reductions are presented as the pounds per treated acre (how many pounds of N reduction are estimated for each acre where the practice is adopted). The costs are represented as the cost per pound of nitrogen removed.	6.3% N Reduction from Crops	30% of land receives target N fertilizer rate			4 lb/ac	**$-3/lb**
			9% of land receives Fall N inhibitor			3 lb/ac	$2/lb
			10% of land uses rye cover crop			2 lb/ac	$33/lb
			6% of land switches from fall to split fertilizer application			6 lb/ac	$3/lb
			5% of land switches from fall to spring fertilizer application			6 lb/ac	**$-1/lb**
			2% of land short season crops adopt a rye cover crop			5 lb/ac	$11/lb
			1% of land is treated by tile line bioreactors			2 lb/ac	$17/lb
			0.7% of land converts to perennial crop			11 lb/ac	$6/lb
			0.3% of land adopts riparian buffers 50 feet wide			12 lb/ac	$4/lb
			0.2% of land adopts controlled drainage			5 lb/ac	$2/lb
			0.2% of land adopts saturated buffers			7 lb/ac	$2/lb
			0.2% of land is drained to treatment wetlands			9 lb/ac	$1/lb
		48.9% N Reduction from Crops	50% of land converts to perennial crop			12 lb/ac	$14/lb
			10% of land adopts saturated buffers			7 lb/ac	$2/lb
			10% of land is treated by tile line bioreactors			2 lb/ac	$17/lb
			10% of land adopts controlled drainage			5 lb/ac	$2/lb
			25% of land (corn and bean crops) uses rye cover crop			2 lb/ac	$33/lb
			10% of land is drained to treatment wetlands			9 lb/ac	$1/lb
			50% of land receives target N fertilizer rate			4 lb/ac	$-3/lb
			25% of land receives Fall N inhibitor			3 lb/ac	$2/lb
			50% of land (short season crops) adopt a rye cover crop			5 lb/ac	$11/lb
			20% of land adopts riparian buffers 50 feet wide			12 lb/ac	$12/lb
P-BMP Spreadsheet Tool Minnesota Watershed Phosphorus Reduction Planning Tool (Lazarus et al., 2015)	The BMPs outlined here were developed using the P-BMP spreadsheet tool with inputs specifically for the Blue Earth River Watershed for average weather conditions. The first/top scenario achieves a 11.9% P reduction from crop lands (enough to meet the 10-year target by making changes to crop land uses alone). The second/bottom scenario achieves a 42.8% P reduction from all crop lands. Parameter load reductions are presented as the pounds per treated acre (how many pounds of P reduction are estimated for each acre where the practice is adopted). The costs are represented as the cost per pound of phosphorus removed.	12% P Reduction from Crops	20% of land adopts reduced P application rate		0.05 lb/ac		$-239/lb
			40% of land (>2% slopes) uses reduced tillage		0.1 lb/ac		$-165/lb
			10% of land (corn and bean crops) uses rye cover crop		0.06 lb/ac		$921/lb
			50% of land switches to preplant/starter fertilizer application		0.02 lb/ac		$1070/lb
			20% of land adopts alternative tile intakes		0.12 lb/ac		$5/lb
			50% of land injects/incorporates manure		0.14 lb/ac		$29/lb
			50% of land (short season crops) adopt a rye cover crop		0.13 lb/ac		$450/lb
			25% of land converts to 50 ft stream buffers		1.64 lb/ac		$43/lb
			10% of land converts to perennial crop		0.29 lb/ac		$176/lb
			1% of land adopts controlled drainage		0.18 lb/ac		$59/lb
		42.8% P	95% of land adopts reduced P application rate		0.04 lb/ac		$-338/lb
			90% of land (corn and bean crops) uses rye cover crop		0.06 lb/ac		$920/lb
			95% of land (>2% slopes) uses reduced tillage		0.11 lb/ac		$-143/lb
			75% of land adopts controlled drainage		0.17 lb/ac		$59/lb
			75% of land adopts alternative tile intakes		0.12 lb/ac		$5/lb

	Summary and Notes	Scenario	Modeled BMPs/Landscape	Reduction in Parameter			Cost
				Sediment	Phosphorus	Nitrogen	
			90% of land switches to preplant/starter fertilizer application		0.03 lb/ac		$980/lb
			90% of land injects/incorporates manure		0.14 lb/ac		$29/lb
			100% of land (short season crops) adopt a rye cover crop		0.13 lb/ac		$450/lb
			75% of land converts to 50 ft buffers		1.6 lb/ac		$50/lb
			75% of marginal land converts to perennial crop		0.28 lb/ac		$175/lb

Model(s) and Reference	Summary and Notes	Scenario	Modeled BMPs/Landscape		Reduction in Parameter		
					Sediment	Phosphorus	Nitrogen
HSPF SAM Scenarios Watershed Pollutant Load Reduction Calculator	Four scenarios were run in the Blue Earth River Watershed. Two scenarios meet (roughly) the 10-year targets for N (5%) and P (10%), and two scenarios meet (roughly) the full goal for N (45%) and P (45%). All scenarios were run for load reduction at the watershed outlet. Expected sediment reductions for each scenario are also shown.	N-10 yr	25% 5% 3%	of area adopts nutrient management (improved rates/timing) of area adopts 50' buffers of area restores wetlands	<1%	3%	6%
		P-10 yr	30% 10% 10% 10% 5%	of area adopts nutrient management (improved rates/timing) of area adopts 50' buffer of area adopts reduced tillage (30%+ residue cover) of area adopts alternative tile intakes of area restores wetlands	1%	10%	10%
		N – full goal	10% 10% 10% 10% 5% 10% 75% 50% 10% 20%	of area adopts filter strips, 50 ft wide (cropland field edge) of area adopts water and sediment control basins of area adopts alternative tile intakes of area adopts conservation cover perennials of area adopts cover crops after early harvest crops of area adopts cover crops with corn and soybeans of area adopts reduced tillage (30%+ residue cover) of area adopts nutrient management (improved rates/timing) of area adopts riparian buffers, 50 ft wide (replacing row crops) of area restores wetlands	6%	37%	46%
		P – full goal	10% 10% 10% 10% 5% 10% 75% 25% 50% 10% 20%	of area adopts filter strips, 50 ft wide (cropland field edge) of area adopts water and sediment control basins of area adopts alternative tile intakes of area adopts conservation cover perennials of area adopts cover crops after early harvest crops of area adopts cover crops with corn and soybeans of area adopts reduced tillage (30%+ residue cover) of area adopts no-till of area adopts nutrient management (improved rates/timing) of area adopts riparian buffers, 50 ft wide (replacing row crops) of area restores wetlands	7%	45%	50%

