Watershed

December 2022

Cottonwood River Watershed Restoration and Protection Strategy Report

MINNESOTA POLLUTION CONTROL AGENCY

CLEAN WATER LAND & LEGACY AMENDMENT

Authors

MPCA

Mike Weckwerth

Mark Hanson

RCRCA

Kerry Netzke

Stantec Associates, Inc.

Jeff Strom

Katie Kemmitt

Tom Berry

Hagen Kaczmarek

Editing and graphic design

Jinny Fricke, MPCA (Final, 12.14.22)

Cover photos clockwise from left: Cottonwood River from Hwy 169 Bridge, Wellner-Hageman Reservoir, and Ravine Head to Cottonwood River in Milford 5 South. Photos courtesy of Brown County Soil and Water Conservation District.

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Key terms and abbreviations

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

Aquatic life impairment: The presence and vitality of aquatic life (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 (DO), turbidity, or certain chemical standards are not met.

Aquatic recreation impairment: Streams are considered impaired for impacts to aquatic recreation (AqR) if *Escherichia coli* (*E. coli*) 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.

Hydrologic Unit Code (HUC): A HUC is assigned by the USGS for each watershed. HUCs are organized in a nested hierarchy by size. For example, the Minnesota River Basin is assigned a HUC-4 of 0702 and the Cottonwood River Watershed is assigned a HUC-8 of 07030008.

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

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

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

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

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

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

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

Executive summary

The Cottonwood River Watershed is in the Hydrologic Unit Code (HUC)-8 major watershed 07020008 located in southwestern Minnesota, in the Minnesota River Basin (MRB) and within the Northern Glaciated Plains and Western Corn Belt Plains ecoregions. The Cottonwood River drains approximately 1,300 square miles of land in portions of Redwood, Brown, Cottonwood, Lyon, and Murray counties. Current land use within the watershed is dominated by agriculture (mostly row crops), followed distantly by rangeland, developed land, wetlands, open water, and forest/shrub land. Rangeland typically follows stream corridors, which is a large reason for less channelization of the streams than in other regions of Minnesota. Although the watershed is largely agricultural, it does contain a few cities, including Balaton, Sanborn, Sleepy Eye, Springfield, Tracy, and small portions of New Ulm and Marshall.

From 2017 to 2018, Intensive Watershed Monitoring (IWM) was contracted with the Redwood-Cottonwood Rivers Control Area (RCRCA) and also conducted by the Minnesota Pollution Control Agency (MPCA) to collect data across the Cottonwood River Watershed for the purpose of assessing the quality of its natural water resources. The IWM assessed 70 river/stream reaches for their ability to support aquatic life (AqL) and/or aquatic recreation (AqR). Of the assessed river/stream reaches, only 19 were fully supporting of AqL and none fully supported AqR. Of the eight lakes assessed in the Cottonwood River Watershed, seven were determined to be impaired by nutrients (total phosphorus [TP]). Based on previous and current monitoring assessment data, there are 11 turbidity/total suspended solids (TSS) impaired river/stream reaches, 17 bacteria impaired river/stream reaches, 26 macroinvertebrates Index of Biotic Integrity (IBI) impaired river/stream reaches, and 13 fish IBI impaired river/stream reaches within the Cottonwood River Watershed.

A Stressor Identification (SID) report was completed for the stream AqL impairments (fish and macroinvertebrate communities). The SID report identified habitat, altered hydrology, and eutrophication as the most common stressors to biologic communities (Cottonwood River Watershed SID Report, MPCA 2022a, to be published December 2022). A Total Maximum Daily Load (TMDL) study (MPCA 2022b) was completed to address the stream and lake AqR impairments (*E. coli* and lake nutrients), as well as the AqL impairments (TSS/turbidity).

Priority resources and strategies for the Cottonwood River Watershed were determined based on input and professional judgement from local partners, previous planning work, recreational use priorities, and comparing tool and model output with existing priorities outlined in county water plans. Some of the top priorities that were identified for the watershed include:

- Grade stabilization structures and practices (e.g., water and sediment control basins, grassed waterways) in high-sloped areas
- Soil health education and outreach
- Restoration and protection of lakes and stream reaches with high recreational use and value:
    - Sleepy Eye Lake
    - Lake Laura
    - Wellner-Hageman Reservoir

- Restoration and protection of lakes and stream reaches that are nearly impaired or barely impaired:
    - Dutch Charley Creek Reach 518
    - Dutch Charley Creek Reach 517
    - Bean Lake
    - Double Lake
    - Hurricane Lake
    - Sleepy Eye Lake
    - Wellner-Hageman Reservoir
    - Lake Laura
- Protection of vulnerable and sensitive groundwater areas:
    - Marshall and Marshall Dudley Drinking Water Supply Management Area/Wellhead Protection Area (DWSMA/WHPA)
    - Red Rock Rural Lake Augusta DWSMA

Restoration strategies for addressing the identified issues in the Cottonwood River Watershed SID and TMDL reports include: implementing stream and riparian buffers, tillage/residue management, adopting cover crops and other strategies to improve soil health, rural water storage, implementing designed erosion control and trapping best management practices (BMPs), nutrient management, pasture management, feedlot runoff controls, septic system improvements, urban stormwater runoff controls, and lake internal load management.

Strategies were also identified for lakes and streams that are currently meeting water quality to maintain and improve current conditions and protect these resources from becoming degraded or impaired. Some of the key protection initiatives identified in this report include protecting groundwater and drinking water, wildlife management areas (WMAs), and lakes and wetlands with rare and/or sensitive species. Specific locations of resource vulnerability are identified in this report and should be used to guide this process.

This Watershed Restoration and Protection Strategy (WRAPS) document is meant to serve as a foundation of technical information that can be used to assist in prioritization of water quality efforts by local governments, landowners, and other stakeholder groups. The information can be used to determine what strategies will be best to restore and protect water resources, as well as focus those strategies to targeted locations.

The topics of each chapter of this report are summarized below:

- **Chapter 1** provides background information on the Cottonwood River Watershed.
- **Chapter 2** details watershed conditions based on results from IWM, SID, and TMDL calculations.
- **Chapter 3** summarizes priority areas for targeting actions to improve water quality, and geographically locates where watershed restoration and protection actions could take place.
- **Chapter 4** documents a monitoring plan necessary to assess conditions in the watershed.

1. Watershed background and assessment

1.1 Watershed Approach and WRAPS

The State of Minnesota uses a "Watershed Approach" to assess and address the water quality within each of the state's 80 major watersheds, on a 10-year monitoring and assessment cycle. In each cycle of the Watershed Approach, rivers, lakes, and wetlands across the watershed are monitored and assessed, WRAPS and local plans are developed, and conservation practices are implemented. Watershed Approach assessment work started in the Cottonwood River Watershed in 2017.

Much of the information presented in this report was produced in earlier Watershed Approach work, prior to the development of the WRAPS report. However, the WRAPS report presents additional data and analyses. To ensure the WRAPS and other analyses appropriately represent the Cottonwood River Watershed, local and state natural resource and conservation professionals (referred to as the WRAPS Local Work Group [LWG]) were convened to help inform and advise on the development of the report.

Key products of this WRAPS report are the HUC-8 and HUC-10 strategies tables that provide high-level strategies and estimated adoption rates necessary to restore and protect water bodies in the Cottonwood River Watershed. Additional tools and data layers that can be used to refine priority areas and target strategies within those priority areas are also provided within this report.

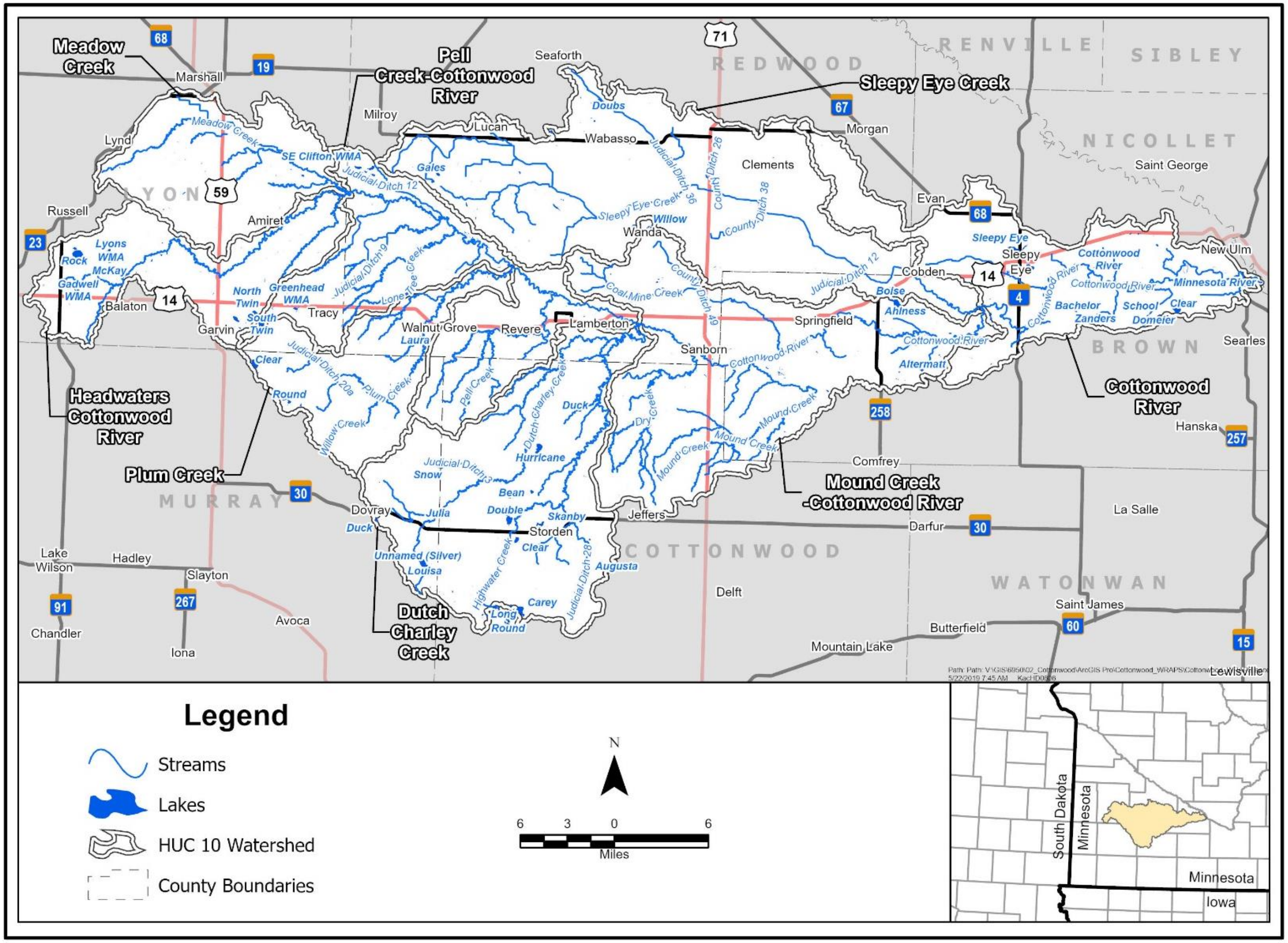
In summary, the purpose of the WRAPS report is to summarize work completed during the Watershed Approach in the Cottonwood River Watershed. The scope of the report is surface water bodies and their AqL and AqR beneficial uses as currently assessed by the MPCA. The primary audience for the WRAPS report is local planners, decision makers, and conservation practice implementers; watershed residents, neighboring downstream states, agricultural business, governmental agencies, and other stakeholders are additional audiences.

This WRAPS report is not a regulatory document but is legislatively required per the (updated) Clean Water Legacy legislation on WRAPS (ROS 2020). 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 October 10, 2022 through November 9, 2022. The WRAPS report 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.

1.2 Watershed Description

Located in southwestern Minnesota, the Cottonwood River Watershed covers approximately 840,000 acres and spans five counties: Brown, Cottonwood, Lyon, Murray, and Redwood (Figure 1). The Cottonwood River is in the Northern Glaciated Plains and Western Corn Belt Plains Level III ecoregions. These ecoregions are characterized by natural prairie vegetation and pothole lakes.

Figure 1. Cottonwood River Watershed overview.



The Cottonwood River flows 144 miles east from its headwaters to its confluence with the Minnesota River. The river's headwaters are in the Coteau des Prairies, an area of high elevation and glacial till deposits characterized by gentle, rolling hills, and steep ravines carved by streams and rivers. The Cottonwood River Watershed is comprised of eight major HUC-10 subwatersheds: Headwaters – Cottonwood River, Meadow Creek, Plum Creek, Pell Creek – Cottonwood River, Dutch Charley Creek, Mound Creek – Cottonwood River, Sleepy Eye Creek, and Cottonwood River. Elevation change along the Cottonwood River's 152-mile path is approximately 851 feet (Figure 2) as it travels to its confluence with the Minnesota River.

The Cottonwood River Watershed contains 1,932 stream miles, 26 named lakes, and about 135 lakes/ponds in total. Eighteen percent of the lakes and ponds are over 100 acres in surface water size while the remainder are as small as 1.5 acres. Approximately 50% of the streams and rivers within the watershed have been channelized. No hydropower dams exist on the Cottonwood River; however, there are a few small dams that have been identified for removal by the Minnesota Department of Natural Resources (DNR).

Row crop, specifically corn and soybean, is the dominant land use in the watershed (Figure 3). Approximately half of the streams within the watershed have been channelized (ditched) to increase drainage of water on the landscape, and in some cases to connect isolated drainage basins to the Cottonwood River Watershed. At least 70% of the wetlands in the region were drained to provide more land for farming. A significant network of subsurface tiles drain to the Cottonwood River, impacting hydrology by exacerbating both high and low flows. Identified stressors to biological communities in the Cottonwood River Watershed include habitat, altered hydrology, and eutrophication.

Several studies, reports, and plans have been written on the Cottonwood River Watershed. The MPCA released the Cottonwood River Watershed Monitoring and Assessment Report in 2020. The Draft Cottonwood River Watershed SID Report and the Cottonwood River Watershed TMDL Study were completed in late 2022 and are available on the MPCA Cottonwood River Watershed webpage or upon request. The DNR completed the Cottonwood River Watershed: Stream Crossing Inventory and Prioritization Report in 2018, the Cottonwood River Watershed Characterization Report in 2020, and the Cottonwood and Redwood River Watersheds SID Report – Lakes in 2021. RCRCA has also conducted extensive monitoring in the Cottonwood River Watershed. Water quality data dating back to 2012 can be found on the RCRCA website.

Figure 2. Cottonwood River Watershed elevation change.

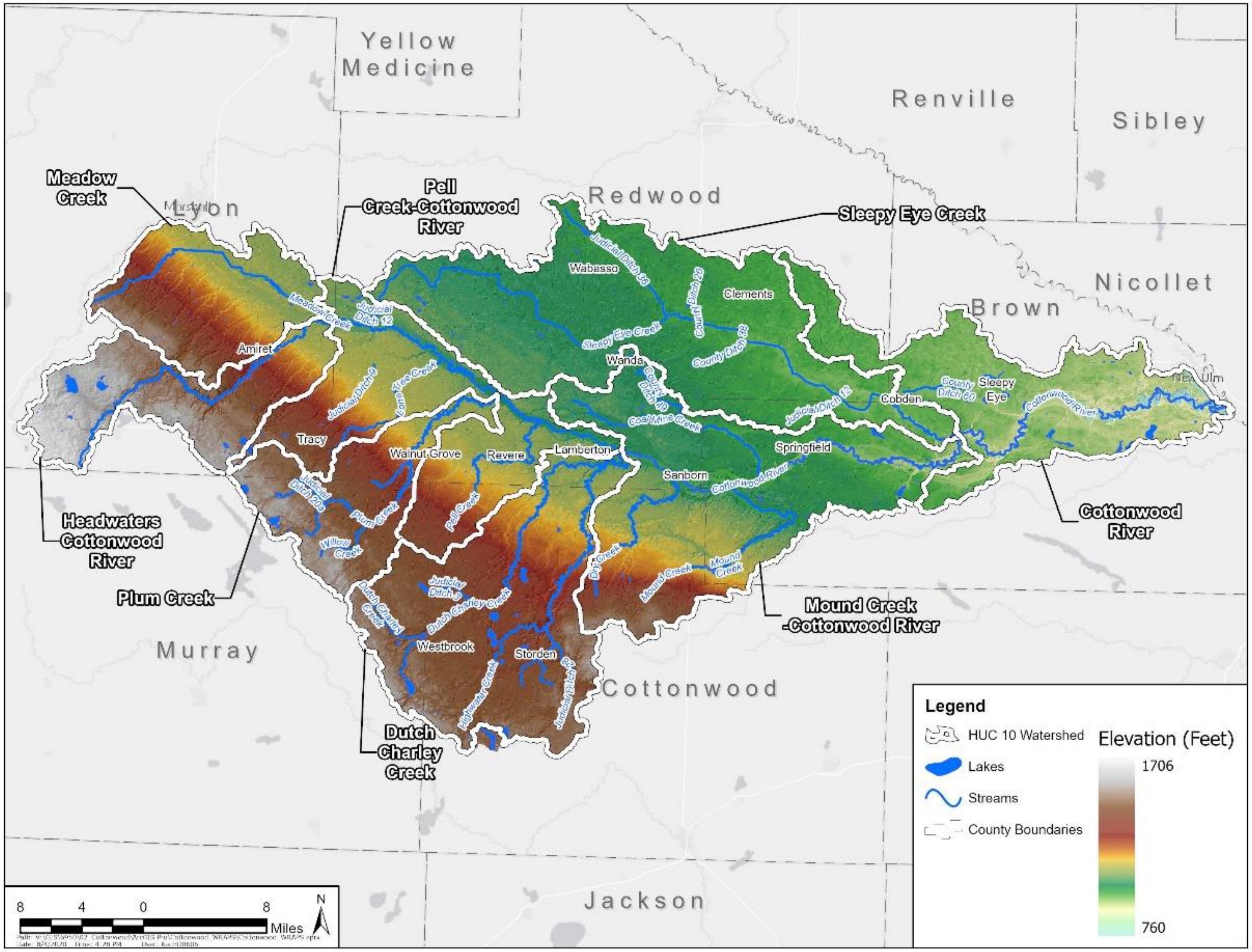
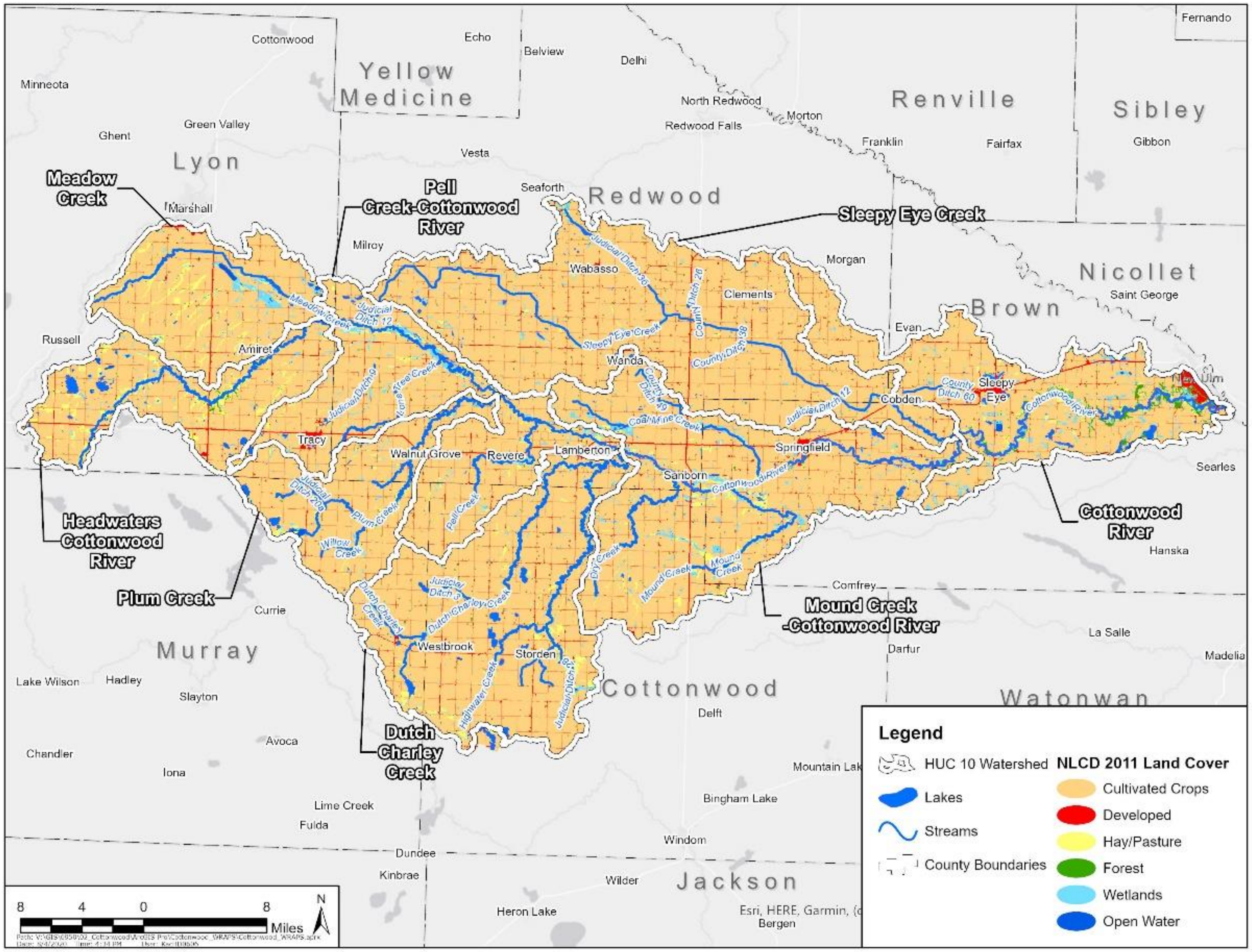


Figure 3. Cottonwood River Watershed land cover.



1.3 Environmental Justice

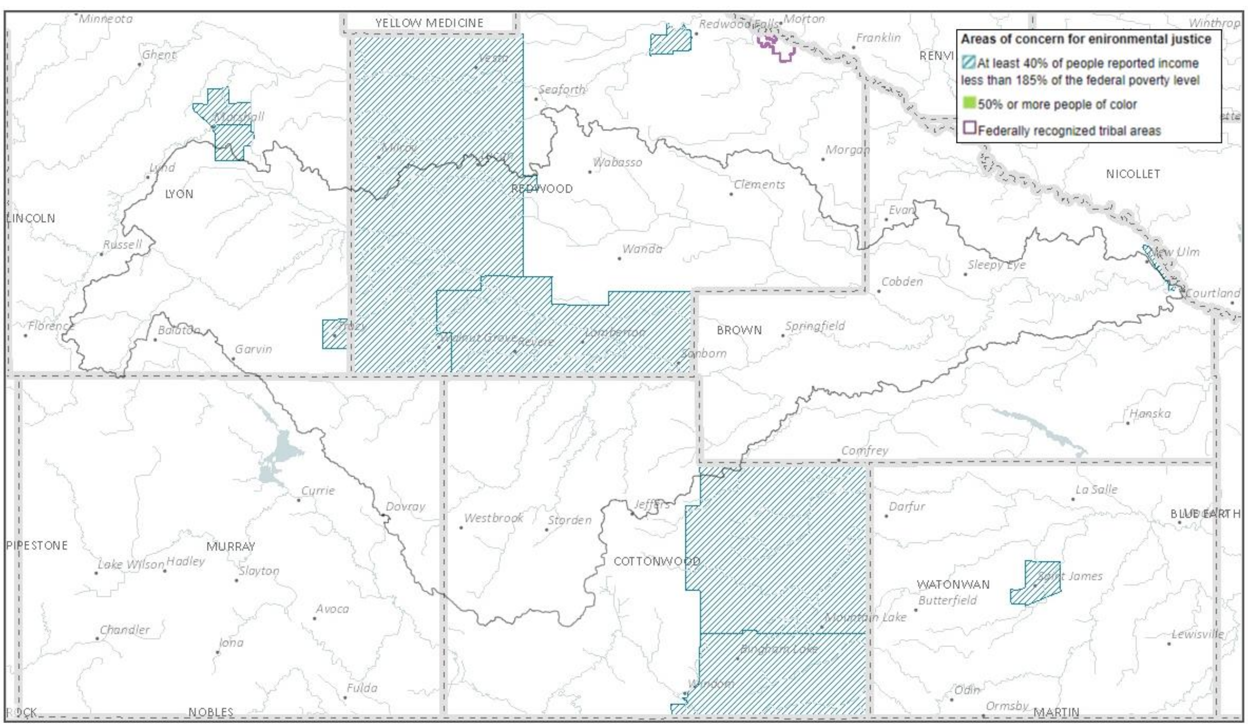
The MPCA is committed to making sure that pollution does not have a disproportionate impact on any group of people — the principle of environmental justice. This means that all people — regardless of their race, color, national origin, or income — benefit from equal levels of environmental protection and have opportunities to participate in decisions that may affect their environment or health. The MPCA strives to provide fair treatment and meaningful involvement with respect to the development, adoption, implementation, and enforcement of environmental laws, regulations, and policies.

The MPCA uses the U.S. Census tract as the geographic unit to identify areas of environmental justice concerns. The agency considers a census tract to be an area of concern for environmental justice if it meets one or both demographic criteria:

- The number of people of color is greater than 50%; or
- More than 40% of the households have a household income of less than 185% of the federal poverty level

Four areas were identified in the Cottonwood River Watershed as areas of environmental justice concerns based on the percentage of residents living below the poverty level including parts of Marshall and New Ulm (Figure 4).

Figure 4. Areas of environmental justice concern in the Cottonwood River Watershed.



Additionally, the MPCA considers communities within Tribal boundaries as areas of concern. This is an initial first step to identify areas where additional consideration or effort is needed to evaluate the potential for disproportionate adverse impacts, to consider ways to reduce those impacts, and to ensure meaningful community engagement as described in MPCA's environmental justice framework. No part of the Cottonwood River Watershed in Minnesota is located within the boundary of a Native American

Reservation (USCB 2018). However, Brown, Cottonwood, Lyon, Murray, and Redwood counties are of interest for the Lower Sioux Indian Community of Minnesota.

Additional information on the locations of areas of environmental justice concerns across the state and the MPCA commitment to environmental justice can be found on the MPCA website.

1.4 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 resources, and local professional review. A summary of the MPCA process is below.

Water Quality Standards

Waters throughout the state are not likely to be as pristine as they would be under undisturbed, "natural background" conditions. However, water bodies are still expected to support designated (or beneficial) uses including fishing (AqL), swimming (AqR), and eating of fish (aquatic consumption). Water quality standards (also referred to as "standards") are set after extensive review of data about the pollutant concentrations that support different designated uses, as well as estimation of natural background water quality 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. When pollutants/parameters in a water body meet the standard (usually when the monitored water quality is better than the water quality standard), the water body is considered supporting of beneficial uses. When pollutants/parameters in a water body do not meet the water quality standard, the water body is considered impaired. If the monitoring data sample size is not robust enough to ensure that the data adequately represent typical conditions within the water body, or if monitoring results seem unclear regarding the condition of the water body, an assessment is delayed until further data are collected; this is referred to as an inconclusive or insufficient finding.

Several different 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 algae-fueling phosphorus. For AqL assessment, streams are monitored for both AqL populations and several pollutants that are harmful to these populations. Lakes are monitored for AqL populations (fish populations). A water 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 IBI score).

This WRAPS report summarizes the water quality monitoring and assessment results; however, the full report is available at Cottonwood River Watershed Monitoring and Assessment Report (MPCA 2020).

Stressor Identification

When streams are found to be bio-impaired, the cause of bio-impairment is studied and identified in a process called SID. This process identifies the parameters negatively affecting the AqL populations, referred to as "stressors". Stressors can be pollutants like nitrate, phosphorus, or sediment or nonpollutants like degraded habitat or high flow. Stressors are identified using the Causal Analysis/Diagnosis Decision Information System (CADDIS; EPA 2019) 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. The full Cottonwood River Watershed SID Report will be published by December of 2022, and is currently available upon request.

Computer Modeling

While monitoring for pollutants and stressors is generally extensive, not every stream or lake can be monitored due to financial and logistical constraints. Computer modeling can extrapolate the known conditions of the watershed to areas with less monitoring data. Computer models, such as Hydrological Simulation Program - FORTRAN (HSPF; USGS 2014), 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 Cottonwood River Watershed are available in the Cottonwood and Redwood Watersheds HSPF Model Extension (Tetra Tech 2019). The Cottonwood River Watershed HSPF model can be utilized through the Scenario Application Manager (SAM; RESPEC 2021), a user-friendly graphical user interface developed to utilize the HSPF model and is available for download.

HSPF model data provide a reasonable estimate of pollutant concentrations across watersheds. The output can be used for source assessment, TMDL calculations, and prioritizing and targeting conservation efforts. However, these data are not used for impairment assessments since monitoring data are required for those assessments. Modeled pollutant and stressor yields are presented throughout this report and will be indicated as such.

For additional Cottonwood River Watershed technical resources, see Appendix E.

2. Watershed Conditions

2.1 Condition Status

This report addresses waters for restoration and protection of AqL uses based on the fishery, macroinvertebrate community, and TSS concentration, as well as AqR uses based on bacteria levels, nutrient levels, and water clarity. Waters that are listed as impaired will be addressed through restoration strategies and a Cottonwood River Watershed TMDL Study. Waters that are not impaired will be addressed through protection strategies to help maintain and improve water quality and recreation opportunities to prevent and/or reverse downward trends (see Section 3.3).

Mercury in fish tissue is a concern for streams and lakes in the Cottonwood River Watershed. All nine water body identifiers (WIDs) of the Cottonwood River mainstem are listed as impaired due to mercury in fish tissue. While not addressed in this WRAPS report, the Cottonwood River Watershed mercury impairments are included in the Minnesota Statewide Mercury TMDL (MPCA 2007).

Streams

Seventy of the 75 stream reaches in the Cottonwood River Watershed were assessed for aquatic use (Table 1). Of the 70 assessed reaches, only 19 fully supported AqL and no streams fully supported recreation. Throughout the watershed, 40 reaches were nonsupporting of AqL and/or recreation. Of those reaches, 34 are nonsupporting of AqL and 16 are nonsupporting of AqR (Figure 5).

Table 1. Assessment status of river and stream reaches in the Cottonwood River Watershed based on 2009 – 2018 data.

HUC-10 Subwatershed	# Total Reaches	# Assessed Reaches	Aquatic Life Use		Aquatic Recreation Use		IF
			FS	NS	FS	NS	
Headwaters Cottonwood River	5	4	0	4	0	1	0
Meadow Creek	11	9	2	6	0	2	0
Pell Creek – Cottonwood River	11	11	3	4	0	2	2
Plum Creek	5	5	2	3	0	2	0
Dutch Charley Creek	13	12	4	5	0	2	1
Mound Creek – Cottonwood River	9	9	1	6	0	4	2
Sleepy Eye Creek	11	11	5	5	0	2	0
Cottonwood River	10	9	2	1	0	1	3

FS = fully supporting, i.e., found to meet the water quality standard; NS = not supporting, i.e., does not meet the water quality standard, and therefore, is impaired; IF = insufficient data, i.e., the data collected were insufficient to make a finding

Lakes

Lakes are assessed for AqR use based on ecoregion-specific water quality standards for TP, chlorophyll-*a* (chl-*a*) (i.e., the green pigment found in algae), and Secchi transparency depth (i.e., water clarity). To be listed as impaired, a lake must fail to meet both water quality standards for TP and either chl-*a* or Secchi depth.

The Cottonwood River Watershed has water quality data on 25 lakes greater than 10 acres. Sleepy Eye Lake was previously listed as impaired for AqR. Implementation activities including septic system upgrades, sediment control practices, education, and lake dredging improved water quality in Sleepy Eye Lake, so it now meets standards and has been delisted. Seven monitored lakes in the watershed do not support AqR use: Rock, Bean, Double, Altermatt, Boise, Clear, and Bachelor. The remaining lakes had insufficient data to make an AqR assessment.

Since 2013, the MPCA in coordination with the DNR, has substantially increased the use of biological monitoring and assessment to determine and report the condition of the state's lakes. This includes sampling fish communities of multiple lakes throughout a major watershed. The fish-based lake IBI (FIBI) utilizes data from trap net and gill net surveys, which focus on the gamefish community, as well as nearshore surveys which focus on the nongame fish community. From this data, a FIBI score can be calculated, which provides a measure of overall fish community health. The DNR developed four FIBI tools to assess many different types of lakes throughout the state. More information on the FIBI can be found at the DNR Lake Index of Biological Integrity website. Two monitored lakes in the Cottonwood River Watershed are impaired for AqL use: Rock and Double (See Section 2.3).

Figure 5. Impairments in the Cottonwood River Watershed.

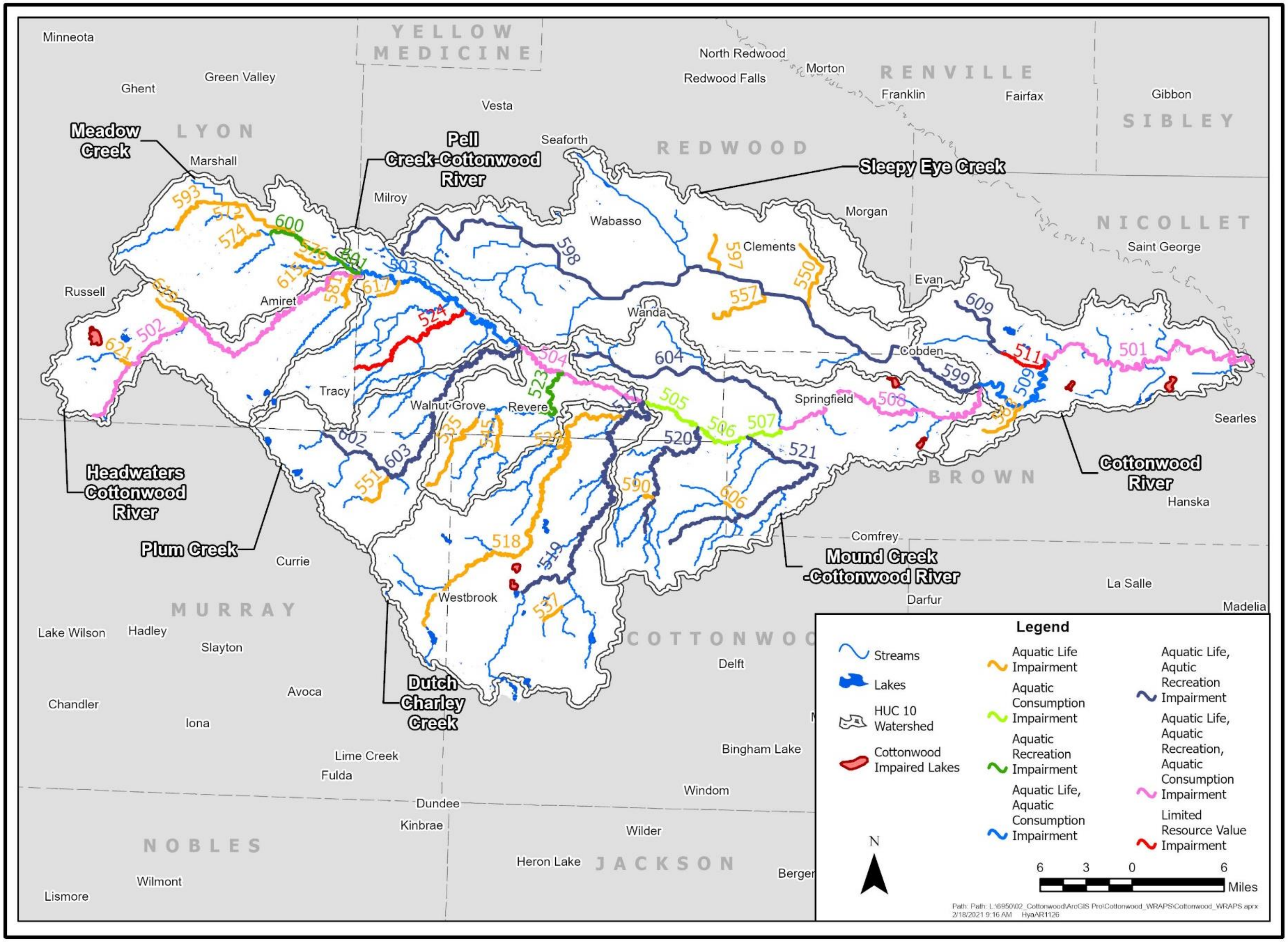


Table 2 below summarizes the ability of the Cottonwood River Watershed assessed lakes to support AqR and AqL uses. A complete list of the results of the AqR lake assessments can be found in the Watershed Monitoring and Assessment Report (MPCA 2020a), and the lake FIBI results can be found in the Cottonwood River and Redwood River Watersheds SID Report – Lakes (DNR 2021).

Table 2. Assessment status of the lakes in the Cottonwood River Watershed based on 2009 – 2018 data.

HUC-10 Subwatershed	Lakes >10 Acres	Aquatic Life Use		Aquatic Recreation Use		IF
		FS	NS	FS	NS	
Headwaters Cottonwood River	4	0	1	0	1	4
Meadow Creek	2	0	0	0	0	3
Pell Creek – Cottonwood River	2	0	0	0	0	2
Plum Creek	3	0	0	0	0	4
Dutch Charley Creek	7	0	1	0	2	7
Mound Creek – Cottonwood River	3	0	0	0	2	2
Sleepy Eye Creek	1	0	0	0	0	2
Cottonwood River	3	0	0	1	2	2

FS = fully supporting, i.e., found to meet the water quality standard; NS = not supporting, i.e., does not meet water quality standards, and therefore, is impaired; IF = insufficient data, i.e., the data collected were insufficient to make a finding.

Fish tissue from Sleepy Eye (1999) and Double Lakes (2015) were tested for mercury and both met aquatic consumption standards. Fish tissue from the Cottonwood River (1990 through 2017) and Sleepy Eye Lake (1999) have been tested for polychlorinated biphenyls (PCBs) and both also met aquatic consumption standards.

2.2 Watershed Trends

Precipitation

Precipitation in the Cottonwood River Watershed is typical of northern climates, with most of the yearly precipitation falling from June through August (DNR 2019). Observed precipitation trends in Minnesota have shown that larger, more frequent extreme precipitation events are occurring state-wide (DNR Climate Change website).

Long-term precipitation data for the watershed were analyzed in the Cottonwood River Watershed Characterization Report (DNR 2020). Data were acquired through the Minnesota State Climatology Office. The watershed's overall precipitation average for the period of record (1890 through 2017) was 26.4 inches. The seven-year moving average for average annual precipitation was above the long-term average from 1983 to 2017, indicating a recent departure from the long-term average showed variable trends over time, with some years exhibiting below average precipitation and others exhibiting above average precipitation (Figure 6). However, analysis using linear regression shows a weak, but increasing departure from the average annual precipitation over time (Figure 7). Average annual seasonal precipitation increased by roughly 59% and 19% for winter and spring, respectively since 1982 and summer and fall precipitation increased by 9% and 14% (DNR 2020).

Figure 6. Annual precipitation for the Cottonwood River Watershed from 1890–2017.

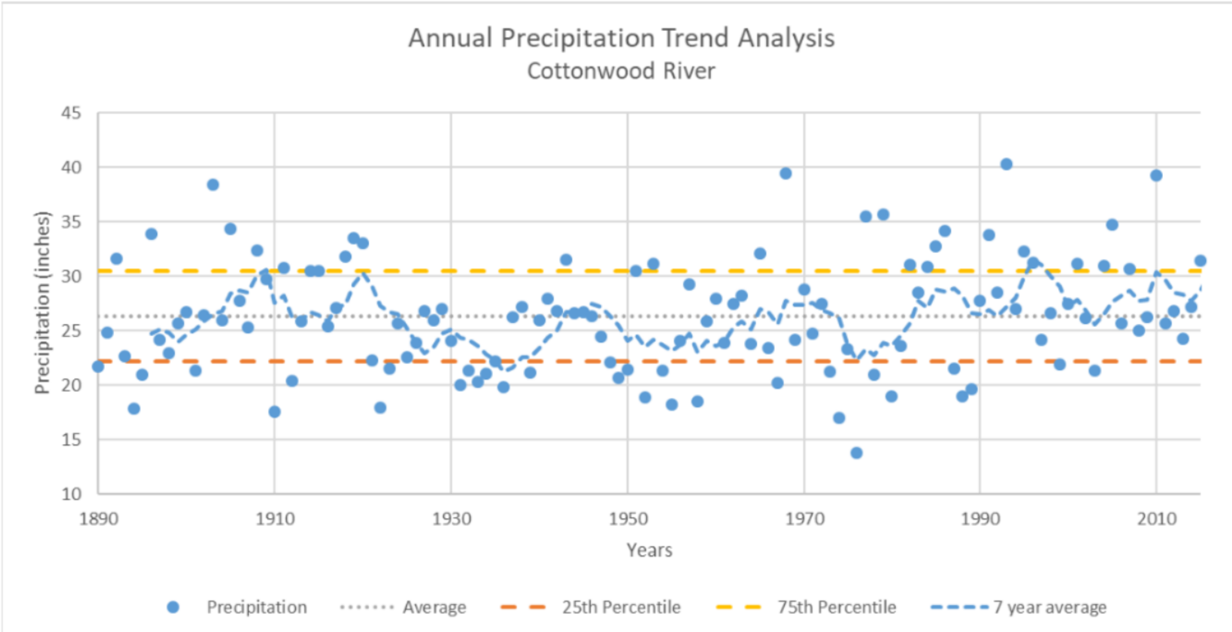
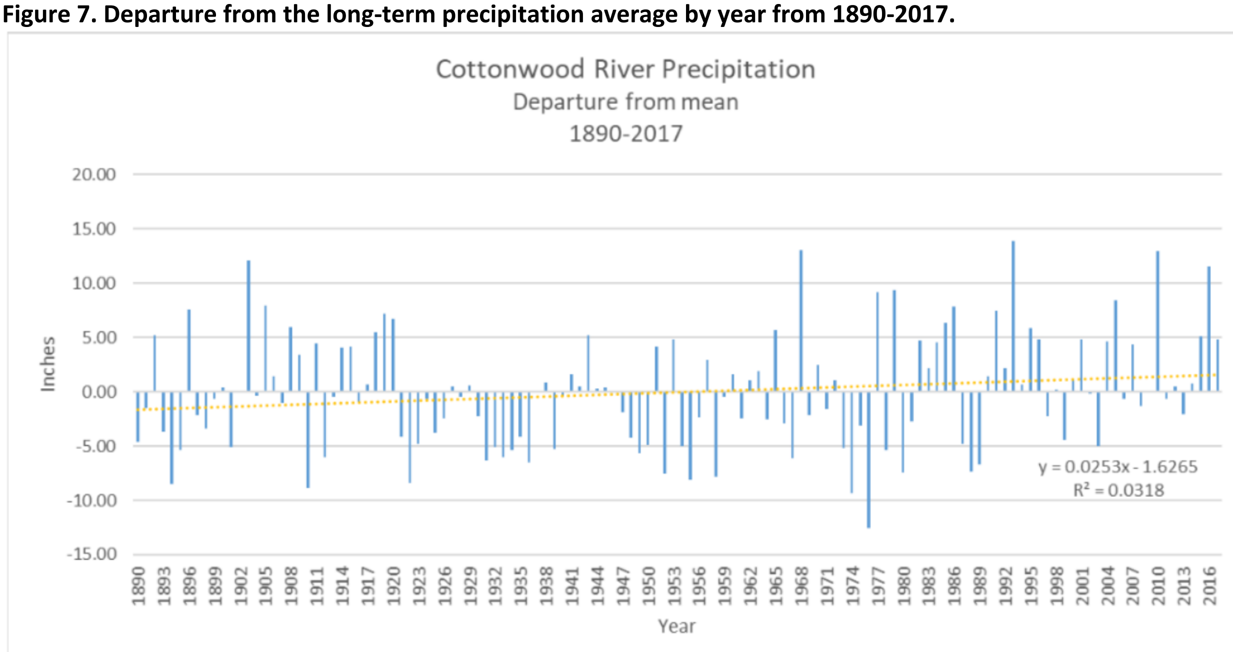


Figure 7. Departure from the long-term precipitation average by year from 1890-2017.