Model(s) & Reference	Summary & Notes	Scenario		Modeled BMPs/Landscape									Reduction in Parameter			Cost
													Sediment	Phosphorus	Nitrogen	
SWAT, InVEST, Sediment Rating Curve Regression, and Optimization Lake Pepin Watershed Full Cost Accounting (Dalzell et al., 2012)	Models 6 BMPs in the 7-mile Creek watershed either: **1**) placed by rule of thumb recommendations (not optimal) or **2**) to maximize TSS reduction for dollars spent (optimal). Completed economic analyses including: **A**) current market value only (using 2011 $) and **B**) integrated, which adds a valuation of ecosystem services (relatively modest value). Does not allow multiple BMPs on same pixel of land. Scenarios are described by percentages of land in each land use. Analysis of 2002-2008 data.	Land uses:		Normal til	Cons til	1/2 P fert	Pasture	Grass	Forest	Wetland	Water	Urban				
		Baseline		83%	0%	0%	2%	0%	4%	5%	1%	5%	0%	0%		0%
		2A	A	3%	14%	64%	3%	1%	5%	5%	1%	5%	4%	-1%		-4%
		2A	B	35%	1%	38%	10%	1%	4%	5%	1%	5%	25%	22%		4%
		2A	C	8%	0%	35%	32%	10%	4%	5%	1%	5%	50%	46%		21%
		2A	D	2%	0%	10%	43%	29%	4%	5%	1%	5%	76%	69%		51%
		2B	a	30%	1%	44%	2%	0%	11%	5%	1%	5%	15%	19%		-8%
		2B	b	26%	0%	41%	13%	1%	7%	5%	1%	5%	25%	28%		-7%
		2B	c	13%	0%	29%	38%	2%	7%	5%	1%	5%	50%	48%		0%
		2B	d	3%	0%	8%	68%	3%	6%	5%	1%	5%	76%	70%		19%
		1A	F	25m grass buffers around waterways									3%	3%		4%
		1A	G	250m grass buffers around waterways									15%	15%		28%
		1A	H	Converting highly erodible lands to grasslands									15%	17%		10%
SPARROW The Minnesota Nutrient Reduction Strategy (draft) (MPCA, 2013i)	Statewide nutrient reduction goals and strategies are developed for the three major drainage basins in Minnesota. For the Mississippi River basin, the milestones (interim targets) between 2014 and 2025 are 20% reduction in N and 8% reduction in P. The scenario to meet those reductions is summarized.	20% N, 8% P Reduction		43% of total area (80% of suitable area) uses target N fertilizer rates 6% of total area (90% of suitable area) uses P test and soil banding 1% of total area (10% of suitable area) in cover crops 1% of total area (25% of suitable area) in riparian buffers 25% of total area (91% of suitable area) in conservation tillage 4% of total area (18% of suitable area) uses wetlands or controlled drainage										8%	20%	
HSPF Minnesota River Basin Turbidity Scenario Report (Tetra Tech, 2009)	5 scenarios (BMP suites) evaluated for effect on TSS and TP in MN River tributaries and mainstem. Scenarios 1, 2 were minimally effective. Scenarios 3, 4, & 5 are summarized here. Analysis on 2001-2005 data.	3		20% land in pasture (perennial veg), targeting steepest land 75% of >3% slope land in cons. tillage (30% residue) and cover crop 50% of surface inlets eliminated Comprehensive nutrient management Drop structures installed on eroding ravines Effluent max P of 0.3mg/L for mechanical facilities For MS4 cities, install ponds to hold and treat 1" of runoff									~20% (Le Sueur watershed)	17% (MN basin)		
		4		All BMPs in Scenario 3 with these additions: Target (20% land in) pasture to knickpoint regions as well Increase residue (on 75% of >3% slope land) to 37.5% Increase eliminated surface inlets to 100% Controlled drainage on land with <1% slope Water basins to store 1" of runoff Minor bank/bluff improvements Eliminate baseflow sediment load									50% (Yellow Med watershed)	26% (MN basin)		
		5		All BMPs in Scenarios 3&4 with these additions: Improved management of the pasture land (CRP) Very major bluff/bank improvements Urban (outside MS4s) source reductions of 50-85%									87% (MN basin)	49% (MN basin)		

Tools for Prioritizing and Targeting – This list is provided to give local land use managers a summary of possible tools available for targeting and prioritizing implementation activities. This list can be used as a starting point for various analyses for planning efforts.

Tool	Description	Example Uses	Notes for GIS Use	Link to Data/Info
National Hydrography Dataset (NHD) and Watershed Boundary Dataset (WBD)	The NHD is a vector GIS layer that contains features such as lakes, ponds, streams, rivers, canals, dams and stream gages, including flow paths. The WBD is a companion vector GIS layer that contains watershed delineations.	General mapping and analysis of surface-water systems. A specific application of the data set is to identify buffers around riparian areas.	GIS layers are available on the USGS website.	http://nhd.usgs.gov/
Impaired Water bodies	Data indicates which stream reaches, lakes, and wetlands have been identified as impaired, or not meeting water quality standards. Attribute table includes information on the impairment parameters.	Examples of region/subwatershed prioritization includes: the number of impairments, specific impairment parameter, % of stream miles/lakes that are impaired, immediate subwatersheds of impaired rivers/lakes, identifying reaches with specific impairment parameters, etc. Field-scale targeting examples include: buffering impaired waters.	GIS layers are available on the PCA website.	https://www.pca.state.mn.us/air-water-land-climate/minnesotas-impaired-waters-list
Hydrological Simulation Program – FORTRAN (HSPF)	Simulation of watershed hydrology and water quality. Incorporates point and nonpoint sources including pervious land surfaces, runoff and constituent loading from impervious land surfaces, and flow of water and transport/transformation of chemical constituents in stream reaches. The model is typically calibrated with monitoring data to ensure accurate results.	Since the model produces data on a subwatershed scale, the model output can be particularly useful for identifying "priority" subwatersheds. The modeled pollutant or concentrations or total loads include TSS, TP, and TN. Point and nonpoint contributions can be extracted separately. Can be used to analyze different BMP "scenarios".	PCA models many major watersheds with HSPF. If completed, model data can be obtained from PCA and imported into GIS.	http://water.usgs.gov/software/HSPF/
HSPF – Scenario Application Manager (SAM)	Designed for those without HSPF training to visualize HSPF data and develop nonpoint and point source BMP scenarios "on the fly" without having to manually manipulate HSPF code.	A local county government could develop HSPF scenarios in SAM that would demonstrate BMPs that would reach local WQ goals; this demonstration could then be used to secure funding for BMP placement.	Can export data from SAM as shapefile for use in GIS.	https://www.respec.com/sam-file-sharing/

Tool	Description	Example Uses	Notes for GIS Use	Link to Data/Info
		This would be done without having to contract out the scenarios with an engineering firm.		
1855 Land Survey Data	Data originally created by land surveyors in the mid-to-late 1800s. Surveys were conducted in one-mile grid and indicated the land cover at the time of the survey. This data has been georeferenced and is available for most of the state. This information has been digitized by PCA staff for the GBERB.	This information could be used to prioritize areas based on changes in the landscape. This information is also helpful to understand landscape limitations (e.g., former lake beds may not be drain well).	Image data is available from MN Geo. Digitized rivers, lakes, and wetlands (in the GBERB only) are available from PCA staff.	http://www.mngeo.state.mn.us/glo/
Drinking Water Supply Management Areas	DWSMA is the MDH approved surface and subsurface area surrounding a public water supply well that completely contains the scientifically calculated wellhead protection area and is managed by the entity identified in a wellhead protection plan. The boundaries of the drinking water supply management area are delineated by identifiable physical features, landmarks or political and administrative boundaries.	This dataset was developed with the intention of protecting the public drinking water supply and complies with the federal Safe Drinking Water Act.	Contact MDH Source Water Protection Unit with questions.	https://www.health.state.mn.us/communities/environment/water/swp/mapviewer.html
Restorable Depressional Wetland Inventory	A GIS layer representing drained, potentially restorable wetlands in agricultural landscapes. Created primarily through photo-interpretation of 1:40,000 scale color infrared photographs acquired in April and May, 1991 and 1992.	Identify restorable wetland areas with an emphasis on: wildlife habitat, surface and ground water quality, reducing flood damage risk. To see a comprehensive map of restorable wetlands, must display this dataset in conjunction with the USGS National Wetlands Inventory (NWI) polygons that have a 'd' modifier in their NWI classification code.	GIS layer is available on the DNR Data Deli website also available from Ducks Unlimited.	https://www.ducks.org/conservation/geographic-information-systems/minnesota-restorable-wetlands

Tool	Description	Example Uses	Notes for GIS Use	Link to Data/Info
"Altered Hydrology" (PCA Analysis)	GIS layers (results of GIS analysis) of hydrology-influencing parameters indicating the amount of change (since European settlement) including: % tiled, % wetland loss, % stream channelized, % increase in waterway length, % not perennial vegetation, % impervious. Analysis done at the same subwatershed scale as the HSPF modeling was completed to facilitate subwatershed prioritization. Analysis was completed using available GIS data layers.	These six layers could be used individually or in combination (using raster calculator) to prioritize subwatersheds to target conservation practices intended to mitigate altered hydrology.	GIS layers are available from MPCA staff.	-
Altered Watercourse Dataset (Channelized Streams)	Statewide data layer that identifies portions of the National Hydrography Dataset (NHD) that have been visually determined to be hydrologically modified (i.e., ditches, channelized streams and impoundments).	Identifies streams with highly modified stream channels for conservation prioritization. Subwatersheds with high levels of channelized streams may be prioritized for specific conservation practices.	GIS layers are available on the MN Geo website.	http://www.mngeo.state.mn.us/ProjectServices/awat/
Tile Drainage (PCA Analysis)	Data created as an estimate of whether a pixel is tiled or not. Assumes tiled if: row crop, <3% slope, poorly drained soil type.	Can be useful for prioritizing highly drained areas to implement BMPs that address altered hydrology.	Data can be obtained from PCA staff	
Light Detection and Ranging (LiDAR)	Elevation data in a digital elevation model (DEM) GIS layer. Created from remote sensing technology that uses laser light to detect and measure surface features on the earth.	General mapping and analysis of elevation/terrain. These data have been used for: erosion analysis, water storage and flow analysis, siting and design of BMPs, wetland mapping, and flood control mapping. A specific application of the data set is to delineate small catchments.	The layers are available on the MN Geospatial Information website for most counties.	http://www.mngeo.state.mn.us/chouse/elevation/lidar.html
Stream Power Index (SPI)	SPI, a calculation based on a LiDAR file, describes potential flow erosion at the given point of the topographic surface. As catchment area and slope gradient increase, the amount of water contributed by upslope areas and the	Useful for identifying areas of concentrated flows which can be helpful for targeting practices such as grassed waterways or WASCOBs. Again, the usefulness may depend on	This layer has been created by PCA staff with little hydroconditioning for the	http://iflorinsky.impb.ru/si.htm

Tool	Description	Example Uses	Notes for GIS Use	Link to Data/Info
	velocity of water flow increase. Varying SPI analyses have been done with different resulting qualities depending on the amount of hydrologic conditioning that has been done.	the level of hydrologic conditioning that has been done.	GBERB and can be obtained from PCA staff.	
Compound Topographic Index (CTI)	CTI, a calculation based on a LiDAR file, is a steady state wetness index. The CTI is a function of both the slope and the upstream contributing area per unit width orthogonal to the flow direction. CTI was designed for hillslope catenas. Accumulation numbers in flat areas will be very large and CTI will not be a relevant variable.	Identifies likely locations of soil saturation which can be useful for targeting certain practices.	Can be downloaded from ESRI.	http://arcscripts.esri.com/details.asp?dbid=11863
NRCS Engineering Toolbox	The free, python-based toolsets for ArcGIS 9.3 and 10.0 allow for user friendly use of Lidar Data for field office applications, Hydro-Conditioning, Watershed Delineation, conservation planning and more.	Many uses including siting and preliminary design of BMPs.	Toolbox and training materials available on the MnGeo site.	http://www.mngeo.state.mn.us/chouse/elevation/lidar.html
RUSLE2	RUSLE2 estimates rates of rill and interrill soil erosion caused by rainfall and its associated overland flow. Several data layers and mathematical calculations are used to estimate this erosion.	Estimating erosion to target field sediment controlling practices.		http://www.ars.usda.gov/Research/docs.htm?docid=6016
Crop Land - National Agricultural Statistics Service (NASS)	Data on the crop type for a specific year. Multiple years data sets available.	Identify crop types, including perennial or annual crops and look at crop rotations/changes from year to year. A specific example of a use is to identify locations with a short season crop to target cover crops practice.	Data available for download from the USDA or use the online mapping tool.	https://www.nass.usda.gov/Data_and_Statistics/
National Land Cover Database (NLCD) from the MRLC	Data on land use and characteristics of the land surface such as thematic class (urban, agriculture, and forest), percent	Identify land uses and target practices based on land use. One example may be to target a residential rain	Data available for download from the MRLC website.	http://www.mrlc.gov/

Tool	Description	Example Uses	Notes for GIS Use	Link to Data/Info
	impervious surface, and percent tree canopy cover.	garden/barrel program to an area with high levels of impervious surfaces.		
CRP land (2008)	Data on which areas were enrolled in the USDA Conservation Reserve Program. This data is no longer available but may exist at the county level.	Potential uses include targeting areas to create habitat corridors or targeting areas coming out of CRP to implement specific BMPs.		http://www.fsa.usda.gov/FSA/webapp?area=home&subject=copr&topic=crp
Soils Data (SSURGO)	Data indicates soil type and properties.	Soil types can be used to determine the acceptableness of a practice based on properties such as permeability or erosivity.	Data can be downloaded or online viewers are available on the NRCS website.	http://www.nrcs.usda.gov/wps/portal/nrcs/detail/soils/survey/?cid=nrcs142p2_053627
Feedlot Locations	Data indicates the location of existing feedlots. Some data in this data layer is not accurate and feedlot locations could be mapped at the owner's address or in the center of the quarter.	May be helpful prioritizing areas to implement strategies that address *E. coli* or nutrients.	Data available on request from MPCA.	
Land Ownership/ Property Boundaries	Data indicates the owner and property boundary. This data is kept at the county level.	May be helpful for targeting efforts, particularly when a proactive approach is taken (e.g., if areas are targeted for specific practices and land owners are contacted to gauge their interest in a specific practice).	Some data available on the MN Geo website. Not all areas may have data in GIS format. Contact specific counties for more details/information.	http://www.mngeo.state.mn.us/chouse/land_own_property.html
Installed Practices	Data from BWSR eLink, MPCA, and NRCS is aggregated in the Healthier Watersheds application.	Knowing which areas have had multiple practices installed could indicate more interested landowners or help identify areas to anticipate water quality improvements.	Contact listed agencies to inquire if any data is available.	https://www.pca.state.mn.us/business-with-us/healthier-watersheds-tracking-the-actions-taken

Tool	Description	Example Uses	Notes for GIS Use	Link to Data/Info
Watershed Health Assessment Framework (WHAF)	An online spatial program that displays information at the major and subwatershed scale. Information includes: hydrology, biology, and water quality.	The online program is helpful for quick viewing and could be used to prioritize subwatersheds based on parameters or criteria in the WHAF.	Online only	http://arcgis.dnr.state.mn.us/ewr/whaf/Explore/
Agricultural Conservation Planning Framework (ACPF; Tomer et al.)	An outlined methodology uses several data layers and established analyses to identify specific locations to target several different BMPs. A "toolbox" is being created to facilitate the use of this methodology in MN.	Targeting specific BMPs (see link).	see demo: https://usdanrcs.adobeconnect.com/p6v40eme1cz/	http://northcentralwater.org/acpf/
Ecological Ranking Tool (Environmental Benefit Index - EBI)	Three GIS layers containing: soil erosion risk, water quality risk, and habitat quality. Locations on each layer are assigned a score from 0-100. The sum of all three-layer scores (max of 300) is the EBI score; the higher the score, the higher the value in applying restoration or protection.	Any one of the three layers can be used separately or the sum of the layers (EBI) can be used to identify areas that are in line with local priorities. Raster calculator allows a user to make their own sum of the layers to better reflect local values or to target specific conservation practices.	GIS layers are available on the BWSR website.	https://www.lccmr.mn.gov/projects/2009/finals/2009_04g_rpt_ecological_ranking.pdf
MN Natural Heritage Information System (Rare Features Data)	NHIS contains information about the location and identities of Minnesota's endangered, threatened, special concern, watch list, and species of greatest conservation need (state and federally listed), as well as records of rare native plant communities, animal aggregations, and geologic features. It is classed as protected data under MN Statute, section 84.0872.	This data can be used to prioritize areas for restoration and conservation protection.		http://www.dnr.state.mn.us/nhnrp/nhis.html
DNR Native Plant Communities	Classification of Minnesota's remnant land cover types. They are classified by considering vegetation, hydrology, landforms, soils, and natural regimes.	This data can be used to prioritize areas for restoration and conservation protection.		http://www.dnr.state.mn.us/npc/index.html