Rainfall trend data have also been aggregated through the Midwestern Regional Climate Center. Gage stations were selected based on location in or near the Cottonwood River Watershed and available period of record. Gage station data were aggregated for the Lamberton Southwest Research and Outreach Center, Marshall, Minneota, and Tracy stations, and the Redwood Falls Municipal Airport. Precipitation data were tabulated annually for the period of record from 1965 through 2019, and for the months of May through October over the period of record 2009 through 2019, and annually for the years 1965 through 2019. Maximum daily (24 hour) totals were also compiled, and data can be found in Appendix C.

Water Quality

Year-to-year weather variations affect water quality conditions and data; for this reason, analyzing long-term data trends is important for gaining insight into changes occurring in a water body over time. In a 2014 MPCA statewide river monitoring report (MPCA 2014b), Cottonwood River water chemistry data were analyzed for trends in pollutant concentrations (Table 3) for both the long-term period of record (1967 through 2009) and recent trends (1995 through 2009). The long-term record indicates that there have been significant improvements in TP, ammonia, and biochemical oxygen demand, and degradation of chloride levels. Recent trends show significant improvements in TSS and TP, and degradation of biochemical oxygen demand. Nitrite/nitrate concentrations showed no trend, which is consistent with the trend analysis of most HUC-8 watersheds in the MRB (MPCA 2014b). There was insufficient data to assess a recent trend in chloride. It is worth noting that even if concentrations are decreasing or stable, increasing flows can have the effect of increasing the overall load of pollutants.

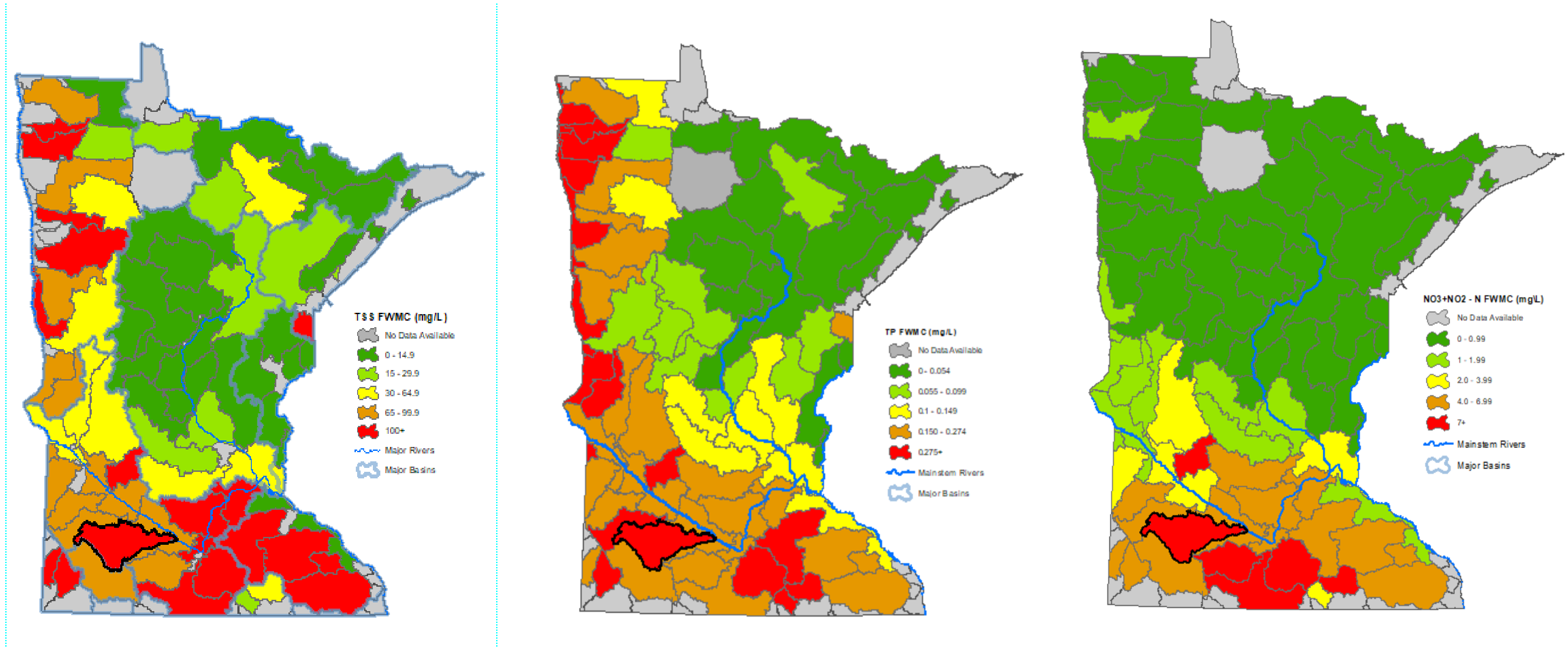
Table 3. Water quality concentration trends of the Cottonwood River (at MN-15, S000-139).

Parameter	Long-term trend (1967-2009)	Recent trend (1995-2009)
Total suspended solids	No trend	Decrease (-55%)
Total phosphorus	Decrease (-50%)	Decrease (-47%)
Nitrite/Nitrate	No trend	No trend
Ammonia	Decrease (-64%)	No trend
Biochemical oxygen demand	Decrease (-64%)	Increase (+54%)
Chloride	Increase (+47%)	Little data

The MPCA's Watershed Pollutant Load Monitoring Network (WPLMN) has established three long-term monitoring locations within the Cottonwood River Watershed: Cottonwood River near New Ulm, Sleepy Eye Creek near Cobden, and Cottonwood River near Leavenworth. The data associated with these sites can be accessed via the WPLMN Data Viewer, which shows the location of long-term monitoring sites throughout the state. It includes links to the MPCA's Environmental Data Access (EDA) portal that contains all submitted monitoring data for the entire period of record, including more recent data through 2019.

When compared with other major watersheds throughout the state, average annual TSS, TP, and nitrite/nitrate flow-weighted mean concentrations (FWMCs from 2007 - 2019) are several times higher for the Cottonwood River Watershed than watersheds in north central and northeast Minnesota. The Cottonwood River Watershed is more typical of the agriculturally rich watersheds found in the northwest and southern regions of the state (Figure 8). See discussion on pages 86 to 89 of the Cottonwood River Watershed Monitoring and Assessment Report (MPCA 2020a) for more information on results of the WPLMN for the Cottonwood River.

Figure 8. Cottonwood River Watershed TSS, TP, and nitrite/nitrates FWMCs (2007 – 2019).



The MPCA completes annual trend analysis on lakes and streams across the state based on long-term transparency measurements. The data collection for this work relies heavily on volunteers across the state and incorporates any agency and partner data submitted to the Environmental Quality Information System (EQuIS). Volunteer stream and lake monitors collect data for one stream site and three lakes in the Cottonwood River Watershed. The calculated trends use a Seasonal Kendall statistical test for waters with a minimum of eight years of Secchi disk measurement in lakes and Secchi tube measurements in streams. A total of 10 water bodies in the watershed had sufficient data for trend analysis. Of those 10 water bodies, two stream sites had increasing clarity and five had decreasing clarity (Table 4).

Table 4. Trends in stream transparency in the Cottonwood River Watershed 2008-2018.

HUC-10 Subwatershed	Water Body Name	Station ID	Trend
07020008-603	Plum Creek	S001-699	Degrading ↓
07020008-603	Plum Creek	S001-913	Improving ↑
07020008-501	Cottonwood River	S001-918	Degrading ↓
07020008-504	Cottonwood River	S004-607	Degrading ↓
07020008-504	Cottonwood River	S002-247	No Trend
07020008-508	Cottonwood River	S001-920	Degrading ↓
07020008-508	Cottonwood River	S007-353	No Trend
07020008-609	Judicial Ditch 30	S004-153	Improving ↑
07020008-519	Highwater Creek	S004-608	Degrading ↓
07020008-599	Sleepy Eye Creek	S001-919	No Trend

Note: Up arrows indicate an improving trend while Down arrows indicate a degrading trend

2.3 Stressors and Sources

To develop appropriate strategies for restoring or protecting the aquatic biological communities of water bodies, the stressors and sources impacting or threatening them must be identified and evaluated. SID is conducted for stream/river reaches with either fish or macroinvertebrate biota impairments and lakes with fish impairments. SID encompasses the evaluation of both pollutant (e.g., TSS, nitrate, TP) and nonpollutant (e.g., altered hydrology, fish passage, habitat) factors as potential stressors. Pollutant source assessments are completed when a biological SID process identifies a pollutant as a stressor, as well as for the typical pollutant impairment listings. Section 3 provides further detail on stressors and pollutant sources.

Stressors of biologically impaired lakes

Two lakes, Rock and Double (the north portion) Lakes in the Cottonwood River Watershed were assessed for AqL by the DNR and both were found to not support AqL based on FIBI scores.

Candidate causes for the biological impairments were examined in the Cottonwood and Redwood River Lake SID Report (DNR 2021). Eutrophication (excess nutrients) was identified as the primary stressor to the impaired lakes as both contain relatively high levels of nutrients and are in watersheds with high land use disturbance (i.e., greater than 40%). Eutrophication has detrimental effects on aquatic biology through changes to aquatic plant diversity and abundance, restructuring of plankton communities, and negative impacts to vegetation-dwelling and sight-feeding predatory fishes.

Stressors of biologically impaired stream and river reaches

There were 30 stream reaches in the Cottonwood River Watershed designated as having impaired AqL due to poor quality biological communities. To identify probable stressors causing these impairments, an intensive field survey and data evaluation was conducted by the MPCA. The resulting SID report provided detailed information and weight of evidence analysis to link stressors to the impairments. Table 5 summarizes the primary stressors for the impaired reaches identified in the Cottonwood River Watershed SID Report (MPCA 2022 - available upon request). Insufficient habitat was the most common stressor to the biology followed by altered hydrology, eutrophication, and connectivity.

Table 5. Primary stressors to AqL in biologically impaired reaches in the Cottonwood River Watershed.

HUC-10 Subwatershed	AUID (Last 3 digits)	River or Stream	Biological impairment	Dissolved oxygen	Eutrophication	TSS	Connectivity	Altered Hydrology	Nitrate	Habitat
Headwaters Cottonwood River	502	Cottonwood River	Fish and macroinvertebrate	o	o	●	●	---	---	●
Upper Cottonwood River	503	Cottonwood River	Fish and macroinvertebrate	o	o	o	---	---	o	●
Dutch Charley Creek	517	Dutch Charley Creek	Fish	---	o	●	---	---	o	●
Dutch Charley Creek	518	Dutch Charley Creek	Fish and macroinvertebrate	●	●	o	●	●	o	●
Dry Creek	520	Dry Creek	Fish and macroinvertebrate	---	o	o	●	o	●	●
Mound Creek	521	Mound Creek	Macroinvertebrate	o	●	---	●	●	o	●
Dutch Charley Creek	529	Unnamed Creek	Macroinvertebrate	---	o	---	---	---	o	●
Highwater Creek	537	CD 38	Macroinvertebrate	o	o	---	o	●	---	●
Pell Creek	545	Unnamed Creek	Fish and macroinvertebrate	---	---	o	●	●	o	●
Sleepy Eye Creek	550	CD 24	Fish and macroinvertebrate	o	o	o	---	●	●	●
Plum Creek	551	Willow Creek	Macroinvertebrate	o	---	o	NA	●	---	o
Sleepy Eye Creek	557	CD 38	Macroinvertebrate	●	●	o	●	●	●	●
Lower Cottonwood River	563	Unnamed Creek	Macroinvertebrate	o	o	---	---	●	---	●
Meadow Creek	569	Unnamed Creek	Macroinvertebrate	o	●	o	●	●	o	●
Meadow Creek	573	Unnamed Creek	Macroinvertebrate	o	o	---	●	●	---	●
Meadow Creek	574	Unnamed Creek	Macroinvertebrate	o	o	o	---	---	o	●
Meadow Creek	576	Unnamed Creek	Macroinvertebrate	●	o	---	●	●	---	●

HUC-10 Subwatershed	AUID (Last 3 digits)	River or Stream	Biological impairment	Dissolved oxygen	Eutrophication	TSS	Connectivity	Altered Hydrology	Nitrate	Habitat
Headwaters Cottonwood River	581	Unnamed Creek	Macroinvertebrate	---	o	●	---	---	o	●
Dry Creek	590	Unnamed Creek	Macroinvertebrate	---	●	o	---	●	o	●
Meadow Creek	593	Unnamed Creek	Macroinvertebrate	o	---	o	---	---	o	●
Sleepy Eye Creek	597	CD 26	Macroinvertebrate	●	●	---	---	●	---	●
Sleepy Eye Creek	598	Sleepy Eye Creek	Fish	o	●	o	---	●	●	●
Sleepy Eye Creek	599	Sleepy Eye Creek	Macroinvertebrate	---	●	●	---	●	●	●
Coal Mine Creek	604	Coal Mine Creek	Macroinvertebrate	●	●	o	NA	●	o	●
Mound Creek	606	Unnamed Creek	Macroinvertebrate	o	●	---	●	●	o	●
Judicial Ditch 30	609	Judicial Ditch 30	Fish	o	●	o	●	●	o	●
Meadow Creek	615	Unnamed Creek	Macroinvertebrate	---	o	o	---	●	o	●
Upper Cottonwood River	617	Cottonwood River	Fish and macroinvertebrate	---	o	o	---	---	o	●
Headwaters Cottonwood River	619	Unnamed Creek	Fish and macroinvertebrate	o	●	●	---	●	o	●
Headwaters Cottonwood River	621	Unnamed Creek	Fish and macroinvertebrate	---	o	o	---	●	---	---

● = stressor; o = inconclusive stressor; --- = not an identified stressor

2.4 Pollutant Sources

This section summarizes the sources of pollutants (sediment, phosphorus, nitrate, *E. coli*) to lakes and streams in the Cottonwood River Watershed, including point sources (such as wastewater treatment plants) or nonpoint sources (such as runoff from the land). Cottonwood River Watershed HSPF model results (Tetra Tech 2019) were used to evaluate the relative magnitude of nonpoint versus point sources in the Cottonwood River Watershed as shown in Table 6. In general, nonpoint source pollution represents the dominant pathway for sediment and nutrient export to most streams and lakes throughout each subwatershed. HSPF does not model bacteria and therefore was not used to estimate *E. coli* sources. More information about the HSPF model is provided in Section 3.2 of this report.

Table 6. HSPF estimated source contributions of sediment, TP, and TN for each major HUC-10 subwatershed in the Cottonwood River Watershed for HSPF-SAM (Version 1.0) model averaging period 1996 - 2017.

	Nonpoint Sources					Point Sources
HUC-10 Subwatershed	Forest and Wetland	Pasture and Grassland	Cropland	Developed	Stream Bed/ Bank/Bluff	
Sediment (TSS, tons/year)						
Headwaters Cottonwood River	2	99	1,457	472	349	2
Meadow Creek	<1	50	1,743	500	679	-
Pell Creek	<1	47	3,743	1,278	8,331	6
Plum Creek	2	55	1,686	562	6,029	-
Dutch Charley Creek	5	117	6,066	1,280	23,412	5
Mound Creek	1	64	2,864	1,434	9,569	4
Sleepy Eye Creek	1	7	5,978	1,314	2,550	3
Cottonwood River	3	17	3,477	1,207	16,204	13
Phosphorus (TP, lbs/year)						
Headwaters Cottonwood River	21	239	18,035	588	1	442
Meadow Creek	20	149	18,590	610	2	-
Pell Creek	35	144	35,488	1,472	773	1,191
Plum Creek	20	135	21,935	617	1,578	-
Dutch Charley Creek	39	258	49,305	1,453	10,028	317
Mound Creek	82	300	62,379	1,965	253	1,956
Sleepy Eye Creek	28	30	64,762	1,799	5	841
Cottonwood River	72	92	37,534	1,691	859	7,309
Nitrogen (TN, lbs/year)						
Headwaters Cottonwood River	4,901	61,605	1,418,356	791	-	1,007
Meadow Creek	4,473	38,874	1,418,083	1,267	-	-
Pell Creek	9,974	35,814	2,498,669	2,465	-	6,364
Plum Creek	3,698	23,903	1,514,182	667	-	-
Dutch Charley Creek	8,456	54,401	3,518,154	2,091	-	2,643
Mound Creek	22,068	59,884	4,480,165	3,387	1	16,468
Sleepy Eye Creek	12,646	11,184	5,445,486	2,759	-	3,674
Cottonwood River	25,379	38,714	3,530,844	5,566	56	5,198

Section 3.6 of the Cottonwood River Watershed TMDL Study (MPCA 2022) provides a thorough description of the relative contribution of point and nonpoint phosphorus sources to the watershed's impaired lakes, as well as point and nonpoint bacteria and sediment sources to the watershed's impaired streams. Below is a brief discussion of the point and nonpoint sources that have been identified in these watersheds. Other sources and practices to reduce pollutant contributions are discussed in Section 3.3.

Point Sources

Point sources are regulated through National Pollutant Discharge Elimination System (NPDES)/State Disposal System (SDS) permits. Regulations of NPDES permits vary, depending on the type of point source. Some permittees are not allowed to discharge (e.g., Confined Animal Feedlot Operations (CAFO) permits), some are allowed to discharge but must treat and measure effluent pollutants to ensure permit requirements are met (e.g., wastewater treatment plant permits), and some permits only allow discharge under special circumstances or require the use of BMPs to limit the discharge of pollutants (e.g., construction permits). As shown in Table 6 (above), point sources account for relatively small percentages of the overall pollutant loads for each of the HUC-10 watersheds. Estimates are based on HSPF model results.

Municipal and Industrial Wastewater

There are 15 active permitted surface wastewater dischargers in the Cottonwood River Watershed (Table 7). These facilities discharge directly to or are located upstream of an impaired reach. Individual TSS, *E. coli*, and/or phosphorus WLAs were provided for each facility in the various TMDL studies that have been completed in the Cottonwood River Watershed. To date, none of the completed TMDLs require any changes to these facilities' discharge permit limits.

Table 7. Point sources in the Cottonwood River Watershed.

HUC-10 Subwatershed	Name	Permit #	Type	Pollutant Reduction Required
Headwaters – Cottonwood River	Balaton WWTP	MN0020559	Municipal	No
	Garvin WWTP	MNG580101	Municipal	No
Pell Creek – Cottonwood River	Revere WWTP	MNG580114	Municipal	No
	Tracy WWTP	MN0021725	Municipal	No
	Walnut Grove WWTP	MN0021776	Municipal	No
Dutch Charley Creek	Lamberton WWTP	MNG580100	Municipal	No
	Westbrook WWTP	MNG580127	Municipal	No
	Storden WWTP	MNG580106	Municipal	No
Mound Creek – Cottonwood River	Sanborn WWTP	MNG580115	Municipal	No
	Springfield WWTP	MN0024953	Municipal	No
Sleepy Eye Creek	Clements WWTP	MNG580094	Municipal	No
	Lucan WWTP	MNG580112	Municipal	No
	Wabasso WWTP	MN0025151	Municipal	No
	Wanda WWTP	MNG580126	Municipal	No
Cottonwood River	Sleepy Eye WWTP	MNG580041	Municipal	No

Municipal, 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 city of New Ulm (MS400228) is the largest city in the Cottonwood River Watershed and is located at the confluence of the Minnesota River. A small portion (~671 acres) of the city of Marshall (MS400241) is also located within the Cottonwood River Watershed near the headwaters of the

Meadow Creek Subwatershed. Both the City of New Ulm and Marshall are subject to the MPCAs MS4 Permit program. 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. 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 & 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 Cottonwood 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 0.15% of land in the Cottonwood River Watershed is currently under a Construction and Industrial Stormwater Permit suggesting these land uses are not a significant source of pollutants in the Cottonwood River Watershed.

Animal Feeding Operations

Livestock animals are potential sources of bacteria, phosphorus, and nitrogen to streams in the Cottonwood 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.

CAFO is an U.S. Environmental Protection Agency (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; but 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, 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, manure management planning 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.

In the Cottonwood River Watershed, Redwood County is the only county that is not delegated to administer feedlot-related activities such as permitting, inspections, and compliance/enforcement. In Redwood County, the MPCA fulfills these responsibilities. Brown, Cottonwood, Lyon, and Murray Counties are delegated counties and therefore administer 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 MPCA registered feedlot database indicates there were approximately 513 active feedlot facilities with over 228,065 livestock AUs throughout the Cottonwood River Watershed as of 2018 (Figure 9). Table 8 summarizes facility type and livestock numbers for each impaired reach, lake, and the entire watershed. In the Cottonwood River Watershed, there are 46 feedlots located within 1,000 feet of a lake or 300 feet of a stream or river, an area generally defined as shoreland. Thirty-seven of these feedlots in shoreland have open lots and could present a potential pollution hazard if the runoff from the open lots is not treated prior to reaching surface water.

Figure 9. MPCA registered feedlots in the Cottonwood River Watershed.

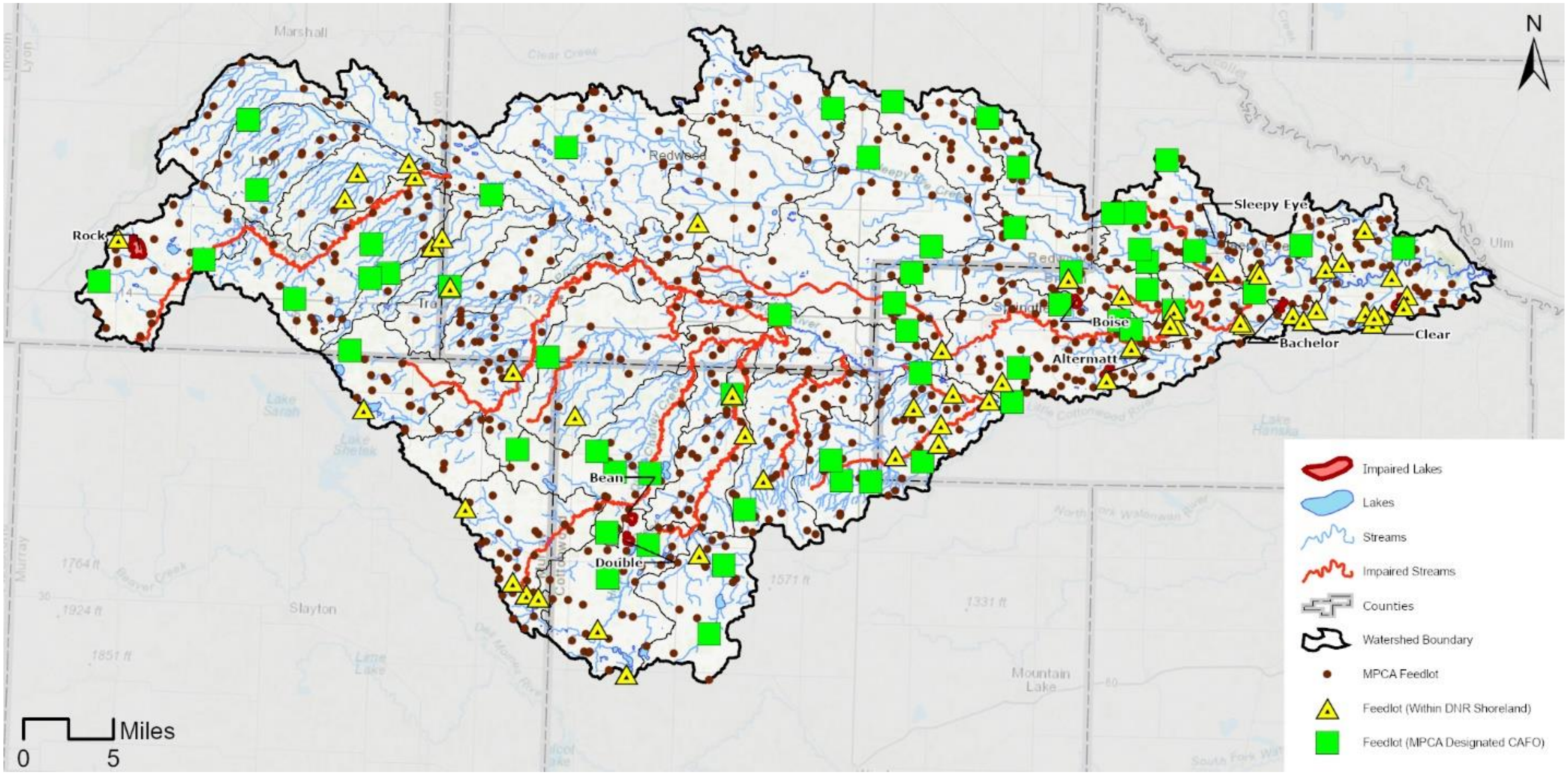


Table 8. MPCA active registered feedlots and feedlot type for each *E. coli* impaired reach and impaired lake in the Cottonwood River Watershed.

Impaired Reach/Lake	Impairment Type	Total Operations		CAFOs		Open Lots		Shoreland		Open Lots in Shoreland	
		Count	AUs	Operations	AUs	Operations	AUs	Operations	AUs	Operations	AUs
Cottonwood River Reach 502	*E. coli*	47	19,325	3	3,768	31	7,597	1	651	-	-
Judicial Ditch 30 Reach 511	*E. coli*	38	10,945	3	3,131	28	6,375	1	10	-	-
Highwater Creek Reach 519	*E. coli*	59	16,618	2	6,195	20	6,553	5	5,515	3	633
Dry Creek Reach 520	*E. coli*	29	5,933	1	900	19	4,087	1	84	1	84
Mound Creek Reach 521	*E. coli*	40	14,146	3	1,860	23	6,769	5	781	4	691
Pell Creek Reach 523	*E. coli*	12	1,799	-	-	9	1,724	1	15	-	-
Coal Mine Creek Reach 604	*E. coli*	12	4,013	1	1,106	9	2,081	-	-	-	-
Coal Mine Creek Reach 609	*E. coli*	29	9,557	3	3,131	21	5,741	-	-	-	-
Bean Lake	Nutrients	-	-	-	-	-	-	-	-	-	-
Double Lake	Nutrients	1	200	-	-	-	-	-	-	-	-
Rock Lake	Nutrients	6	1,631	-	-	4	560	1	651	-	-
Clear Lake	Nutrients	6	272	-	-	6	272	5	208	5	208
Altermatt Lake	Nutrients	4	1,486	-	-	4	1,486	1	549	1	549
Boise Lake	Nutrients	1	900	-	-	-	-	-	-	-	-
Bachelor Lake	Nutrients	-	-	-	-	-	-	-	-	-	-
Entire Cottonwood River Watershed	**Multiple**	**513**	**228,065**	**64**	**91,155**	**322**	**98,170**	**46**	**13,108**	**37**	**5,555**

Nonpoint Sources

Nonpoint sources of pollution, unlike pollution from industrial and municipal wastewater treatment plants, can come from many different sources. Nonpoint source pollution is accumulated by rainfall or snowmelt moving over and through the ground. As the runoff moves, it picks up and carries natural and human-made pollutants, finally depositing them into lakes and streams. Common nonpoint pollutant sources in the Cottonwood River Watershed are summarized below. Specific strategies to address nonpoint pollutant sources are discussed in Section 3.3.

Watershed runoff

Nonpoint pollutant loads in rural areas can come from nonpermitted sources such as sediment erosion from upland fields, tile drainage, gully erosion, and livestock pastures in riparian zones (Schottler et al. 2013). Runoff from these sources can carry sediment, bacteria, phosphorus, and other nutrients to surface waters. Upland nonpoint sources of sediment, nitrate, and phosphorus were evaluated using the Cottonwood HSPF Model (Tetra Tech 2019). The results provide hourly runoff flow rates, sediment concentrations, and nutrient concentrations, along with other water quality constituents, at the outlet of any modeled subwatershed for the model time period of 1996 through 2017. Model documentation contains additional details about model development and calibration (Tetra Tech 2019). Within each subwatershed, the upland areas are separated into multiple land use categories and are further parameterized based on hydrologic soil group. Simulated loads from upland areas represent the pollutant loads that are delivered to the modeled stream or lake; the loading rates do not represent field-scale soil loss estimates.

Overall, across the entire Cottonwood River HUC-8 Watershed, approximately 27% of the TSS load, 88% of the TP load, and 99% of the TN load is from cultivated crops and hay/pasture lands that were identified in the 2016 National Land Cover Database (NLCD) land use layer. Relative contributions by source vary widely between individual reaches.

Altered hydrology

Near-channel sources of sediment and nutrients are those near the stream channel, including bluffs, banks, ravines, and the stream channel itself. Hydrologic changes in the landscape and altered precipitation patterns driven by climate change can lead to increased nitrate, TSS, and sediment-bound phosphorus in surface waters. Subsurface drainage tiling, channelization of waterways, land cover alteration, and increases in impervious surfaces all decrease detention time in the watershed and increase flow from fields and in streams. Draining and tiling wetland areas can decrease water storage on the landscape, which can lead to lower evapotranspiration and increased river flow (Schottler et al. 2013).

The straightening and ditching of natural rivers increase the slope of the original watercourse and moves water off the land at a higher velocity in a shorter amount of time. These changes to the way water moves through a watershed and how it makes its way into a river can lead to increases in water velocity, scouring of the river channel, and increased erosion of the riverbanks (Schottler et al. 2013, Lenhart et al. 2013).

HSPF model output suggests approximately 65% of the TSS load, 4% of the TP load, and <1% of the TN load at the outlet of the Cottonwood River Watershed comes from near-channel sources. Additionally, the Cottonwood River Watershed Characterization Report (DNR 2020) provides an in-depth discussion of the processes, sources, and potential strategies to address near-channel sources in the Cottonwood River Watershed. This report includes the following components: characterization of the watershed, analysis of historical and existing hydrological data, assessment of geomorphic conditions and stream connectivity throughout the watershed. The report recommends three areas of focus with accompanying implementation practices for addressing hydrology in the Cottonwood River Watershed:

- **Upland restoration**
    - Increase water storage (temporary and long-term)
    - Increase perennial vegetation
    - Increase soil organic matter
- **In- and near-channel**
    - Stabilize banks that endanger infrastructure
    - Re-size bridges and culverts to allow flood flows on the floodplain, when applicable
    - Reconnect areas with longitudinal barriers to fish passage
- **Protection**
    - Existing lakes, wetlands, and wet marshes should be protected
    - Protect areas of significant groundwater-surface water interaction
    - Protect areas that are already enrolled in conservation programs or other BMPs
    - Protect areas that have been shown to remain stable over time

Runoff from manure application

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 manure management plans and land application of manure. The MPCA has developed templates, guides, and standards for the development and implementation of manure management plans, manure nutrient management, and application rates. Manure management plans 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. Manure management plans 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 a significant amount of late winter solid manure application (before the ground thaws) in the Cottonwood 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 Manure Management Plan (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. 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.

Natural bacterial reproduction and wildlife

It has been suggested that *E. coli* bacteria has the capability to reproduce naturally in water and sediment and therefore should be considered when identifying bacteria sources. Two Minnesota studies describe the presence and growth of “naturalized” or “indigenous” strains of *E. coli* in watershed soils (Ishii et al. 2010), and ditch sediment and water (Sadowsky et al. 2015). The latter study, supported with Clean Water, Land, and Legacy funding, was conducted in the Seven Mile Creek Watershed, an agricultural landscape in south central Minnesota. DNA fingerprinting of *E. coli* from sediment and water samples collected in Seven Mile Creek from 2008 through 2010 resulted in the identification of 1,568 isolates comprised of 452 different *E. coli* strains. Of these strains, approximately 64% were represented by a single isolate, suggesting new or transient sources of *E. coli*. The remaining 36% of strains were represented by multiple isolates, suggesting persistence of specific *E. coli*. Discussions with the primary author of the Seven Mile Creek study suggest that while 36% might be used as a rough indicator of “background” levels of bacteria at this site during the study period, this percentage is not directly transferable to the concentration and count data of *E. coli* used in water quality standards and TMDLs. Additionally, because the study is not definitive as to the ultimate origins of this bacteria, it would not be appropriate to consider it as “natural” background.

Below is a summary of other studies that have found the persistence of *E. coli* in soil, beach sand, and sediments throughout the year in the United States without the continuous presence of sewage or mammalian sources:

- An Alaskan study (Adhikari et al. 2007) found that total coliform bacteria in soil were able to survive for six months in subfreezing conditions.

- A study in Michigan (Marino and Gannon 1991) documented survival and growth of fecal coliform in storm sewer sediment.
- Two studies in Maryland (Park et al. 2016; Pachepsky et al. 2017) demonstrated that release of *E. coli* from streambed sediments during baseflow periods is substantial and that water column *E. coli* concentrations are dependent on not only land management practices but also in-stream processes.

Wildlife, which includes deer and waterfowl, also represents a small portion of the bacteria produced in the impaired reach watersheds. These could include but are not limited to open water areas with high waterfowl densities and lawns or golf courses near streams where geese or other waterfowl congregate.

Failing septic systems and unsewered communities

Failing subsurface sewage treatment systems (SSTS) near waterways can be a source of bacteria, phosphorus, and nitrogen to streams and lakes, especially during low flow periods when these sources continue to discharge, and runoff driven sources are not active. SSTS can fail for a variety of reasons including excessive water use, poor design, physical damage, and lack of maintenance. Common limitations that contribute to failure include seasonal high-water table, fine-grained soils, bedrock, and fragipan (i.e., altered subsurface soil layer that restricts water flow and root penetration). SSTS can fail hydraulically through surface breakouts or hydrologically from inadequate soil filtration.

The MPCA differentiates between systems that fail to protect groundwater (FTPGW) and those that are an imminent threat to public health and safety (ITPHS). Generally, FTPGW systems are those that do not provide adequate treatment and may contaminate groundwater. For example, a system deemed failing to protect groundwater may have a functioning, intact tank and soil absorption system, but fails to protect groundwater by providing a less than sufficient amount of unsaturated soil between where the sewage is discharged and the periodically saturated soil level or bedrock. FTPGW systems can also include, but are not limited to the following:

- Seepage pits/cesspools/drywells/leaching pits
- Systems with less than the required vertical separation
- Systems not abandoned in accordance with Minn. R. 7080.2500

Systems considered ITPHS are severely failing or were never designed to provide adequate raw sewage treatment. These include SSTS and straight pipe systems that transport raw or partially treated sewage directly to a lake, stream, drainage system, or ground surface. ITPHS systems can include, but are not limited to the following:

- Straight pipes
- Sewage surfacing in the yard
- Sewage backing up into the home
- Unsafe tank lids
- Structurally unsound tanks
- Unsafe electrical conditions

Currently, the exact number and status of SSTSs in the Cottonwood River Watershed is unknown. However, counties provide regular estimates of FTPGW and ITPHS compliance rates to the MPCA. Table 9 shows estimates of FTPGW and ITPHS systems in the each of the counties included in the Cottonwood River Watershed (MPCA personal communication 2018). It should be noted that these rates are county-wide estimates and were developed using a wide range of methods and resources and are intended for planning purposes only.

Table 9. Estimated SSTS compliance rates by county (MPCA personal communication 2018).

County	FTPGW SSTS	ITPHS SSTS
Brown	20%	24%
Cottonwood	40%	39%
Lyon	24%	5%
Murray	15%	10%
Redwood	30%	5%

Note: Estimated compliance rates reported by county and supplied to MPCA. Intended for planning purposes only.

Atmospheric deposition

Atmospheric deposition represents the phosphorus that is bound to particulates in the atmosphere and is deposited directly onto surface waters. Atmospheric inputs of phosphorus from wet and dry deposition can be estimated using published rates based on annual precipitation (Barr Engineering 2004). The atmospheric deposition values used for dry (< 25 inches), average, and wet precipitation years (>38 inches) are 24.9, 26.8, and 29.0 kilograms (kg)/kilometer $(km)^2$-year, respectively. These values are equivalent to 0.22, 0.24, and 0.26 pounds/acre/year for dry, average, and wet years, respectively. Atmospheric deposition does not represent a significant source of phosphorus to the water bodies in the Cottonwood River Watershed.

Lake internal loading

For many lakes, especially shallow lakes, internal loading can represent a significant portion of the annual TP load. Internal load can come from several sources including soluble phosphorus release from the sediment, rough fish (i.e., common carp), submerged aquatic vegetation (SAV), wind resuspension and physical disturbances such as motorized boat traffic.

Under anoxic conditions at the lake bottom, weak iron-phosphorus adsorption bonds on sediment particles break, releasing phosphorus into the water column. In shallow lakes that undergo intermittent mixing of the water column throughout the growing season, the released phosphorus can mix with surface waters throughout the summer and become available for algal growth. In deeper lakes with a more stable summer stratification period, the released phosphorus has the potential to remain in the bottom water layer throughout much of the growing season until stratification breaks down in late summer or fall. In many lakes, high sediment phosphorus release rates (RRs) are the result of a large pool of phosphorus in the lake bottom that has accumulated over several decades of watershed loading to the lake. Thus, even if significant watershed load reductions have been achieved through BMPs and other efforts, internal loading from the sediment can remain high and in-lake water quality may not improve.

Common carp and other rough fish uproot aquatic macrophytes during feeding and spawning and re-suspend bottom sediments, releasing phosphorus into the water column and decreasing water clarity. Additionally, wind energy and motorboat traffic in shallow depths can disturb sediment that can be mixed into the water column and represent another potential source of internal load.

Certain SAV species such as invasive curly-leaf pondweed (CLP) can outcompete and suppress native vegetation species. CLP begins its growth cycle earlier in the season compared to other species and typically dies back in mid-summer. As a result, lakes with heavy CLP infestation can have little or no submerged vegetation by late summer. This can cause lower DO levels, increased sediment re-suspension, and phosphorus release from sediment.

Upstream lakes and streams

A few of the impaired lakes and streams in the Cottonwood River Watershed receive a significant amount of their phosphorus load from upstream lakes and major stream reaches. For these lakes and stream reaches, restoration and protection efforts should focus on improving upstream watershed conditions and the water quality of the upstream lakes and streams.

2.5 TMDL Summary

A TMDL is a calculation of how much of a pollutant a lake or stream can receive before it fails to meet state water quality standards. These standards are based on the beneficial uses that a given water can support, which include AqR and AqL. TMDL studies are required by the Clean Water Act for all impaired lakes and streams. The Cottonwood River Watershed TMDL Report (MPCA 2022) was drafted in conjunction with this WRAPS document, and addresses 11 TSS impairments, 8 bacteria impairments, and 8 lake nutrient impairments throughout the Cottonwood River Watershed (Table 10). See Appendix B for the pollutant loading, load/wasteload allocations, and the load reduction goals needed to meet water quality standards for each of the impaired water bodies.

Impairments not caused by pollutants, for example AqL use impairment based on macroinvertebrate IBI caused by degraded physical habitat, were not addressed through the TMDL process. Loading computations (TMDLs) are not required or appropriate for such impairments. The strategies in Section 3 of this report address streams and lakes with non-TMDL related impairments.

Table 10. Summary of impaired lakes and streams addressed in the Cottonwood River Watershed TMDL Report (MPCA 2022).

HUC-10 Subwatershed	Stream or Lake Name	Reach AUID (Last 3 Digits) or Lake ID	Pollutant(s)
Headwaters –Cottonwood River	Cottonwood River	502	AqL: TSS, AqR: *E. coli*
	Rock Lake	42-0052-00	AqR: Lake nutrients
Meadow Creek – Headwaters to Cottonwood River	Meadow Creek	515	AqR: *E. coli*
Plum Creek	Plum Creek (JD 20A)	602 & 603[1]	AqL: TSS
Pell Creek – Cottonwood River	Cottonwood River	504	AqL: TSS
	Pell Creek	523	AqR: *E. coli*

HUC-10 Subwatershed	Stream or Lake Name	Reach AUID (Last 3 Digits) or Lake ID	Pollutant(s)
	Pell Creek	535	AqL: TSS
Dutch Charley Creek	Dutch Charley Creek	517	AqL: TSS
	Dutch Charley Creek	518	AqL: TSS
	Highwater Creek	519	AqL: TSS, AqR: *E. coli*
	Lake Bean	17-0054-00	AqR: Lake nutrients
	Double (North Portion)	17-0056-01	AqR: Lake nutrients
Sleepy Eye Creek	Sleepy Eye Creek	599	AqL: TSS
Mound Creek – Cottonwood River	Cottonwood River	508	AqL: TSS
	Coal Mine Creek	604	AqR: *E. coli*
	Dry Creek	520	AqR: *E. coli*
	Mound Creek	521	AqR: *E. coli*
	Altermatt Lake	08-0054-00	AqR: Lake nutrients
	Boise Lake	08-0096-00	AqR: Lake nutrients
Cottonwood River	Cottonwood River	509	AqL: TSS
	Judicial Ditch 30	609	AqR: *E. coli*
	Judicial Ditch 30	511	AqR: *E. coli*
	Bachelor Lake	08-0029-00	AqR: Lake nutrients
	Clear Lake	08-0011-00	AqR: Lake nutrients
	Sleepy Eye	08-0045-00	AqR: Lake nutrients

[1] Plum Creek Reach 516 was split into two separate reaches, 602 and 603, during the 2019 assessment process.