Tool	Description	Example Uses	Notes for GIS Use	Link to Data/Info
Protected Lands and Easements	This data is pulled from multiple GIS layers and summarizes fee title and easement lands held by DNR, TNC, BWSR, USDA, USFWS, and USFS.	This data can be used to prioritize areas for restoration and conservation protection. It gives connection points in the landscape for creating larger blocks of habitat that serve to preserve our diversity.		https://gisdata.mn.gov/
Lakes of Phosphorus Sensitivity Significance	A ranked priority list for Minnesota's unimpaired lakes based on sensitivity to additional phosphorus loading. The most sensitive lakes will likely see substantial declines in water clarity with increased nutrient pollution loading.	Dataset valuable to local governments and state agencies tasked with prioritizing unimpaired lakes for protection efforts.	GIS layer available from Minnesota Geospatial Information Office.	https://gisdata.mn.gov/dataset/env-lakes-phosphorus-sensitivity
Zonation	A values-based framework and software for large-scale spatial conservation prioritization. Allows balancing of alternative land uses, landscape condition and retention, and feature-specific connectivity responses. Produces a hierarchical prioritization of the landscape based on the occurrence levels of features in sites/grid cells. It iteratively removes the least valuable remaining cell, accounting for connectivity and generalized complementarity in the process.	Surveys are created and given to targeted audiences to identity their priorities. These survey priorities are then used by the program. The output of Zonation can be used to identify areas that align with the conservation values of the survey respondents.	Zonation results can be exported to GIS. Paul Radomski (DNR) and colleagues have expertise with Zonation.	https://www.syke.fi/en-US/Research__Development/Nature/Specialist_work/Zonation_in_Finland/Zonation_software
Lakes of Biological Significance	Lakes were identified and classified by DNR subject matter experts on objective criteria for four community types (aquatic plants, fish, amphibians, birds).	Lakes with higher biological significance can be prioritized for restoration and protection.		https://gisdata.mn.gov/dataset/env-lakes-of-biological-signific

Tool	Description	Example Uses	Notes for GIS Use	Link to Data/Info
Indicators of Hydrologic Alteration (IHA)	The Indicators of Hydrologic Alteration (IHA) is a software program that provides useful information for those trying to understand the hydrologic impacts of human activities or trying to develop environmental flow recommendations for water managers. assess how rivers, lakes and groundwater basins have been affected by human activities over time – or to evaluate future water management scenarios. Assess how rivers, lakes and groundwater basins have been affected by human activities over time – or to evaluate future water management scenarios.	The software program assesses 67 ecologically-relevant statistics derived from daily hydrologic data. For instance, the IHA software can calculate the timing and maximum flow of each year's largest flood or lowest flows, then calculates the mean and variance of these values over some period of time. Comparative analysis can then help statistically describe how these patterns have changed for a particular river or lake, due to abrupt impacts such as dam construction or more gradual trends associated with land and water use changes.		https://www.conservationgateway.org/ConservationPractices/Freshwater/EnvironmentalFlows/MethodsandTools/IndicatorsofHydrologicAlteration/Pages/indicators-hydrologic-alt.aspx
InVEST	InVEST is a suite of software models used to map and value the goods and services from nature that sustain and fulfill human life. InVEST enables decision makers to assess quantified tradeoffs associated with alternative management choices and to identify areas where investment in natural capital can enhance human development and conservation.	InVEST models can be run independently, or as script tools in the ArcGIS Arc Toolbox environment. You will need a mapping software such as QGIS or ArcGIS to view your results. Running InVEST effectively does not require knowledge of Python programming, but it does require basic to intermediate skills in ArcGIS.		https://naturalcapitalproject.stanford.edu/software/invest
RIOS	RIOS provides a standardized, science-based approach to watershed management in contexts throughout the world. It combines biophysical, social, and economic data to help users identify the best locations for protection and restoration activities in order to maximize the ecological return on investment, within the bounds of what is socially and politically feasible.			https://www.rios.com/
Map Window GIS + MMP Tools	Map Window GIS + MMP Tools is a free GIS that can be used for the following: 1. As a front-end to MMP when creating nutrient management plans. 2. As a front-end to Irris Scheduler when doing irrigation and nitrogen scheduling. 3. For designing research plots (randomized complete block field experiments).			http://www.purdue.edu/agsoftware/mapwindow/

Tool	Description	Example Uses	Notes for GIS Use	Link to Data/Info
Objective Model Custom Weight Tool	A decision support tool designed for USFWS resource managers to make thoughtful and strategic choices about where to spend limited management resources. This tool makes the processes used to prioritize these management units more transparent, improving the defensibility of management decisions. Originally created for the Morris Wetland Management District (WMD)			http://www.umesc.usgs.gov/management/dss/morris_wmd.html
WARPT: Wetlands-At-Risk Protection Tool	The Wetlands-At-Risk Protection Tool, or WARPT, is a process for local governments and watershed groups that acknowledges the role of wetlands as an important part of their community infrastructure, and is used to develop a plan for protecting at-risk wetlands and their functions. The basic steps of the process include quantifying the extent of at-risk wetlands, documenting the benefits they provide at various scales, and using the results to select the most effective protection mechanisms.			http://www.wetlandprotection.org/

Compiled by J Boettcher with help from many colleagues.

Phosphorus Sensitivity Scores for Lakes in the Blue Earth River Watershed

The phosphorus sensitivity index is a measure of phosphorus sensitivity expressed as inches lost in water clarity with an increase in 100 lbs of phosphorus loading. With a higher the score, there's more potential for algal growth and these lakes should have more consideration to protect the resource from impairment.

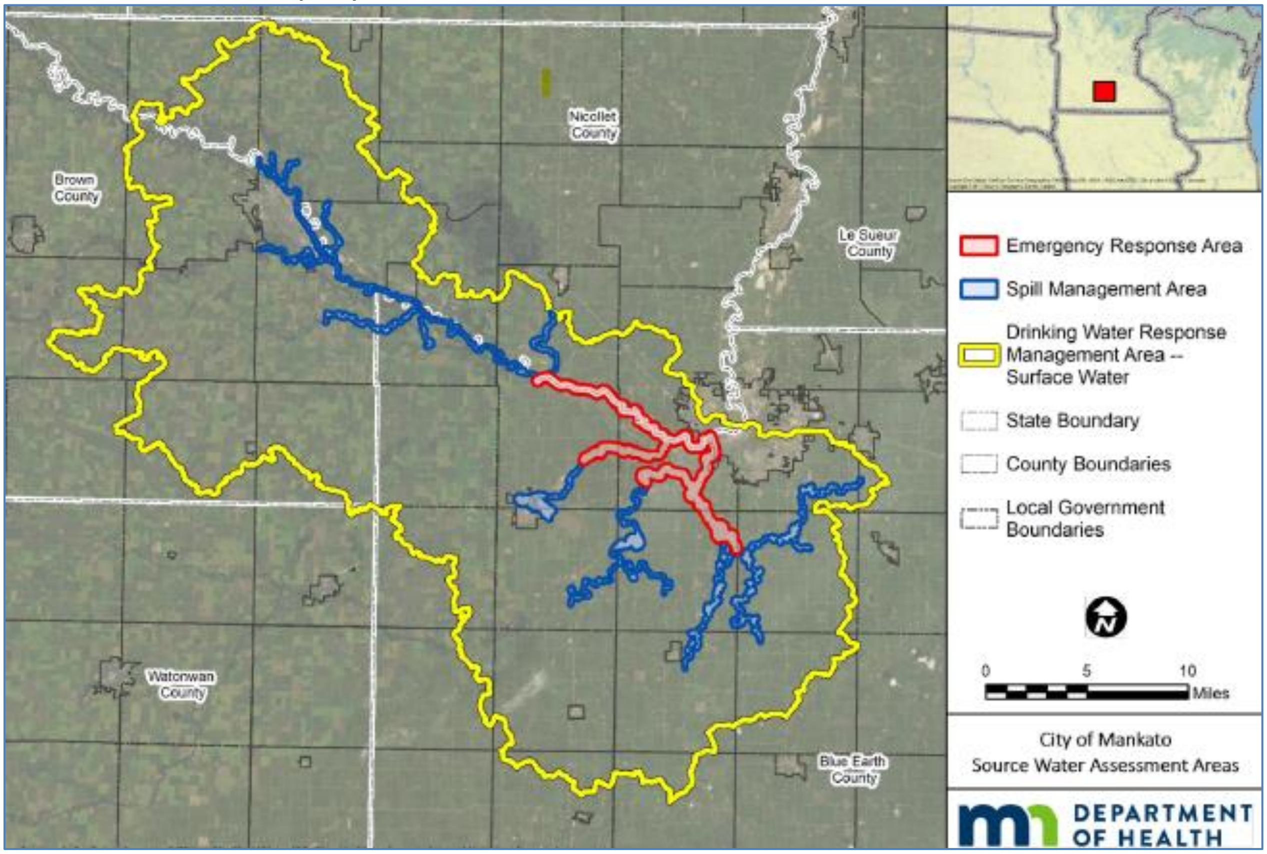
Lake Prioritization for lakes in Blue Earth River Watershed.

Lake	Lake Phosphorus Sensitivity Index	Protection Class
South Silver	22	Highest
Imogene	8	Medium
Clam	2	Lower
Independence	4	Lower
South Walnut	0	Lower
Walnut	4	Lower
Watkins	0	Lower
Wilmert	2	Lower
Amber	5	N/A (Impaired)
Big Twin	8	N/A (Impaired)
Budd	0	N/A (Impaired)
Cedar	0	N/A (Impaired)
East Chain	0	N/A (Impaired)
Fish	3	N/A (Impaired)
Fox	1	N/A (Impaired)
George	3	N/A (Impaired)
Hall	1	N/A (Impaired)
Ida	4	N/A (Impaired)
Iowa	0	N/A (Impaired)
Rice	2	N/A (Impaired)
Sisseton	0	N/A (Impaired)

Source Water Assessment Area for the City of Mankato

The Source Water Assessment Area (SWAA) includes the entire Blue Earth and Minnesota River watersheds upstream from the city of Mankato's Ranney wells to the state boundaries with Iowa, and South Dakota. The map below shows the emergency response area (9,422 acres), spill management area (14,701 acres), and the drinking water response management area (291,666 acres). *The Mankato Surface Water Intake Protection Plan Source Water Assessment* for Mankato's surface water supply was completed in by the MDH in 2022.

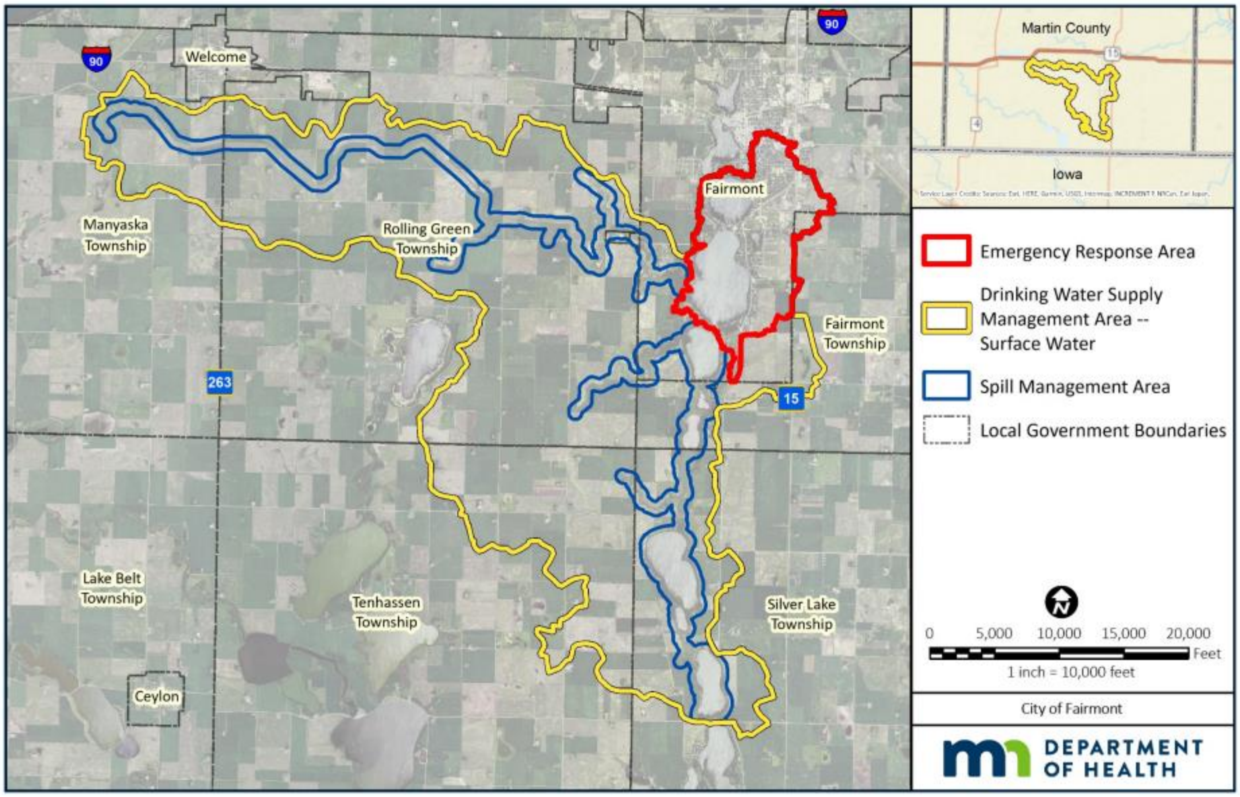
Source Water Assessment Map, City of Mankato



Source Water Assessment for the City of Fairmont

The SWAA for the City of Fairmont was developed to protect its public water supply from Budd Lake, which is part of the Fairmont Chain of Lakes. Flow through the Chain of Lakes proceeds from south to north in the following order: North Silver Lake, Wilmert Lake, Mud Lake, Amber Lake, Hall Lake, Budd Lake, Sisseton Lake, and George Lake. Also feeding into the Chain, mostly upstream of Hall Lake, are Dutch Creek and several public ditches. Luedtke Slough, which is located to the southeast of Budd Lake, is also connected to Budd Lake via groundwater and two engineered stormwater outfall connections to Budd and Hall Lakes. The total watershed area above and including Budd Lake is approximately 26,400 acres. The plan was completed in 2019 and the full report is availble: Source Water Assessment: City of Fairmont Public Water System.