2.6 Protection Considerations

Although most assessed water bodies in the Cottonwood River Watershed do not meet water quality standards, there are a handful of streams and lakes that fully support AqL and/or AqR. Protecting streams, lakes, wetlands, groundwater, and other resources from degradation is typically more cost effective than trying to restore resources after they become degraded. This section provides a brief discussion of some of the reports, tools, and information that are available to guide protection efforts in the Cottonwood River Watershed. All the items highlighted below are based on input and work done by state agencies and local partners and were used to guide the identification and prioritization of strategies in Section 3.3.

Stream Protection

Recently, the MPCA, DNR, and other state agencies worked together to develop a Stream Protection and Prioritization Tool that can be used to generate a prioritized list of streams. The list is based on the results of water quality assessments, the level of risk posed from near shore areas, the level of risk posed from the contributing watershed, and the level of protection already in place in the watershed (Figure 10). The tool utilizes state-wide coverages; therefore, additional local information must be weighed including factors such as forest management practices, potential development trends, and mining impacts.

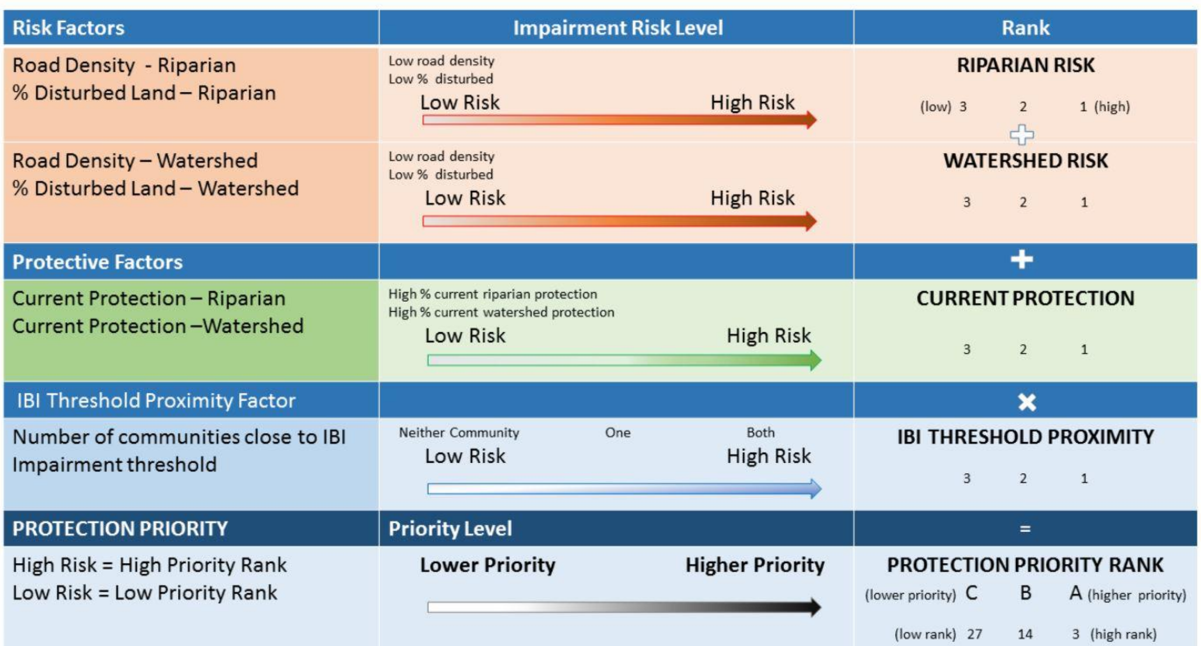
The process is limited to streams that have water quality assessments that include fish and/or macroinvertebrates and the streams must be meeting water quality standards – i.e., they are fully supporting of AqL. The first step considers how close these communities are to being impaired or degraded.

The second step looks at near shore (riparian) risks to healthy stream communities. In developing the tool, the following parameters were considered: the presence of steep slopes, percent altered streams, percent wetland loss, road density, population density, population change, feedlots, septic system density, and a variety of land use categories (percent agriculture, percent row crop, percent impervious surface, percent undeveloped). This analysis indicates that road density and disturbed land use (cultivated and urban uses) can best predict impacts or changes in stream biological health. These same risks are then also evaluated for the larger, upstream watershed.

The third step looks at how well protected the near shore areas and upstream watershed already are. To complete this step, analysis of lands in public ownership or with public easements is conducted.

A prioritized list of streams is then generated for the entire watershed. The list may then be further prioritized by splitting out, or separately considering, modified streams (ditches), general use streams (good biology and habitat), and exceptional streams (best biological communities and habitat).

Figure 10. Stream protection and prioritization tool matrix.



The Stream Protection and Prioritization Tool was applied (where applicable) to all the assessed nonimpaired stream reaches throughout the Cottonwood River Watershed. Once all of the nonimpaired stream reaches in the watershed were ranked and prioritized, they were grouped into priority categories: the top third is high priority (A), the next third are medium priority (B), and the final third are low priority (C). Nineteen stream reaches in the Cottonwood River Watershed had the required data and information for assessment using the tool (Table 11, Figure 11). All 19 stream reaches were identified as Priority A (highest priority for protection) since their riparian risk is relatively high and their current level of protection is low to medium. A more detailed list of protection streams can be found in Appendix A.

Figure 11. Streams, lakes, wetlands, fens, and WMAs identified for protection in the Cottonwood River Watershed.

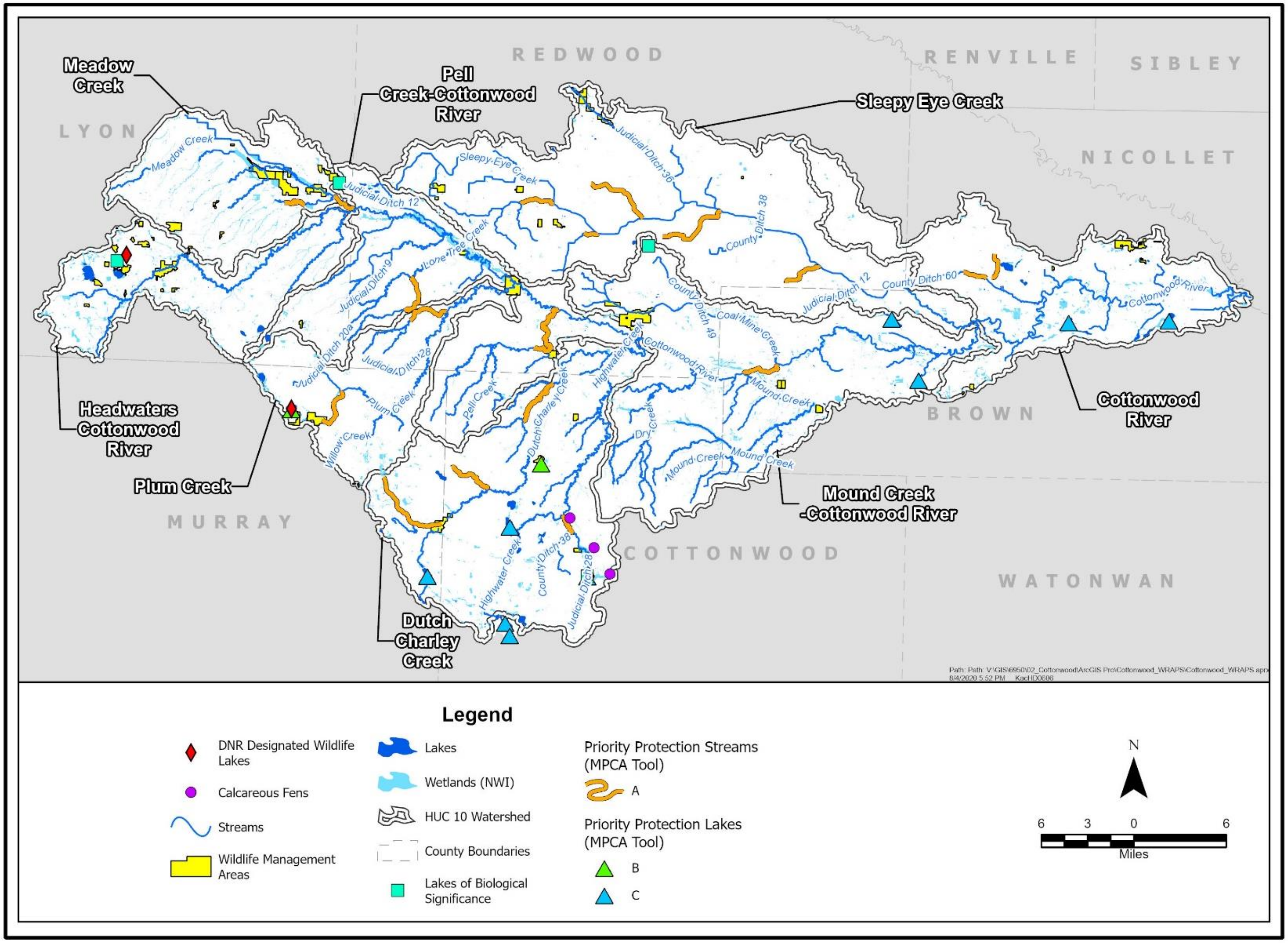


Table 11. Stream protection and prioritization tool results for the Cottonwood River Watershed (data from assessment period 2009 – 2018).

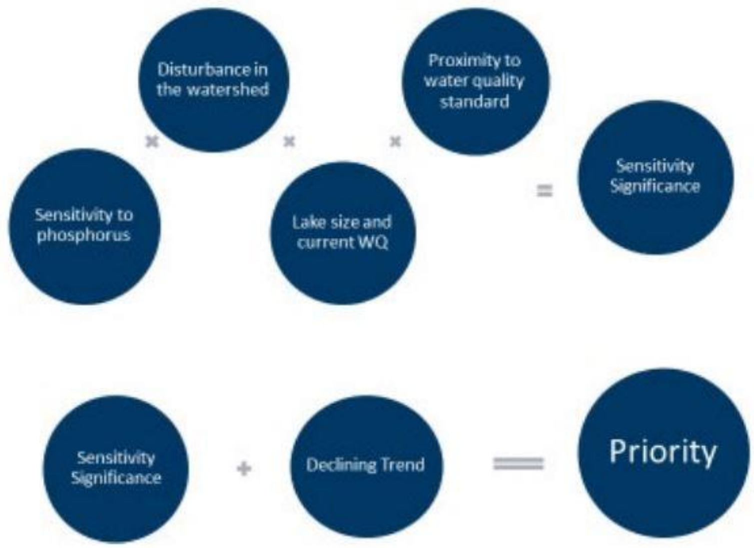
HUC-10 Subwatershed	Stream Name	Reach AUID	Riparian Risk	Watershed Risk	Current Protection Level	Protection Priority Class
Meadow Creek	Unnamed creek	578	med/high	high	low	A
	Meadow Creek	601	high	high	low	A
Plum Creek	Unnamed creek	586	high	high	medium	A
	Unnamed creek	623	high	high	low	A
Pell Creek – Cottonwood River	Pell Creek	523	med/high	high	med/low	A
	Judicial Ditch 9	548	high	high	med/low	A
	Unnamed creek	584	high	high	low	A
Dutch Charley Creek	Judicial Ditch 3	588	med/high	high	low	A
	County Ditch 38	527	med/low	high	med/low	A
	Unnamed creek	587	med/high	high	low	A
	County Ditch 19	589	high	high	med/low	A
Sleepy Eye Creek	County Ditch 54	543	high	high	low	A
	County Ditch 68	561	high	high	low	A
	Unnamed ditch	594	high	high	low	A
	Unnamed creek	595	high	high	low	A
	Judicial Ditch 35	596	high	high	low	A
Mound Creek – Cottonwood River	Cottonwood River	507	medium	high	med/low	A
Cottonwood River	County Ditch 60	564	high	high	low	A
	County Ditch 5	565	high	high	low	A

Lake Protection

The MPCA and other state agencies have also developed a Lake Protection and Prioritization Tool to generate a prioritized list of protection lakes in each major watershed throughout the State (Figure 12). The analysis is based on water quality assessment results, the amount of clarity lost if phosphorus is added, the amount of land use disturbance, lake size, and what is known about current trends in water quality. Eight nonimpaired lakes in the Cottonwood River Watershed had the required data and information for assessment using the Lake Protection and Prioritization Tool (Table 12, Figure 11, Appendix A).

The first step considers how much lake clarity would be lost with an increase of 100 pounds of phosphorus to the lake. This is also known as the lake's phosphorus sensitivity.

Figure 12. Lake Protection and Prioritization Tool Framework.



The second step considers the significance of this sensitivity – i.e., the likelihood that this increase in phosphorus would occur. Factors considered include the percentage of disturbed land use (cultivated and urban uses), the surface area of the lake, the current phosphorus concentration and loading to the lake, and the proximity of the lake to the impairment threshold. Any information on declining trends in water quality are also considered.

The third step for lakes results in a prioritized list of lakes, each with a load reduction goal. The goal is calculated as a 5% reduction in predicted phosphorus loading (pounds/year) for any given lake. The goal is not regulatory; it is intended to give local groups a value to aim for, in lieu of just maintaining current phosphorus levels. This provides a way to measure progress over time for a given lake; estimated load reductions in phosphorus can be tracked as new practices are implemented.

Once all the nonimpaired lakes in the watershed have been ranked and prioritized, they are grouped into priority categories: high priority (A), medium priority (B), and lower priority (C). No lakes in the Cottonwood River Watershed were identified as Priority A, two lakes (Hurricane and Round Lakes) were identified as Priority B, and nine lakes were identified as Priority C. Many of these lakes do not have enough water quality data to fully assess impairment status and the available data suggest they may actually be considered impaired if more data were available. Additional data needs for the non-assessed lakes vary, but a minimum of eight individual data points for TP, Chl-*a*, and Secchi are required over a minimum of two years (MPCA 2022c). Sleepy Eye Lake was removed from the State's impaired waters list following completion of the protection and prioritization exercise due to improved water quality conditions in recent years. Thus, Sleepy Eye Lake has been added to the priority list and should be considered a high priority lake for protection in the Cottonwood River Watershed.

Table 12. Lake protection and prioritization tool results for the Cottonwood River Watershed (data from assessment period 2009 – 2018).

HUC-10 Subwatershed	Lake Name	Lake ID	Mean TP (µg/L)	Transparency Trend[1]	Percent Disturbed Land	Protection Priority Class
Dutch Charley Creek	Hurricane	17-0037-00	48.0	N/A	81%	B
Plum Creek	Round	51-0038-00	38.0	N/A	82%	B
Dutch Charley Creek	Augusta	17-0033-00	158.3	N/A	92%	C
Dutch Charley Creek	Round	17-0048-01	544.5	N/A	86%	C
Dutch Charley Creek	Long	17-0048-02	330.5	N/A	86%	C
Dutch Charley Creek	Double	17-0056-00	99.0	N/A	93%	C
Dutch Charley Creek	Louisa	51-0006-00	203.0	N/A	82%	C
Cottonwood River	Sleepy Eye[2]	08-0045-00	85.3	Improving	80%	High

[1] N/A = Not enough data currently to evaluate trends
[2] Recently removed from impaired waters list

The Cottonwood River Watershed stakeholder group considered the results from the State's protection and prioritization tool as well as local knowledge and priorities to develop a list of lakes throughout the watershed that should be targeted for protection. The stakeholder group's list of protection lakes is shown in Table 13 and was developed using the following criteria:

- **Nonimpaired lakes in the watershed with high recreation value** – specifically Lake Laura, Wellner-Hageman Reservoir, and Sleepy Eye Lake. Lake Laura, located in Redwood County, and Wellner-Hageman Reservoir, located in Brown County, are center pieces of two County/Regional parks (Plum Creek and Mound Creek County Parks, respectively). Sleepy Eye Lake was recently removed from the impaired waters list due to improved water quality conditions in recent years and therefore should be considered a high priority protection lake. Located in the city of Sleepy Eye, Sleepy Eye Lake is a relatively deep lake (max depth 21 feet) for this region and is a popular recreational lake for boating, swimming, and fishing.
- **Lakes on the Minnesota DNR list of priority shallow lakes** – specifically Hurricane, Augusta, Round (17-0048-01), Long, Double, Louisa, and Round (51-0038-00).
- **Designated wildlife lakes within the Cottonwood River Watershed** – specifically Augusta, Round, Long, and Mahlke Marsh.
- **Lakes that have been identified as lakes of biological significance by the Minnesota DNR Ecological and Water Resources Division** - This designation is based on the presence of unique plant or animal communities (including aquatic plants, fish, birds, and amphibians) and are divided into three classes (outstanding, high, or moderate) based on biological significance. There are currently four lakes of biological significance in the Cottonwood River Watershed. One

of these lakes (Leedom Slough) is classified as "Outstanding", one is classified as "High" (Willow), and two lakes (Augusta and Christianson Marsh) are classified as "Moderate".

Table 13. Lakes identified as priorities for protection by the Cottonwood River Watershed stakeholders.

HUC-10 Subwatershed	Lake Name	Lake ID
Cottonwood River	Sleepy Eye	08-0045-00
Dutch Charley Creek	Hurricane	17-0037-00
Dutch Charley Creek	Augusta	17-0033-00
Dutch Charley Creek	Round	17-0048-01
Dutch Charley Creek	Long	17-0048-02
Dutch Charley Creek	Double	17-0056-00
Dutch Charley Creek	Louisa	51-0006-00
Headwaters – Cottonwood River	Mahlke Marsh	42-0060-00
Headwaters – Cottonwood River	Leedom Slough	42-0114-00
Mound Creek	Wellner-Hageman Reservoir	08-0129-00
Pell Creek – Cottonwood River	Christianson Marsh	42-0008-00
Plum Creek	Round	51-0038-00
Plum Creek	Laura	64-0150-00
Plum Creek	Willow	51-0044-00

Wildlife Management Areas

Currently, there are three federal and 48 state WMAs that have a portion of, or are entirely within, the Cottonwood River Watershed (Figure 11). The WMAs in the Cottonwood River Watershed individually range in size from less than 10 acres to just over 1,000 acres, and collectively cover more than 6,100 acres of the watershed. Nearly all WMAs in the Cottonwood River Watershed are comprised of restored wetlands, prairie/grassland complexes, or a combination of these resources.

WMAs are part of Minnesota's outdoor recreation system and are established to protect those lands and waters that have a high potential for wildlife production, public hunting, trapping, fishing, and other recreational uses. Thousands of hunters use these public wildlife lands throughout the state each year. They are the backbone to DNR's wildlife management efforts in Minnesota and are key to:

- protecting wildlife habitat for future generations
- providing citizens with opportunities for hunting, fishing, and wildlife watching
- promoting important wildlife-based tourism in the state

Minnesota's Legislature and sportsmen have funded WMA land acquisition in a multitude of different ways. The mainstay of funding has been the surcharge on the small game hunting license. Hunting license fees, bonding funds, Reinvest in Minnesota (RIM) funds, including Critical Habitat License Plate dollars, and Environmental and Natural Resources Trust Fund (ENRTF) funds have been used to purchase WMA lands. Conservation groups also donate land and money to support the acquisition of WMA lands. Another major source of WMA acquisition funding available to DNR and private conservation partners is the Outdoor Heritage Fund. The Outdoor Heritage Fund is one of several created by the Clean Water, Land and Legacy Amendment to the Minnesota State constitution in 2008.

Continued management efforts on existing WMA lands and acquisition of new parcels will be critical to maintaining quality wildlife habitat and water quality in Minnesota. According to a 2002 Citizen's Advisory Committee Report on the direction the WMA system should take, acquisition efforts should be accelerated with a long-term 50-year goal of acquiring 702,200 acres of new WMA lands.

Wetland Protection

Drainage of wetlands over the past century and a half has made extensive portions of the Cottonwood River Watershed conducive for row crop agriculture (DNR 2020). Estimates of historic wetland extent were derived by MPCA using drainage class assignments from the soil survey (MPCA 2020a). This analysis suggests all seven of the Cottonwood HUC-10 subwatersheds have experienced significant wetland loss, of at least 70% conversion, mostly due to drainage. The least amount of wetland conversion has occurred in the westernmost HUC-10 subwatersheds – Meadow Creek and Headwaters of the Cottonwood River. These subwatersheds have more slope and rockier glacial till making them somewhat less conducive to high productivity row cropping practices. Subwatersheds in the flatter regions of the watershed, particularly to the north and south of the main river corridor, have less than 10% of their original wetland extent remaining today because the land is more conducive to row cropping practices.

Based on plant community floristic quality, 82% of the wetlands in the Cottonwood River Watershed are estimated to be in fair or poor condition and an estimated 11% are in good condition. Based on invertebrate communities, 41% of wetlands in the Cottonwood River Watershed are estimated to be in good condition and 57% are in fair or poor condition (estimates based on statewide probabilistic surveys for the temperate prairie ecoregions; MPCA 2020a).

Wetlands are affected by many pollutants and related stressors, and it is often very difficult and costly to rehabilitate wetlands that are in a degraded condition. Thus, it will be more cost effective in the Cottonwood River Watershed to focus on identifying and protecting the few remaining high-quality wetlands. Management practices to limit additional wetland hydrologic alterations and efforts to reduce the spread of invasive species promise to be the most cost-effective ways to protect and restore water quality in the Cottonwood River Watershed. The enrollment of functioning wetlands in priority areas in available programs such as the Conservation Reserve Program (CRP) to restore or enhance the wetlands and permanently or temporarily protect them through conservation easements could also help preserve wetland functions that benefit water quality in the watershed. Wetland restoration is a common approach to improve water quality in lakes and streams. The MPCA and the University of Minnesota have developed an online restorable wetland prioritization tool, which can identify restorable wetlands, prioritize areas more likely to result in sustainable wetlands, and predict the benefits of restoration.

One wetland type that should be considered for protection in the Cottonwood River Watershed is seasonally flooded wetlands. Seasonally flooded wetlands are frequently farmed and are commonly only inundated with surface water for short periods of time following snowmelt in the spring and precipitation events during the growing season, yet they can provide important wetland functions such as flood storage. The protection or management of these wetlands, even if only temporarily or seasonally during critical periods while still allowing for cropping under most conditions, could allow for multiple benefits. Management of drainage systems in these types of wetlands to allow for temporary flood storage during early season flooding events prior to cropping could provide a seasonal benefit to the watershed. These wetlands also provide important habitat for migratory waterfowl and other wildlife early in the season, and the management of these wetlands would benefit these wildlife species as well. It is estimated 7.9% of the current wetland area in the watershed (~3,072 acres) is comprised of wetlands with temporary hydrology which are routinely farmed in dry years (MPCA 2020a).

Calcareous fens are another wetland type that should be targeted for protection in the Cottonwood River Watershed. Calcareous fens are one of the rarest wetland communities in Minnesota and are characterized by mostly saturated soil wetlands underlain by deep accumulations of peat resulting from groundwater discharges which are high in alkaline ions, particularly calcium and magnesium. The constant water supply and rich mineral content characteristic of calcareous fens supports a diverse assemblage of rare and unique plants. Calcareous fens are dominated by narrow-leafed grass-like plants including sedges, grasses, and specially adapted forbs. Because of their rareness and sensitivity to disturbance, calcareous fens in Minnesota are specially designated in State Water Quality Standards to be protected from impacts to water quality.

Three calcareous fens occur in the Cottonwood River Watershed, all of them (Storden 21, Storden 34, and Amo 2) are in the Highwater Creek Subwatershed (Figure 11). All three of these calcareous fens are recognized in State Water Quality Standards, Minn. R. ch. 7050.0335, subp. 2 to be unlisted restricted discharge Outstanding Resource Value Waters (ORVWs).

Groundwater and Drinking Water Protection

The main supply of drinking water to the residents and businesses in the Cottonwood River Watershed is groundwater – either from private wells, community wells, or rural water supplier. It is important to protect and keep water on the land as much as possible throughout the watershed, particularly certain areas that are sensitive to groundwater pollution. The Environmental Health Division of the Minnesota Department of Health (MDH) administers numerous programs of interest to local water management planning, including drinking water protection and wellhead protection among others.

The communities of Lamberton, Marshall, Sleepy Eye, and Springfield have vulnerable drinking water systems suggesting a connection and influence from surface water in the watershed. Balaton, New Ulm, and Red Rock Rural Water vulnerable wellfields are on the edge of the watershed. Contaminants on the surface can move into the drinking water aquifers more quickly in these areas. Unused and abandoned wells also create the potential for groundwater contamination. The communities of Clements, Cobden, Sanborn, Tracy, Walnut Grove, and Westbrook have low vulnerability to contamination, which means that in those areas the deep aquifers are well protected. Ensuring abundant and high-quality supplies of groundwater is critical, especially considering altered hydrology and the impacts on groundwater recharge.

Table 13 illustrates the number and size of Well Head Protection Areas (WHPAs) and DWSMAs within the Cottonwood River HUC-10 subwatersheds. The table also includes the areas within each subwatershed that have high pollution sensitivity and are vulnerable to groundwater contamination.

Table 14. Summary of groundwater and drinking water features in the Cottonwood River Watershed.

HUC-10 Subwatershed	WHPAs / DWSMAs	WHPA (acres)	DWSMA (acres)	Vulnerable Groundwater Areas (acres)	High Pollution Sensitivity (acres)
Headwaters – Cottonwood River	Balaton	0	8	2,669	--
Meadow Creek	Marshall and Marshall Dudley	2,346	3,662	1,588	--
Pell Creek – Cottonwood River	Lamberton, Tracy	141	292	6,369	--
Plum Creek	Walnut Grove	--	--	2,917	--
Dutch Charley Creek	Lamberton, Red Rock Rural Water Lake Augusta	230	543	3,090	--
Mound Creek – Cottonwood River	Sanborn, Springfield	936	1,434	5,093	9
Sleepy Eye Creek	Clements 1, Clements 2, Cobden	24	206	11,916	9
Cottonwood River	Cobden, New Ulm, Sleepy Eye East, Sleepy Eye West	886	1,983	32,544	--

Further, Figure 13 below depicts the geographic location and extent of the WHPAs, DWSMAs, high pollution sensitivity and vulnerable groundwater areas. Pollution sensitivity of groundwater and near-surface materials throughout the state was determined by estimating the transmission time of water through 3 feet of soil and 7 feet of surficial geology, to a depth of 10 feet from the land surface. Areas with very low transmission times are more sensitive to pollution, whereas areas with high transmission times are less sensitive to pollution. Similarly, the statewide vulnerable groundwater area geographic Information systems (GIS) layer was developed by the Minnesota Department of Agriculture (MDA) by overlaying DNR and USDA Natural Resources Conservation Service (NRCS) soil maps to identify areas with coarse textured soils, shallow bedrock, and karst geology. There are no karst features in the Cottonwood River Watershed, however, there are several areas with coarse textured soils and/or shallow bedrock.

Protection strategies that should be considered for vulnerable and sensitive groundwater areas include:

- Focus nitrogen BMPs in or near vulnerable DWSMAs due to the mutual benefits of protecting drinking water supplies as well as surface water resources
- Further identify vulnerable and sensitive features by expanding the existing inventory
- Increase monitoring or target existing local monitoring in vulnerable and sensitive groundwater areas to gage trends and timing of pollutant concentrations
- Plant vegetative buffers, increase living cover, and improve soil health through cover crops and reduced tillage
- Promote SSTS compliance through education, maintenance, and inspection

- Education and outreach to farmers and feedlot operators regarding nutrient management in vulnerable and sensitive areas
- Alternative type drainage intakes that filter and/or trap contaminants
- Well sealing to prevent direct conduits of pollutants to groundwater

The MDA has developed the Groundwater Protection rule (Minn. R. 1573.001) to minimize potential sources of nitrate pollution to the state's groundwater and protect drinking water. "The rule restricts fall application of nitrogen fertilizer in areas vulnerable to contamination, and it outlines steps to reduce the severity of the problem in areas where nitrate in public water supply wells is already elevated" (MDA 2020). A map of areas subject to the fall fertilizer restriction can be found on the MDA website. Several areas within the Cottonwood River Watershed are identified as having the fall fertilizer restriction. For land application of manure, restrictions of fall application in areas vulnerable to contamination apply to feedlots with NPDES permits (large operations with greater than or equal to 1,000 AUs).

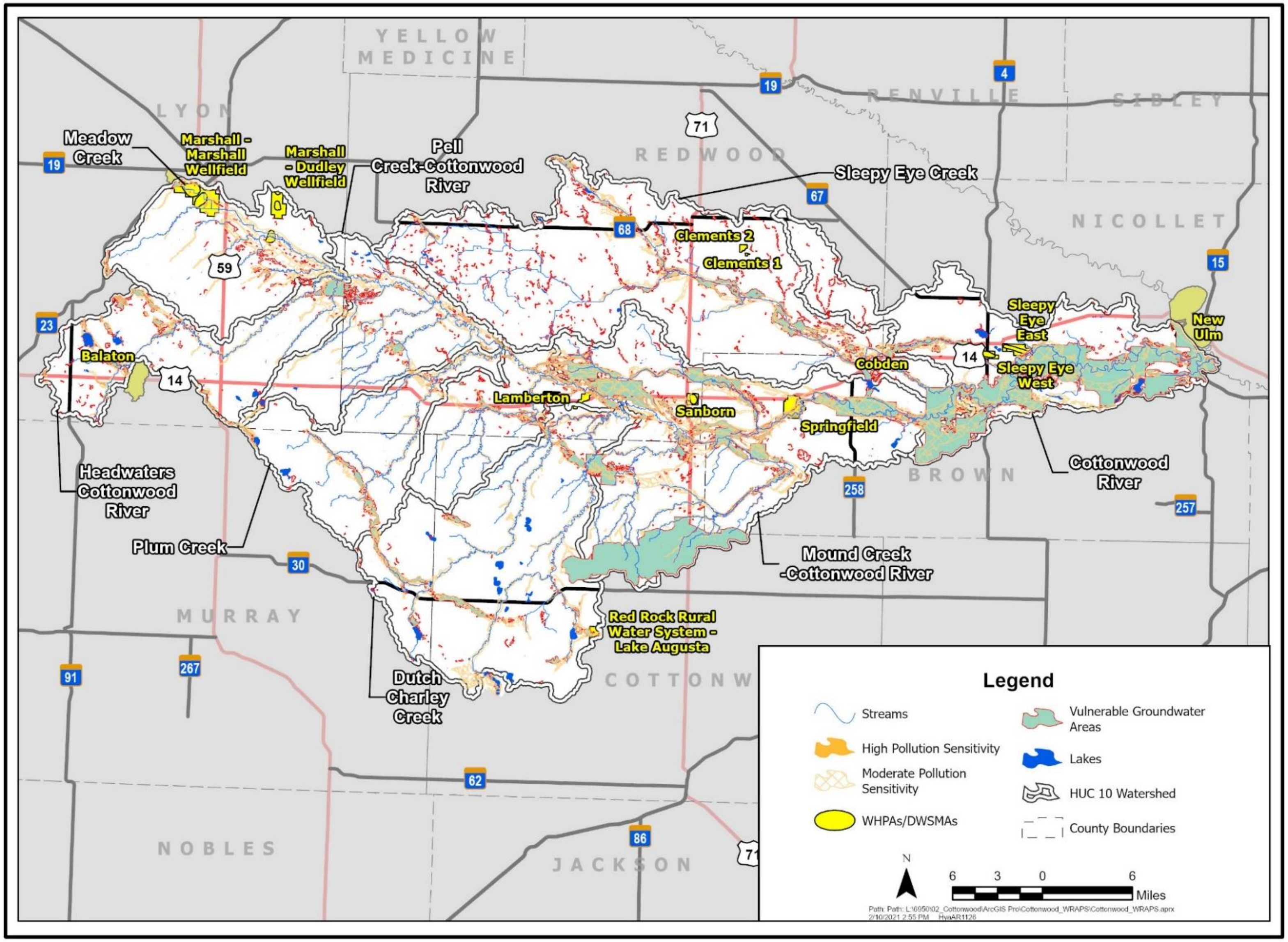
In addition to drinking water sources located directly in the Cottonwood River Watershed, the Cottonwood River contributes flow to the Minnesota River upstream of the city of Mankato and is within the city's source water assessment spill management and DWSMAs. Mankato utilizes Ranney wells located beneath the Minnesota and Blue Earth Rivers to supply some of the city's drinking water. These wells are directly influenced by surface waters making them vulnerable to contaminants in the river systems. The main drinking water issues for Mankato include:

- Nitrate concentrations have trended upward in upstream source water. Nitrate concentrations higher than 10 milligrams per liter (mg/L) require dilution with other water sources, as nitrate is a Safe Drinking Water Act listed contaminant.
- In extreme cases, high nitrate can also contribute to secondary problems, including harmful algal blooms and algal toxins, which can occur under high nutrient (nitrate and phosphorus) conditions.
- Stormwater and surface water runoff from agricultural and urban lands can further influence water quality, particularly TSS and nutrients, which can complicate drinking water treatment processes.

Because of the direct influence of surface water on the Ranney wells, the city of Mankato is dependent on the ongoing restoration and protection of the Cottonwood River Watershed to supply clean and drinkable water to its residents. Many of the implementation activities conducted by the MPCA, soil and water conservation districts (SWCDs), farming community, private landowners, and local entities can help protect and improve surface water quality.

For more information on the Mankato Source Water Assessments and the Source Water Intake Protection Plan, please visit the MDH Source Water Assessment webpage at Source Water Assessments: Minnesota Department of Health.

Figure 13. Groundwater protection areas in the Cottonwood River Watershed (WHPAs, DWSMAs, vulnerable and sensitive groundwater areas).



3. Strategies for restoration and protection

The Clean Water Legacy Act (CWLA) (ROS 2020) requires that WRAPS reports contain strategies that are capable of cumulatively achieving needed pollution load reductions for point and nonpoint sources, including water quality goals, strategies, and targets by parameter of concern, and an example of the scales and timeline of adoption to meet water quality protection and restoration goals.

This section of the WRAPS report provides the results of such prioritization and strategy development. Because many of the nonpoint source strategies outlined in this section rely on voluntary implementation by landowners, land users, and residents of the watershed, it is imperative to create social capital (trust, networks, and positive relationships) with those who will be needed to voluntarily implement BMPs. Thus, effective ongoing civic engagement is critical for making progress toward clean water.

The implementation strategies, including associated scales of adoption and timelines, provided in this section are the result of watershed modeling efforts and professional judgment based on what is known at this time and, thus, should be considered approximate. The strategies are not prescriptive, but instead represent one path to achieving pollutant reductions needed to meet the watershed goals and targets. Furthermore, many strategies are predicated on needed funding being secured. As such, the proposed actions outlined are subject to adaptive management—an iterative approach of implementation, evaluation, and course correction.

3.1 Targeting of Geographic Areas

The following section describes the information and tools gathered throughout the Cottonwood River WRAPS project to develop restoration and protection strategies for the lakes and streams throughout the watershed. Follow-up field reconnaissance will be the next part of the process to validate the identified areas potentially needing work.

It is understood that management needs for the Cottonwood River Watershed exceed available resources, and therefore prioritization and focus is necessary to achieve goals in high priority areas. The following subsections highlight previous plans, reports, studies, methods, and tools that can be used to help prioritize issues of concern and geographic areas in the watershed for restoration and protection. Later in the report, tables of management strategies were drafted to include those management approaches deemed most important. While this information provides substantial direction, it is expected that local water management authorities will further define the highest priority projects and geographic areas based on scientific, social, political, and financial considerations.

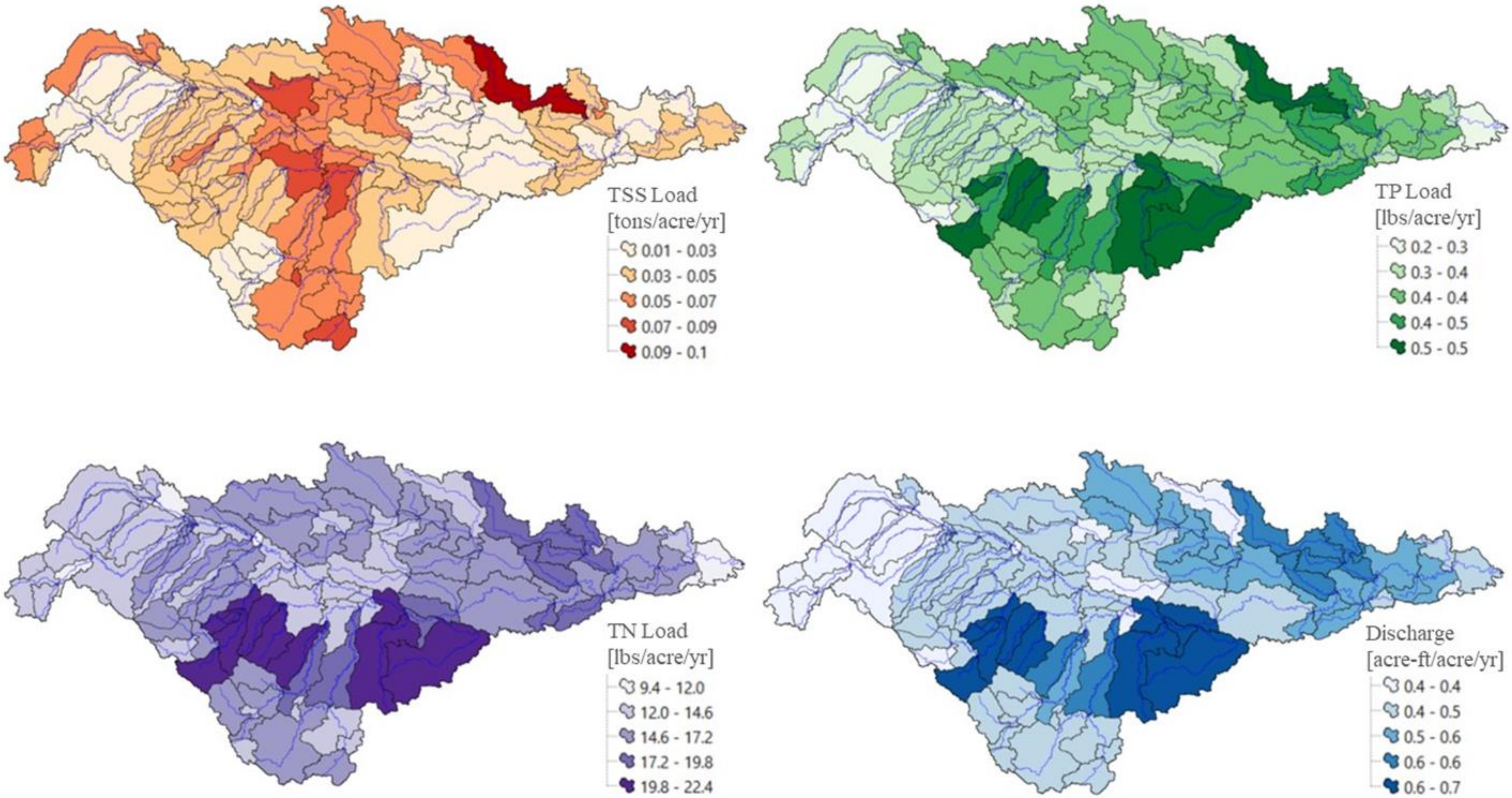
Hydrologic Simulation Program-FORTRAN

HSPF is a large-basin, watershed model that simulates nonpoint source runoff and water quality in urban and rural landscapes. The Cottonwood River Watershed HSPF model incorporates real-world meteorological data and is calibrated to real-world stream flow and water quality data. HSPF model development includes the addition of point source data in the watershed, including both domestic and industrial WWTFs.

HSPF was used to predict the relative magnitude of runoff, TSS, TP, and TN pollution generated in each subwatershed of the Cottonwood River Watershed. The HSPF model was also used to evaluate the extent of contributions from point, nonpoint, and atmospheric sources where necessary. Development of the HSPF model helps to better understand existing water quality conditions and predict how water quality might change under different land management practices and/or climatic changes at the subwatershed scale. HSPF also provides a means to evaluate the impacts of alternative management strategies to reduce these loads and improve water quality conditions.

Runoff, TSS, TP, and TN yields predicted from the HSPF model in the Cottonwood River Watershed are mapped in Figure 14. Darker shaded areas on the maps indicate areas of the watershed with higher yields (unit/area/year) for water and pollutants. The maps indicate the areas of the Cottonwood River Watershed with the highest water yield are also the highest in nutrient yield. This suggests implementing BMPs in these areas could have the potential for multiple benefits to water quality. Consistency with the TSS yield map is also apparent though not as distinct. Implementation focus on areas with higher yields, especially when there is overlap with waters of local importance, is a potential way to prioritize restoration efforts in the watershed.

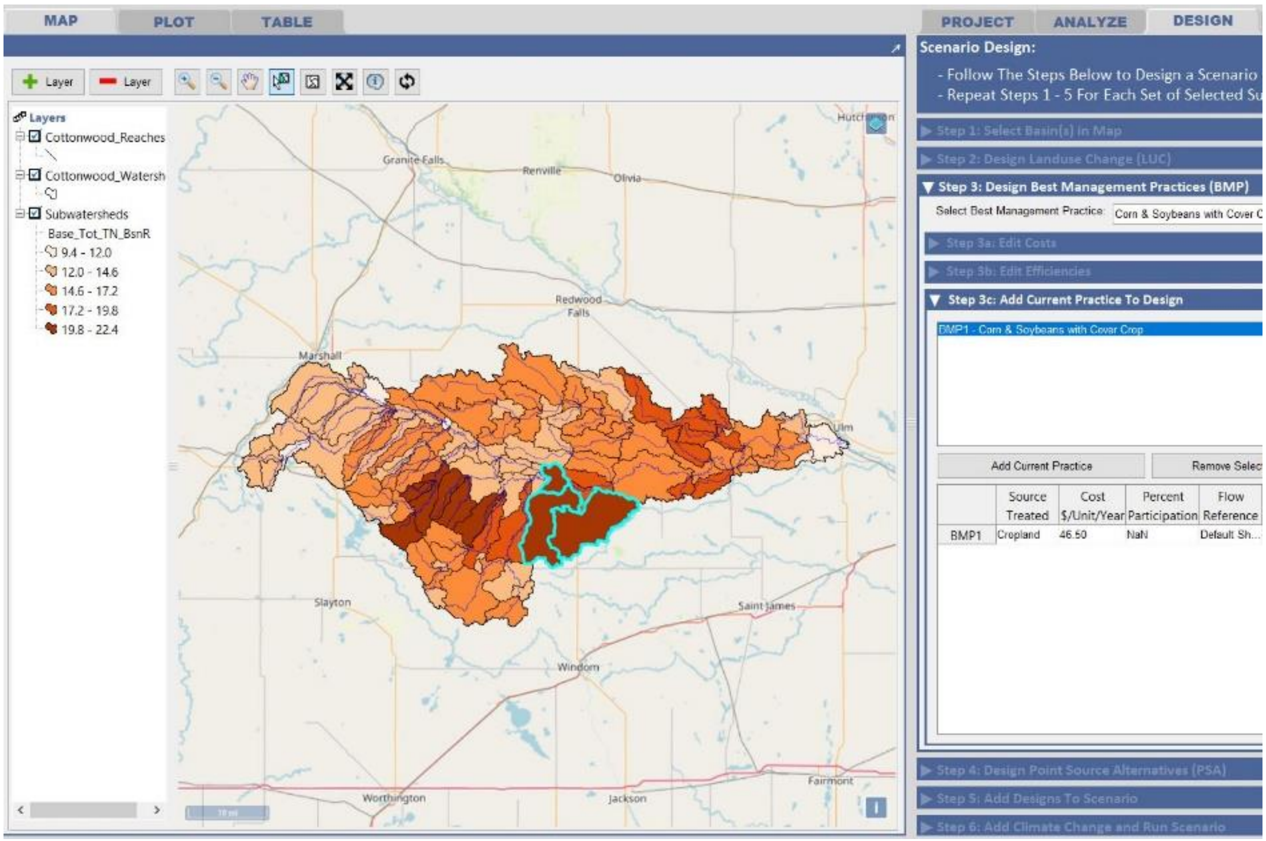
Figure 14. HSPF-predicted TSS loading yields (upper left), TP loading yields (upper right), TN loading yields (lower left), and discharge (lower right) for each HSPF subwatershed in the Cottonwood River Watershed.