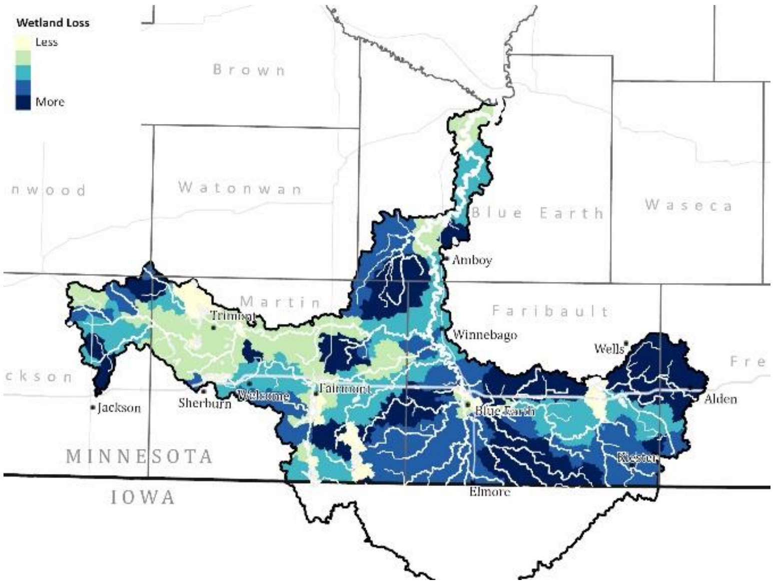
Source Water Assessment Map, City of Fairmont



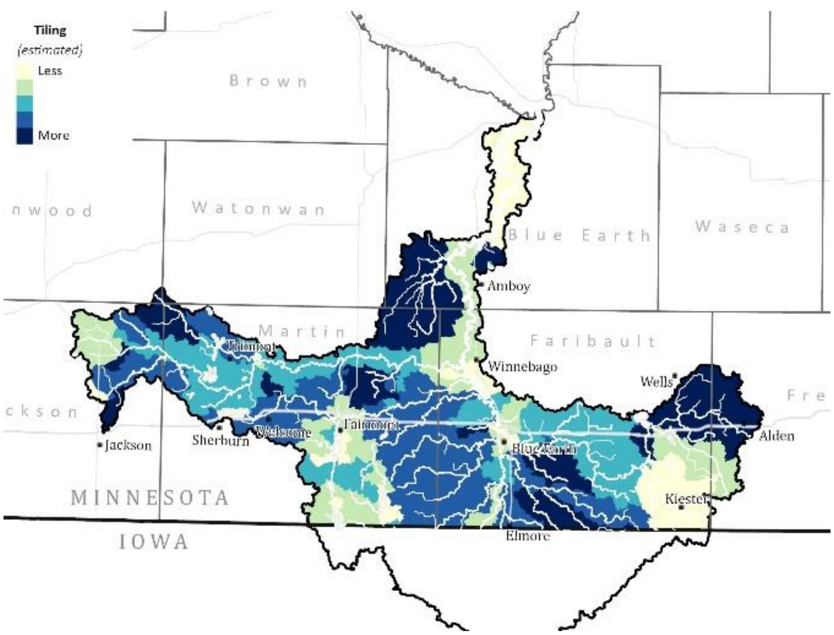
Altered Hydrology GIS Analysis

The altered hydrology analysis illustrated in Section 2.2 was created from the following six GIS layers and weights: estimated percent tiled (5), percent of land in nonperennial land uses (5), percent impervious surface (50), estimated percent wetland loss (10), road crossing per stream length (20), percent of stream length that is channelized (7).

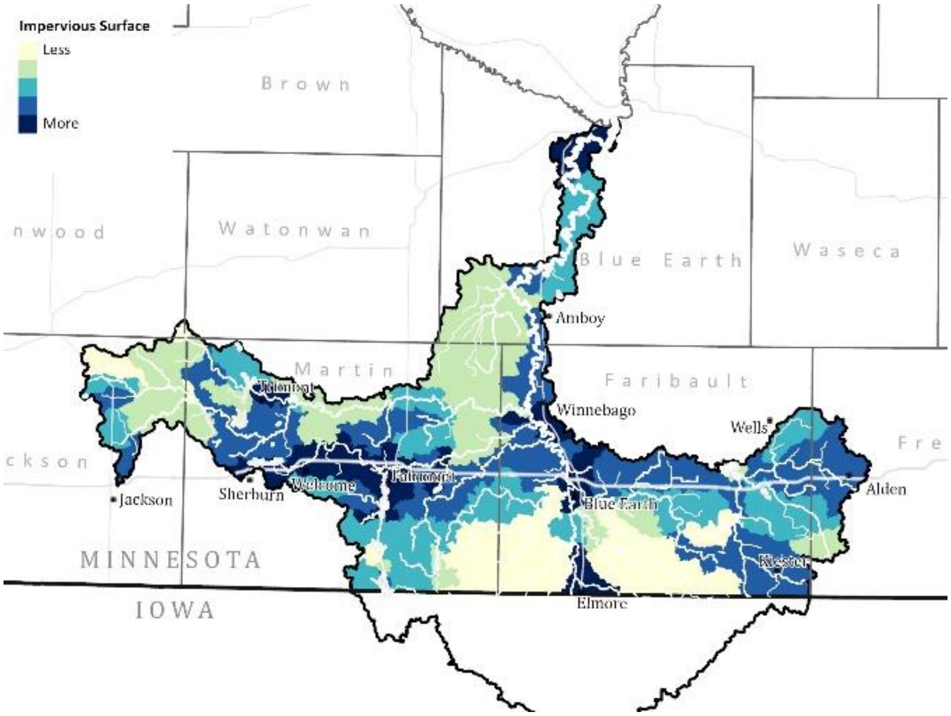
Wetland Loss



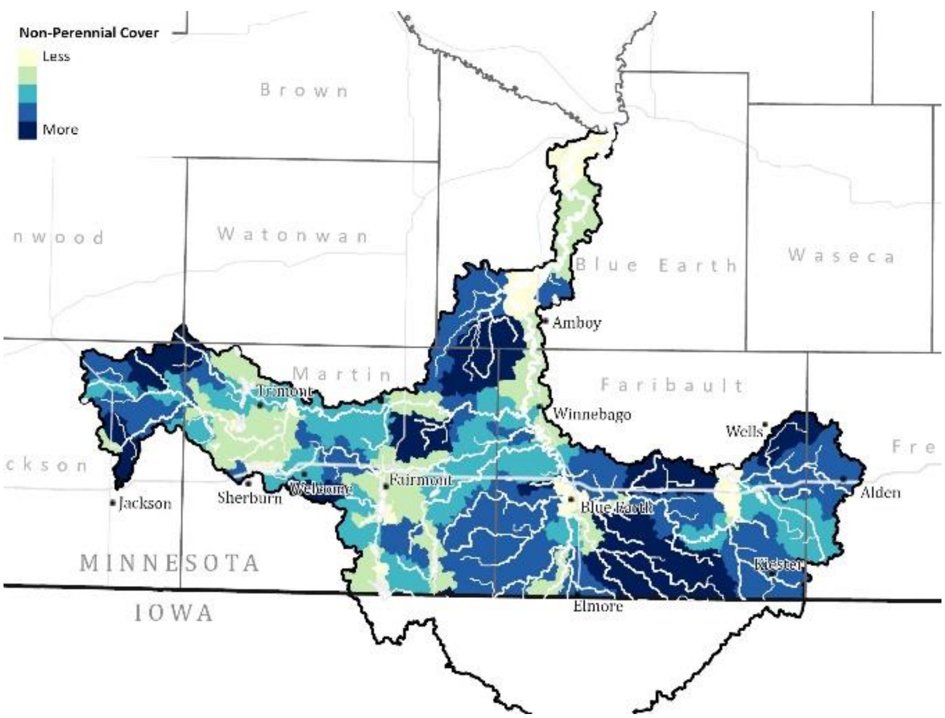
Tiling



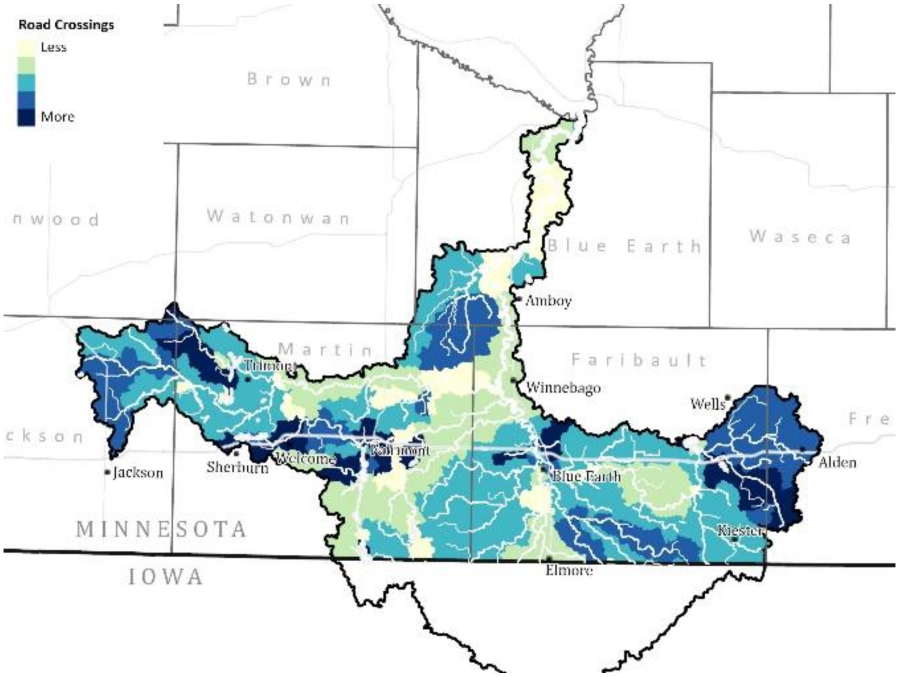
Impervious Surface



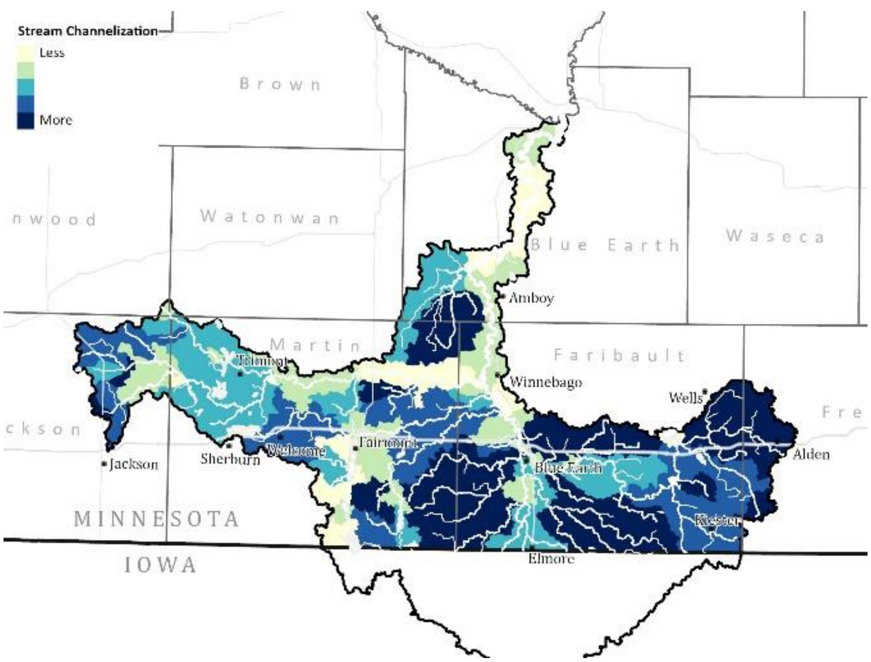
Nonperennial Cover



Road Crossings

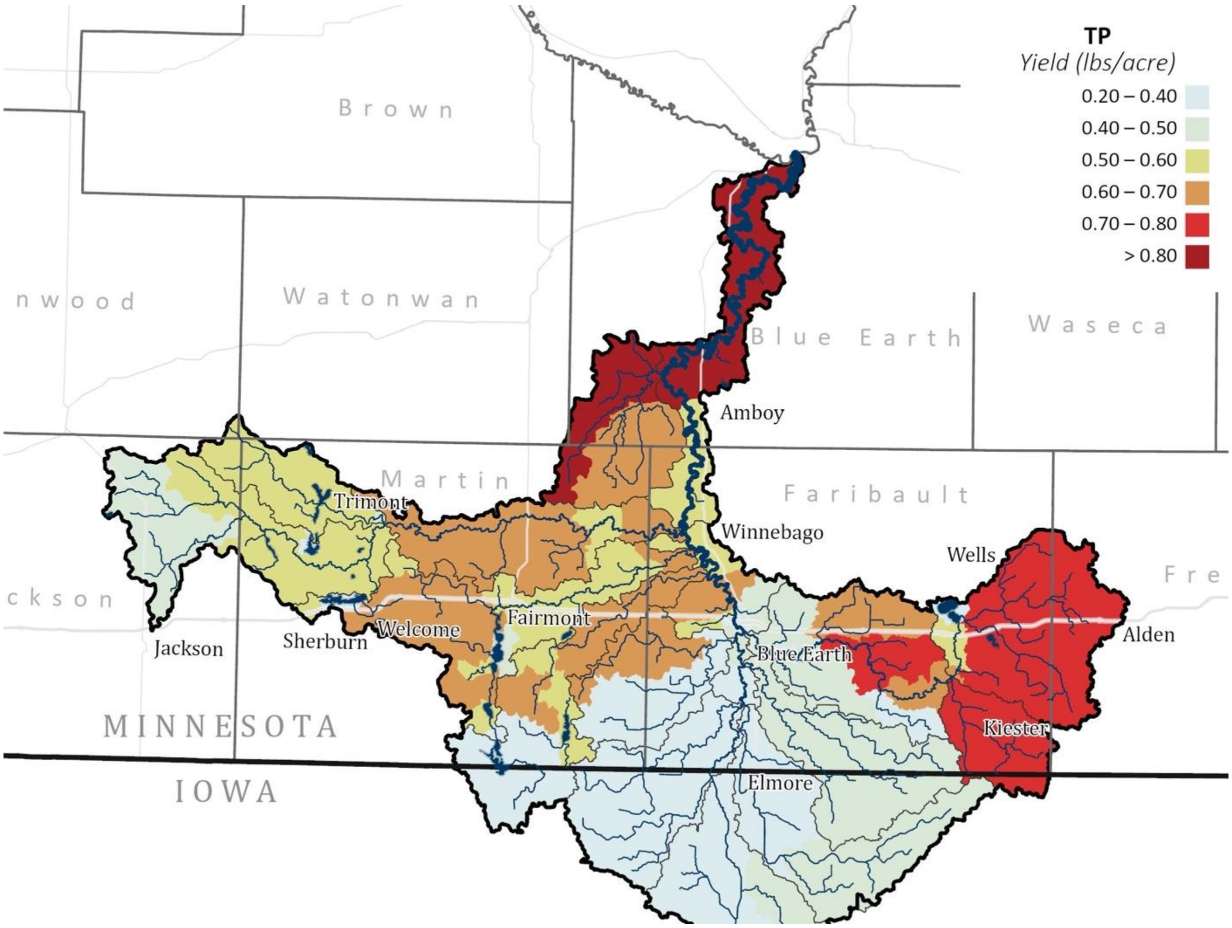


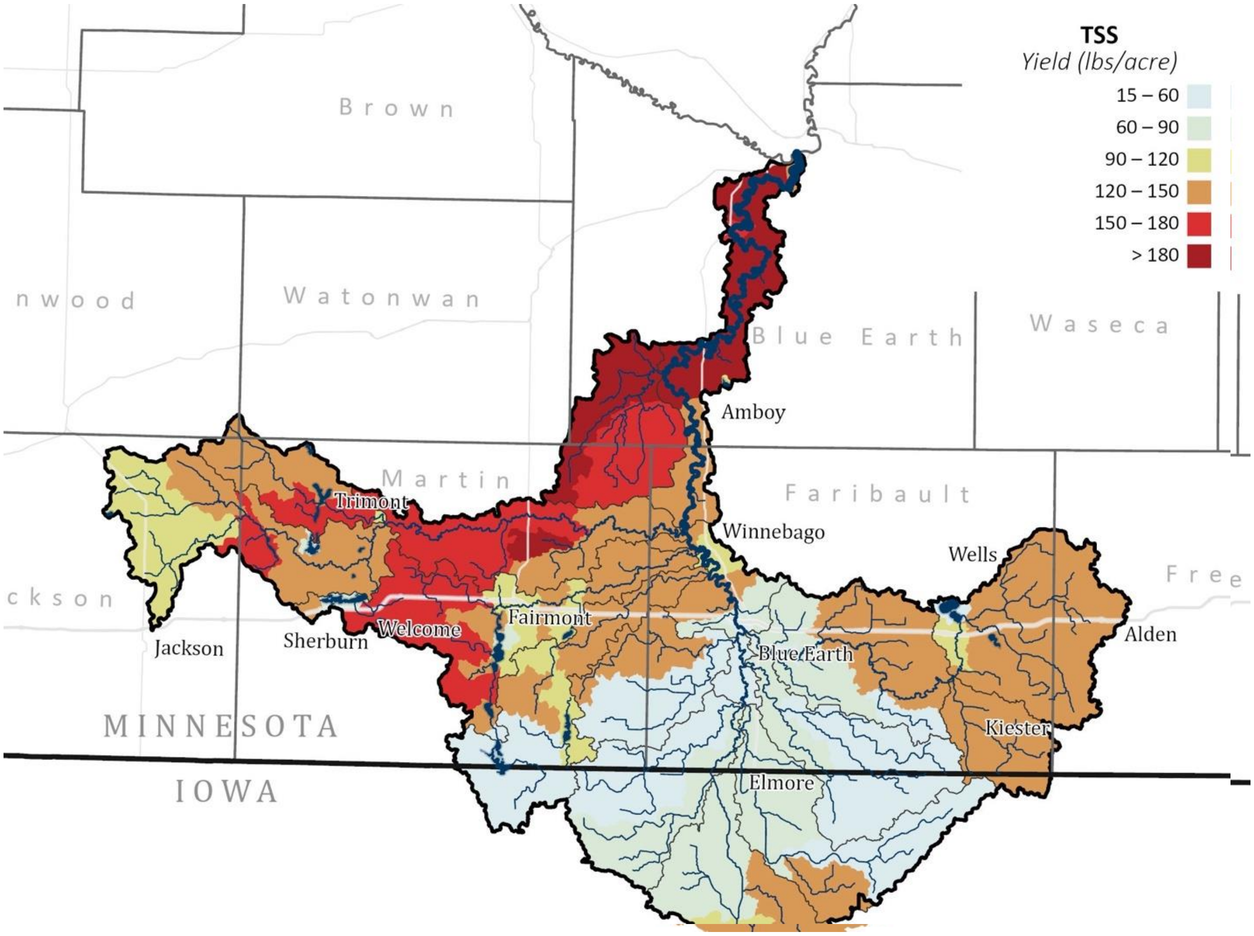
Stream Channelization



HSPF Yield Maps

HSPF yield maps help to provide information on subwatersheds that have limited or no data collected. This analysis provides information on potentially high loading areas that could be the focus of added data collection or emphasis for potential implementation practices.





Strategies Table Calculator Notes and Assumptions

Strategies Table Calculator Notes and Assumptions

Land use (known): 1,001,805 total acres,777,240 acres in MN, 85% cultivated ag, 1% forest/shrub, 3% grass/pasture, 7% all developed, 4% open water and wetland
1,250 miles of streams/ditches in MN 360 miles in Iowa (note: GIS calculation)
70% of watershed (80% of crops) is tile drained none are treating or keeping drained water on the land (all tile water is untreated and drained into ditch/stream)
Source assessments presented in WRAPS report used in calculations with the following refinements of the identified sources:
• 6.1% of watershed equivalent drain to open intakes [6.7% of the watershed (10% of tiled field acres) and 10% have effective control of nutrient/sediment runoff]
• 73% of watershed has nutrient/sediment loss from crop groundwater or crop surface runoff
• 0.2% of watershed (50% of pastures) are pastures that are contributing nutrients, sediment, and bacteria
• 15% of watershed (18% of crops) gets manure - 13.5% of watershed gets subsurface manure, 1.5% of watershed gets surface manure (115,000 manured acres from the 370,000 AUs)
• 0.1% of land has applied manure traveling through open intakes (=6.1% land serviced by intakes * 1.5% estimated that gets manure applied)
• When ag-wide control measure goes in, assume manured and nonmanured have same adoption rate as do tiled and untiled (by % of land use)