HSPF-SAM

The SAM is a graphical interface to the HSPF model applications (Figure 15). The SAM decision-support tool provides a user-friendly, comprehensive approach to analyze HSPF results graphically and spatially, design and simulate alternative scenarios with HSPF, and develop cost-optimized scenarios based on user-defined water quality targets. HSPF-SAM simplifies the complexities of the HSPF model into transparent estimates of the significant pollutant sources while allowing users to apply their local knowledge and expertise of watershed planning and implementation.

Figure 15. HSPF-SAM tool interface for the Cottonwood River Watershed.



Some of the main features of HSPF-SAM include:

- Ability to access model results and assess watershed conditions
- Strong GIS components that interface with the HSPF model to simulate the transport and fate of pollutants
- A BMP database with adjustable efficiencies and costs
- Ability to generate multiple implementation scenarios to test the impact of various BMPs in various subwatersheds
- Ability to create and compare different BMP cost/benefit scenarios

The Cottonwood River Watershed HSPF-SAM tool is available for download through the [MPCA/RESPEC File Share Website.]

Cottonwood River Watershed Hydrologic Conditioning and Terrain Analysis

The Cottonwood River Watershed was one of three watersheds analyzed in the Southwest Prairie Technical Service Area (SW TSA) Digital Elevation Model (DEM) Conditioning and Terrain Analysis project, along with the West Fork Des Moines and Redwood River watersheds (HEI 2016). The goal of the project was to identify strategic locations in these watersheds for BMPs that are effective at reducing sediment loads to downstream water resources. This was achieved through a process referred to as terrain analysis which uses GIS and high-resolution topographic data collected using Light Detection and Ranging (LiDAR) technology combined with soil and land use information to identify critical areas across the watershed where erosion and sediment loss caused by surface water runoff may be the greatest.

This hydrologic conditioning and terrain analysis, which was completed by Houston Engineering in 2016, developed the following products that would be useful for the next stage of watershed planning and implementation (e.g., 1W1P):

- A hydrologically conditioned DEM for the entire Cottonwood River Watershed that accurately depicts the flow of water across the landscape and can be used in BMP targeting tools such as the Prioritize, Target, and Measure Application (PTMApp) and the Agricultural Conservation Planning Framework (ACPF).
- Stream Power Index values which provide a relative indication of the erosive power of overland, concentrated, and surface water runoff across the landscape (Figure 16). This analysis can be used to locate areas with high potential for erosion and gully formation.
- Sediment yield analysis using the Revised Universal Soil Loss Equation (RUSLE) to identify areas in the watershed with higher potential for sediment loading to surface waters (Figure 17).
- Compound Topographic Index (CTI) analysis to identify priority "wet areas" (i.e., flat slopes with relatively large contributing areas) for potential wetland management and restoration (Figure 18)
- SPI and sediment yield ranked data to establish priority areas for implementing BMPs (Figure 19). Areas which only contribute runoff for a relatively "large" precipitation event (10-year, 24-hour) for water quality analysis purposes are identified to facilitate discussions about where the benefits of BMPs can be maximized.

The final report and associated GIS products (i.e., maps and geodatabases) for the Cottonwood River Watershed Hydrologic Conditioning and Terrain Analysis Project (HEI 2016) are available upon request from the RCRCA.

Figure 16. Cottonwood River Watershed catchment scale Stream Power Index (SPI) and rankings.

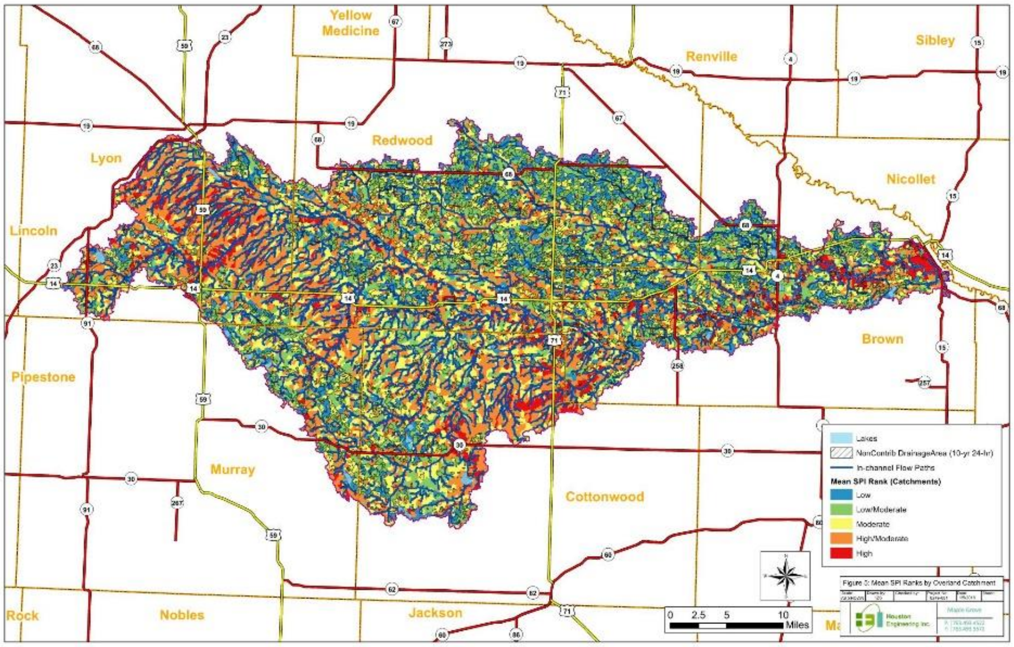


Figure 17. Cottonwood River Watershed catchment scale sediment yields and rankings.

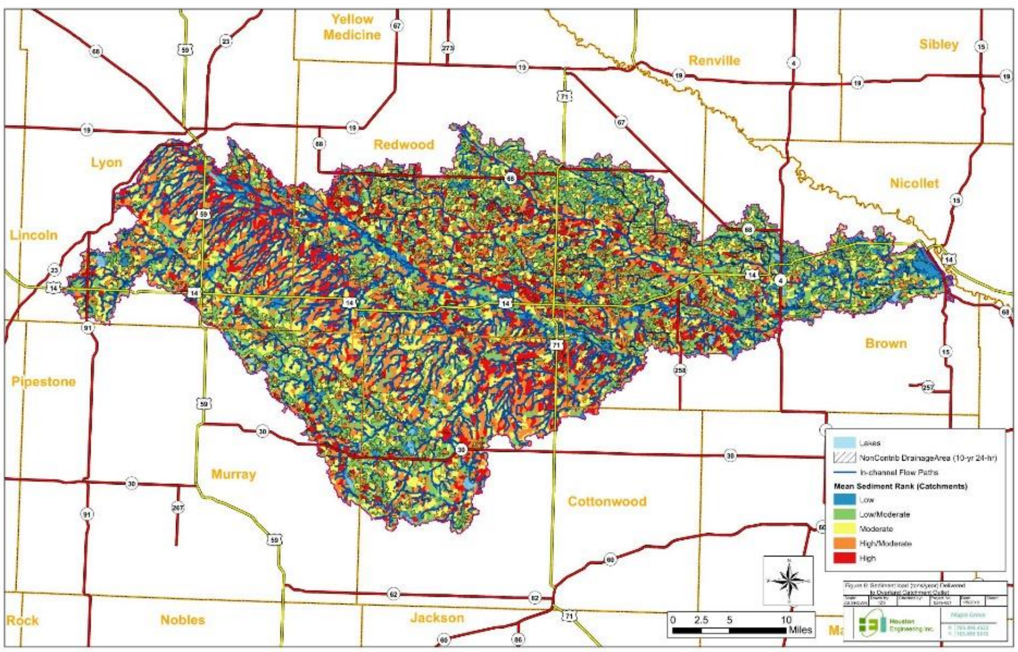


Figure 18. Cottonwood River Watershed catchment scale CTI.

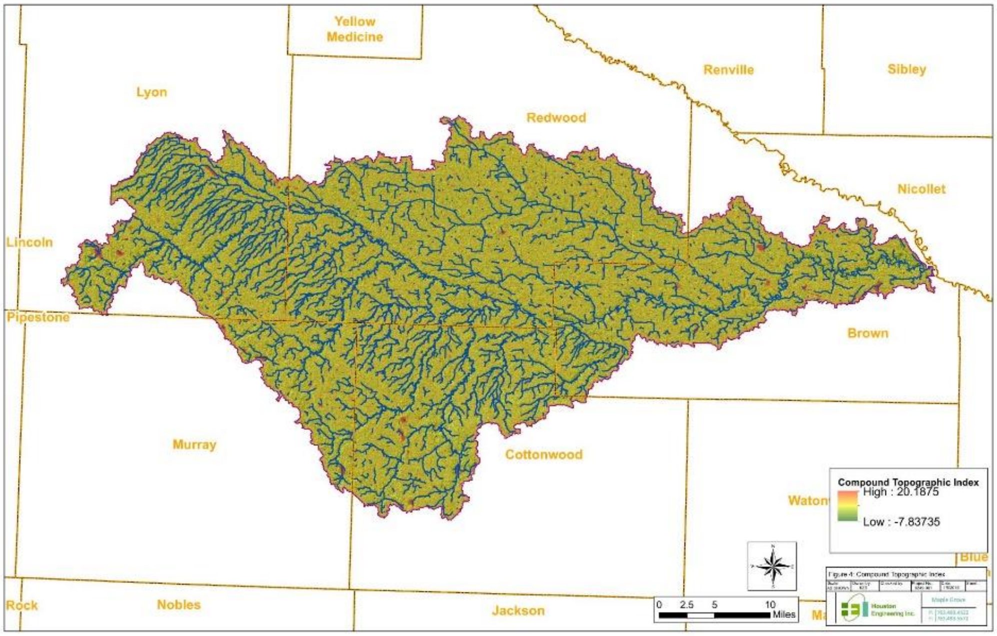
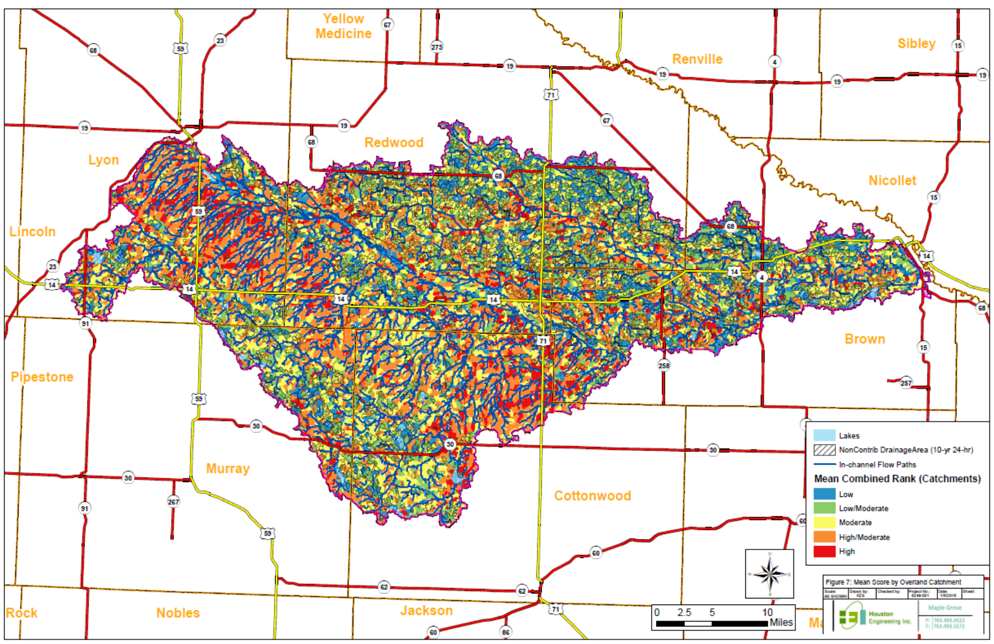


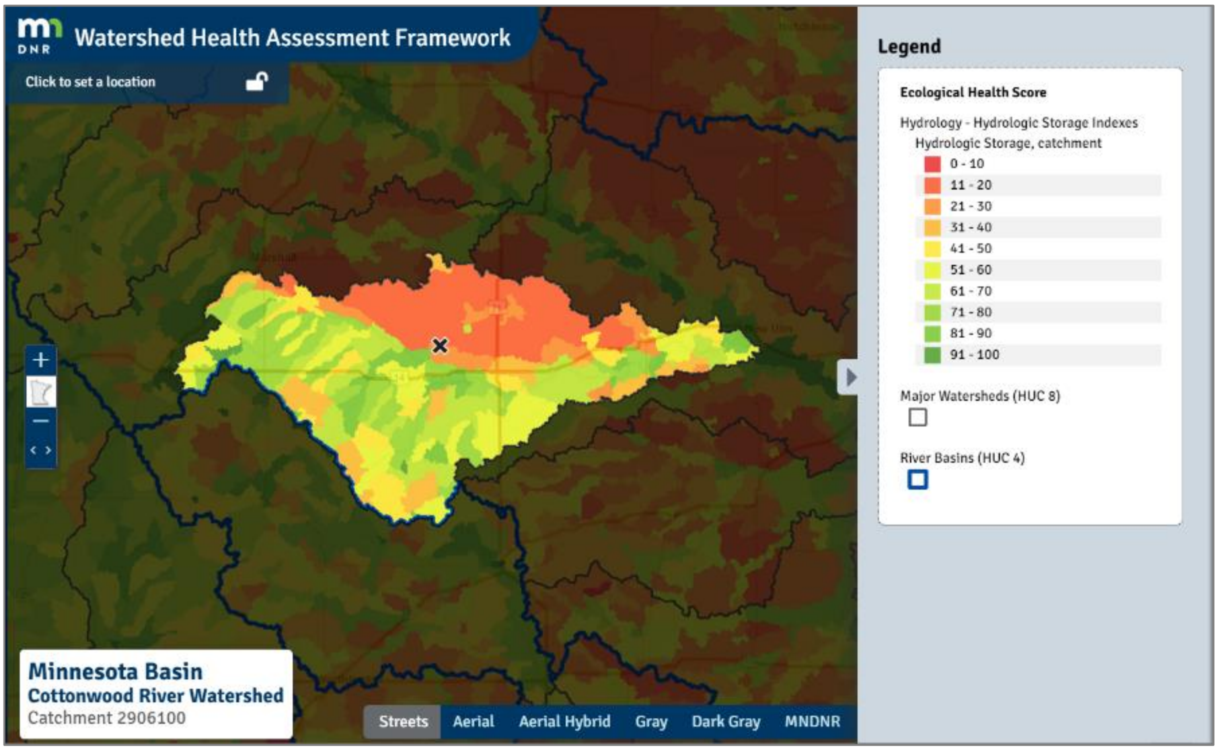
Figure 19. Ranked value scoring system that combines the SPI and sediment yield analyses to identify priority areas for conservation practices.



Watershed Health Assessment Framework

The DNR developed the Watershed Health Assessment Framework (WHAF), which provides a comprehensive overview of the ecological health of Minnesota's watersheds. The WHAF is based on a "whole-system" approach that explores how all parts of the system work together to provide a healthy watershed. The WHAF divides the watershed's ecological processes into five components: biology, connectivity, geomorphology, hydrology, and water quality. A suite of watershed health index scores on a scale of 1 to 100 have been calculated that represent many of the ecological relationships within and between the 5 components. For example, Figure 20 shows how areas within the Cottonwood River Watershed score for hydrologic storage features. Areas scoring low (red; 0 to 10) have very few storage features remaining while areas scoring high (green; 91 to 100) have many remaining storage features. Local resource professionals can use this information to prioritize restoration of protection activities to achieve water quality goals. Scores for each of the components can also be averaged for an overall watershed health score. The scores for each of Minnesota's 80 major watersheds have been built into a statewide GIS database that provides a baseline health condition report for each of the 80 major watersheds in the state. The Cottonwood River Watershed has a watershed health score of 48 (1 to 100), which is typical of most of the other watersheds in the MRB. The DNR has applied the condition report to larger (HUC-8) watersheds, as well as smaller (HUC-12) subwatersheds.

Figure 20. Hydrologic storage analysis by individual catchment for the Cottonwood River Watershed using the DNR's online WHAF tool.



Cottonwood River Watershed Characterization Report

As part of the State of Minnesota's watershed approach, the DNR produces watershed characterization reports which analyze historical and existing hydrologic data, assess geomorphic conditions within the watershed, and assess stream connectivity. The Cottonwood River Watershed Characterization Report (DNR 2020) provides insight on hydrology, geomorphology, and connectivity in the watershed as well as management practices that will help restore watershed health. The report utilized both desktop and field methods for characterization and assessment of the river and its tributaries and drainage area.

In order to continue to restore and protect the Cottonwood River Watershed, the DNR outlines a tiered approach that: 1) preserves native communities; 2) restores, enhances, and creates larger habitat networks; and 3) incorporates BMPs into the agricultural landscape. When planning restoration and protection practices in the Cottonwood River Watershed it is important to focus on practices that promote multiple benefits across the five components (biology, connectivity, geomorphology, hydrology, and water quality). Since the leading cause of many of the geomorphic issues in the Cottonwood River Watershed result from a change in land use, hydrologic pathways, and climate, restoration of this watershed should begin with BMPs in the upland agricultural landscape. The DNR identifies various strategies in these areas that will help store water and reduce flood events that are accelerating river/stream instability throughout the watershed. Some of the identified strategies include:

- Increase temporary and long-term water storage through restoring historical depressional wetlands/marshes/lake basins, restoring floodplain connectivity in drainage ditches (e.g., constructed two-stage ditches and/or limiting ditch maintenance when possible to allow floodplain benches to form) and natural channels, restore sinuouisity in channelized natural streams, install multi-purpose drainage management practices, and install stormwater retention practices in urban areas
- Increase perennial vegetation by establishing perennial buffer strips along all waterways that are compliant with the Minnesota Buffer Law and by installing grassed waterways along concentrated flow pathways
- Increase soil organic matter by utilizing low and no-till practices and promoting the use of cover crops
- Treat and prevent sediment and nutrient runoff by installing bioreactors and alternative tile intakes, increasing crop residue, updating noncompliant SSTS, and other best management strategies described above

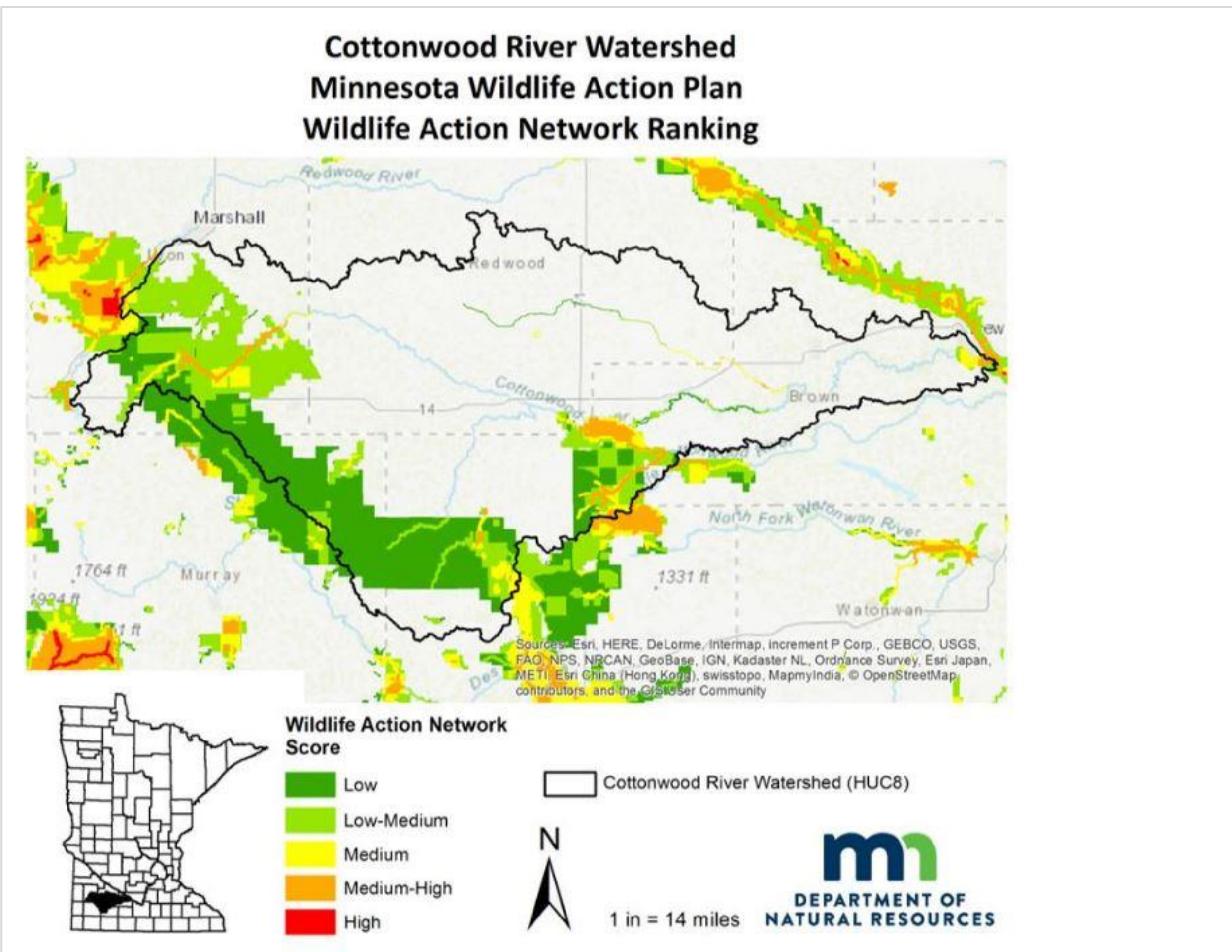
The Cottonwood River Watershed Characterization Report also cautions against the installation of in-stream structures unless the bank is an anomaly to the system, if infrastructure is in jeopardy, or if an opportunity arises to re-meander a historically channelized stream. Funding should be prioritized to first address the cause of instability (e.g., altered hydrology, historic channelization) instead of the symptom (e.g., eroding bank, trees in the river). Prioritization of work should be based on specific goals and objectives, location in the watershed, constraints, size of project, addressing the cause of the problem, likelihood of success of the project, and the project’s ability to address all (or multiple) watershed health components. The following is a list of in- and near-channel strategies that could be considered for priority locations, as they are identified, within the Cottonwood River Watershed:

- Stabilize banks that endanger infrastructure through planting of perennial vegetation along stream channels, protecting the toe of the bank with natural materials when possible (e.g., toe-wood), and installing grade-control structures (e.g., constructed riffles and cross-vanes)
- Re-size bridges and culverts to allow flood flows on the floodplain by properly sizing the crossing for the bankfull channel and installing multiple relief culverts along the floodplain for locations with wide floodplains
- Reconnect areas with longitudinal barries to fish passage by removing retrofit dams and replacing perched culverts
- Analyze the necessity and amount of sediment removal in private and public ditch cleanout projects as this forces the aquatic environment to reset when done

Minnesota State Wildlife Action Plan

Minnesota's Wildlife Action Plan (2015-2025) focuses on conservation and protection for rare, declining, or vulnerable nongame wildlife species. This includes certain birds, mammals, reptiles, amphibians, fish, and mussels, and other invertebrates. The plan focuses on prioritizing efforts within connected habitat networks to assist species movement and adaption because of climate change. It also provides a framework to advocate for the preservation of biological diversity through the acquisition, preservation, and management of important wildlife habitats. The Wildlife Action Network (WAN) within the plan is comprised of terrestrial and aquatic habitat cores and corridors to support biological diversity and ecosystem resilience with a focus on Species of Greatest Conservation Need (SGCN). The mapped WAN illustrates high, medium-high, medium, low-medium, and low scores based on SGCN population viability, SGCN richness, spatially prioritized Sites of Biodiversity Significance, Lakes of Biological Significance, and Stream Indices of Biological Integrity. Local resource professionals could use this information during the planning and implementation process to focus conservation efforts on high to medium priority zones (i.e., red, yellow, and orange polygons; Figure 21), that will result in projects and practices with multiple environmental benefits (i.e., protecting and restoring perennial vegetation for habitat enhancement and for clean water). Additional information on the Minnesota Wildlife Action Plan can be found on the following webpage: https://www.dnr.state.mn.us/mnwap/index.html.

Figure 21. Minnesota State Wildlife Action Plan priority areas for the Cottonwood River Watershed.



Minnesota Prairie Conservation Plan

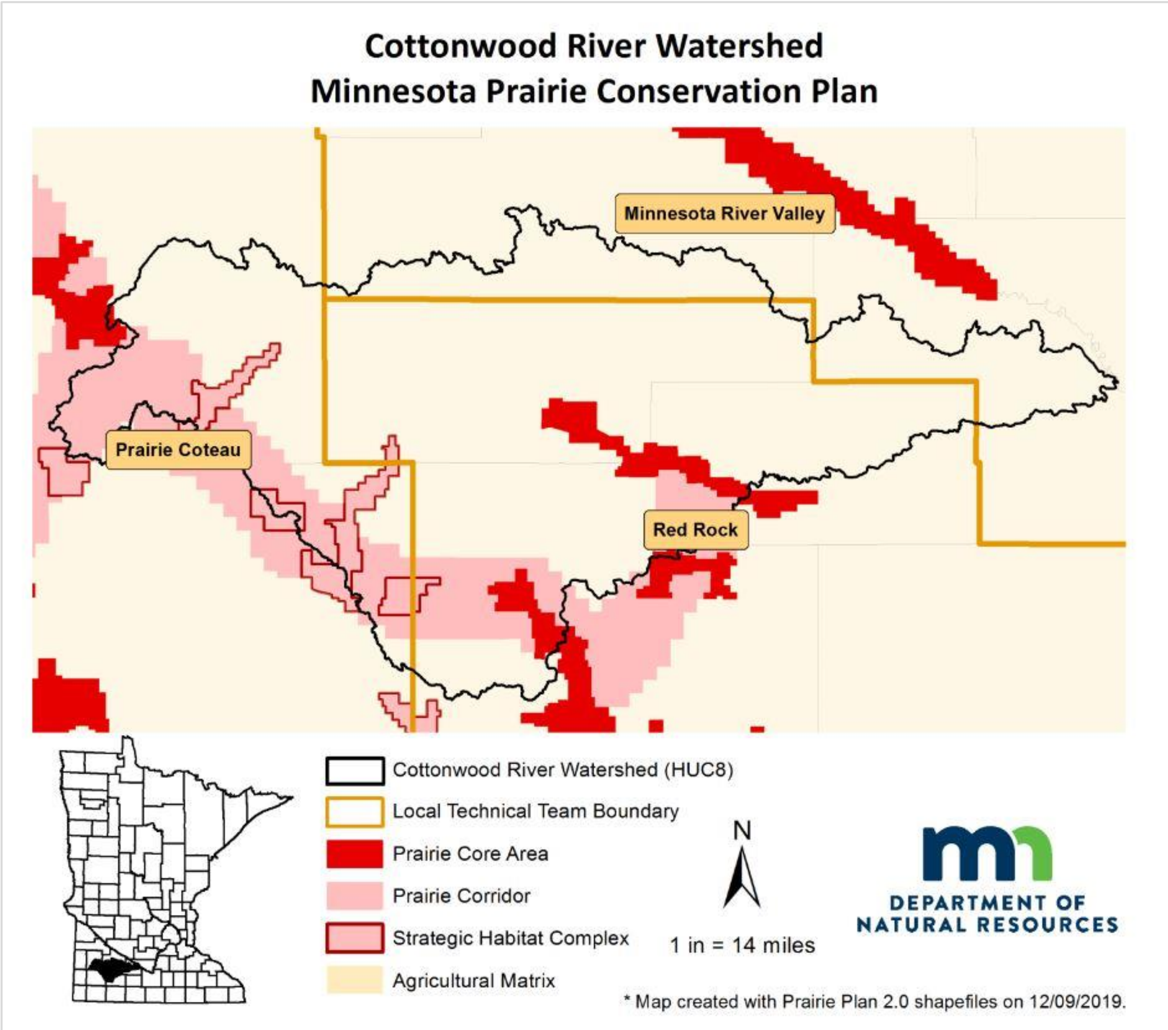
Prairie habitats once covered one third of Minnesota but presently less than two percent remain. Native prairie, other grasslands, and wetlands provide habitat for many species and are key components of functional landscapes. The Minnesota Prairie Conservation Plan is a habitat plan for native prairie grassland, and wetlands in the Prairie Region of western Minnesota with the goal to protect, restore, and enhance remaining native prairie, other grassland, and wetland habitat. In strategic locations, the Prairie Plan has identified key prairie core areas (i.e., high concentration of native prairie), corridors, and habitat complexes to create a connected landscape for wildlife and provide opportunities for sustainable grass-based agriculture such as grazing and haying.

There are six main aspects of the work:

- Implementation by multi-disciplinary Local Technical Teams in prairie focus areas
- Secure permanent protection of high-quality prairie landscapes, including native prairies, wetlands, and other habitats
- Retain restored and natural grassland in these landscapes
- Enhance the quality and function of prairie habitat using prescribed fire, conservation grazing, haying, invasive species control, and woody plant removal
- Secure the resources needed to monitor progress, assess results, and implement adaptive strategies that increase success and efficiency
- Integrate the efforts of the Prairie Plan Local Technical Teams to increase success and efficiency

The Cottonwood River Watershed includes three local technical teams (Figure 22): Prairie Coteau, Red Rock, and Minnesota River Valley. These established and active Prairie Plan Local Technical Teams are available to assist and provide support to the Cottonwood River Watershed and its landowners to achieve wildlife value and water quality goals through targeted placement of perennial vegetation or other agricultural BMPs. This could serve as an important resource as the Cottonwood River Watershed moves into the watershed planning and implementation phase.

Figure 22. Prairie Conservation Plan areas in the Cottonwood River Watershed.



Cottonwood River Subwatershed Analysis

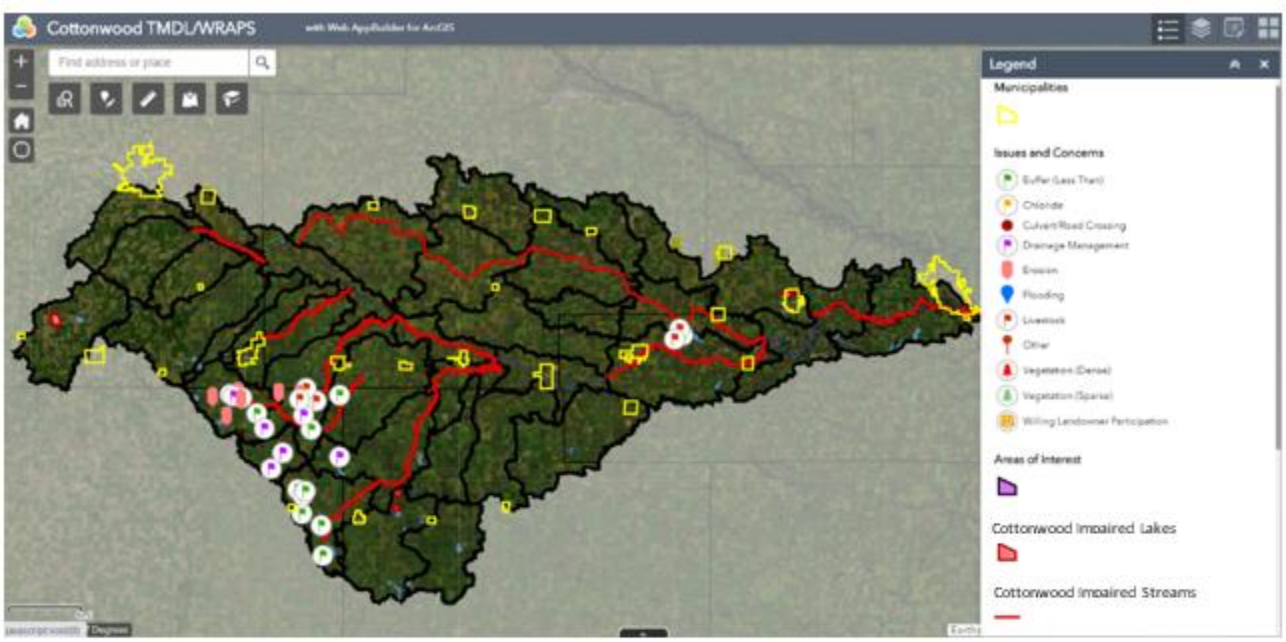
During the early stages of the development of this WRAPS, the Cottonwood River Watershed LWG expressed an interest in creating individual HUC-12 subwatershed summaries that conveyed information about the watershed at smaller, more defined scales than is typically done in WRAPS reports. An example summary is included in Appendix D and all the summaries can be found on the MPCA's Cottonwood River Webpage. The primary goal of the subwatershed summaries is to provide a tool to educate and inform local resource managers of relevant features and characteristics of each subwatershed in the Cottonwood River Watershed. As discussed throughout this section, there are several studies, assessments, tools, and models that have been completed for the Cottonwood River Watershed. This information was compiled during this WRAPS project and used to inform each subwatershed summary. This process, referred to as the Cottonwood River Subwatershed Analysis, is summarized below.

- **Scale**. It was decided by the LWG that the Cottonwood River Subwatershed Analysis would be presented at the HUC-12 subwatershed scale. There are 36 individual HUC-12 subwatersheds in the Cottonwood River Watershed that range in size from approximately 8,900 acres to 39,000 acres. The LWG determined the HUC-12 scale is an ideal scale to help facilitate future watershed planning discussions and develop targeted and measurable outcomes.

- **Data and Information**. A summary of the assessment data, GIS layers, and modeling tools that were compiled for the Cottonwood River Subwatershed Analysis are presented in Appendix D. Most of the data and information that was compiled for the subwatershed analysis was created by various agencies and therefore available through online sources. The compiled data were aggregated by HUC-12 subwatershed and organized in tabular format (Excel spreadsheet) as well as an online interactive GIS mapping tool (Figure 23).
- **Subwatershed Summaries.** Two-page summaries were created for each of the 36 HUC-12 subwatersheds in the Cottonwood River Watershed as described in Appendix D. The first page of each summary is a general map of the subwatershed that shows county boundaries, city boundaries, impaired and unimpaired water bodies, elevation change across the subwatershed, and general location of the HUC-12 subwatershed in the greater Cottonwood River Watershed. The second page includes text, figures, and graphics depicting the general subwatershed characteristics, pollutant sources, TMDL reductions, and a list of general restoration and protection strategies for the subwatershed. Thus, these summaries provide a general overview and description of the subwatershed, the primary issues of concern, and strategies needed for improvement.

The two-page summaries are intended to be concise, readable, and easy to interpret for a wide range of audiences. The primary goal for these summaries was to provide a starting point for future subwatershed planning and implementation efforts. If desired, the summaries may be appended to include future more specific subwatershed goals and implementation plans as developed during the One Watershed, One Plan (1W1P) process and/or other local water plans.

Figure 23. Image showing the online interactive tool developed for the Cottonwood River Subwatershed Analysis.



3.2 Civic Engagement

Redwood-Cottonwood Rivers Control Area

The RCRCA was formed in 1983 as a joint powers organization comprised of eight counties and eight SWCDs. The organization was created to prevent the development of a watershed district as the local government units (LGUs) desired more local input and control into the watershed's activities. RCRCA, in cooperation with partner groups and landowners, works to improve water quality, reduce erosion, and enhance recreational opportunities by providing education, outreach, monitoring and technical assistance within the watershed boundaries. The RCRCA has been very successful at securing grant funding to analyze and assess both watersheds and secure implementation funding for the construction of BMPs. One of the organization's goals was to see the dredging of Lake Redwood in the Redwood River Watershed to restore it to its original depth and vitality as a lake. The RCRCA, in cooperation with partner groups and landowners, works to improve water quality, reduce erosion, and enhance recreational opportunities by providing education, outreach, monitoring and technical assistance within the watershed boundaries. The RCRCA was highly engaged in each step of the Cottonwood River Watershed project, including monitoring, document review, and hosting meetings.

Accomplishments and Future Plans

The MPCA contracted with RCRCA, who partnered with 10 local governmental units in the Cottonwood River Watershed (Lyon County and SWCD, Murray County and SWCD, Redwood County and SWCD, Cottonwood County and SWCD, and Brown County and SWCD) to directly advance civic engagement throughout the Redwood and Cottonwood River Watersheds for much of the duration of this project. Through these partnerships, the MPCA provided grant funds for the local partners to engage directly with watershed residents and landowners on a variety of water quality topics. These projects were successful in helping local watershed partners connect with watershed residents to build relationships that will be integral in implementing the strategies described in this report. The work begun under these projects will continue as implementation continues throughout both watersheds. Section 3.3 provides a description as to what has been done in the watersheds.

Public Notice for Comments

An opportunity for public comment on the draft WRAPS report was provided via a public notice in the *State Register* from October 10, 2022 through November 9, 2022. There were no comments received as a result of the notice.

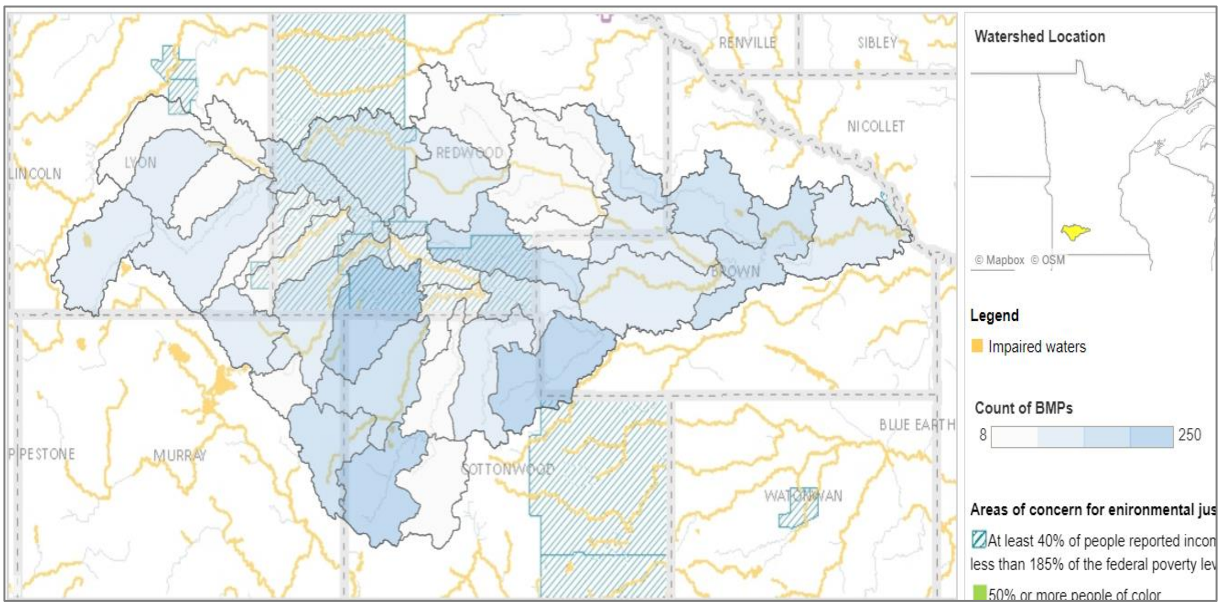
Work Done To-Date

To date, some agricultural and urban runoff in the Cottonwood River Watershed has been reduced through the implementation of conservation practices and stormwater BMPs. As discussed in Section 2.2, the Cottonwood River has seen long-term reductions in TP, ammonia, and biochemical oxygen demand over the last 50 years (Table 3). The new MPCA Healthier Watersheds Accountability Report shows that over 3,300 BMPs were installed and reported through federal, state, and locally funded programs and grants in the Cottonwood River Watershed between 2004 and 2021. Table 15 summarizes the major types of BMPs that have been implemented throughout the watershed, while Figure 24 shows the number of BMPs per subwatershed.

Table 15. Reported major BMPs in the Cottonwood River Watershed by BMP type (2004-2021).

BMP Type	Total BMPs
Tile Inlet Improvements	266
Tillage/residue Management	480
Nutrient Management (Cropland)	430
Septic System Improvements	48
Designed Erosion Control	271
Converting Land to Perennials	157
Buffers and Filters	59
Living Cover to Crops in Fall/Spring	135
Stream Banks, Bluffs, and Ravines	101
Pasture Management	63
Tile Drainage Treatment/Storage	11
Habitat and Stream Connectivity	9
Crop Rotation	19

Figure 24. Number of reported BMPs in the Cottonwood River Watershed by subwatershed (2004-2021).



Further, two MDA led initiatives - The Nutrient Management Initiative (NMI) and The Agricultural Water Quality Certification Program (MAWQCP) – have engaged farmers and increased agricultural BMP adoption in the Cottonwood River Watershed. The NMI Program has provided financial incentives for participants to conduct on-farm trials for fertilizer rate management. A total of 31 nutrient trials took place in the Cottonwood and Redwood River Watersheds between 2006 and 2019. MAWQCP is a voluntary opportunity for farmers and agricultural landowners to take the lead in implementing conservation practices that protect water quality. Those who implement and maintain sufficient approved farm management practices are certified and in turn obtain regulatory certainty for a period of 10 years. In the Cottonwood River Watershed, there are 16 MAWQCP-certified producers that cover 12,239 acres. BMPs implemented to-date through this program include:

- 84 alternative/closed tile intakes

- 231 acres of pest management
- 19 sediment basins
- 4 acres of filter strips
- 1,431 acres of residue management
- 887 acres of nutrient management
- 946 acres nitrogen BMPs
- 313 acres cover crops
- 2,000 ft grassed waterway

Strategies

While significant progress has been made in the Cottonwood River Watershed, more is needed. The following strategies were identified as key strategies to restore and protect lakes, streams, and groundwater in the Cottonwood River Watershed. These strategies were identified through stakeholder input during the WRAPS process as well as individual county water plans, the Cottonwood River Watershed Characterization Report (DNR 2020) and other local planning efforts. A combination of BMPs (also referred to as layered BMP suites, stacked BMPs, or BMP treatment trains) that includes multiple key strategies discussed below will likely be necessary within each subwatershed to address the widespread surface water impairments throughout the Cottonwood River Watershed. The combinations of BMPs discussed throughout this WRAPS report were derived from Minnesota's Nutrient Reduction Strategy (NRS) (MPCA 2015) and related tools. As such, they were vetted by a statewide engagement process prior to being applied in the Cottonwood River Watershed.

Agricultural Practices

Although agricultural land often contributes higher levels of pollutants/stressors compared to undisturbed land, 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. 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.

The NRCS has long adopted a systems approach to addressing agricultural nonpoint source pollution. This approach, known as Avoiding, Controlling, and Trapping (ACT), encourages producers to implement a system of practices, where appropriate, that can effectively protect specific high-priority resource concerns in selected watersheds. Below is a brief discussion of the types of practices that fit within each component of this approach.

<u>Avoiding</u>

Avoidance helps manage nutrients and sediment source control from agricultural lands, including animal production facilities. This includes any practices that help producers avoid pollution by reducing the amount of nutrients available in runoff or leaching into groundwater and surface water resources. General planning considerations to support Avoiding include:

- Applying fertilizer (chemical, manure, etc.) in accordance with MDA application guidelines
- Developing a nutrient management plan to identify nitrogen and phosphorus management actions that will reduce losses
- Crediting other sources of nitrogen and phosphorus (e.g., previous legume crops, organic matter) when calculating optimal nutrient application rates
- Properly storing fertilizer (e.g., storage building with impermeable floors)
- Composting manure to reduce the overall volume for disposal

Controlling

Controlling refers to land treatment in fields or facilities that prevents the loss of pollutants to groundwater and surface water. This includes practices such as conservation tillage and residue management, which improve infiltration, reduce runoff, and control erosion. Specific practices such as No-till/Strip/Till/Direct Seed (329) and Mulch Tillage (345) are foundation practices of this method. Practices such as Cover Crop (340) will also do double duty by helping with Avoidance as well as Controlling. Terraces (600), Strip cropping (585), and Grassed Waterways (412) also help control erosion and may manage runoff to reduce nutrient loading. Other practices and planning considerations to support Controlling include implementing crop rotations to minimize use of fertilizer, and the use of precision irrigation systems to apply water uniformly and with greater efficiency to reduce water loss and pollutant transport.

There is growing awareness of the role that soil biology plays in sustaining crop productivity and supporting healthy ecosystems. "Soil livestock" - the soil bacteria, fungi, protozoa, nematodes, arthropods, earthworms, and other animals the live in or move through the soil -- are critical to soil health. They can support decomposition and nutrient cycling, leading to healthy plant growth, control soil erosion, improve water availability, and protect crops from pests and diseases.

The basic principles of soil health include (source – BWSR):

- Minimize soil disturbance. Tillage, overgrazing, or misapplication of farm inputs can result in bare or compacted soil, disrupted soil habitat, increased soil temperature, and increased runoff and erosion.
- Keep the soil covered as much as possible. Living plants and mulch buffer the soil from weather extremes.
- Maximize plant diversity. Crop rotations and cover crops support diverse soil microorganisms and the soil food web.
- Keep living roots in the soil throughout the year. The soil/root interface, or rhizosphere, is where the most intense microbial activity takes place, feeding soil microbes and the soil food web.
- Integrate livestock where possible. Controlled grazing can improve soil health through hoof action, insect consumption, gleaning following harvest, and direct application of manure where feasible.

Thus, building and maintaining soil health, through controlling practices such as reduced tillage and cover crops, has the potential to improve agricultural profitability by reducing input costs and increasing productivity. At the same time, they help protect water resources by increasing the water holding capacity of soil and reducing the transport of pollutants to streams and lakes.

Research, education, outreach, and decision-making tools to support soil health practices have increased throughout the region in recent years and farmers and other land managers are becoming more and more interested in implementing soil health practices and initiatives. There are various university groups and federal and state agencies that have soil health programs and resources available to support farmers and land managers. Some of these programs and resources include: NRCS's Soil Health Resources, the Soil Health Institute, Midwest Cover Crop Council (MCCC), Sustainable Agriculture Research & Education (SARE), Minnesota Farming Association of Minnesota Soil Health Portal, University of Minnesota Extension, the University of Minnesota Forever Green Initiative, and the Minnesota Office for Soil Health (MOSH).

Another group that is very active in soil health initiatives throughout Southwest Minnesota is the Minnesota Soil Health Coalition. This Coalition is a farmer led and driven organization dedicated to provide education, farmer to farmer mentoring, networking and plain language technical information. Two key goals of the coalition are to provide farmer to farmer mentoring and soil health testing that compiles management, economic, and agronomic data to provide real world information more quickly to the producers of Minnesota.

Trapping

Trapping is last line of defense to trap or treat pollutants within the field or at the edge of field prior to being delivered to downstream water bodies. Common Trapping practices and planning considerations include:

- Wetland enhancement and/or restoration (659 and 657)
- Ponds and other structures for on-site water control (378 and 587)
- Planting riparian buffers and Filter Strips (390, 391, and 393)
- Grade Stabilization Structures (410) and Water and Sediment Control Basins (638)
- Establishing Windbreaks/Shelterbelts (380)
- Perennial vegetative buffers of 50 feet along lakes, rivers, and streams and 16.5 feet along ditches

Maintaining 50-foot-wide perennial vegetative buffers along lakes, rivers, and streams and 16.5-foot-wide buffers along ditches is required by Minn. Stat. § 103F.48, commonly referred to as the Minnesota Buffer Law. Buffer compliance rates for the counties of the Cottonwood River Watershed are at or above 97%.

Drainage Management

Minnesota drainage law is found in Minn. Stat. ch. 103.E. Counties within the Cottonwood River Watershed have varying levels of ditch record management. Drainage systems in Minnesota are managed under the jurisdiction of one of several authorities. The three most common are: a county board of commissioners, a joint county drainage authority, or a watershed district board of managers. When a drainage system in located entirely in one county, the jurisdictional authority is a county board of commissioners. When a drainage system crosses over into another county, that drainage system is under the jurisdiction of a joint county drainage authority. And lastly, when an organized watershed district is present, the drainage system falls under the purview of the watershed district. There can be a transfer of jurisdictional authority, but that detail goes beyond the scope of this WRAPS. Ditch records can vary. Paper ditch records are common, others have scanned paper records to a digital format and others have converted the records into GIS. A ditch records modernization initiative is managed through BWSR.

There are various grant opportunities, programs, and initiatives available to ditch authorities to improve their drainage system in ways that also promote storage, water quality, and other benefits. One example is BWSR's Clean Water Fund (CWF) Multipurpose Drainage Management (MDM) grant. This grant supports the use of various practices and designs to achieve multiple water management goals, including supporting beneficial use, flood control, water quality, drainage, and wildlife habitat (aquatic and terrestrial). Both rural and urban multipurpose water management can involve reducing runoff volume, peak flows, erosion, sedimentation, and nutrient transport, as well as increasing infiltration, evapotranspiration, and wildlife habitat. Specific MDM practices include but are not limited to: side inlets (410), wetland restorations (657), water and sediment control basins (638), grassed waterways (412), saturated buffers (604), and controlled subsurface drainage (554 and 587). Due to substantial agricultural drainage infrastructure, MDM will be vital for the Cottonwood River Watershed to achieve the goals described above and to protect and improve drainage systems in a way that reduces future maintenance.

Feedlot Management

All feedlots in Minnesota are regulated by Minn. R. ch. 7020. The MPCA has regulatory authority of feedlots but counties may choose to participate in a delegation of the feedlot regulatory authority to the local unit of government. Delegated counties are then able to enforce Minn. R. ch. 7020 (along with any other local rules and regulations) within their respective counties for facilities that are under the CAFO threshold. In the Cottonwood River Watershed, the counties of Brown, Cottonwood, Lyon, and Murray are delegated the feedlot regulatory authority. The only nondelegated county in the Cottonwood River Watershed is Redwood County. The Counties and MPCA will continue to implement the feedlot program and work with producers on manure management plans.

SSTS (Septic System) Improvements

SSTS, commonly known as septic systems, are regulated by Minn. Stat. §§ 115.55 and 115.56. Counties and other LGUs that regulate SSTS must meet the requirements for local SSTS programs in Minn. R. ch. 7082. Counties and other LGUs must adopt and implement SSTS ordinances in compliance with Minn. R. chs. 7080 - 7083.

These regulations detail:

- Minimum technical standards for individual and mid-size SSTS
- A framework for LGUs to administer SSTS programs

- Statewide licensing and certification of SSTS professionals, SSTS product review and registration, and establishment of the SSTS Advisory Committee

Counties and other LGUs enforce Minn. R. chs. 7080 through 7083 through their local SSTS ordinance and issue permits for systems designed with flows up to 10,000 gallons per day. There are approximately 200 LGUs across Minnesota and depending on the location an LGU may be a county, city, township, or sewer district. LGU SSTS ordinances vary across the state. Some require SSTS compliance inspections prior to property transfer, require permits for SSTS repair and septic tank maintenance, and may have other requirements which are stricter than the state regulations.

SSTS Assessments

The counties that comprise the Cottonwood River Watershed have the following septic assessment criteria:

- Brown – any permit in shoreland, sale, or property transfer
- Cottonwood – sale or property transfer
- Lyon – sale or property transfer
- Murray - sale or property transfer requires inspection as does addition of “living area”
- Redwood - any permit in shoreland or bedroom addition requires inspection

SSTS Upgrades/Replacement process

The upgrade or replacement process for septic systems generally is uniform across the state. Counties and other LGUs must adopt and implement SSTS ordinances in compliance with Minn. R. chs. 7080 – 7083. In general, the upgrade process includes an application, soils verification, a septic design, permit, and final inspection including as-built record of what was installed. The MPCA has a low-interest Clean Water Partnership (CWP) loan program available to local governmental units interested in leading a project to control nonpoint-source pollution that threatens water quality. Septic system upgrades are eligible for these loans.

Low Income Fix-up Grants

Most counties across the state have low interest loan programs for qualified residents to upgrade failing septic systems. Loans can come from a variety of sources including but not limited to special property tax assessments, grants, and the AgBMP Loan Program which is administered through the county or SWCD. The counties that comprise the Cottonwood River Watershed have the following septic system loan options:

- Brown – low interest loans
- Cottonwood – low interest loans
- Lyon – low interest loans
- Murray – low interest loans, low-income grants when available
- Redwood – low interest loans

SSTS Maintenance and Education

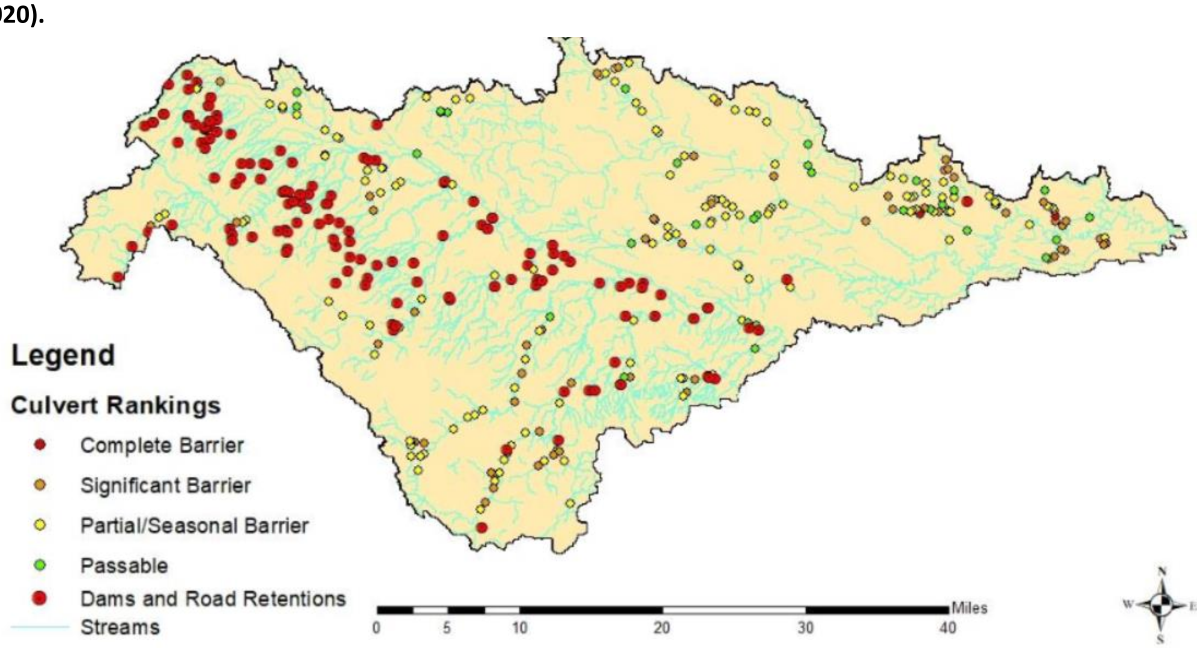
The MPCA suggests that septic tanks be evaluated at least every three years and pumped free of solids. The rate of solids accumulation is dependent on many factors. The University of Minnesota Extension developed a septic system owners guide to counties for distribution to residents at a reduced cost. Counties also provide a variety of digital and physical educational sources for residents to ensure proper SSTS operation and maintenance.

Culvert replacement and other barriers

DNR staff, as part of the Cottonwood River Watershed Characterization Report (DNR 2020), reviewed the Minnesota Department of Transportation (MNDOT) bridge and culvert GIS dataset to determine that there are 166 bridges and 229 culverts on perennial streams within the Cottonwood River Watershed (Figure 25). Further GIS analysis of stream lines and road lines, however, indicated that there may be as many as 1,452 road and stream intersections that have some form of crossing within the Cottonwood River Watershed. Bridges and culverts can have drastic impacts on rivers and streams, especially when improperly sized. Improperly sized bridges and culverts can create flood flow confinement (FFC), which can cause channel widening, alter sediment transport capacity, and sediment deposition (Zytkovicz and Murtada 2013). Desktop reconnaissance and field observations performed by the DNR identified approximately 132 dam and road retention structures, and 63 significant or complete culvert barriers to fish migration in the Cottonwood River Watershed. In total, 196 fish barriers were identified within the watershed.

DNR staff also conducted an extensive review of historic records to determine that there are five dams within the Cottonwood River Watershed that are determined to be barriers to fish passage. Additionally, six other structures are probable barriers and two other structures are possible barriers; however, it was not possible to make a final determination from the limited amount of information and photographs within the structure's files.

Figure 25. Longitudinal barriers identified in the Cottonwood River Watershed Characterization Report (DNR 2020).



Urban Stormwater Management

Although land cover in the Cottonwood River Watershed is predominantly cultivated crops, there are a few medium-sized cities located throughout the watershed. The city of New Ulm (MS400228; population 13,237) and a small portion of the city of Marshall (MS400241; population 13,530) are located at the confluence of the Minnesota River and near the headwaters of Meadow Creek HUC-10 subwatershed, respectively. These cities are the only communities in the watershed that are subject to the MPCA's MS4 Permit program. There are also 26 smaller municipalities throughout the Cottonwood River Watershed that are not subject to MS4 permits (Figure 1).

While urban areas often contribute higher levels of pollutants/stressors than natural areas, it has been demonstrated throughout the State that city stormwater systems can be designed and built for zero or minimal runoff depending on the size and intensity of the rain event. 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 specific urban BMP strategies, studies, calculators, and special considerations for Minnesota, as well as links regarding industrial and stormwater programs.

In-Lake Management

There are eight lakes in the Cottonwood River Watershed that have been assessed for AqR, all of which are considered shallow lakes by DNR definition (maximum depth of 15 feet or less, or greater than 80% littoral area). Shallow lakes are ecologically different from deep lakes in that they have a greater proportion of sediment area to lake volume, allowing potentially larger sediment contributions to nutrient loads and higher potential sediment resuspension that can decrease water clarity. Biological organisms also play a greater role in maintaining water quality. Rough fish, especially carp, can uproot SAV and stir up sediment. SAV helps stabilize the sediment, reducing the amount that can be resuspended and cloud water clarity. SAV also provides refuge for zooplankton, a group of small crustaceans that consumes algae.

All these interactions in shallow lakes occur within a theoretical paradigm of two alternative stable states: a clear water, macrophyte-dominated state and turbid water, algae-dominated state (Scheffer 2004). The clear water state is characterized by low algal biomass, an abundant and diverse SAV community, a balanced fish community (if any) and large bodied zooplankton daphnia. Alternatively, the turbid water state is characterized by high phytoplankton biomass, little to no SAV, and has an imbalanced fish community often dominated by common carp, bullheads, and/or fathead minnow. Shallow lakes often exist in an area of hysteresis with the lake flipping between the clear and turbid water states due to sudden changes in the fish community. The persistence of the clear water state is often the favored outcome of management activities but can be difficult to maintain in agricultural landscapes. Understanding and identifying the potential mechanisms driving the state of water quality in a shallow lake is critical to successful and sustained management of shallow lakes.

Within the Cottonwood River Watershed, seven of the eight assessed lakes are considered impaired by nutrients (phosphorus), suggesting they are currently in a turbid water state. TMDL studies were completed on all seven of these impaired lakes. The TMDLs indicate all seven impaired lakes will need some level of internal load reduction to be flipped to a clear water state and meet State water quality standards. While the TMDL studies provide an estimate of the total internal phosphorus (mass) load reductions needed for each lake, the studies do not identify or quantify each potential internal source/driver. The DNR has performed biological assessments on many of the impaired lakes throughout the watershed through fish surveys, fish IBIs, vegetation surveys, and vegetation FQIs. While these assessments are helpful, a more detailed analysis/study will be needed on each lake to identify specific biological (fish and vegetation), physical (hydrology, wind), and/or chemical (sediment chemistry) factors driving internal load in each lake, and a list of management strategies (i.e., lake drawdown, rough fish removals/barriers, plant management, sediment P inactivation) to address these drivers. The MPCA recommends feasibility studies for any lakes in which water level drawdown or chemical treatment is considered. The Minnesota State and Regional Government Review of Internal Phosphorus Load Control (MPCA 2020b) paper provides more information on internal phosphorus load BMPs and considerations.

Climate protection co-benefit of strategies

Many agricultural BMPs that reduce the load of nutrients and sediment to receiving waters also act to decrease emissions of greenhouse gases (GHGs) to the air. Agriculture 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; while conservation cover, riparian buffers, vegetative filter strips, field borders, and cover crops reduce GHG emissions as compared to cropland with conventional tillage.

The NRCS has developed a ranking tool for cropland BMPs that can be used by LGUs 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 http://comet-planner.com/.

Funding Sources

There are a variety of funding sources to help cover some of the cost to implement practices that reduce pollutants from entering surface waters and groundwater. Below are several programs that contain web links to the programs and contacts for each entity. The contacts for each grant program can assist in the determination of eligibility for each program, as well as funding requirements and amounts available.

- Agriculture BMP Loan Program (MDA)
- Agricultural Water Quality Certification Program (MDA)
- Clean Water Fund Grants (BWSR) (several types)
- Clean Water Partnership Loans (MPCA)

- Environment and Natural Resources Trust Fund (ENRTF; Legislative-Citizen Commission on Minnesota Resources)
- Environmental Assistance Grants Program (MPCA)
- Phosphorus Reduction Grant Program (Minnesota Public Facilities Authority)
- Clean Water Act Section 319 Grant Program (MPCA)
- Small Community Wastewater Treatment Construction Loans & Grants (Minnesota Public Facilities Authority)
- Source Water Protection Grant Program (MDH)
- Surface Water Assessment Grants (SWAG; MPCA)
- Wastewater and Stormwater Financial Assistance Programs (MPCA)
- Conservation Partners Legacy Grant Program (DNR)
- Environmental Quality Incentives Program (NRCS)
- Conservation Reserve Program (USDA)
- Clean Water State Revolving Fund (EPA)

Watershed Priorities

The tools, models, subwatershed analyses, Watershed Characterization Report (DNR 2020), and county water plans have been integral in identifying and organizing information around watershed priorities that are taking place throughout the Cottonwood River Watershed. In lieu of completing a formal ranked prioritization exercise during the development of this report, efforts were concentrated on comparing tool and model output with existing priorities outlined in county water plans and local professional judgement. Discussions with the LWG consisting of partners from a variety of different groups and affiliations helped to refine the scope of priorities discussed in this WRAPS report. Partners participating in the Cottonwood River Watershed LWG included staff from county environmental services/planning and zoning departments, SWCDs, RCRCA, MPCA, DNR, BWSR, MDA, MDH, and other interested and affected citizens, LGUs, and agencies. Implementation of restoration and protection projects are very likely to directly involve these partners, so the local knowledge and expertise of the LWG weighed heavily in the creation of strategy tables in this report.

Some of the top priorities that were identified by the LWG during the Cottonwood River WRAPS process include:

- Implementing grade stabilization structures and practices (e.g., water and sediment control basins (638) and grassed waterways (412) in higher sloped areas of the watershed that experience significant erosion and soil loss
- Continue educating and working with landowners to manage the health of their soils to promote infiltration/filtration, minimize soil loss, and protect surface and groundwater quantity and quality (e.g., cover crops, no-till/reduced till, manure, and fertilizer management)
- Restore and/or protect lakes and stream reaches with high recreational use and value

    - Sleepy Eye Lake
    - Lake Laura (Plum Creek County Park)
    - Wellner-Hageman Reservoir (Mound Creek County Park)
- Restore and/or protect lakes and stream reaches that are nearly impaired or barely impaired (i.e., within 40% of water quality standards):
    - Dutch Charley Creek Reach 518 (impaired by TSS, within 5% of standard)
    - Dutch Charley Creek Reach 517 (impaired by TSS, within 39% of standard)
    - Bean Lake (impaired by TP, within 40% of standard)
    - Double Lake (impaired by TP, within 38% of standard)
    - Hurricane Lake (not impaired, within 6% of standard)
    - Sleepy Eye Lake (not impaired, within 9% of standard)
    - Wellner-Hageman Reservoir (not impaired, within 14% of standard)
    - Lake Laura (not impaired, within 18% of standard)
- Protect vulnerable and sensitive groundwater areas throughout the watershed, particularly WHPAs and DWSMAs with highly vulnerability:
    - Marshall and Marshall Dudley DWSMAs/WHPAs
    - Red Rock Rural Lake Augusta DWSMA

Cottonwood River Watershed Restoration and Protection Strategies Tables

This section provides detailed tables identifying restoration and protection strategies watershed-wide, and for individual lakes and streams in each HUC-10 subwatershed. The watershed-wide implementation strategy table (further discussion below) oultines strategies and actions to address some of the major watershed-wide initiatives such as altered hydrology, groundwater protection, and improving biological communities. The individual HUC-10 tables address specific lakes and reaches within each major subwatershed and were developed by reviewing results of the TMDL studies, the Cottonwood River Watershed Characterization Report (DNR 2020), HSPF and other modeling tools and conditions affecting each subwatershed or impairment, and input and feedback from the LWG and local citizen groups. Within these tables, over 12 different strategy types were identified as key strategies in achieving short and long term TMDL reduction goals and protection of water bodies currently meeting state water quality standards. Eight of these strategy types (i.e., BMPs) are available within the Cottonwood River Watershed HSPF-SAM application tool (see Section 3.1 for description) and therefore adoption of these BMPs can be evaluated using this tool. The Cottonwood River Watershed HSPF-SAM tool contains a database for each BMP type that contains the following information included in the HUC-10 tables. For the Strategies Tables shown below, the MPCA's Watershed Pollutant Load Reduction Calculator was used to estimate BMP adoption rates to achieve the 10-year targets and water quality goals. The BMP adoption rates represent one path to restoration and protection and are not intended to be prescriptive. Local resource managers are in the best position to make decisions on practices that are most likely to be adopted and successful.

BMP Suitable Acres for Subwatershed

"BMP Suitable Acres for Subwatershed" represents the total land area within each HUC-10 subwatershed that is practical to implement that BMP based on land characteristics such as soil, slope, etc., depending on the type of BMP (Table 16). For example, the available land fraction for implementing cover crops for corn and soybean rotations is the total acres of corn and beans within the subwatershed. A combination of stakeholder input and literature review were completed to determine the default Suitable Acres for each BMP that is included in HSPF-SAM. The MPCA compiled estimates of the number of Suitable Acres for all BMPs included in HSPF-SAM for each HUC-12 subwatershed throughout the State. The Cottonwood River HUC-12 Suitable Acre numbers were selected from the State-wide database and aggregated for each HUC-10 for incorporation into the WRAPS tables below.

Current BMP Adoption Level

HSPF-SAM also provides the fraction of the suitable land areas where a BMP has already been implemented. These numbers represent practices implemented between 2004 through 2015 and were provided by request from the NRCS Resource Economics Analysis and Policy Division Strategic Information Team. Practices implemented before 2004 were assumed to be past their useful life and considered no longer in place. Using both "BMP Suitable Acres" and "Current Strategy Adoption Level" together, the user can identify the fraction of land area currently available for a BMP to be implemented.

Table 16. Methodology employed to determine suitable and current adoption level for BMPs within the HSPF-SAM application (MPCA 2017).

SAM BMP	Suitable Acres Methodology	Current Adoption Level (Acres) Methodology
Riparian buffers, 50 ft wide (replacing row crops)	50 ft buffers either side of all streams and ditches adjacent to cropland	Acres implemented by NRCS Practice 391 and 472
Riparian buffers, 50 ft wide (pasture)	50 ft buffers either side of all streams and ditches adjacent to pasture	Acres implemented by NRCS Practice 391 and 472
Reduced tillage (30% + residue cover)	Total cropland acres >2% slope	Acres implemented by NRCS Practice 329, 345, and 346
Reduced tillage (no-till)	Total cropland acres >2% slope	Acres implemented by NRCS Practice 329, 345, and 346
Corn & soybeans with cover crop	Total corn & soybean acres	Acres implemented by NRCS Practice 340
Restore tiled wetlands	Minnesota Restorable Wetland Inventory	2012 NLCD Wetland Acres
Controlled tile drainage	Total Drained Cropland – found by: (1) cropland planted to corn, beans, wheat, or sugar beets; (2) in proximity (1/4 mile) to artificial drainages, canal ditches, or streams; (3) SSURGO Hydrologic Soil Group C or D (4) 0–1% slopes	Acres implemented by NRCS Practice 554
Water and sediment control basins (cropland)	Total cropland acres >2% slope	Acres implemented by NRCS Practice 638

SAM BMP	Suitable Acres Methodology	Current Adoption Level (Acres) Methodology
Alternative tile intakes	Total Drained Cropland – found by: (1) cropland planted to corn, beans, wheat, or sugar beets; (2) in proximity (1/4 mile) to artificial drainages, canal ditches, or streams; (3) SSURGO Hydrologic Soil Group C or D (4) 0–3% slope	N/A
Nutrient management + manure incorporation	Total cropland acres	Acres implemented by NRCS Practice 590

Watershed-wide Strategies Table

This section provides watershed-wide strategies (Table 17) for addressing the Cottonwood River Watershed's biological impairments, as well as watershed-wide initiatives such as addressing altered hydrology and groundwater protection. The Cottonwood River Watershed SID Report identifies major stressors conributing to the watershed's biological impairments, but does not provide specific strategies to address each impairment. Many of the strategies listed in the HUC-10 subwatershed tables intended to address TSS, bacteria, and nutrients will also address the watershed's biological impairments; however, some additional strategies are needed. The watershed-wide strategy table includes these additional strategies that are not already listed in the HUC-10 subwatershed tables. These watershed-wide strategies should be implemented throughout the watershed, where possible and in conjunction with the HUC-10 subwatershed strategies to help address the high number of biological impairments.

Watershed-wide strategies were selected from the MPCA's WRAPS template if they addressed one or more of the stressors identified in the SID report (altered hydrology, loss of connectivity, loss of physical habitat, low DO concentrations, eutrophication, suspended solids, nitrate concentrations, and chloride/conductivity toxicity). Watershed-wide strategies were also incorporated from the DNR's Watershed Characterization Report (DNR 2020).

Table 17. Watershed-wide strategies and actions proposed for the Cottonwood River Watershed.

HUC-10 Subwatershed	Water Body and Location		Parameter (incl. nonpollutant stressors)	Water Quality		Strategy type (see key below)	Strategy scenario showing estimated scale of adoption to meet 10 yr. milestone and final water quality targets.		Estimated Adoption Rate				Estimated Years to Achieve Water Quality Target
	Water Body (ID)	Location and Upstream Influence Counties		Current Conditions (load or concentration)	Goals/Targets and Estimated % Reduction		Specific Implementation Strategy	Biological Stressor(s) addressed	Current strategy adoption level, if known	Interim 10-year Milestone	Suggested adoption to meet TMDL and protection goals	Units	
All	All Cottonwood River Watershed biotic impaired reaches	Lyon, Murray, Redwood, Cottonwood, & Brown	All Cottonwood River Watershed MIBI & FIBI Impairments; Stressors: habitat, altered hydrology, eutrophication, nitrate, etc.	See tables corresponding to individual HUC-10 Subwatersheds	See tables corresponding to individual HUC-10 Subwatersheds	Habitat and stream connectivity management	Restore streams to their stable forms using Natural Channel Design principles	Habitat, Connectivity, Altered Hydrology, TSS	Unknown	Assess and prioritize projects on a reach-by-reach basis	Assess and prioritize projects on a reach-by-reach basis	Completed Projects	20 - 50
							Properly size and replace road crossings to prevent fish barriers and restore floodplain connectivity	Habitat, Connectivity	Unknown				
							Create or restore wetlands for habitat (657, 658)	Habitat, Altered Hydrology, Nitrate	See individual HUC-10 strategy tables				
							Restore floodplains and reconnect with channel using two-stage ditches or by limiting ditch maintenance so floodplain benches form	Habitat, Altered Hydrology, Connectivity, TSS	Unknown				
							Riparian tree planting to improve shading (390, 612)	Habitat, Eutrophication, Dissolved Oxygen	Unknown				
							Riparian plantings to reduce nuisance waterfowl levels (390, 612)	Habitat	Unknown				
							Restoration and Management of Declining Habitats (643)	Habitat	Unknown				
						Protect/restore stream banks, bluffs, & ravines	Re-meander channelized stream reaches (584)	Altered Hydrology, Habitat, TSS	Unknown				
							Ravine stabilization (410)	TSS	Unknown				
							Riparian bluffs stabilized or restored (580)	TSS	Unknown				
							Restore riffle substrate	Habitat	Unknown				
							Protect toe of banks with natural materials and install grade control structures like constructed riffles and cross-vanes	Habitat, Altered Hydrology, TSS	Unknown				
							Stream habitat improvement and management [395]	Habitat	Unknown				
							Establish, maintain, and/or protect deep-rooted, native perennial vegetation in the riparian corridor	TSS, Habitat	Unknown				

HUC-10 Subwatershed	Water Body and Location		Parameter (incl. nonpollutant stressors)	Water Quality		Strategy type (see key below)	Strategy scenario showing estimated scale of adoption to meet 10 yr. milestone and final water quality targets.			Estimated Adoption Rate			Estimated Years to Achieve Water Quality Target
	Water Body (ID)	Location and Upstream Influence Counties		Current Conditions (load or concentration)	Goals/Targets and Estimated % Reduction		Specific Implementation Strategy	Biological Stressor(s) addressed	Current strategy adoption level, if known	Interim 10-year Milestone	Suggested adoption to meet TMDL and protection goals	Units	
						Wastewater point-source management	Wastewater nutrient (NO3 and TP) reductions	Eutrophication, Nitrate, Dissolved Oxygen	See individual HUC-10 strategy tables				
						Upland water storage	Create or restore wetlands for water storage (656, 810M) and other multipurpose drainage management practices	Altered Hydrology, TSS, Nitrate	See individual HUC-10 strategy tables				
						Nitrate Reduction	see Groundwater Protection strategies below and HUC-10 Subwatershed table - Sleepy Eye Creek & Mound Creek HUC-10	Nitrate	See individual HUC-10 strategy tables				
	All Cottonwood River Watershed Groundwater and Drinking Water Resources	Lyon, Murray, Redwood, Cottonwood, & Brown	Groundwater Quality	See tables corresponding to individual HUC-10 Subwatersheds	See tables corresponding to individual HUC-10 Subwatersheds	Protect groundwater quality, particularly vulnerable areas	Implement Minnesota's Groundwater Protection Rule to restrict fall application of nitrogen fertilizer in areas vulnerable to contamination	Nitrate	Unknown	Assess and prioritize projects	Assess and prioritize projects	Assess and prioritize projects	50
							Expand monitoring to further identify and target vulnerable and sensitive groundwater areas	NA	NA				
							Education and outreach to farmers and feedlot operators regarding nutrient management in vulnerable and sensitive areas	Nitrate	Unknown				
							Plant vegetative buffers, increase living cover, and improve soil health through cover crops and reduced tillage, prioritize in or near vulnerable groundwater and water supply management areas	Nitrate, TSS, Eutrophication	See individual HUC-10 strategy tables				
							Install alternative tile intakes (606, 170M, 172M, 173M)	TSS, Nitrate, Eutrophication	See individual HUC-10 strategy tables				
							Seal abandoned wells	Nitrate	Unknown				
							Promote SSTS compliance through education, maintenance, and inspection	Nitrate, Eutrophication	See individual HUC-10 strategy tables				

HUC-10 Subwatershed Strategies

Headwaters - Cottonwood River HUC-10

The Headwaters Cottonwood River HUC-10 Subwatershed (Figure 26, Table 18) is the northwest-most subwatershed and is the headwaters of the Cottonwood River. The subwatershed encompasses approximately 100 square miles and is almost entirely in Lyon County. Small portions of Balaton (population 600) and Garvin (population 121) fall within the watershed. All the stream reaches are considered warmwater. Primary stream reaches include the Cottonwood River and three unnamed creeks.

Land use within the subwatershed is predominately cropland (86%). Developed land use comprises 4% of the watershed. Wetlands comprise 4% and forests are less than 2% of the watershed area. Open water accounts for 1% of the subwatershed area including North Twin (48 acres), McKay (218 acres), Rock (392 acres) Lakes, and Mahlke Marsh (63 acres).

Figure 26. Headwaters – Cottonwood River HUC-10 Subwatershed.

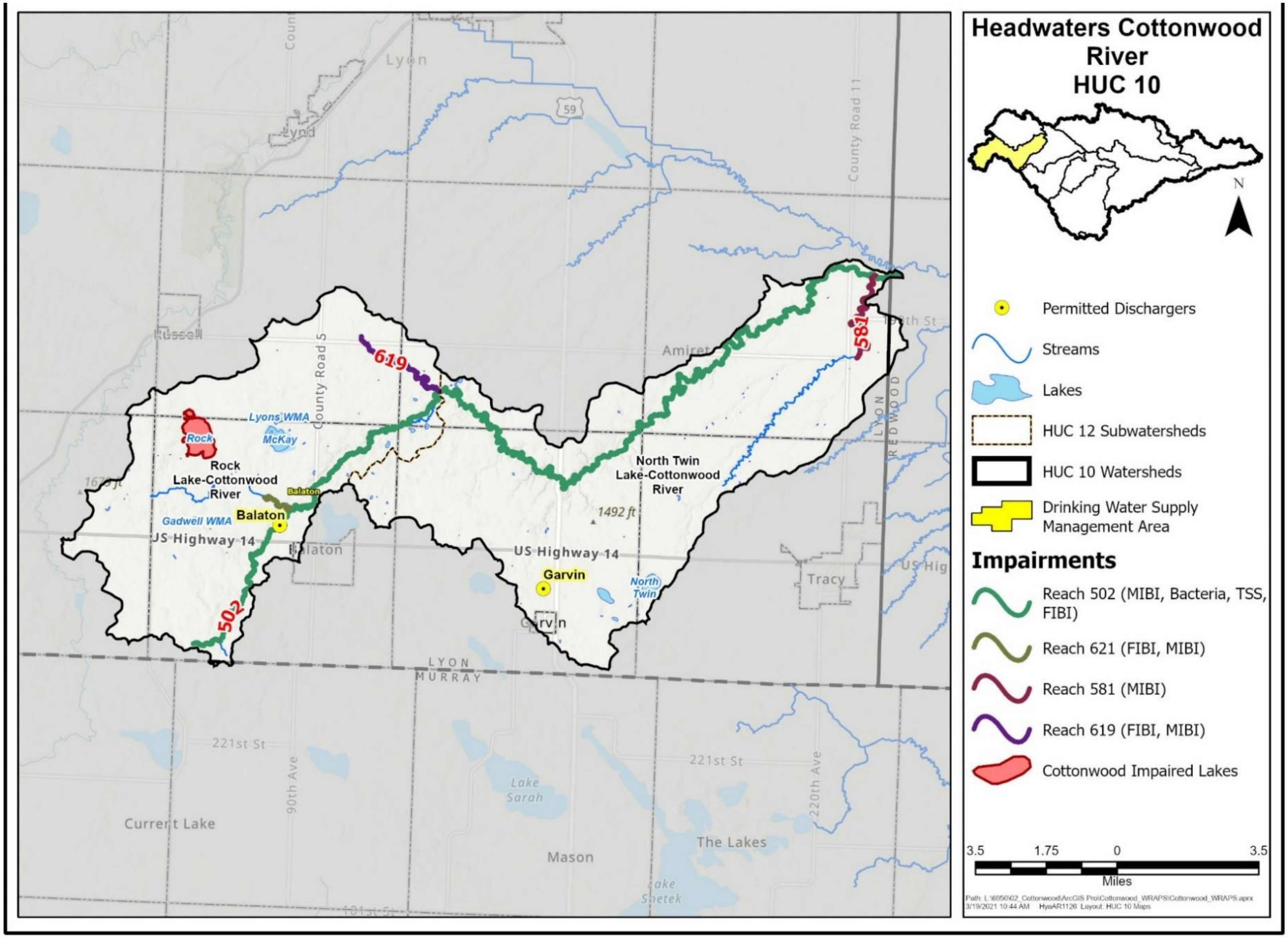


Table 18. Strategies and actions proposed for the Headwaters – Cottonwood River HUC-10 Subwatershed.

HUC-10 Subwatershed	Water Body and Location		Parameter (incl. nonpollutant stressors)	Water Quality		Strategy type (see key below)	Strategy scenario showing estimated scale of adoption to meet 10 yr. milestone and final water quality targets						Estimated Years to Achieve Water Quality Target
								Estimated Adoption Rate					
	Water Body (ID)	Location and Upstream Influence Counties		Current Conditions (load, concentration, IBI score)	Goals/Targets and Estimated % Reduction		Specific Implementation Strategy	HSPF-SAM Strategy/BMP Suitable Acres for Subwatershed	Current strategy adoption level, if known	Interim 10-year Milestone	Suggested adoption to meet TMDL and protection goals	Units	
HUC-10 Subwatershed: Headwaters Cottonwood River; HUC-12 Subwatersheds: Rock Lake, North Twin Lake	Cottonwood River (07020008-502)	Lyon	TSS	90th percentile TSS concentration = 75 mg/L	Maximum 90th percentile TSS concentration = 65 mg/L; 13% reduction	Buffers - field edge	50-ft buffers on streams adjacent to cropland/pasture (390, 391, 327)	cropland: 12,000; pasture: 705	cropland: 3%; pasture: 16%	cropland: 5%; pasture: 20%	cropland: 15%; pasture: 20%	% suitable acres	35
						Tillage/residue management	Adopt reduced tillage (30% + residue cover) and no-till (329, 345, 346)	reduced till: 21,920; no-till: 21,920	reduced till: 15%; no-till: 15%	reduced till: 20%; no-till: 20%	reduced till: 20%; no-till: 20%	% suitable acres	
						Add cover crops for living cover in fall/spring	Implement cover crops with corn & soybeans (340)	49,820	3%	5%	10%	% suitable acres	
						Upland water storage/retention	Restore tiled wetlands in marginal areas and as opportunities arise (656, 810M)	5,680	<1%	2%	5%	% suitable acres	
						Conservation practice installation	Construct water and sediment control basins (638) and grassed waterways (412)	WASCOBs & GWs: 21,950	WASCOBs: <1%; GWs: <1%	WASCOBs: 2%; GWs: 5%	WASCOBs: 10%; GWs: 10%	% suitable acres	
						Urban stormwater runoff control	ID and implement stormwater BMPs to treat sediment loading from Cities of Garvin and Balaton	NA	Unknown	Complete assessment and feasibility	Implement identified projects and education	Completed assessments and projects	
	Cottonwood River (07020008-502)	Lyon	*E. coli*	1,063 cfu/100 mL maximum monthly geomean	Maximum monthly geomean <126 cfu/100 mL; 93% reduction	Reduce sediment loads	Implement TSS reduction strategies outlined above						50
						Manure management (cropland)	Fertilizer and manure management and incorporation (590)	49,600	16%	20%	75%	% suitable acres	
						Pasture management	Implement exclusion fencing, grazing rotations in shoreland and high priority areas	NA	Unknown	Work with producers to identify and implement priority projects	Implement priority projects	Completed projects	
						Feedlot runoff controls	Implement feedlot runoff reduction/treatment (635, 784) where needed	NA	Unknown	Work with producers to identify and implement projects	Implement projects	Completed projects	

HUC-10 Subwatershed	Water Body and Location		Parameter (incl. nonpollutant stressors)	Water Quality		Strategy type (see key below)	Strategy scenario showing estimated scale of adoption to meet 10 yr. milestone and final water quality targets						Estimated Years to Achieve Water Quality Target
								Estimated Adoption Rate					
	Water Body (ID)	Location and Upstream Influence Counties		Current Conditions (load, concentration, IBI score)	Goals/Targets and Estimated % Reduction		Specific Implementation Strategy	HSPF-SAM Strategy/BMP Suitable Acres for Subwatershed	Current strategy adoption level, if known	Interim 10-year Milestone	Suggested adoption to meet TMDL and protection goals	Units	
						Septic system improvements	Provide education and maintenance materials for SSTS parcels. Work through current ordinances with landowners to upgrade failing and noncompliant SSTS	NA	Point of sale inspections	Work with landowners to identify and upgrade SSTSs	Upgrade all failing and noncompliant SSTSs	SSTS upgrades	
						Urban stormwater runoff control	ID and implement stormwater BMPs to treat bacteria loading from Garvin and Balaton	NA	Unknown	Complete assessment and feasibility study	Implement targeted projects and educational programs	Completed study and projects	
	Cottonwood River (07020008-502)	Lyon	FIBI & MIBI; Stressors: TSS, Connectivity, Habitat	FIBI = 44; MIBI = 37	FIBI > 55; MIBI > 41	Implement TSS & bacteria reduction strategies outlined above; see watershed-wide table for additional strategies to address stream biological impairments							50
	Unnamed Creek (07020008-581)		MIBI; Stressors: TSS, Habitat	MIBI = 34	MIBI > 41								
	Unnamed Creek (07020008-619)		FIBI & MIBI; Stressors: Eutrophication, TSS, Altered hydrology, Habitat	FIBI = 43; MIBI = 24	FIBI> 55; MIBI > 41								
	Unnamed Creek (07020008-621)		FIBI & MIBI; Stressors: Altered hydrology	FIBI = 41; MIBI = 19	FIBI > 55; MIBI > 37								
	Rock Lake (42-0052-00)	Lyon	Phosphorus (TP); FIBI	5,530 lb TP/yr; 199 ppb TP summer avg.; FIBI = 3	1,600 lb TP/yr; < 90 ppb TP summer avg.; FIBI >36	Reduce sediment loads	Implement TSS reduction strategies outlined above						50
						Reduce phosphorus loading	Implement eutrophication reduction strategies outlined above in watershed-wide table						
						Shoreline restoration & protection	Promote and maintain riparian areas with use of shoreline buffers	NA	NA	ID projects/areas	Implement priority improvements	Improvements	
						Monitoring	Continue monitoring fish community and rough fish populations	NA	Surveyed every 5 years	Continue current schedule	Manage as necessary	Completed surveys	

HUC-10 Subwatershed	Water Body and Location		Parameter (incl. nonpollutant stressors)	Water Quality		Strategy type (see key below)	Strategy scenario showing estimated scale of adoption to meet 10 yr. milestone and final water quality targets						Estimated Years to Achieve Water Quality Target
								Estimated Adoption Rate					
	Water Body (ID)	Location and Upstream Influence Counties		Current Conditions (load, concentration, IBI score)	Goals/Targets and Estimated % Reduction		Specific Implementation Strategy	HSPF-SAM Strategy/BMP Suitable Acres for Subwatershed	Current strategy adoption level, if known	Interim 10-year Milestone	Suggested adoption to meet TMDL and protection goals	Units	
						Lake internal load management	Assess common carp and other rough fish to determine impact on water quality and native vegetation; develop management strategies	NA	None	Assess fish and develop management plan	Manage as necessary	Assessments and management actions	
	Balaton DWSMA	Lyon	GW Quality	Moderate vulnerability	Protect GW quality, particularly vulnerable areas	See watershed-wide table for strategies to protect groundwater; implement TSS & bacteria strategies outlined above							50
	Groundwater - general	Lyon	GW Quality	Vulnerable GW areas = 2,669 acres									
	Mahlke Marsh (42-0060-0)	Lyon	Phosphorus (TP)	Unknown	Maintain or improve existing water quality (Standard = 90 ppb)	Implement TSS & bacteria strategies outlined above; implement eutrophication strategies outlined above in watershed-wide table							50
	Leedom Slough (42-0114-00)	Lyon	Phosphorus (TP)	Unknown		Monitoring	Water quality monitoring to track trends, fill data gaps, and support future assessments	NA	NA	Develop and implement monitoring plan	Routine monitoring	Monitor water quality	

Color Key:

(pink)	Restoration
(green)	Protection

Meadow Creek HUC-10

Meadow Creek HUC-10 Subwatershed (702000802) is in the northwest corner of the Cottonwood River Watershed in Lyon County (Figure 27, Table 19). A small portion of the city of Marshall (population 13,651) falls within the watershed. The subwatershed drains 98 square miles. Streams within the watershed are a combination of natural and ditched and all are warmwater.