• 2% of total watershed sediment load travels through open tile intakes

• 0.1% of stream bank erosion is from bank trampling in addition to other pasture sediment contributions
• 0.1% of P is from pastures
• 5% of watershed load of phosphorus (from crop surface runoff) travels through open tile intakes
• 70% of the watershed (equivalent of) is contributing P through ground water and tile drainage
• 1% of bacteria load travels through open tile intakes (into the tile)
Except a few cases were noted in the calculator, the estimated reduction per strategy adoption is:
Pollutant Reduction from a BMP at a watershed scale = (% of watershed to adopt) X (% reduction efficiency) X (% of load from source type) / (% watershed that has that source type)
The primary assumptions of this equation are:
• % reductions in pollutant loads from implementing a BMP result in the same pollutant loading reductions to water bodies (e.g., 50% less sediment lost from field x results in 50% less sediment contributed to water bodies by field x)
• The pollutant contributions of land types and efficiencies of BMPs are equivalent throughout the watershed (except where additional treatment occurs as noted in the above assumptions)
• The parameter reductions associated with the strategy assume a mixture of most and least effective BMPs per strategy (a mid-range reduction versus a high or low). So, in addition to the inherent error estimating BMP reduction efficiencies, the estimated reductions could more significantly vary from actual reductions if the least effective or most effective BMPs within a strategy type are adopted. For instance, under the "reduce tillage" strategy type, if no-till is adopted exclusively (or contrarily the basic conservation tillage is adopted exclusively), the reduction from this strategy will likely be higher (contrary case: lower) than the estimated reduction.

4.5 Appendix 5: References

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