Land use within the watershed is predominately agricultural (89%). Developed land accounts for 4% of the subwatershed area. A small portion of the watershed is wetlands (4%), and even less is forested (less than 1%). Open water accounts for less than 1% of the land area and includes Round Lake (166 acres), Clear Lake (104 acres), and Lake Marshall (250 acres).

Figure 27. Meadow Creek HUC-10 Subwatershed.

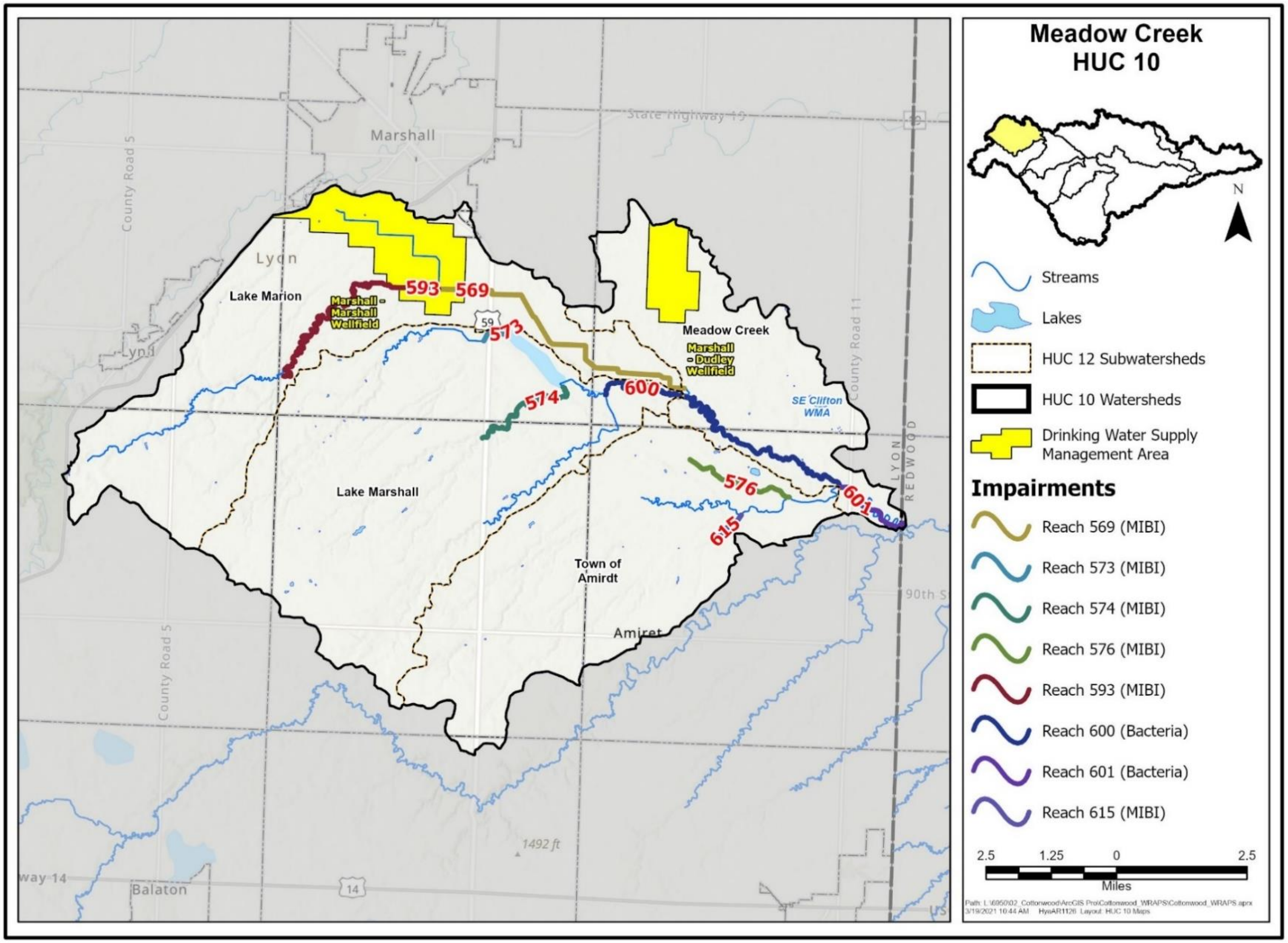


Table 19. Strategies and actions proposed for the Meadow Creek HUC-10 Subwatershed.

HUC-10 Subwatershed	Water Body and Location		Parameter (incl. nonpollutant stressors)	Water Quality		Strategy type (see key below)	Strategy scenario showing estimated scale of adoption to meet 10 yr. milestone and final water quality targets						Estimated Years to Achieve Water Quality Target
									Estimated Adoption Rate				
	Water Body (ID)	Location and Upstream Influence Counties		Current Conditions (load, concentration, IBI score)	Goals / Targets and Estimated % Reduction		Specific Implementation Strategy	HSPF-SAM Strategy/BMP Suitable Acres for Subwatershed	Current strategy adoption level, if known	Interim 10-year Milestone	Suggested adoption to meet TMDL and protection goals	Units	
HUC-10 Subwatershed: Meadow Creek; HUC-12 Subwatersheds: Lake Marion, Lake Marshall, Town of Amirdt, Meadow Creek	Cottonwood River (07020008-504) Note: this is a downstream impairment located in Pell Creek - Cottonwood River HUC-10 Subwatershed	Redwood, Upstream = Lyon, Murray, Cottonwood	TSS	90th percentile TSS concentration = 78 mg/L	Maximum 90th percentile TSS concentration = 65 mg/L; 17% reduction	Buffers - field edge	50-ft buffers on streams adjacent to cropland/pasture (390, 391, 327)	cropland: 16,480; pasture: 640	cropland: 3%; pasture: 7%	cropland: 5%; pasture: 20%	cropland: 15%; pasture: 20%	% suitable acres	35
						Tillage/residue management	Adopt reduced tillage (30% + residue cover) and no-till (329, 345, 346)	reduced till: 17,600; no-till: 17,600	reduced till: 3%; no-till: 3%	reduced till: 20%; no-till: 20%	reduced till: 20%; no-till: 20%	% suitable acres	
						Add cover crops for living cover in fall/spring	Implement cover crops with corn & soybeans (340)	50,980	2%	5%	10%	% suitable acres	
						Upland water storage/retention	Restore tiled wetlands in marginal areas and as opportunities arise (656, 810M)	7,350	<1%	2%	5%	% suitable acres	
						Conservation practice installation	Construct water and sediment control basins (638) and grassed waterways (412)	WASCOBs & GWs: 17,590	WASCOBs: <1%; GWs: <1%	WASCOBs: 2%; GWs: 5%	WASCOBs: 10%; GWs: 10%	% suitable acres	
						Open tile inlet & side inlet improvements	Install alternative tile intakes (606, 170M, 172M, 173M)	940	<1%	2%	5%	% suitable acres	
							Identify and implement side inlet improvements (410)	NA	Unknown	Implement necessary improvements and upland treatment	Implement necessary improvements	Improvements	
	Meadow Creek (07020008-600 & 601) Note: this reach has been split and was previously 515	Lyon	Fecal coliform	734 cfu/100 mL maximum monthly geomean	Maximum monthly geomean <200 cfu/100 mL; 73% reduction	Reduce sediment loads	Implement TSS reduction strategies outlined above						50
						Manure management (cropland)	Fertilizer and manure management and incorporation (590)	49,960	11%	20%	75%	% suitable acres	
						Pasture management	Implement exclusion fencing, grazing rotations in shoreland and high priority areas	NA	Unknown	Work with producers to identify and implement priority projects	Implement priority projects	Completed projects	
						Feedlot runoff controls	Implement feedlot runoff reduction/treatment (635, 784) where needed	NA	Unknown	Work with producers to identify and implement projects	Implement projects	Completed projects	

HUC-10 Subwatershed	Water Body and Location		Parameter (incl. nonpollutant stressors)	Water Quality		Strategy type (see key below)	Strategy scenario showing estimated scale of adoption to meet 10 yr. milestone and final water quality targets						Estimated Years to Achieve Water Quality Target
									Estimated Adoption Rate				
	Water Body (ID)	Location and Upstream Influence Counties		Current Conditions (load, concentration, IBI score)	Goals / Targets and Estimated % Reduction		Specific Implementation Strategy	HSPF-SAM Strategy/BMP Suitable Acres for Subwatershed	Current strategy adoption level, if known	Interim 10-year Milestone	Suggested adoption to meet TMDL and protection goals	Units	
						Septic system improvements	Provide education and maintenance materials for SSTS parcels. Work through current ordinances with landowners to upgrade failing and noncompliant SSTS	NA	Point of sale inspections	Work with landowners to identify and upgrade SSTSs	Upgrade all failing and noncompliant SSTSs	SSTS upgrades	
						Urban stormwater runoff control	ID and implement stormwater BMPs to treat bacteria loading from city of Marshall	NA	Unknown	Complete assessment and feasibility study	Implement targeted projects and educational programs	Completed study and projects	
	Unnamed Ditch (07020008-573)	Lyon	MIBI; Stressors: Connectivity, Altered hydrology, Habitat	MIBI = 13	MIBI > 22	Implement TSS & bacteria reduction strategies outlined above; see watershed-wide table for additional strategies to address stream biological impairments							50
	Unnamed Creek (07020008-574)	Lyon	MIBI; Stressors: Habitat	MIBI = 20	MIBI > 41								
	Unnamed Creek (07020008-576)	Lyon	MIBI; Stressors: Dissolved oxygen, Connectivity, Altered hydrology, Habitat	MIBI = 5	MIBI > 22								
	Unnamed Ditch (07020008-569)	Lyon	MIBI; Stressors: Eutrophication, Connectivity, Altered hydrology, Habitat	MIBI = 12	MIBI > 22								
	Unnamed Creek (07020008-593)	Lyon	MIBI; Stressors: Habitat	MIBI = 32	MIBI > 37								
	Unnamed Creek (07020008-615)	Lyon	MIBI; Stressors: Altered hydrology, Habitat	MIBI = 17	MIBI > 24								
										-	-		

HUC-10 Subwatershed	Water Body and Location		Parameter (incl. nonpollutant stressors)	Water Quality		Strategy type (see key below)	Strategy scenario showing estimated scale of adoption to meet 10 yr. milestone and final water quality targets						Estimated Years to Achieve Water Quality Target
									Estimated Adoption Rate				
	Water Body (ID)	Location and Upstream Influence Counties		Current Conditions (load, concentration, IBI score)	Goals / Targets and Estimated % Reduction		Specific Implementation Strategy	HSPF-SAM Strategy/BMP Suitable Acres for Subwatershed	Current strategy adoption level, if known	Interim 10-year Milestone	Suggested adoption to meet TMDL and protection goals	Units	
	Meadow Creek (07020008-601)	Lyon	High watershed and riparian risk (MPCA tool)	low protection	Increase protection of stream reaches	Implement TSS & bacteria strategies outlined above; see watershed-wide table for strategies to protect stream biota							50
	Unnamed Creek (07020008-578)	Lyon	High watershed and riparian risk (MPCA tool)	low protection									
	Marshall WHPA	Lyon	GW quality	High vulnerability	Protect GW quality, particularly vulnerable areas	See watershed-wide table for strategies to protect groundwater; implement TSS & bacteria strategies outlined above							
	Marshall Dudley DWSMA/WHPA	Lyon	GW quality	High vulnerability									
	Groundwater - general	Lyon	GW quality	Vulnerable GW areas = 1,588 acres									

Color Key:

	Restoration
	Protection

Plum Creek HUC-10

The Plum Creek HUC-10 Subwatershed (0702000803) drains 90 square miles in the southwestern portion of the Cottonwood River Watershed (Figure 28, Table 20). The subwatershed spans Lyon, Murray, and Redwood Counties. A portion of Walnut Grove (population 687) is within the watershed. Most of the streams are natural and are tributaries to Plum Creek. Three miles of Plum Creek are channelized, and 30 miles are natural. Willow Creek is another notable stream within the subwatershed.

Land use within the watershed is mostly agricultural (89%). Four percent of the land area is developed. A small portion of the land area is forested (1%) and wetland (2%). Just over 1% of the watershed is open water and includes Clear Lake (252 acres), Round Lake (51-0038-00, 166 acres), Jackson Marsh (58 acres), Jacobson's Marsh (28 acres), and Lake Laura (22 acres), which is an Area II reservoir impoundment located in Plum Creek County Park.

Figure 28. Plum Creek HUC-10 Subwatershed.

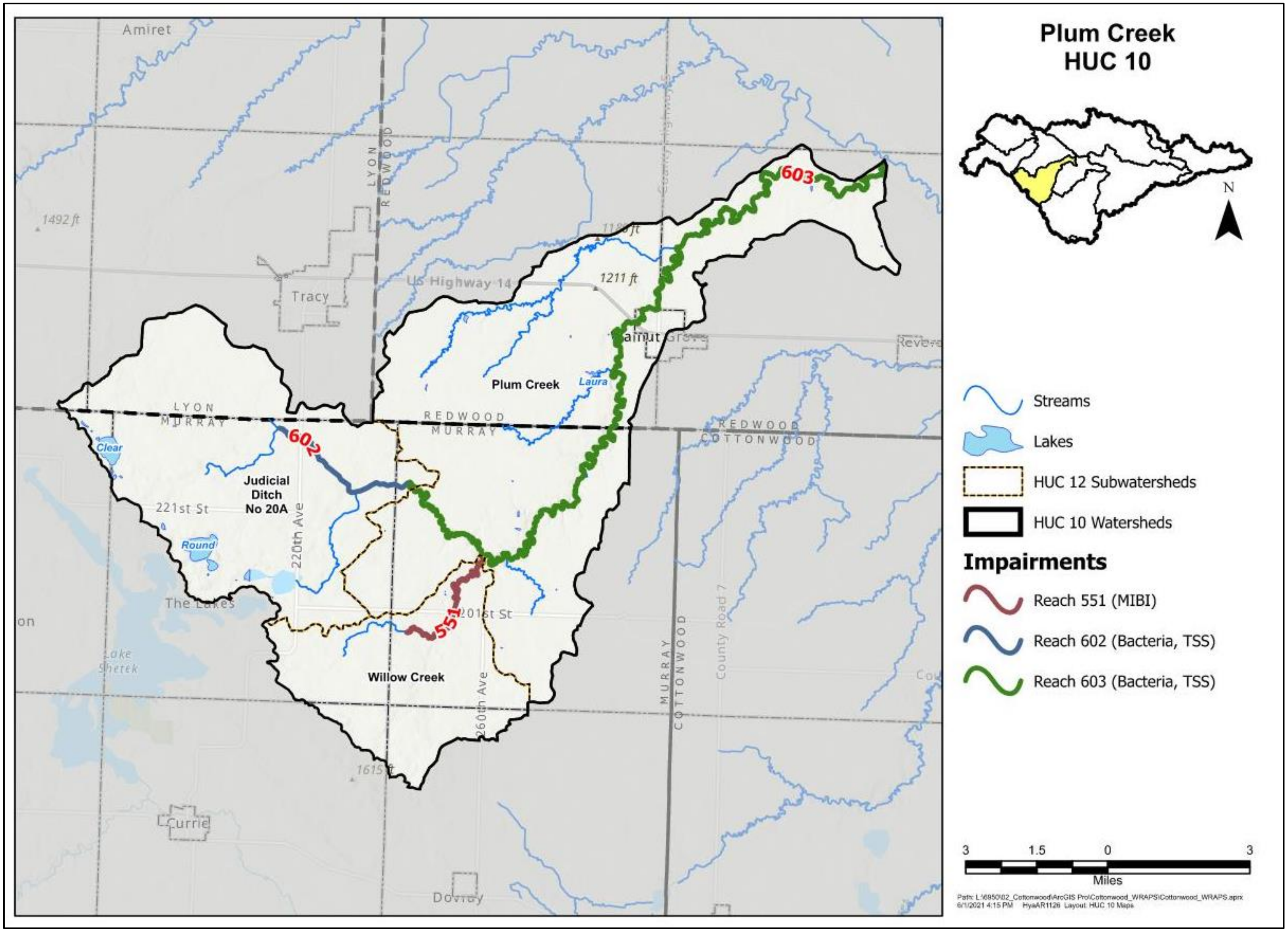


Table 20. Strategies and actions proposed for the Plum Creek HUC-10 Subwatershed.

HUC-10 Subwatershed	Water Body and Location		Parameter (incl. nonpollutant stressors)	Water Quality		Strategy type (see key below)	Strategy scenario showing estimated scale of adoption to meet 10 yr. milestone and final water quality targets						Estimated Years to Achieve Water Quality Target
								Estimated Adoption Rate					
	Water Body (ID)	Location and Upstream Influence Counties		Current Conditions (load, concentration, IBI score)	Goals/Targets and Estimated % Reduction		Specific Implementation Strategy	HSPF-SAM Strategy/BMP Suitable Acres for Subwatershed	Current strategy adoption level, if known	Interim 10-year Milestone	Suggested adoption to meet TMDL and protection goals	Units	
HUC-10 Subwatershed: Plum Creek; HUC-12 Subwatersheds: Judicial Ditch #20A, Willow Creek, Plum Creek	Plum Creek - Headwaters to Cottonwood River (07020008-602 & 603) Note: this reach has been split and was previously 516	Redwood, Murray Upstream = Lyon	TSS	90th percentile TSS concentration= 77 mg/L	Maximum 90th percentile TSS concentration = 65 mg/L; 16% reduction	Buffers - field edge	50-ft buffers on streams adjacent to cropland/pasture (390, 391, 327)	cropland: 11,550; pasture: 165	cropland: 2%; pasture: 18%	cropland: 15%; pasture: 15%	cropland: 50%; pasture: 50%	% suitable acres	35
						Tillage/residue management	Adopt reduced tillage (30% + residue cover) and no-till (329, 345, 346)	reduced till: 17,450; no-till: 17,450	reduced till: 16%; no-till: 16%	reduced till: 25%; no-till: 20%	reduced till: 40%; no-till: 25%	% suitable acres	
						Add cover crops for living cover in fall/spring	Implement cover crops with corn & soybeans (340)	51,450	8%	15%	20%	% suitable acres	
						Upland water storage/retention	Restore tiled wetlands in marginal areas and as opportunities arise (656, 810M)	7,350	<1%	5%	10%	% suitable acres	
						Conservation practice installation	Construct water and sediment control basins (638) and grassed waterways (412)	WASCOBs & GWs: 17,920	WASCOBs: 1%; GWs: <1%	WASCOBs: 3%; GWs: 3%	WASCOBs: 5%; GWs: 5%	% suitable acres	
						Urban stormwater runoff control	ID and implement stormwater BMPs to store water and treat sediment loading from town of Walnut Grove	NA	Unknown	Complete assessment and feasibility	Implement identified projects and education	Completed assessments and projects	
	Plum Creek - Headwaters to Cottonwood River (07020008-602 & 603) Note: this reach has been split and was	Redwood, Murray Upstream = Lyon	Fecal coliform	1,719 cfu/100 mL maximum monthly geomean	Maximum monthly geomean <200 cfu/100 mL; 88% reduction	Reduce sediment loads	Implement TSS reduction strategies outlined above						50
						Manure management (cropland)	Fertilizer and manure management and incorporation (590)	52,990	8%	12%	15%	% suitable acres	
						Pasture management	Implement exclusion fencing, grazing rotations in shoreland and high priority areas	NA	Unknown	Work with producers to identify and implement priority projects	Implement priority projects	Completed projects	

HUC-10 Subwatershed	Water Body and Location		Parameter (incl. nonpollutant stressors)	Water Quality		Strategy type (see key below)	Strategy scenario showing estimated scale of adoption to meet 10 yr. milestone and final water quality targets						Estimated Years to Achieve Water Quality Target
								Estimated Adoption Rate					
	Water Body (ID)	Location and Upstream Influence Counties		Current Conditions (load, concentration, IBI score)	Goals/Targets and Estimated % Reduction		Specific Implementation Strategy	HSPF-SAM Strategy/BMP Suitable Acres for Subwatershed	Current strategy adoption level, if known	Interim 10-year Milestone	Suggested adoption to meet TMDL and protection goals	Units	
	previously 516					Feedlot runoff controls	Implement feedlot runoff reduction/treatment (635, 784) where needed	NA	Unknown	Work with producers to identify and implement projects	Implement projects	Completed projects	
						Septic system improvements	Provide education and maintenance materials for SSTS parcels. Work through current ordinances with landowners to upgrade failing and noncompliant SSTS	NA	Point of sale inspections	Work with landowners to identify and upgrade SSTSs	Upgrade all failing and noncompliant SSTSs	SSTS upgrades	
						Urban stormwater runoff control	ID and implement stormwater BMPs to treat and reduce bacteria loading from town of Walnut Grove	NA	Unknown	Complete assessment and feasibility	Implement targeted projects	Completed study and projects	
	Willow Creek (07020008-551)	Murray	MIBI; Stressors: Altered hydrology	MIBI = 25	MIBI > 37	Implement TSS & bacteria reduction strategies outlined above; see watershed-wide table for additional strategies to address stream biological impairments							50
	Unnamed Creek (07020008-586)	Murray	High watershed and riparian risk (MPCA tool)	Med. Protection	Increase protection of stream reaches	Implement TSS & bacteria strategies outlined above; see watershed-wide table for strategies to protect stream biota							50
	Unnamed Creek (07020008-623)	Murray	High watershed and riparian risk (MPCA tool)	Low Protection									
	Round Lake (17-0048-01)	Murray	Phosphorus (TP)	38 ppb TP summer avg.	TP Reduction: 5 lbs/yr	Implement TSS & bacteria strategies outlined above; implement eutrophication strategies outlined above in watershed-wide table							
						Monitoring	Expand water quality monitoring program to track trends, fill data gaps, and support future assessments	NA	NA	Develop and implement monitoring plan	Routine monitoring	Monitor water quality	

HUC-10 Subwatershed	Water Body and Location		Parameter (incl. nonpollutant stressors)	Water Quality		Strategy type (see key below)	Strategy scenario showing estimated scale of adoption to meet 10 yr. milestone and final water quality targets						Estimated Years to Achieve Water Quality Target
								Estimated Adoption Rate					
	Water Body (ID)	Location and Upstream Influence Counties		Current Conditions (load, concentration, IBI score)	Goals/Targets and Estimated % Reduction		Specific Implementation Strategy	HSPF-SAM Strategy/BMP Suitable Acres for Subwatershed	Current strategy adoption level, if known	Interim 10-year Milestone	Suggested adoption to meet TMDL and protection goals	Units	
	Lake Laura (64-0150-00)	Redwood, Murray	Phosphorus (TP)	77 ppb TP summer avg.	Maintain or improve existing water quality (Standard = 90 ppb)		Complete fish survey according to DNR methods and protocols	NA	No surveys on record	Complete surveys	Use survey results to evaluate if fisheries management is needed	Completed survey	
	Willow (51-0044-00)	Murray	Phosphorus (TP)	Unknown	Maintain or improve existing water quality (Standard = 90 ppb)		Expand water quality monitoring program to track trends, fill data gaps, and support future assessments	NA	NA	Develop and implement monitoring plan	Routine monitoring	Monitor water quality	
	Groundwater - general	Redwood, Murray	GW Quality	Vulnerable GW areas = 2,917 acres	Protect GW quality, particularly vulnerable areas	See watershed-wide table for strategies to protect groundwater; implement TSS & bacteria strategies outlined above							

Color Key:

	Restoration
	Protection

Pell Creek – Cottonwood River HUC-10 Subwatershed

The Pell Creek – Cottonwood River HUC-10 Subwatershed (702000804) is in the northwest and center of the Cottonwood River Watershed in Lyon, Redwood, Murray, and Cottonwood counties (Figure 29, Table 21). The towns of Tracy (population 2,323), Revere (population 77), and a portion of Walnut Grove (population 687) fall within the watershed. The watershed is approximately 161 square miles.

Land use within the watershed is mostly agricultural (88%) and developed (5%). Nearly 5% of the watershed is wetlands. Less than 1% is forested. A small amount of the land area is open water (less than 1%) and includes South Twin (58 acres) and an unnamed lake (42 acres). Pell Creek, Lone Tree Creek, Judicial Ditches 9 and 22, and the Cottonwood River flow through this subwatershed.

Figure 29. Pell Creek – Cottonwood River HUC-10 Subwatershed.

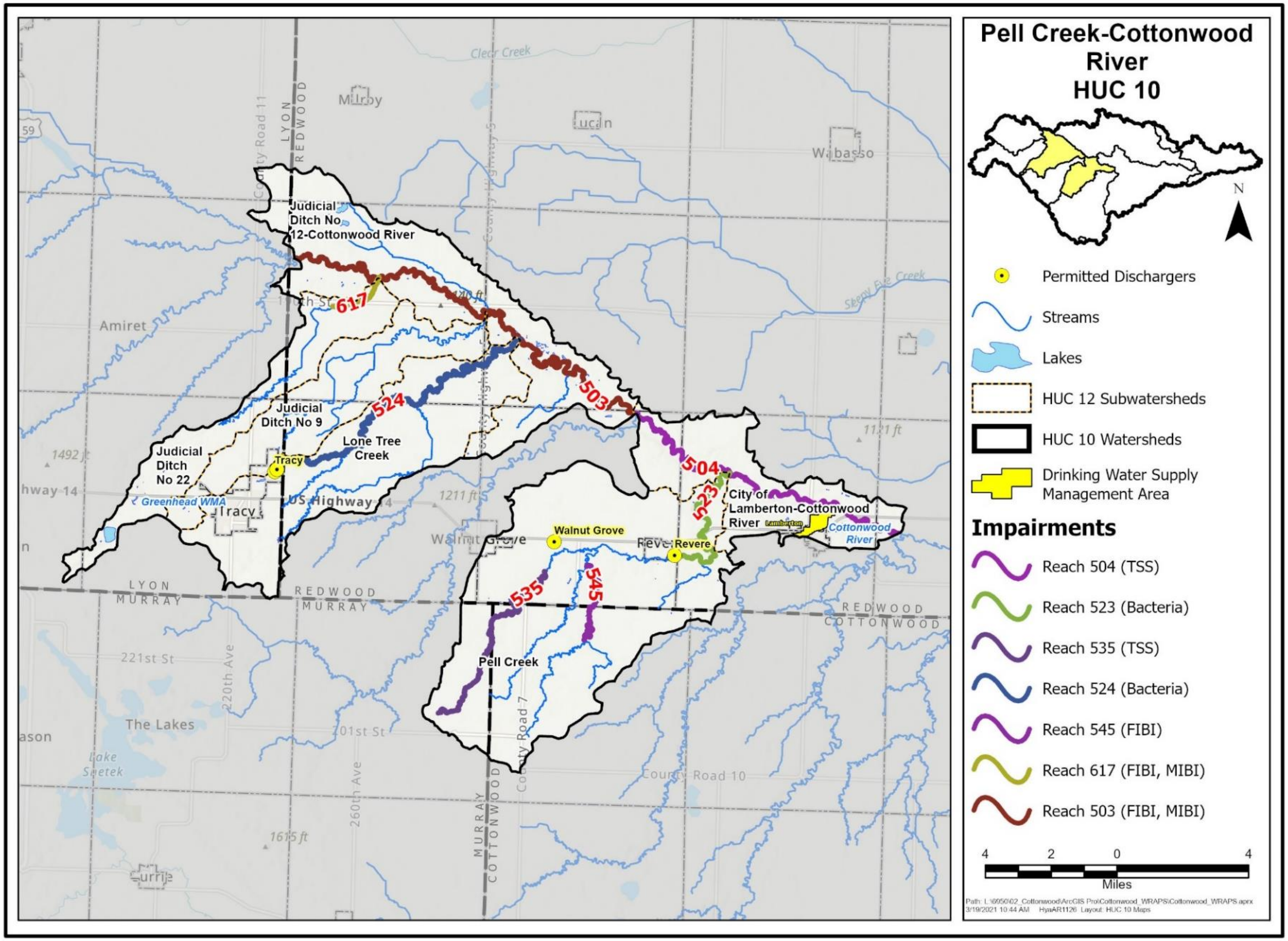


Table 21. Strategies and actions proposed for the Pell Creek – Cottonwood River HUC-10 Subwatershed.

HUC-10 Subwatershed	Water Body and Location		Parameter (incl. nonpollutant stressors)	Water Quality		Strategy type (see key below)	Strategy scenario showing estimated scale of adoption to meet 10 yr. milestone and final water quality targets						Estimated Years to Achieve Water Quality Target
								Estimated Adoption Rate					
	Water Body (ID)	Location and Upstream Influence Counties		Current Conditions (load, concentration, IBI score)	Goals / Targets and Estimated % Reduction		Specific Implementation Strategy	HSPF-SAM Strategy/BMP Suitable Acres for Subwatershed	Current strategy adoption level, if known	Interim 10-year Milestone	Suggested adoption to meet TMDL and protection goals	Units	
HUC-10 Subwatershed: Pell Creek - Cottonwood River; HUC-12 Subwatersheds: Judicial Ditch #22, Judicial Ditch #9, Lone Tree Creek, Judicial Ditch #12 - Cottonwood River, Pell Creek, City of Lamberton - Cottonwood River	Cottonwood River (07020008-504)	Location = Redwood, Upstream = Lyon, Murray, Cottonwood	TSS	90th percentile TSS concentration = 78 mg/L	Maximum 90th percentile TSS concentration = 65 mg/L; 17% reduction	Buffers - field edge	50-ft buffers on streams adjacent to cropland/pasture (390, 391, 327)	cropland: 19,900; pasture: 370	cropland: 3%; pasture: 19%	cropland: 5%; pasture: 20%	cropland: 15%; pasture: 20%	% suitable acres	35 - 50
						Tillage/residue management	Adopt reduced tillage (30% + residue cover) and no-till (329, 345, 346)	reduced till: 14,770; no-till: 14,770	reduced till: 10%; no-till: 10%	reduced till: 15%; no-till: 15%	reduced till: 20%; no-till: 20%	% suitable acres	
						Add cover crops for living cover in fall/spring	Implement cover crops with corn & soybeans (340)	83,740	3%	5%	10%	% suitable acres	
	Pell Creek (07020008-535)	Murray, Cottonwood, Redwood	TSS	90th percentile TSS concentration < 65 mg/L	Maximum 90th percentile TSS concentration = 65 mg/L; 5% reduction to ensure standard attainment	Upland water storage/retention	Restore tiled wetlands in marginal areas and as opportunities arise (656, 810M)	14,260	<1%	2%	5%	% suitable acres	
						Conservation practice installation	Construct water and sediment control basins (638) and grassed waterways (412)	WASCOBs & GWs: 15,750	WASCOBs: <1%; GWs: <1%	WASCOBs: 2%; GWs: 5%	WASCOBs: 10%; GWs: 10%	% suitable acres	
						Urban stormwater runoff control	ID and implement stormwater BMPs to store water and treat sediment loading town of Revere and city of Lamberton	NA	Unknown	Complete assessment and feasibility	Implement identified projects and education	Completed assessments and projects	
	Pell Creek (07020008-523)	Cottonwood	*E. coli*	2,005 cfu/100 mL maximum monthly geomean	Maximum monthly geomean <126 cfu/100 mL; 94% reduction	Reduce Sediment Loads	Implement TSS reduction strategies outlined above						50
						Manure management (cropland)	Fertilizer and manure management and incorporation (590)	84,220	14%	20%	75%	% suitable acres	
						Pasture management	Implement exclusion fencing, grazing rotations in shoreland and high priority areas	NA	Unknown	Work with producers to identify and implement priority projects	Implement priority projects	Completed projects	
	Lone Tree Creek (07020008-524)	Redwood, Upstream = Lyon	Fecal coliform	1,770 cfu/100 mL maximum monthly geomean	Maximum monthly geomean <200 cfu/100 mL; 89% reduction	Feedlot runoff controls	Implement feedlot runoff reduction/treatment (635, 784) where needed	NA	Unknown	Work with producers to identify and implement projects	Implement projects	Completed projects	
						Septic system improvements	Provide education and maintenance materials for SSTS parcels. Work through current ordinances with landowners to	NA	Point of sale inspections	Work with landowners to identify and upgrade SSTSs	Upgrade all failing and noncompliant SSTSs	SSTS upgrades	

HUC-10 Subwatershed	Water Body and Location		Parameter (incl. nonpollutant stressors)	Water Quality		Strategy type (see key below)	Strategy scenario showing estimated scale of adoption to meet 10 yr. milestone and final water quality targets						Estimated Years to Achieve Water Quality Target
								Estimated Adoption Rate					
	Water Body (ID)	Location and Upstream Influence Counties		Current Conditions (load, concentration, IBI score)	Goals / Targets and Estimated % Reduction		Specific Implementation Strategy	HSPF-SAM Strategy/BMP Suitable Acres for Subwatershed	Current strategy adoption level, if known	Interim 10-year Milestone	Suggested adoption to meet TMDL and protection goals	Units	
							upgrade failing and noncompliant SSTS						
						Urban stormwater runoff control	ID and implement stormwater BMPs to treat and reduce bacteria loading from town of Revere	NA	Unknown	Complete assessment and feasibility	Implement targeted projects	Completed study and projects	
	Cottonwood River (07020008-503)	Redwood	FIBI & MIBI; Stressors: Habitat	FIBI = 45; MIBI = 32	FIBI > 50; MIBI > 41	Implement TSS & bacteria reduction strategies outlined above; see watershed-wide table for additional strategies to address stream biological impairments							50
	Unnamed Creek (07020008-545)	Redwood	FIBI; Stressors: Habitat, Altered hydrology, Connectivity	FIBI = 46	FIBI > 55								
	Judicial Ditch 22 (07020008-617)	Redwood	FIBI & MIBI; Stressors: Habitat	FIBI = 45; MIBI = 32	FIBI > 55; MIBI > 37								
	Judicial Ditch 9 (07020008-548)	Redwood	High watershed and riparian risk (MPCA tool)	Med/Low protection	Increase protection of stream reaches	Implement TSS & bacteria strategies outlined above; see watershed-wide table for strategies to protect stream biota							50
	Unnamed Creek (07020008-584)	Redwood	High watershed and riparian risk (MPCA tool)	Low protection									
	Christianson Marsh (42-0008-00)	Lyon	Phosphorus (TP)	Unknown	Maintain or improve existing water quality (Standard = 90 ppb)	Implement TSS & bacteria strategies outlined above; implement eutrophication strategies outlined above in watershed-wide table							
						Monitoring	Expand water quality monitoring program to track trends, fill data gaps, and support future assessments	NA	NA	Develop and implement monitoring plan	Routine monitoring	Monitor water quality	
	Lamberton DWSMA/WHPA	Redwood	GW Quality	Moderate vulnerability	Protect GW quality, particularly vulnerable areas	See watershed-wide table for strategies to protect groundwater; implement TSS & bacteria strategies outlined above							
	Groundwater - general	Redwood, Cottonwood, Lyon	GW Quality	Vulnerable GW areas = 6,369 acres									

Color Key:

(pink)	Restoration
(green)	Protection

Dutch Charley Creek HUC-10 Subwatershed

Dutch Charley Creek HUC-10 Subwatershed (702000805) is the most southern subwatershed and drains 208 square miles of the Cottonwood River Watershed (Figure 30, Table 22). The subwatershed spans Murray, Cottonwood, and Redwood Counties. The towns of Storden, Westbrook, and a portion of Lamberton are located within the drainage area. All the stream reaches are warmwater. Dutch Charley Creek is 90% natural channel.

Land use in the subwatershed is predominantly agricultural (89%) and developed (3%). Just over 1% of the land area is open water, 3% is wetlands, and 2% is forested. Major water bodies in the subwatershed include Dutch Charley Creek, Highwater Creek, and several unnamed tributaries. There are several lakes in this subwatershed including Augusta (441 acres), Long (197 acres), Hurricane (158 acres), Bean (164 acres), Double Lake – North Portion (136 acres), and Double – South Portion (114 acres).

Figure 30. Dutch Charley Creek HUC-10 Subwatershed.

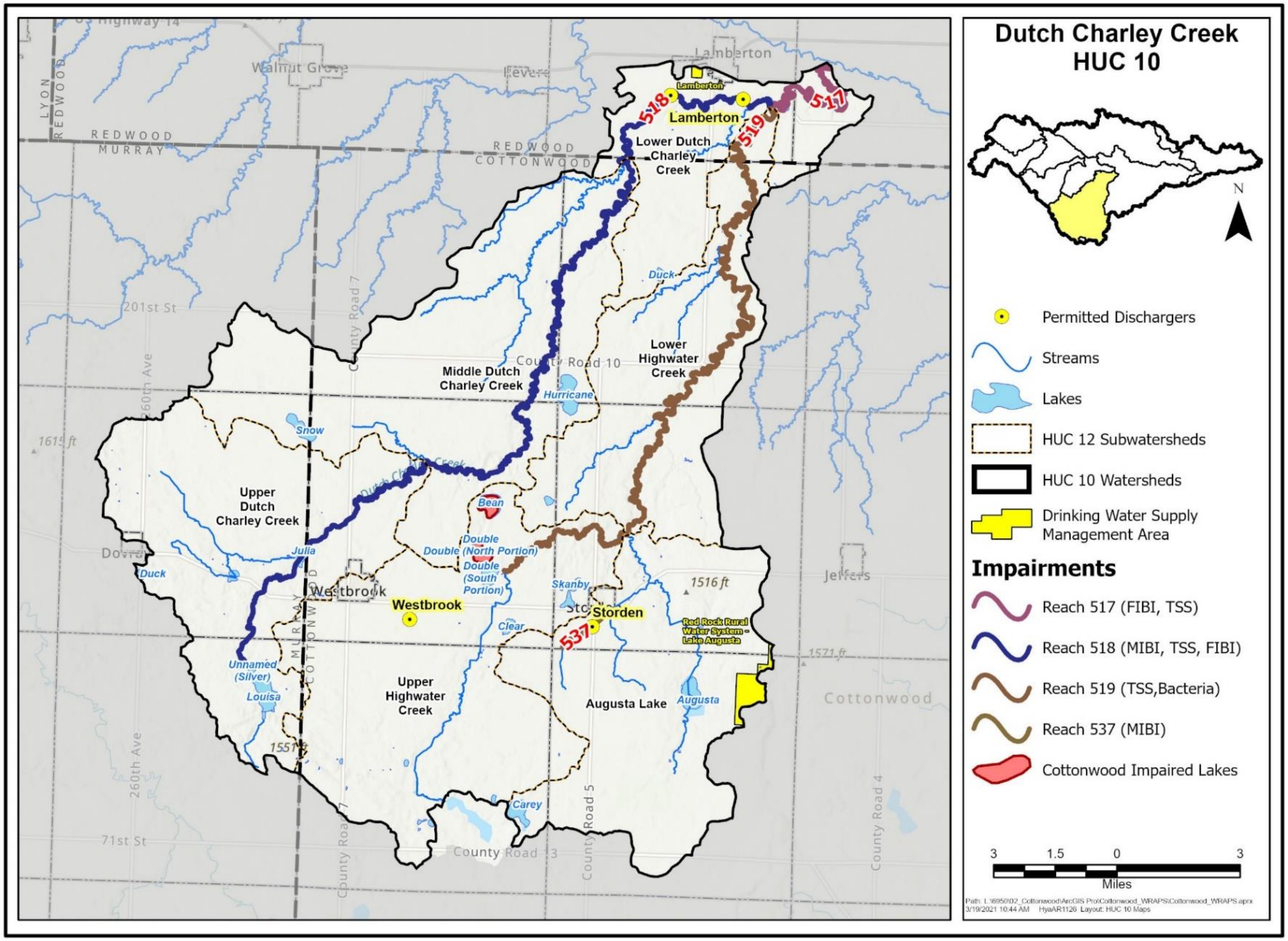


Table 22. Strategies and actions proposed for the Dutch Charley Creek HUC-10 Subwatershed.

HUC-10 Subwatershed	Water Body and Location: Water Body (ID)	Water Body and Location: Location and Upstream Influence Counties	Parameter (incl. nonpollutant stressors)	Water Quality: Current Conditions (load, concentration, IBI score)	Water Quality: Goals/Targets and Estimated % Reduction	Strategy type (see key below)	Strategy scenario showing estimated scale of adoption to meet 10 yr. milestone and final water quality targets: Specific Implementation Strategy	Estimated Adoption Rate: HSPF-SAM Strategy/BMP Suitable Acres for Subwatershed	Estimated Adoption Rate: Current strategy adoption level, if known	Estimated Adoption Rate: Interim 10-year Milestone	Estimated Adoption Rate: Suggested adoption to meet TMDL and protection goals	Estimated Adoption Rate: Units	Estimated Years to Achieve Water Quality Target
HUC-10 Subwatershed: Dutch Charley Creek; HUC-12 Subwatersheds: Upper Dutch Charley Creek, Middle Dutch Charley Creek, Lower Dutch Charley Creek, Upper Highwater Creek, Lower Highwater Creek, Augusta Lake	Dutch Charley Creek (07020008-517)	Location = Redwood, Upstream = Cottonwood and Murray	TSS	90th percentile TSS concentration = 79 mg/L	Maximum 90th percentile TSS concentration = 65 mg/L; 18% reduction	Buffers - field edge	50-ft buffers on streams adjacent to cropland/pasture (390, 391, 327)	cropland: 21,100; pasture: 380	cropland: 4%; pasture: 24%	cropland: 8%; pasture: 30%	cropland: 15%; pasture: 30%	% suitable acres	20 - 35
						Tillage/residue management	Adopt reduced tillage (30% + residue cover) and no-till (329, 345, 346)	reduced till: 35,630; no-till: 35,630	reduced till: 11%; no-till: 11%	reduced till: 20%; no-till: 20%	reduced till: 20%; no-till: 20%	% suitable acres	
						Add cover crops for living cover in fall/spring	Implement cover crops with corn & soybeans (340)	112,210	2%	5%	10%	% suitable acres	
	Dutch Charley Creek (07020008-518)	Murray, Cottonwood, and Redwood	TSS	90th percentile TSS concentration < 65 mg/L	Maximum 90th percentile TSS concentration = 65 mg/L; 5% reduction to ensure standard attainment	Upland water storage/retention	Restore tiled wetlands in marginal areas and as opportunities arise (656, 810M)	17,200	<1%	2%	5%	% suitable acres	
							Implement controlled tile drainage water management (554)	4,620	<1%	2%	5%	% suitable acres	
						Conservation practice installation	Construct water and sediment control basins (638) and grassed waterways (412)	WASCOBs & GWs: 36,000	WASCOBs: 7%; GWs: <1%	WASCOBs: 10%; GWs: 5%	WASCOBs: 10%; GWs: 10%	% suitable acres	
	Highwater Creek (07020008-519)	Redwood and Cottonwood	TSS	90th percentile TSS concentration < 65 mg/L	Maximum 90th percentile TSS concentration = 65 mg/L; 5% reduction to ensure standard attainment	Open tile inlet & side inlet improvements	Install alternative tile intakes (606, 170M, 172M, 173M)	4,770	1%	2%	5%	% suitable acres	
							Identify and implement side inlet improvements (410)	NA	Unknown	Implement necessary improvements and upland treatment	Implement necessary improvements	Improvements	
						Urban stormwater runoff control	ID and implement stormwater BMPs to store water and treat sediment loading from towns of Storden, Westbrook, and Lamberton	NA	Unknown	Complete assessment and feasibility	Implement identified projects and education	Completed assessments and projects	
	Highwater Creek (07020008-519)	Redwood and Cottonwood	*E. coli*	2,729 cfu/100 mL maximum monthly geomean	Maximum monthly geomean <126 cfu/100 mL; 95% reduction	Reduce sediment loads	Implement TSS reduction strategies outlined above						50
						Manure management (cropland)	Fertilizer and manure management and incorporation (590)	112,800	11%	20%	75%	% suitable acres	
						Pasture management	Implement exclusion fencing, grazing rotations in shoreland and high priority areas	NA	Unknown	Work with producers to identify and implement priority projects	Implement priority projects	Completed projects	

HUC-10 Subwatershed	Water Body and Location		Parameter (incl. nonpollutant stressors)	Water Quality		Strategy type (see key below)	Strategy scenario showing estimated scale of adoption to meet 10 yr. milestone and final water quality targets						Estimated Years to Achieve Water Quality Target
								Estimated Adoption Rate					
	Water Body (ID)	Location and Upstream Influence Counties		Current Conditions (load, concentration, IBI score)	Goals/Targets and Estimated % Reduction		Specific Implementation Strategy	HSPF-SAM Strategy/BMP Suitable Acres for Subwatershed	Current strategy adoption level, if known	Interim 10-year Milestone	Suggested adoption to meet TMDL and protection goals	Units	
						Feedlot runoff controls	Implement feedlot runoff reduction/treatment (635, 784) where needed	NA	Unknown	Work with producers to identify & implement projects	Implement projects	Completed projects	
						Septic system improvements	Provide education and maintenance materials for SSTS parcels. Work through current ordinances with landowners to upgrade failing and non-compliant SSTS	NA	Point of sale inspections	Work with landowners to identify and upgrade SSTSs	Upgrade all failing and noncompliant SSTSs	SSTS upgrades	
						Urban stormwater runoff control	ID and implement stormwater BMPs to treat and reduce bacteria loading from towns of Storden, Westbrook, and Lamberton	NA	Unknown	Complete assessment and feasibility	Implement 2 targeted projects	Completed study and projects	
	Double Lake - North Portion (17-0056-01)	Cottonwood	Phosphorus (TP); Fish IBI	1,023 lb TP/yr; 126 ppb TP summer avg.; Fish IBI = 17	454 lb TP/yr; <90 ppb TP summer avg; Fish IBI >36	Reduce sediment loads	Implement TSS reduction strategies outlined above						50
						Reduce phosphorus loading	Implement eutrophication reduction strategies outlined above in watershed-wide table						
						Shoreline restoration & protection	Promote and maintain riparian areas with use of shoreline buffers	NA	NA	ID projects/areas	Implement priority improvements	Improvements	
						Monitoring	Continue monitoring fish community and rough fish populations	NA	Surveyed every 5 years	Continue current schedule	Manage as necessary	Completed surveys	
	Lake Bean (17-0054-00)	Cottonwood	Phosphorus (TP)	1,560 lb TP/yr; 129 ppb TP summer avg.	716 lb TP/yr; <90 ppb TP summer avg.	Lake internal load management	Develop lake management plan to address internal sources of phosphorus (sediment and carp)	NA	Sediment cores and carp assessment completed during TMDL study (Double)	Development management plan	Manage as necessary	Management plan and actions	
	Dutch Charley Creek (07020008-517)	Redwood, Upstream = Cottonwood and Murray	FIBI; Stressors: TSS, Habitat	FIBI = 50	FIBI >50	Implement TSS & bacteria reduction strategies outlined above; see watershed-wide table for additional strategies to address stream biological impairments							50

HUC-10 Subwatershed	Water Body and Location		Parameter (incl. nonpollutant stressors)	Water Quality		Strategy type (see key below)	Strategy scenario showing estimated scale of adoption to meet 10 yr. milestone and final water quality targets						Estimated Years to Achieve Water Quality Target
								Estimated Adoption Rate					
	Water Body (ID)	Location and Upstream Influence Counties		Current Conditions (load, concentration, IBI score)	Goals/Targets and Estimated % Reduction		Specific Implementation Strategy	HSPF-SAM Strategy/BMP Suitable Acres for Subwatershed	Current strategy adoption level, if known	Interim 10-year Milestone	Suggested adoption to meet TMDL and protection goals	Units	
	Dutch Charley Creek (07020008-518)	Cottonwood	FIBI & MIBI; Stressors: Dissolved oxygen, Eutrophication, Connectivity, Altered hydrology, Habitat	FIBI = 38; MIBI = 26	FIBI >55; MIBI > 41								
	Unnamed Creek (07020008-529)	Cottonwood	MIBI; Stressors: Habitat	MIBI = 29	MIBI > 41								
	County Ditch # 38 (07020008-537)	Cottonwood	MIBI; Stressors: Habitat, Altered hydrology, Connectivity	MIBI = 17	MIBI > 22								
	Judicial Ditch 3 (07020008-588)	Cottonwood	High watershed and riparian risk (MPCA tool)	Low protection	Increase protection of stream reaches	Implement TSS & bacteria strategies outlined above; see watershed-wide table for strategies to protect stream biota							50
	County Ditch 38 (07020008-527)	Cottonwood	High riparian risk med. watershed risk (MPCA tool)	Med/Low protection									
	Unnamed Creek (07020008-587)	Cottonwood	High watershed and riparian risk (MPCA tool)	Low protection									
	County Ditch 198 (07020008-589)	Murray	High watershed and riparian risk (MPCA tool)	Med/Low protection									
	Hurricane (17-0037-00)	Cottonwood	Phosphorus (TP)	48 ppb TP summer avg.	TP Reduction: 7 lbs/yr	Implement TSS & bacteria strategies outlined above; implement eutrophication strategies in watershed-wide table							
	Augusta (17-0033-00)	Cottonwood	Phosphorus (TP)	158 ppb TP summer avg.	TP Reduction: 235 lbs/yr	Monitoring	Expand water quality monitoring program to track trends, fill data gaps, and support future assessments	NA	NA	Develop and implement monitoring plan	Routine monitoring	Monitor water quality	
	Long (17-0048-02)	Cottonwood	Phosphorus (TP)	331 ppb TP summer avg.	TP Reduction: 100 lbs/yr								
	Louisa (51-0006-00)	Murray	Phosphorus (TP)	203 ppb TP summer avg.	TP Reduction: 92 lbs/yr		Complete fish survey according to DNR methods and protocols	NA	No surveys on record	Complete surveys	Use survey results to	Completed survey	

HUC-10 Subwatershed	Water Body and Location		Parameter (incl. nonpollutant stressors)	Water Quality		Strategy type (see key below)	Strategy scenario showing estimated scale of adoption to meet 10 yr. milestone and final water quality targets						Estimated Years to Achieve Water Quality Target
								Estimated Adoption Rate					
	Water Body (ID)	Location and Upstream Influence Counties		Current Conditions (load, concentration, IBI score)	Goals/Targets and Estimated % Reduction		Specific Implementation Strategy	HSPF-SAM Strategy/BMP Suitable Acres for Subwatershed	Current strategy adoption level, if known	Interim 10-year Milestone	Suggested adoption to meet TMDL and protection goals	Units	
	Round (17-0048-01) Double-South (17-0056-00)	Cottonwood Cottonwood	Phosphorus (TP) Phosphorus (TP)	544.5 TP summer avg. 99 TP summer avg.	TP Reduction: 179 lbs/yr TP Reduction: 26 lbs/yr						evaluate if fisheries mgt. is needed		
	Lamberton DWSMA/WHPA	Redwood	GW quality	Moderate vulnerability	Protect GW quality, particularly vulnerable areas	See watershed-wide table for strategies to protect groundwater; implement TSS & bacteria strategies outlined above							
	Red Rock Rural Lake Augusta DWSMA	Cottonwood	GW quality	High Vulnerability									
	Groundwater - general	Redwood, Cottonwood, Murray	GW quality	Vulnerable GW areas = 3,090 acres									

Color Key:

	Restoration
	Protection

Mound Creek – Cottonwood River HUC-10 Subwatershed

Mound Creek – Cottonwood River HUC-10 Subwatershed (702000806) is in the southern region of the Cottonwood River Watershed and is approximately 230 square miles, spanning Brown, Redwood, and Cottonwood Counties (Figure 31, Table 23). The Cities of Sanborn (population 361), Springfield (population 2,030), and a portion of Jeffers (population 358) fall within the subwatershed. Streams in this subwatershed are a combination of channelized and natural.

Land use is predominantly agricultural (88%) and developed 4%. Nearly 5% of this watershed is wetlands, the highest proportion of all HUC-10 watersheds in the Cottonwood River Watershed. Just over 1% is forested. Less than 1% of this watershed is open water and includes Boise Lake (152 acres) Altermatt Lake (125 acres), and the Wellner-Hageman Reservoir (75 acres). Major water bodies in the subwatershed include Dry Creek, Mound Creek, and Coal Mine Creek. HUC-12 subwatersheds include Dry Creek, Mound Creek, Coal Mine Creek, and Middle Cottonwood River.

Figure 31. Mound Creek – Cottonwood River HUC-10 Subwatershed.

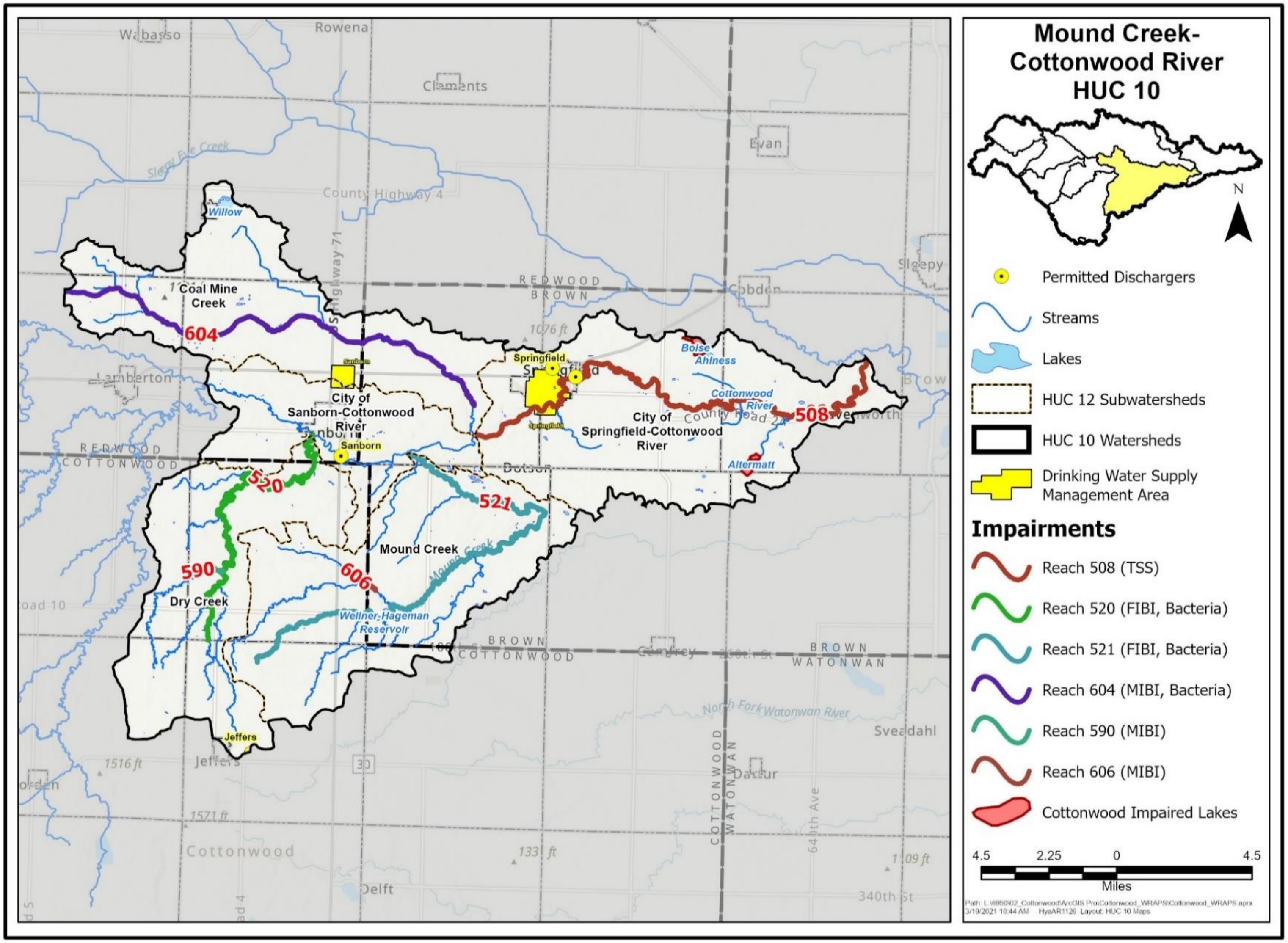


Table 23. Strategies and actions proposed for the Mound Creek – Cottonwood River HUC-10 Subwatershed.

HUC-10 Subwatershed	Water Body and Location: Water Body (ID)	Water Body and Location: Location and Upstream Influence Counties	Parameter (incl. nonpollutant stressors)	Water Quality: Current Conditions (load, concentration, IBI score)	Water Quality: Goals/Targets and Estimated % Reduction	Strategy type (see key below)	Strategy scenario showing estimated scale of adoption to meet 10 yr. milestone and final water quality targets: Specific Implementation Strategy	Estimated Adoption Rate: HSPF-SAM Strategy/BMP Suitable Acres for Subwatershed	Estimated Adoption Rate: Current strategy adoption level, if known	Estimated Adoption Rate: Interim 10-year Milestone	Estimated Adoption Rate: Suggested adoption to meet TMDL and protection goals	Estimated Adoption Rate: Units	Estimated Years to Achieve Water Quality Target
HUC-10 Subwatershed: Mound Creek - Cottonwood River; HUC-12 Subwatersheds: Dry Creek, Mound Creek, City of Sanborn - Cottonwood River, Coal Mine Creek, City of Springfield - Cottonwood River	Cottonwood River (07020008-508)	Brown; Upstream = Cottonwood and Redwood	TSS	90th percentile TSS concentration = 130 mg/L	Maximum 90th percentile TSS concentration = 65 mg/L; 50% reduction	Buffers - field edge	50-ft buffers on streams adjacent to cropland/pasture (390, 391, 327)	cropland: 28,190; pasture: 820	cropland: 3%; pasture: 18%	cropland: 10%; pasture: 30%	cropland: 15%; pasture: 40%	% suitable acres	50
						Tillage/residue management	Adopt reduced tillage (30% + residue cover) and no-till (329, 345, 346)	reduced till: 26,610; no-till: 26,610	reduced till: 16%; no-till: 16%	reduced till: 25%; no-till: 25%	reduced till: 35%; no-till: 35%	% suitable acres	
						Add cover crops for living cover in fall/spring	Implement cover crops with corn & soybeans (340)	118,690	3%	6%	15%	% suitable acres	
						Upland water storage/retention	Restore tiled wetlands in marginal areas and as opportunities arise (656, 810M)	22,870	<1%	2%	5%	% suitable acres	
							Implement controlled tile drainage water management (554)	1,710	<1%	1%	3%	% suitable acres	
						Conservation practice installation	Construct water and sediment control basins (638) and grassed waterways (412)	WASCOBs & GWs: 31,540	WASCOBs: 6%; GWs: <1%	WASCOBs: 10%; GWs: 5%	WASCOBs: 20%; GWs: 10%	% suitable acres	
						Open tile inlet & side inlet improvements	Install alternative tile intakes (606, 170M, 172M, 173M)	1,390	1%	5%	20%	% suitable acres	
							Identify and implement side inlet improvements (410)	NA	Unknown	Implement necessary improvements and upland treatment	Implement necessary improvements	Improvements	
						Urban stormwater runoff control	ID and implement stormwater BMPs to store water and treat sediment loading city of Springfield	NA	Unknown	Complete assessment and feasibility	Implement identified projects and education	Completed assessments and projects	
	Dry Creek (07020008-520)	Cottonwood	*E. coli*	3,248 cfu/100 mL maximum monthly geomean	Maximum monthly geomean <126 cfu/100 mL; 96% reduction	Reduce sediment loads	Implement TSS reduction strategies outlined above						50
	Mound Creek (07020008-521)	Brown		1,709 cfu/100 mL maximum monthly geomean	Maximum monthly geomean <126 cfu/100 mL; 93% reduction	Nutrient management (cropland)	Fertilizer and manure management and incorporation (590)	120,220	25%	35%	75%	% suitable acres	
						Pasture management	Implement exclusion fencing, grazing rotations in shoreland and high priority areas	NA	Unknown	Work with producers to identify and implement priority projects	Implement priority projects	Completed projects	

HUC-10 Subwatershed	Water Body and Location: Water Body (ID)	Water Body and Location: Location and Upstream Influence Counties	Parameter (incl. nonpollutant stressors)	Water Quality: Current Conditions (load, concentration, IBI score)	Water Quality: Goals/Targets and Estimated % Reduction	Strategy type (see key below)	Strategy scenario showing estimated scale of adoption to meet 10 yr. milestone and final water quality targets: Specific Implementation Strategy	Estimated Adoption Rate: HSPF-SAM Strategy/BMP Suitable Acres for Subwatershed	Estimated Adoption Rate: Current strategy adoption level, if known	Estimated Adoption Rate: Interim 10-year Milestone	Estimated Adoption Rate: Suggested adoption to meet TMDL and protection goals	Estimated Adoption Rate: Units	Estimated Years to Achieve Water Quality Target
	Coal Mine Creek (07020008-604)	Redwood		1,740 cfu/100 mL maximum monthly geomean	Maximum monthly geomean <126 cfu/100 mL; 93% reduction	Feedlot runoff controls	Implement feedlot runoff reduction/treatment (635, 784) where needed	NA	Unknown	Work with producers to identify and implement projects	Implement projects	Completed projects	
						Septic system improvements	Provide education and maintenance materials for SSTS parcels. Work through current ordinances with landowners to upgrade failing and noncompliant SSTS	NA	Point of sale inspections	Work with landowners to identify and upgrade SSTSs	Upgrade all failing and noncompliant SSTSs	SSTS upgrades	
						Urban stormwater runoff control	ID and implement stormwater BMPs to treat and reduce bacteria loading from town of Sanborn	NA	Unknown	Complete assessment and feasibility	Implement targeted projects	Completed study and projects	
	Boise (08-0096-00)	Brown	Phosphorus (TP)	2,188 lb TP/yr; 287 ppb TP summer avg.	445 lb TP/yr; <90 ppb TP summer avg.	Reduce sediment loads	Implement TSS reduction strategies outlined above						50
						Reduce phosphorus loading	Implement eutrophication reduction strategies outlined above in watershed-wide table						
						Monitoring	Survey fish community using standard DNR methods	NA	None	Complete survey	Survey every 5 years	Completed surveys	
	Altermatt (08-0054-00)	Brown	Phosphorus (TP)	4,186 lb TP/yr; 403 ppb TP summer avg.	509 lb TP/yr; <90 ppb TP summer avg.	Monitoring	Expand water quality monitoring program to track trends, fill data gaps, and support future assessments	NA	None	Develop and implement monitoring plan	Routine monitoring	Monitor water quality	
						Lake internal load management	Assess common carp and other rough fish to determine impact on water quality and native vegetation; develop management strategies	NA	None	Assess fish and development management plan	Manage as necessary	Assessments and mgt. actions	
	Dry Creek (07020008-520)	Cottonwood	MIBI; Stressors: Eutrophication, Habitat, Connectivity, Nitrate	FIBI = 45; MIBI = 31	FIBI >55; MIBI > 41	Implement TSS & bacteria reduction strategies outlined above; see watershed-wide table for additional strategies to address stream biological impairments (with particular focus on Nitrate strategies that are part of Groundwater Protection)							50
	Mound Creek (07020008-521)	Brown	FIBI & MIBI: Stressors: Eutrophication, Habitat, Altered Hydrology, Connectivity	MIBI = 21	MIBI > 41								

HUC-10 Subwatershed	Water Body and Location		Parameter (incl. nonpollutant stressors)	Water Quality		Strategy type (see key below)	Strategy scenario showing estimated scale of adoption to meet 10 yr. milestone and final water quality targets						Estimated Years to Achieve Water Quality Target
	Water Body (ID)	Location and Upstream Influence Counties		Current Conditions (load, concentration, IBI score)	Goals/Targets and Estimated % Reduction		Specific Implementation Strategy	Estimated Adoption Rate: HSPF-SAM Strategy/BMP Suitable Acres for Subwatershed	Current strategy adoption level, if known	Interim 10-year Milestone	Suggested adoption to meet TMDL and protection goals	Units	
	Unnamed Creek (07020008-590)	Cottonwood	MIBI; Stressors: Habitat, Altered hydrology	MIBI = 16	MIBI > 41								
	Coal Mine Creek (07020008-604)	Redwood	MIBI; Stressors: DO, Eutrophication, Habitat, Altered hydrology	MIBI = 10, 40	MIBI > 22								
	Unnamed Creek (07020008-606)	Brown	MIBI; Stressors: Eutrophication, Habitat, Altered hydrology, Connectivity	MIBI = 0	MIBI > 22								
	Cottonwood River (07020008-507)	Brown	High watershed and medium riparian risk (MPCA tool)	Med/low protection	Increase protection	Implement TSS & bacteria strategies outlined above; see watershed-wide table for strategies to protect stream biota							50
	Wellner-Hageman Reservoir	Brown	Phosphorus (TP)	77 ppb TP summer avg.	Maintain or improve existing water quality (Standard = 90 ppb)	Implement TSS & bacteria strategies outlined above; Implement eutrophication reduction strategies outlined above in watershed-wide table							
						Monitoring	Expand water quality monitoring program to track trends, fill data gaps, and support future assessments	NA	NA	Develop & implement monitoring plan	Routine monitoring	monitor water quality	
	Sanborn DWSMA/WHPA	Redwood	GW quality	Low vulnerability	Protect GW quality, particularly vulnerable areas	See watershed-wide table for strategies to protect groundwater; implement TSS & bacteria strategies outlined above							
	Springfield DWSMA/WHPA	Brown	GW quality	Moderate vulnerability									
	Groundwater - general	Redwood, Cottonwood, Brown	GW quality	Vulnerable GW areas = 5,093 acres									

Color Key:

Restoration

Protection

Sleepy Eye Creek HUC-10 Subwatershed

Sleepy Eye Creek HUC-10 Subwatershed (702000807) is in the northern and northeast region of the Cottonwood River Watershed in Redwood and Brown Counties (Figure 32, Table 24). The watershed drains 273 square miles. The towns of Wanda (population 55), Wabasso (population 765), Clements (population 177), and portions of Lucan (population 168) and Coben (population 20) fall within the subwatershed. Most streams in the watershed are channelized (ditched).

Most of the watershed is agricultural (94%) and developed (4%). Just over 1% of the watershed is wetlands and under 1% is forested. Less than 1% of the land area is open water, and there is one unnamed lake (38 acres) within the watershed. Other water bodies within the subwatershed include Sleepy Eye Creek (Judicial Ditch 36), County Ditches 24, 26, 38, 54, and 68, and Judicial Ditch 35. The channelized portion of Sleepy Eye Creek is large and called Judicial Ditch 36.

Figure 32. Sleepy Eye Creek HUC-10 Subwatershed.

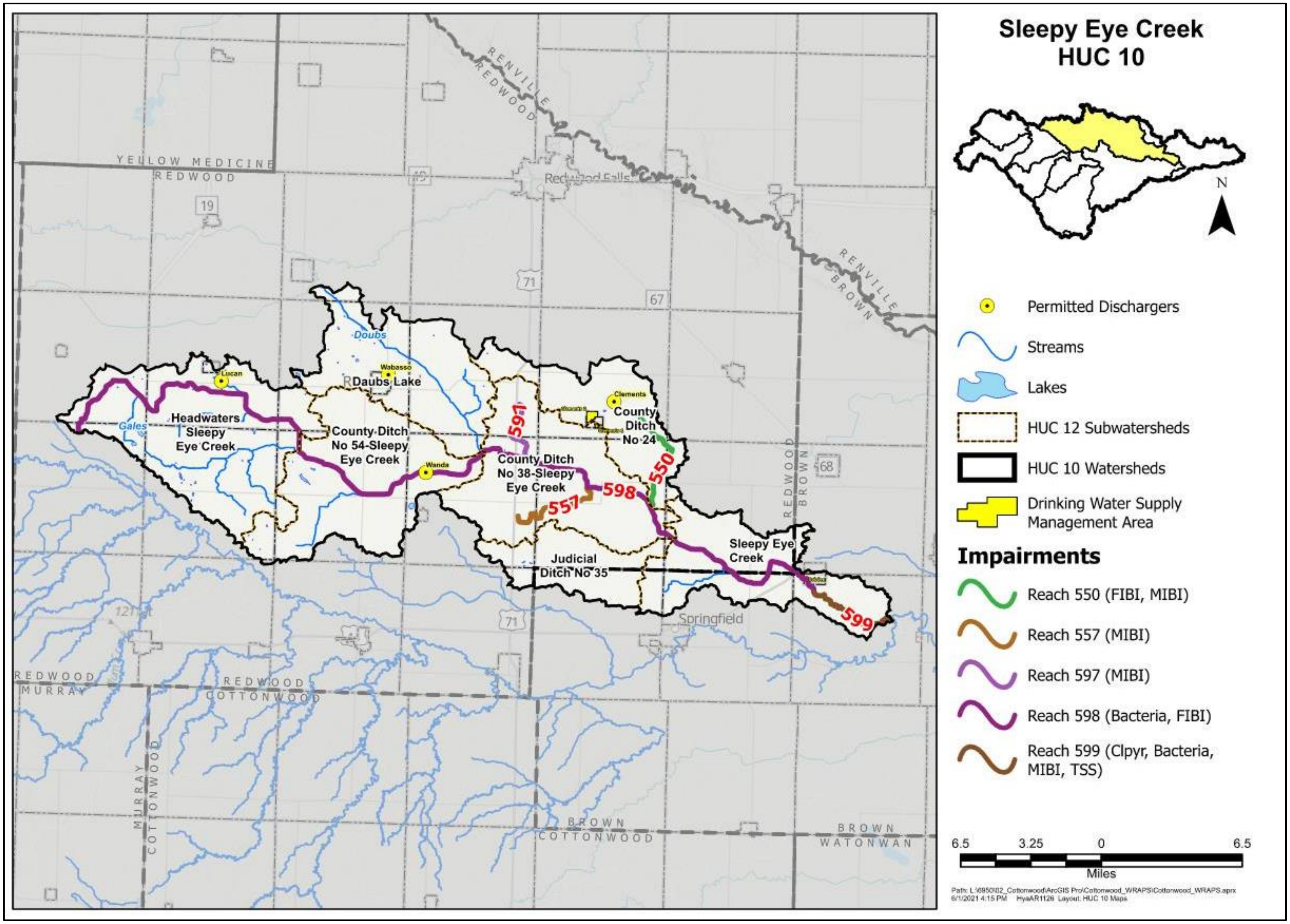


Table 24. Strategies and actions proposed for the Sleepy Eye Creek HUC-10 Subwatershed.

HUC-10 Subwatershed	Water Body and Location		Parameter (incl. nonpollutant stressors)	Water Quality		Strategy type (see key below)	Strategy scenario showing estimated scale of adoption to meet 10 yr. milestone and final water quality targets						Estimated Years to Achieve Water Quality Target
									Estimated Adoption Rate				
	Water Body (ID)	Location and Upstream Influence Counties		Current Conditions (load, concentration, IBI score)	Goals/Targets and Estimated % Reduction		Specific Implementation Strategy	HSPF-SAM Strategy/BMP Suitable Acres for Subwatershed	Current strategy adoption level, if known	Interim 10-year Milestone	Suggested adoption to meet TMDL and protection goals	Units	
HUC-10 Subwatershed: Sleepy Eye Creek; HUC-12 Subwatersheds: Headwaters Sleepy Eye Creek, County Ditch #54 - Sleepy Eye Creek, Daubs Lake, County Ditch #24, County Ditch #38 - Sleepy Eye Creek, Judicial Ditch #35, Sleepy Eye Creek	Sleepy Eye Creek (07020008-599)	Brown, Cottonwood, and Redwood	TSS	90th percentile TSS concentration = 85 mg/L	Maximum 90th percentile TSS concentration = 65 mg/L; 24% reduction	Buffers - field edge	50-ft buffers on streams adjacent to cropland/pasture (390, 391, 327)	cropland: 20,940; pasture: 54	cropland: <1%; pasture: 2%	cropland: 5%; pasture: 20%	cropland: 15%; pasture: 20%	% suitable acres	40
						Tillage/residue management	Adopt reduced tillage (30% + residue cover) and no-till (329, 345, 346)	reduced till: 27,970; no-till: 27,970	reduced till: 6%; no-till: 6%	reduced till: 10%; no-till: 10%	reduced till: 20%; no-till: 20%	% suitable acres	
						Add cover crops for living cover in fall/spring	Implement cover crops with corn & soybeans (340)	152,500	3%	6%	15%	% suitable acres	
						Upland water storage/retention	Restore tiled wetlands in marginal areas and as opportunities arise (656, 810M)	36,990	<1%	2%	5%	% suitable acres	
							Implement controlled tile drainage water management (554)	9,410	<1%	1%	3%	% suitable acres	
						Conservation practice installation	Construct water and sediment control basins (638) and grassed waterways (412)	WASCOBs & GWs: 31,130	WASCOBs: <1%; GWs: <1%	WASCOBs: 5%; GWs: 5%	WASCOBs: 10%; GWs: 10%	% suitable acres	
						Open tile inlet & side inlet improvements	Install alternative tile intakes (606, 170M, 172M, 173M)	21,670	2%	7%	15%	% suitable acres	
							Identify and implement side inlet improvements (410)	NA	Unknown	Implement necessary improvements and upland treatment	Implement necessary improvements	Improvements	
						Urban stormwater runoff control	ID and implement stormwater BMPs to store water and treat sediment loading from towns of Lucan, Wabasso, Wanda, and Clements	NA	Unknown	Complete assessment and feasibility	Implement identified projects and education	Completed assessments and projects	
	Sleepy Eye Creek (07020008-598 & 599) Note: Reach has been split, previously 512	Brown, Cottonwood, and Redwood	Fecal coliform	1,418 cfu/100 mL maximum monthly geomean	Maximum monthly geomean <200 cfu/100 mL; 86% reduction	Reduce sediment loads	Implement TSS reduction strategies outlined above						50
						Nutrient management (cropland)	Fertilizer and manure management and incorporation (590)	157,140	15%	25%	40%	% suitable acres	
						Pasture management	Implement exclusion fencing, grazing rotations in shoreland and high priority areas	NA	Unknown	Work with producers to identify and	Implement priority projects	Completed projects	

HUC-10 Subwatershed	Water Body and Location: Water Body (ID)	Water Body and Location: Location and Upstream Influence Counties	Parameter (incl. nonpollutant stressors)	Water Quality: Current Conditions (load, concentration, IBI score)	Water Quality: Goals/Targets and Estimated % Reduction	Strategy type (see key below)	Specific Implementation Strategy	HSPF-SAM Strategy/BMP Suitable Acres for Subwatershed	Estimated Adoption Rate: Current strategy adoption level, if known	Estimated Adoption Rate: Interim 10-year Milestone	Estimated Adoption Rate: Suggested adoption to meet TMDL and protection goals	Estimated Adoption Rate: Units	Estimated Years to Achieve Water Quality Target
										implement priority projects			
						Feedlot runoff controls	Implement feedlot runoff reduction/treatment (635, 784) where needed	NA	Unknown	Work with producers to identify and implement projects	Implement projects	Completed projects	
						Septic system improvements	Provide education and maintenance materials for SSTS parcels. Work through current ordinances with landowners to upgrade failing and noncompliant SSTS	NA	Point of sale inspections	Work with landowners to identify and upgrade SSTSs	Upgrade all failing and noncompliant SSTSs	SSTS upgrades	
	Sleepy Eye Creek (07020008-599) Note: Reach has been split, previously 512	Brown	MIBI; Stressors: Eutrophication, TSS, Altered hydrology, Nitrate, Habitat	MIBI = 24	MIBI > 37	Implement TSS & bacteria reduction strategies outlined above; see watershed-wide table for additional strategies to address stream biological impairments (with particular focus on Nitrate strategies that are part of Groundwater Protection)							50
	County Ditch # 24 (07020008-550)	Redwood	FIBI & MIBI; Stressors: Altered hydrology, Nitrate, Habitat	FIBI = 28; MIBI = 9	FIBI > 33; MIBI > 22								
	Sleepy Eye Creek (07020008-557)	Redwood	MIBI; Stressors: Dissolved oxygen, Eutrophication, Connectivity, Altered hydrology, Nitrate, Habitat	MIBI = 17	MIBI > 22								
	Sleepy Eye Creek (07020008-597)	Redwood	MIBI; Stressors: Dissolved oxygen, Eutrophication, Altered hydrology, Habitat	MIBI = 13	MIBI > 22								

Strategy scenario showing estimated scale of adoption to meet 10 yr. milestone and final water quality targets

HUC-10 Subwatershed	Water Body and Location		Parameter (incl. nonpollutant stressors)	Water Quality		Strategy type (see key below)	Strategy scenario showing estimated scale of adoption to meet 10 yr. milestone and final water quality targets						Estimated Years to Achieve Water Quality Target
	Water Body (ID)	Location and Upstream Influence Counties		Current Conditions (load, concentration, IBI score)	Goals/Targets and Estimated % Reduction		Specific Implementation Strategy	HSPF-SAM Strategy/BMP Suitable Acres for Subwatershed	Estimated Adoption Rate: Current strategy adoption level, if known	Interim 10-year Milestone	Suggested adoption to meet TMDL and protection goals	Units	
	Sleepy Eye Creek (07020008-598)	Redwood	FIBI; Stressors: Eutrophication, Altered hydrology, Nitrate, Habitat	FIBI = 29	FIBI > 35								
	County Ditch 54 (07020008-543)	Redwood	High watershed and riparian risk (MPCA tool)	Low protection	Increase protection of stream reaches	Implement TSS & bacteria strategies outlined above; see watershed-wide table for strategies to protect stream biota							50
	County Ditch 68 (07020008-561)		High watershed and riparian risk (MPCA tool)	Low protection									
	Unnamed Ditch (07020008-594)		High watershed and riparian risk (MPCA tool)	Low protection									
	Unnamed Creek (07020008-595)		High watershed and riparian risk (MPCA tool)	Low protection									
	Judicial Ditch 35 (07020008-596)		High watershed and riparian risk (MPCA tool)	Low protection									
	Clements DWSMA/WHPA	Redwood	GW quality	Low vulnerability	Protect GW quality, particularly vulnerable areas	See watershed-wide table for strategies to protect groundwater; implement TSS & bacteria strategies outlined above							
	Cobden DWSMA/WHPA	Brown	GW quality	Low vulnerability									
	Groundwater - general	Redwood, Cottonwood, Brown	GW quality	Vulnerable GW areas = 11,916 acres									

Color Key:

(pink)	Restoration
(green)	Protection

Cottonwood River HUC-10 Subwatershed

The Cottonwood River HUC-10 Subwatershed (0702000808) is in the northeastern most region of the Cottonwood River Watershed in Brown and Redwood Counties (Figure 33, Table 25). The subwatershed drains 154 square miles. The town of Sleepy Eye (population 3,401) and portions of New Ulm (population 13,242) and Cobden (population 20) are in the subwatershed. Streams in the subwatershed are mostly channelized.

The watershed is predominantly agricultural (83%) and developed (6%). Four percent of the watershed is forested, the largest proportion of all HUC-10s in the Cottonwood River Watershed. Four percent is wetlands. About 2% of the watershed is open water including Clear Lake (237 acres), Sleepy Eye Lake (230 acres), and Bachelor Lake (92 acres). Other major water bodies in the subwatershed include County Ditches 3, 4, 5, and 60, Judicial Ditch 30, and the Cottonwood River.

Figure 33. Cottonwood River HUC-10 Subwatershed.

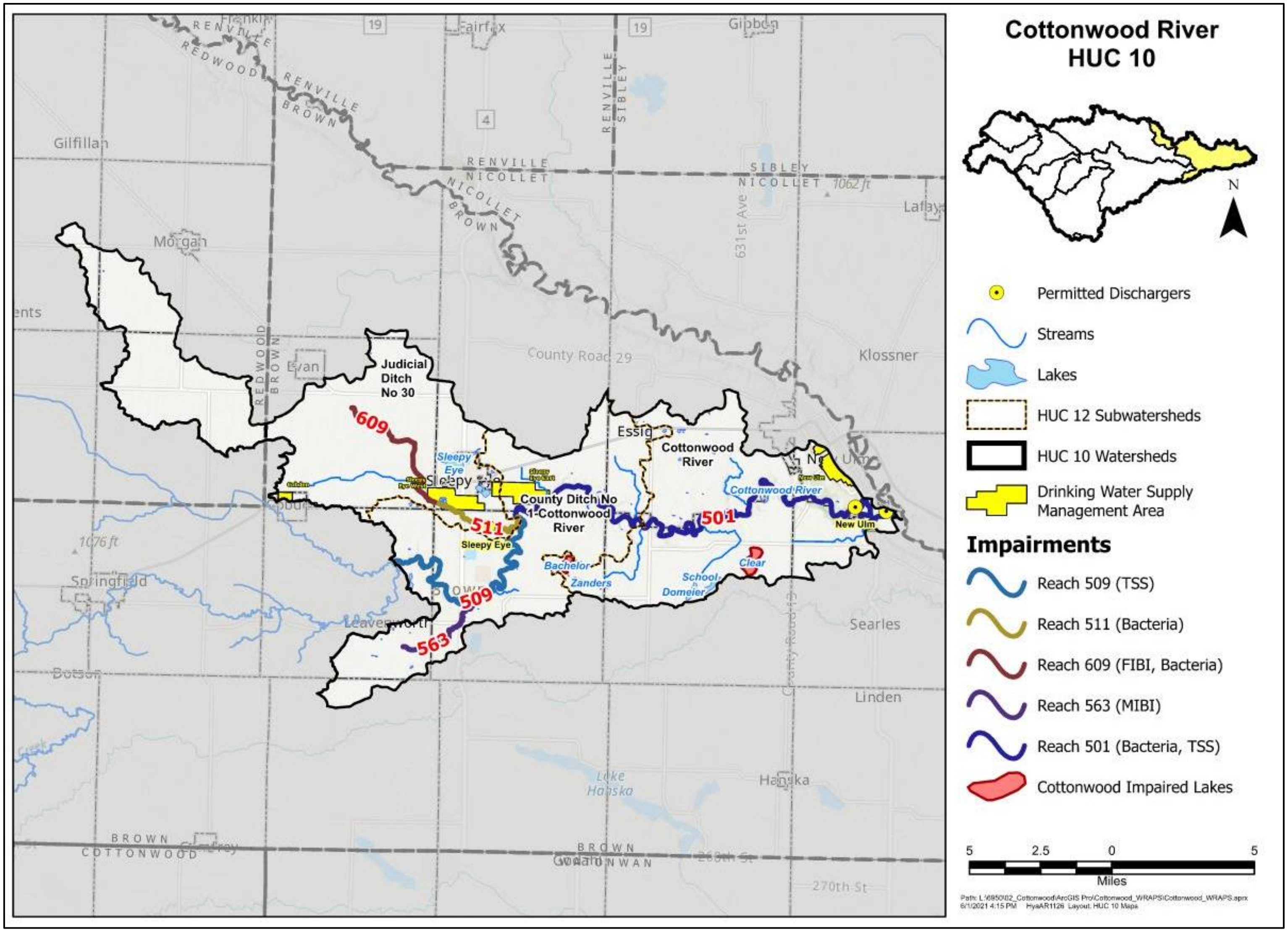


Table 25. Strategies and actions proposed for the Cottonwood River HUC-10 Subwatershed.

HUC-10 Subwatershed	Water Body and Location		Parameter (incl. nonpollutant stressors)	Water Quality		Strategy type (see key below)	Strategy scenario showing estimated scale of adoption to meet 10 yr. milestone and final water quality targets						Estimated Years to Achieve Water Quality Target
									Estimated Adoption Rate				
	Water Body (ID)	Location and Upstream Influence Counties		Current Conditions (load, concentration, IBI score)	Goals/Targets and Estimated % Reduction		Specific Implementation Strategy	HSPF-SAM Strategy/BMP Suitable Acres for Subwatershed	Current strategy adoption level, if known	Interim 10-year Milestone	Suggested adoption to meet TMDL and protection goals	Units	
HUC-10 Subwatershed: Cottonwood River; HUC-12 Subwatersheds: Judicial Ditch #30, County Ditch #1 - Cottonwood River, Cottonwood River	Cottonwood River (07020008-509)	Brown; Upstream = Redwood, Cottonwood, Murray, Lyon	TSS	90th percentile TSS concentration = 104 (HSPF simulated)	Maximum 90th percentile TSS concentration = 65 mg/L; 38% reduction	Buffers - field edge	50-ft buffers on streams adjacent to cropland/pasture (390, 391, 327)	cropland: 12,830; pasture: 240	cropland: 1%; pasture: 5%	cropland: 10%; pasture: 30%	cropland: 15%; pasture: 40%	% suitable acres	40
						Tillage/residue management	Adopt reduced tillage (30% + residue cover) and no-till (329, 345, 346)	reduced till: 13,850; no-till: 13,850	reduced till: 19%; no-till: 19%	reduced till: 25%; no-till: 25%	reduced till: 30%; no-till: 30%	% suitable acres	
						Add cover crops for living cover in fall/spring	Implement cover crops with corn & soybeans (340)	71,640	4%	8%	15%	% suitable acres	
						Upland water storage	Restore tiled wetlands in marginal areas and as opportunities arise (656, 810M)	18,660	<1%	2%	5%	% suitable acres	
							Implement controlled tile drainage water management (554)	14,790	<1%	1%	3%	% suitable acres	
						Conservation practice installation	Construct water and sediment control basins (638) and grassed waterways (412)	WASCOB & GWs: 17,750	WASCOBs: <1%, GWs: <1%	WASCOBs: 8%, GWs: 5%	WASCOBs: 10%, GWs: 10%	% suitable acres	
						Open tile inlet & side inlet improvements	Install alternative tile intakes (606, 170M, 172M, 173M)	29,590	7%	10%	20%	% suitable acres	
							Identify and implement side inlet improvements (410)	NA	Unknown	Implement necessary improvements and upland treatment	Implement necessary improvements	Improvements	
						Urban stormwater runoff control	ID and implement stormwater BMPs to store water and treat sediment loading from city of Sleepy Eye	NA	Unknown	Complete assessment and feasibility	Implement identified projects and education	Completed assessments and projects	
	Cottonwood River (07020008-501)	Brown; Upstream = Redwood, Cottonwood, Murray, Lyon	Fecal coliform	284 cfu/100 mL maximum monthly geomean	Maximum monthly geomean <200 cfu/100 mL; 30% reduction	Reduce Sediment Loads	Implement TSS reduction strategies outlined above						50
						Nutrient management (cropland)	Fertilizer and manure management and incorporation (590)	75,940	42%	50%	60%	% suitable acres	
	Judicial Ditch # 30 (07020008-511)	Location = Brown; Upstream = Redwood	*E. coli*	921 cfu/100 mL maximum monthly geomean	Maximum monthly geomean <126 cfu/100 mL; 86% reduction	Pasture management	Implement exclusion fencing, grazing rotations in shoreland and high priority areas	NA	Unknown	Work with producers to identify implement priority projects	Implement priority projects	Completed projects	

HUC-10 Subwatershed	Water Body and Location		Parameter (incl. nonpollutant stressors)	Water Quality		Strategy type (see key below)	Strategy scenario showing estimated scale of adoption to meet 10 yr. milestone and final water quality targets						Estimated Years to Achieve Water Quality Target
									Estimated Adoption Rate				
	Water Body (ID)	Location and Upstream Influence Counties		Current Conditions (load, concentration, IBI score)	Goals/Targets and Estimated % Reduction		Specific Implementation Strategy	HSPF-SAM Strategy/BMP Suitable Acres for Subwatershed	Current strategy adoption level, if known	Interim 10-year Milestone	Suggested adoption to meet TMDL and protection goals	Units	
	Judicial Ditch #30 (07020008-609)	Location = Brown; Upstream = Redwood	*E. coli*	2,064 cfu/100 mL maximum monthly geomean	Maximum monthly geomean <126 cfu/100 mL; 94% reduction	Feedlot runoff controls	Implement feedlot runoff reduction/treatment (635, 784) where needed	NA	Unknown	Work with producers to identify and implement projects	Implement projects	Completed projects	
						Septic system improvements	Provide education and maintenance materials for SSTS parcels. Work through current ordinances with landowners to upgrade failing and noncompliant SSTS	NA	Point of sale inspections	Work with landowners to identify and upgrade SSTSs	Upgrade all failing and noncompliant SSTSs	SSTS upgrades	
						Urban stormwater runoff control	ID and implement stormwater BMPs to treat and reduce bacteria loading from the city of New Ulm and Sleepy Eye	NA	Unknown	Complete assessment and feasibility	Implement 1 targeted project	Completed study and projects	
	Unnamed Creek (07020008-563)	Brown	MIBI: Stressors: Altered hydrology, Habitat	MIBI = 18	MIBI > 41	Implement TSS & bacteria reduction strategies outlined above; see watershed-wide table for additional strategies to address stream biological impairments							50
	Judicial Ditch #30 (07020008-609)	Brown; Upstream = Redwood	FIBI: Stressors: Eutrophication, Connectivity, Altered hydrology, Habitat	FIBI = 0	FIBI >35								
	Clear Lake (08-0011-00)	Brown	Phosphorus (TP)	2,429 lb TP/yr; 151 ppb TP summer avg.	1,139 lb TP/yr; <90 ppb TP summer avg.	Reduce sediment loads	Implement TSS reduction strategies outlined above						50
						Reduce phosphorus loading	Implement eutrophication reduction strategies outlined above in watershed-wide table						
						Monitoring	Continue water quality monitoring to track trends	NA	NA	Develop & implement monitoring plan	Routine monitoring	monitor water quality	
	Bachelor (08-0029-00)	Brown	Phosphorus (TP)	1,269 lb TP/yr; 400 ppb TP summer avg.	154 lb TP/yr; <90 ppb TP summer avg.		Continue monitoring fish community (Clear Lake); Complete fish survey according to DNR methods and protocols (Bachelor Lake)	NA	Surveyed approx. every 5 years (Clear Lake); No survey on record (Bachelor)	Continue current schedule (Clear Lake); Complete a survey (Bachelor)	Manage as necessary	Completed surveys	

HUC-10 Subwatershed	Water Body and Location		Parameter (incl. nonpollutant stressors)	Water Quality		Strategy type (see key below)	Strategy scenario showing estimated scale of adoption to meet 10 yr. milestone and final water quality targets						Estimated Years to Achieve Water Quality Target
									Estimated Adoption Rate				
	Water Body (ID)	Location and Upstream Influence Counties		Current Conditions (load, concentration, IBI score)	Goals/Targets and Estimated % Reduction		Specific Implementation Strategy	HSPF-SAM Strategy/BMP Suitable Acres for Subwatershed	Current strategy adoption level, if known	Interim 10-year Milestone	Suggested adoption to meet TMDL and protection goals	Units	
						Lake internal load management	Develop lake management plan to address internal sources of phosphorus (carp and rough fish)	NA	carp assessment completed (Clear Lake); assess rough fish (Bachelor)	Development management plan	Manage as necessary	Management plan and actions	
	Sleepy Eye Lake (08-0045-00)	Brown	Phosphorus (TP)	2,427 lb TP/yr; 85 ppb TP summer avg.	1,024 lb TP/yr; <65 ppb TP summer avg.	Urban stormwater runoff control	ID and implement stormwater BMPs to treat and reduce sediment and phosphorus loads from city of Sleepy Eye	NA	Unknown	Complete feasibility study	Implement 1 project	Completed study and projects	50
						Monitoring	Continue water quality monitoring to track trends	NA	NA	Develop & implement monitoring plan	Routine monitoring	Monitor water quality	
							Continue monitoring fish community	NA	Surveyed approx. every 5 years	Continue current schedule	Manage as necessary	Completed surveys	
							Survey vegetation community and track AIS; manage as necessary	NA	Periodically surveyed	Complete surveys, manage as necessary	Complete surveys, manage as necessary	Surveys and management	
	County Ditch 60 (07020008-564)	Brown	High watershed and riparian risk (MPCA tool)	Low protection	Increase protection	Implement TSS & bacteria strategies outlined above; see watershed-wide table for strategies to protect stream biota							
	County Ditch 5 (07020008-565)	Brown	High watershed and riparian risk (MPCA tool)	Low protection									
	Cobden DWSMA/WHPA	Brown	GW quality	Low vulnerability	Protect GW quality, particularly vulnerable areas	See watershed-wide table for strategies to protect groundwater; implement TSS & bacteria strategies outlined above							
	New Ulm DWSMA/WHPA	Brown	GW quality	Low/Moderate vulnerability									
	Sleepy Eye DWSMA/WHPA	Brown	GW quality	Low/Moderate vulnerability									
	Groundwater - general	Brown, Redwood	GW quality	Vulnerable GW areas = 32,544 acres									

Color Key:

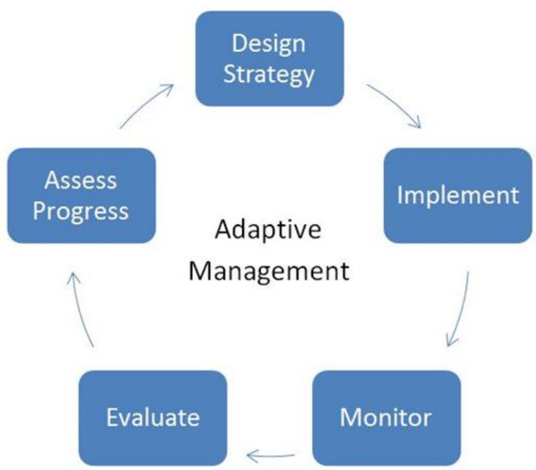
(pink)	Restoration
(green)	Protection

4. Monitoring and Research

The collection of current land and water data is an important component to both assess progress and inform management and decision-making. For improved watershed management to work in the Cottonwood River Watershed, accurate data needs to be collected and analyzed. Monitoring of both land management and water resources is needed to inform and calibrate watershed models and evaluate progress towards defined goals and desired outcomes. Section 7 of the Cottonwood River Watershed TMDL (MPCA 2022) report includes more information on monitoring.

It is the intent of the implementing organizations in this watershed to make steady progress in terms of pollutant reduction. The response of the lakes and streams will be monitored and subsequently evaluated as management practices are implemented. The management approach to achieving the goals should be adapted as new monitoring data are collected and evaluated (i.e., adaptive management approach, Figure 34). Continued monitoring and "course corrections" responding to monitoring results are the most appropriate strategy for attaining the water quality goals established in these watersheds. Management activities will be changed or refined to efficiently meet the TMDL and lay the groundwork for de-listing the impaired water bodies.

Figure 34. Adaptive management framework.



The overall schedule for this TMDL and WRAPS project is 2020 through 2030. During this time, it is expected that on average, if water quality conservation measures are implemented, water quality pollutant concentrations will decline each year equivalent to approximately 2.2% of the starting (i.e., long-term) pollutant load reduction for the TSS impairments, 4.2% for the bacteria impairments, and 3.3% for the lake TP impairments. These progress benchmarks will generally result in meeting water quality standards by 2040 for most of the water bodies.

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

Data from numerous monitoring programs will continue to be collected and analyzed throughout the Cottonwood River Watershed. Monitoring is conducted by local, state, and federal entities, and special projects as described below.

Intensive Watershed Monitoring

Through the State of Minnesota's Watershed Approach, the MPCA collects water quality and biological data for 2 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 Cottonwood River Watershed was completed in 2017 and 2018. Water chemistry monitoring for seven lakes and 16 streams was completed through a Surface Water Assessment Grant (SWAG) with RCRCA. Lake samples were collected from May through September for both years. 2017 stream samples were collected May through September, while 2018 samples were collected from June through August. RCRCA staff collected the samples, transported samples to the laboratory, verified results entered in the EQuIS database, and administered the grant. These efforts are summarized in the Cottonwood River Watershed Monitoring and Assessment Report (MPCA 2020a).

The second cycle of monitoring and assessment will start in 2027. 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.

Watershed Pollutant Load Monitoring Network

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 for TSS, TP, Nitrate/Nitrogen. 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, at or near the center of the channel. Samples are collected more frequently when water flow is moderate and high, when pollutant levels are typically elevated and most changeable. 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. There are three WPLMN sites within the Cottonwood River Watershed: Sleepy Eye Creek nr Cobden, CR8; Cottonwood River nr Leavenworth, CR8; Cottonwood River nr New Ulm, MN68 (see discussion in Section 2.2).

Volunteer Stream and Lake Monitoring Program

The MPCA's Volunteer Stream and Lake Monitoring Program relies on a network of private 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 the State. There is currently a limited number of volunteers performing monitoring within the Cottonwood River

Watershed. The MPCA and LGUs have sought and will continue to seek more volunteer monitors to track trends of water quality transparency for surface waters within the watershed.

RCRCA

RCRCA has a long history of water quality monitoring in the Cottonwood River Watershed with a special focus on sediment and nutrient contributions from tributaries of the Cottonwood River. Water quality monitoring efforts have been based on a three-tier system. Primary, secondary, and tertiary monitoring stations have been developed to assess areas of the watershed delivering the greatest amount of sediment and nutrients to the Cottonwood River. This information has been used to select priority management areas and measure progress toward watershed goals.

University of Minnesota

There are multiple research initiatives led by the University of Minnesota in the Cottonwood River Watershed focused on sustainable agricultural practices, climate change, and water quality including: the University of Minnesota Southwest Research and Outreach Center; Resilience Under Accelerated Change (REACH); Integrated Landscape Management for Agricultural Production and Water Quality; Quantifying Hydrologic Impacts of Drainage Under Corn Production Systems in the Upper Midwest; and Innovations for Sustainable Food, Energy, And Water Supplies in Intensively Cultivated Regions: Integrating Technologies, Data, And Human Behavior. The following gives a brief overview of each initiative.

The University of Minnesota Southwest Research and Outreach Center is in Lamberton and hosts multiple ongoing research efforts (Figure 35). The Center aims to test soil and water management and conservation practices to provide drainage for farm fields while also minimizing negative impacts to nearby surface water. Management systems being tested at the UMN Research and Outreach Center at Lamberton include in-field (e.g., cover cropping), edge of field (e.g., constructed wetlands and bioreactors), and beyond the field (low-grade weirs in ditches) management strategies that can be applied to landscapes in order to maintain drainage capacity while simultaneously reducing peak flows and nutrient export and increasing water availability for in-season crop production use.

Figure 35. The University of Minnesota Southwest Research and Outreach Center at Lamberton, Minnesota.

The REACH project spanned from 2012 through 2018 and aimed to understand how geological history, climate change, and intensive agriculture are affecting changes in water quantity, water quality and ecosystem integrity in the MRB. Over the course of the project, REACH collaborators created an interdisciplinary body of work that has highlighted the importance of specific places, times and processes in determining how human- and climate-induced changes to intensively managed agricultural landscapes propagate through river networks to result in impacts to downstream water quality.

The Integrated Landscape Management for Agricultural Production and Water Quality project was funded by MDA and intended to better understand the relationship between land management and the overall health of lakes, rivers and streams. Using watershed-scale modeling and field observations, researchers identified optimal combinations of sustainable agriculture practices for improving the health of lakes, rivers, and streams.

Quantifying Hydrologic Impacts of Drainage Under Corn Production Systems in the Upper Midwest applied a combination of field research and modeling to quantify the water balances of corn production systems, with and without the presence of subsurface drainage, along a precipitation gradient from eastern South Dakota to south central Minnesota. Understanding the hydrologic response of drainage and crop water consumption at both the field and watershed scale will help corn growers be economically competitive while also informing development of tools and management approaches that can minimize their environmental impact under various climate conditions.

Innovations for Sustainable Food, Energy, And Water Supplies in Intensively Cultivated Regions: Integrating Technologies, Data, And Human Behavior: This project is ongoing and is focused on food production in Southern Minnesota. Researchers from the biophysical, socioeconomic, and computational sciences are investigating two types of innovations using data from the northern U.S. Corn Belt. First, a novel oilseed crop, winter camelina, is being studied for its potential incorporation into existing corn-soybean rotations to produce a new supply of biodiesel energy while lowering water resource impacts and creating positive ecological benefits. Second, emerging systems of sustainability certification are being studied for their potential to lead to broad-scale adoption of this new cropping system. Detailed computational models are being evaluated and applied for systems-level assessments of two innovations: developing novel approaches to influence beneficial land use, and accounting for energy and environmental impacts within food supply chains. This project is funded by the National Science Foundation and supported by the MDA.

Pesticide Monitoring

The purpose of the MDA's pesticide monitoring program is to determine the presence and concentration of pesticides in Minnesota waters, and present long-term trend analysis based on information collected over the past 30 years. Trend analysis requires long-term investments in monitoring within the MDA's established networks. The MDA releases an annual water quality monitoring report that includes all pesticide water quality data and long-term trends available on MDA's website. The MDA will continue to conduct statewide pesticide monitoring in the future and will provide additional information related to the occurrence of pesticides in Minnesota waters.

The MDA completed 14 pesticide water quality sample collection events from seven lakes within the Cottonwood and Redwood River watersheds from 2012 through 2019. Double Lake was added to the 2020 303(d) Impaired Waters List for the insecticide chlorpyrifos due to one detection each in 2017 and 2018. No other lakes sampled in the Cottonwood River Watershed were above an applicable pesticide water quality reference value.

The MDA completed 517 pesticide and/or nutrient water quality sample collection events from 10 river and stream locations within the Cottonwood and Redwood River watersheds from 1992 through 2019. Sleepy Eye Creek at Cobden and the Cottonwood River at New Ulm were sampled within the Cottonwood Watershed. Sleepy Eye Creek was designated on the 2018 Impaired Waters List for the insecticide chlorpyrifos due to detection in 2015 and 2016. No other river and stream pesticide impairments have been identified in the Cottonwood River Watershed. The MDA will continue to monitor the Cottonwood River and Sleepy Eye Creek into the future to allow for analysis of pesticide detections over time.

Finally, the MDA completed 10 pesticide water quality sample collection events from 5 wetlands within the Cottonwood and Redwood River watersheds in 2014. No pesticide detections in the wetlands in either watershed was above the applicable water quality reference values.

Diagnostic and Targeted Monitoring

The Cottonwood River Watershed SID Report, TMDL allocations, and source assessment exercises were developed using available monitoring data, surveys, assessments, and models. For some of the impairments or protection waters, additional targeted data and information collection might be warranted prior to investing significant money and resources into restoring or protecting these water bodies. Collecting additional diagnostic and targeted monitoring data might help calibrate and/or validate modeling results, refine the TMDL source assessments, pinpoint geographic locations of problem areas, and provide baseline data prior to project implementation. It is not feasible or necessary for each impairment to have detailed, costly, field-derived source assessments. In many cases, information gained from enhanced source assessment for one impairment can be extrapolated to other impairments in the watershed or even region. The MPCA has developed guidance on when it is appropriate to consider funding for enhanced phosphorus source assessment for lakes and microbial source tracking for streams. This guidance is intended to inform MPCA's decisions on dedicating State funding or staff time to enhanced source assessment activities. Several potential targeted monitoring activities were identified in the Cottonwood River Watershed SID and TMDL reports. Many of these have been incorporated into the individual strategies tables in this WRAPS as activities that could be further considered, contingent on funding availability and priorities:

- Microbial source tracking in select bacteria impaired streams to identify sources of fecal contamination
- Longitudinal (upstream to downstream) *E. coli* monitoring surveys in certain bacteria impaired stream reaches to further refine and evaluate potential locations of elevated bacteria loading
- Collect flow and water quality (e.g., TP) in major tributaries and wetlands flowing to impaired lakes. Compare monitoring results to HSPF and lake response models for validation and/or re-calibration
- Collect sediment cores to evaluate phosphorus release from lake sediments and compare to model predictions
- Conduct/update fish and/or vegetation surveys according to DNR methodology for lakes that have never been surveyed or have limited or outdated survey data

5. References

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Appendix A: Lake and Stream Protection and Prioritization Results

Table A-1. Results of the lake protection prioritization tool as described in Section 2.6. Hurricane and Round Lakes were identified as medium priorities for protection efforts in the Cottonwood River Watershed.

Lake ID	Lake Name	Mean TP (µg/L)	Trend	% Disturbed Land Use	5% load reduction goal	Priority
08-0011-00	Clear	163.1		79%	54	C
08-0029-00	Bachelor	400.4		94%	31	C
08-0045-00	Sleepy Eye	85.3	No evidence of trend	80%	16	N/A
08-0054-00	Altermatt	402.8		87%	22	C
08-0096-00	Boise	287.0		94%	79	C
17-0033-00	Augusta	158.3		92%	235	C
17-0037-00	Hurricane	48.0		81%	7	B
17-0048-01	Round	544.5		86%	179	C
17-0048-02	Long	330.5		86%	100	C
17-0054-00	Bean	129.4		94%	14	N/A
17005600	Double	99.0		93%	26	C
17-0056-01	Double (North Portion)	125.9		93%	36	N/A
42-0052-00	Rock	198.5		90%	106	N/A
51-0006-00	Louisa	203.0		82%	92	C
51-0038-00	Round	38.0		82%	5	B

Table A-2. Results of the stream protection prioritization tool as described in Section 2.6. Each reach was identified as high priority for protection efforts in the Cottonwood River Watershed.

WID	Stream Name	TALU	Cold/Warm	Community Nearly Impaired	Riparian Risk	Watershed Risk	Current Protection Level	Protection Priority Class
07020008-548	Judicial Ditch 9	General	warm	one	high	high	med/low	A
07020008-578	Unnamed creek	General	warm	one	med/high	high	low	A
07020008-588	Judicial Ditch 3	General	warm	one	med/high	high	low	A
07020008-523	Pell Creek	General	warm	one	med/high	high	med/low	A
07020008-507	Cottonwood River	General	warm	one	medium	high	med/low	A
07020008-527	County Ditch 38	General	warm	one	med/low	high	med/low	A
07020008-587	Unnamed creek	General	warm	neither	med/high	high	low	A
07020008-543	County Ditch 54	Modified	warm	one	high	high	low	A
07020008-589	County Ditch 19	Modified	warm	one	high	high	med/low	A
07020008-586	Unnamed creek	Modified	warm	one	high	high	medium	A
07020008-561	County Ditch 68	Modified	warm	neither	high	high	low	A
07020008-564	County Ditch 60	Modified	warm	neither	high	high	low	A
07020008-565	County Ditch 5	Modified	warm	neither	high	high	low	A
07020008-584	Unnamed creek	Modified	warm	neither	high	high	low	A
07020008-594	Unnamed ditch	Modified	warm	neither	high	high	low	A
07020008-595	Unnamed creek	Modified	warm	neither	high	high	low	A
07020008-596	Judicial Ditch 35	Modified	warm	neither	high	high	low	A
07020008-601	Meadow Creek	Modified	warm	neither	high	high	low	A
07020008-623	Unnamed creek	Modified	warm	neither	high	high	low	A

Appendix B: Stream and Lake TMDL Summaries

Figure B-1. Cottonwood River Reach 502 TSS load duration curve and monitored loads and exceedances.

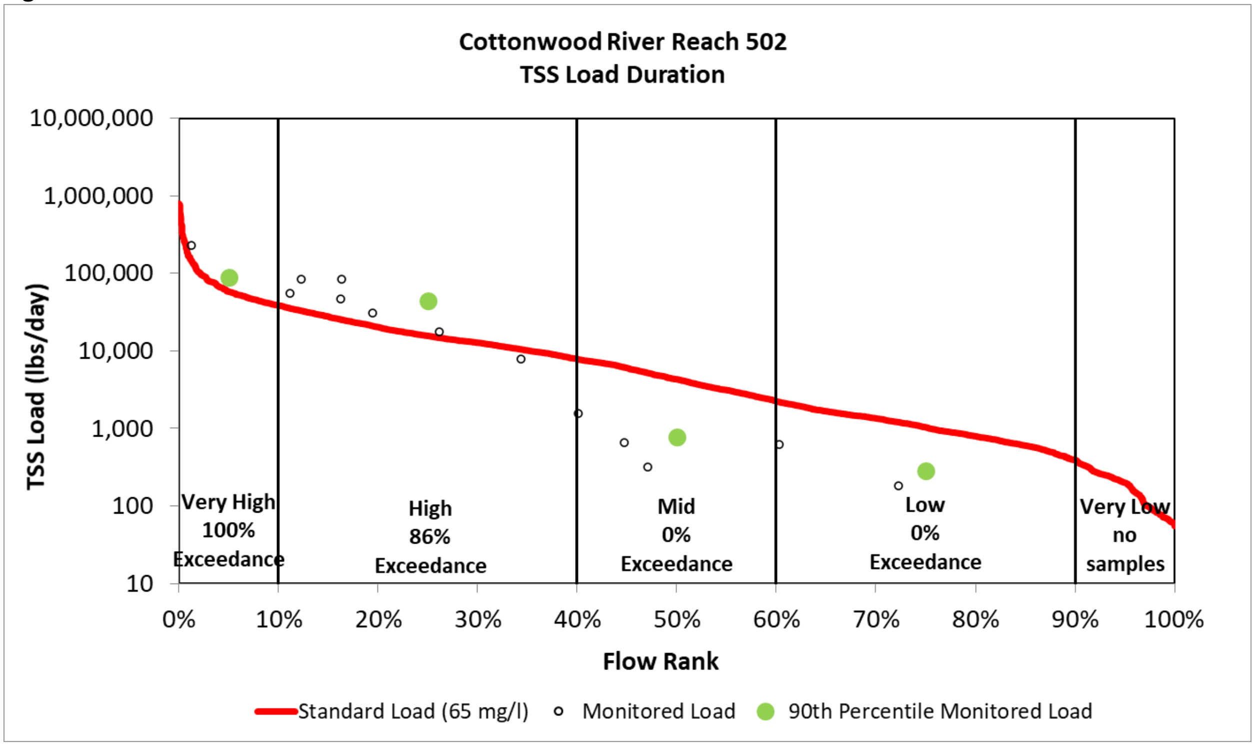


Table B-1. TSS TMDL summary for Cottonwood River Reach 502.

Total Suspended Solids		Flow zones*				
		Very high	High	Mid-range	Low	Very low
Sources		TSS load (lbs/day)				
Wasteload	Garvin WWTP (MNG580101)	63	63	63	63	**
	Balaton WWTP (MN0020559)	306	306	306	306	**
	Construction/Industrial SW	86	23	6	2	**
	Total WLA	**455**	**392**	**375**	**371**	**
Load	**Total LA**	**54,513**	**14,430**	**3,708**	**608**	**
MOS		**2,893**	**780**	**215**	**52**	**10**
Total load		**57,861**	**15,602**	**4,298**	**1,031**	**199**
Existing 90th percentile concentration (mg/L)* **		**75**				
Overall estimated percent reduction* **		**13%**				

* Model simulated flow for HSPF reach 90 (2008-2017) was used to develop the flow zones and LCs for this reach.
** The permitted wastewater design flows exceed the stream flow in the indicated flow zone(s). The allocations are expressed as an equation rather than an absolute number: allocation = (flow contribution from a given source) x (65 mg/L or NPDES permit concentration) x (conversion factors).
*** Water quality monitoring station(s) used to estimate reductions: S009-440.

Figure B-2. Cottonwood River Reach 504 TSS load duration curve and monitored loads and exceedances.

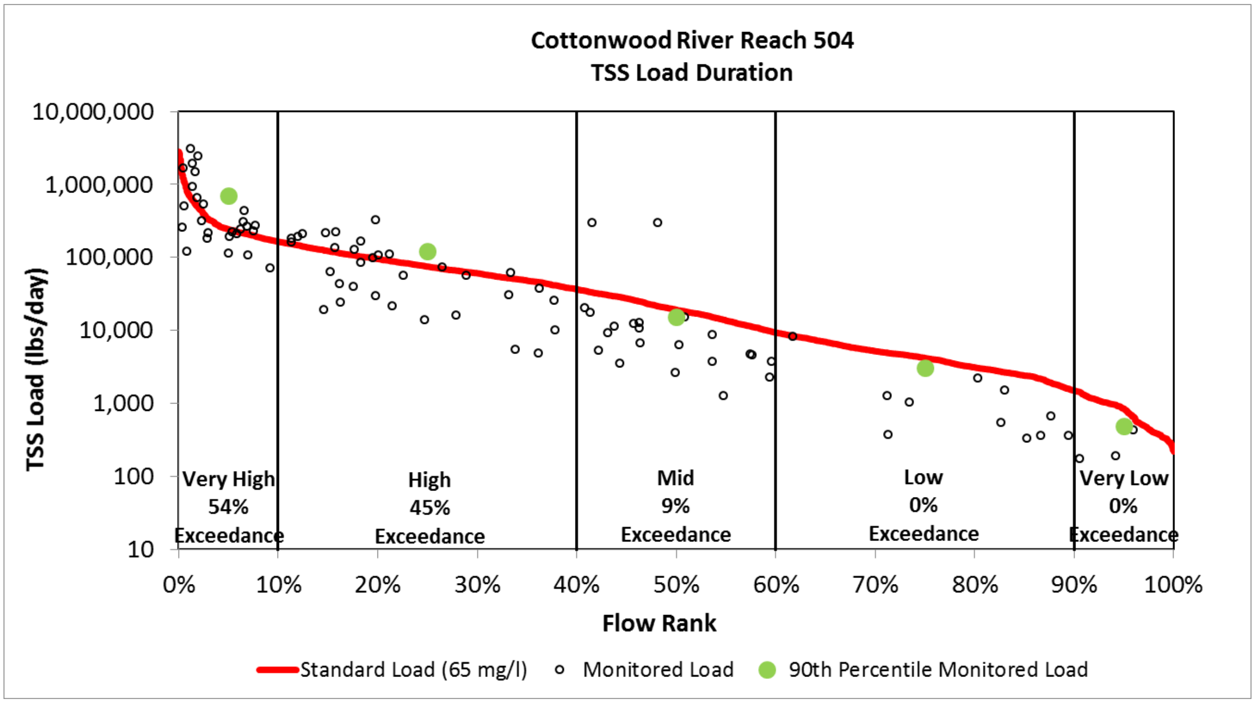


Table B-2. TSS TMDL summary for Cottonwood River Reach 504.

Total Suspended Solids		Flow zones*				
		Very high	High	Mid-range	Low	Very low
Sources		TSS load (lbs/day)				
Wasteload	Garvin WWTP (MNG580101)	63	63	63	63	***
	Revere WWTP (MNG580114)	56	56	56	56	***
	Tracy WWTP (MN0021725)	1,312	1,312	1,312	1,312	***
	Balaton WWTP (MN0020559)	306	306	306	306	***
	Walnut Grove WWTP (MN0021776)	51	51	51	51	***
	City of Marshall MS4 (MS400241)****	591	184	47	10	***
	Construction/Industrial SW	360	112	29	6	***
	Total WLA	**2,739**	**2,084**	**1,864**	**1,804**	***
Load	**Total LA**	**227,061**	**69,361**	**16,411**	**2,179**	***
MOS		**12,095**	**3,760**	**962**	**210**	**42**
Total load		**241,895**	**75,205**	**19,237**	**4,193**	**836**
Existing 90th percentile concentration (mg/L)**		**78**				
Overall estimated percent reduction**		**17%**				

* Model simulated flow for HSPF reach 250 (2008-2017) was used to develop the flow zones and LCs for this reach.
** Water quality monitoring station(s) used to estimate reductions: S002-247.
*** The permitted wastewater design flows exceed the stream flow in the indicated flow zone(s). The allocations are expressed as an equation rather than an absolute number: allocation = (flow contribution from a given source) x (65 mg/L or NPDES permit concentration) x (conversion factors). The LA is the remainder after the WLA is applied.
**** Although a small portion of the city of Marshall falls within the drainage area for this reach, reductions are not required.

Figure B-3. Cottonwood River Reach 508 TSS load duration curve and monitored loads and exceedances.

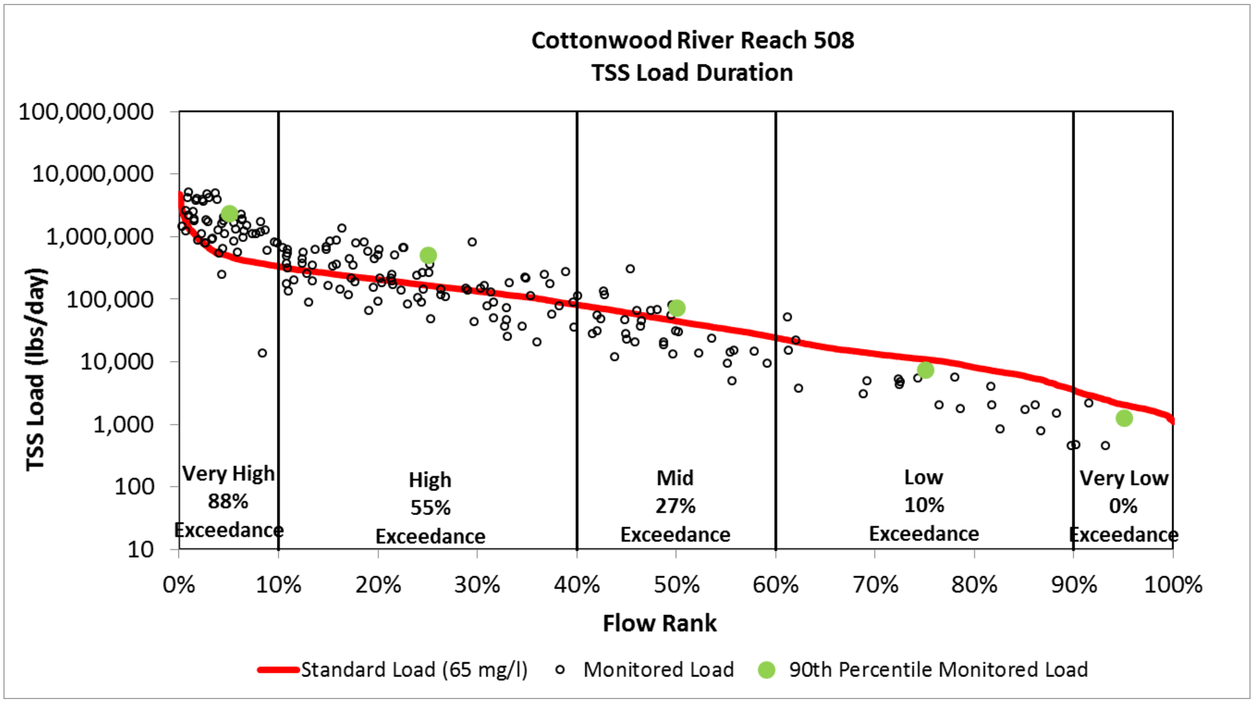
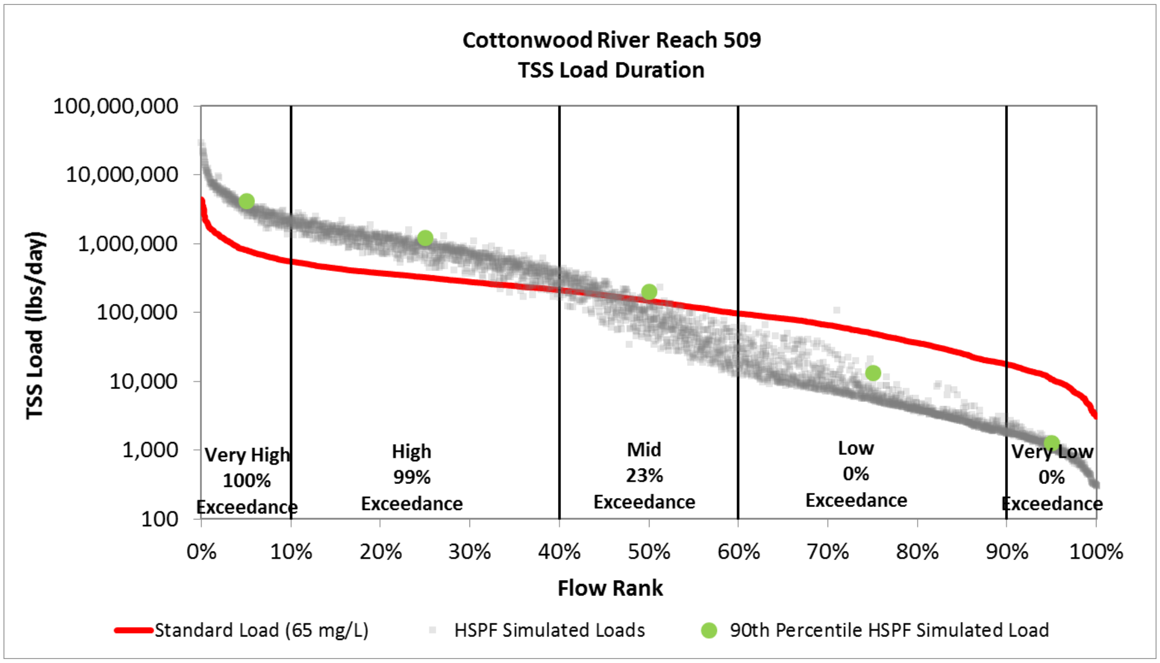


Table B-3. TSS TMDL summary for Cottonwood River Reach 508.

Total Suspended Solids		Flow zones*				
		Very high	High	Mid-range	Low	Very low
Sources		TSS load (lbs/day)				
Wasteload	Sanborn WWTP (MNG580115)	128	128	128	128	**
	Springfield WWTP (MN0024953)	195	195	195	195	**
	Balaton WWTP (MN0020559)	306	306	306	306	**
	Garvin WWTP (MNG580101)	63	63	63	63	**
	Revere WWTP (MNG580114)	56	56	56	56	**
	Tracy WWTP (MN0021725)	1,312	1,312	1,312	1,312	**
	Walnut Grove WWTP (MN0021776)	51	51	51	51	**
	Storden WWTP (MNG580106)	99	99	99	99	**
	Westbrook WWTP (MNG580127)	611	611	611	611	**
	Lamberton WWTP (MNG580100)	489	489	489	489	**
	City of Marshall MS4 (MS400241)****	591	184	47	10	**
	Construction/Industrial SW	726	247	66	16	**
	Total WLA	**4,627**	**3,741**	**3,423**	**3,336**	**
Load	**Total LA**	**458,470**	**153,751**	**38,880**	**7,114**	**
	MOS	**24,374**	**8,289**	**2,226**	**550**	**103**
	Total load	**487,471**	**165,781**	**44,529**	**11,000**	**2,059**
Existing 90th percentile concentration (mg/L)* **		**130**				
Overall estimated percent reduction* **		**50%**				

* Model simulated flow for HSPF reach 370 (2008-2017) was used to develop the flow zones and LCs for this reach.
** The permitted wastewater design flows exceed the stream flow in the indicated flow zone(s). The allocations are expressed as an equation rather than an absolute number: allocation = (flow contribution from a given source) x (65 mg/L or NPDES permit concentration) x (conversion factors).
*** Water quality monitoring station(s) used to estimate reductions: S001-920.
**** Although a small portion of the city of Marshall falls within the drainage area for this reach, reductions are not required.

Figure B-4. Cottonwood River Reach 509 TSS load duration curve and HSPF simulated TSS loads and exceedances.



TableB-4. TSS TMDL summary for Cottonwood River Reach 509.

Total Suspended Solids		Flow zones*				
		Very high	High	Mid-range	Low	Very low
Sources		TSS load (lbs/day)				
Wasteload	Sanborn WWTP (MNG580115)	128	128	128	128	***
	Springfield WWTP (MN0024953)	195	195	195	195	***
	Balaton WWTP (MN0020559)	306	306	306	306	***
	Garvin WWTP (MNG580101)	63	63	63	63	***
	Revere WWTP (MNG580114)	56	56	56	56	***
	Tracy WWTP (MN0021725)	1,312	1,312	1,312	1,312	***
	Walnut Grove WWTP (MN0021776)	51	51	51	51	***
	Storden WWTP (MNG580106)	99	99	99	99	***
	Westbrook WWTP (MNG580127)	611	611	611	611	***
	Lamberton WWTP (MNG580100)	489	489	489	489	***
	Lucan WWTP (MNG580112)	86	86	86	86	***
	Wanda WWTP (MNG580126)	67	67	67	67	***
	Clements WWTP (MNG580094)	61	61	61	61	***
	Wabasso WWTP (MN0025151)	28	28	28	28	***
	City of Marshall MS4 (MS400241)****	591	184	47	10	***
	Construction/Industrial SW	968	339	91	23	***
	Total WLA	**5,282**	**4,246**	**3,861**	**3,756**	***
Load	**Total LA**	**611,988**	**211,942**	**54,449**	**10,661**	***
MOS		**32,488**	**11,378**	**3,069**	**759**	**180**
Total load		**649,758**	**227,566**	**61,379**	**15,176**	**3,598**
Existing 90th percentile concentration (mg/L)**		**104**				
Overall estimated percent reduction**		**38%**				

* Model simulated flow for HSPF reach 430 (2008-2017) was used to develop the flow zones and LCs for this reach.

** The impairment listing for this reach is based on Secchi Tube data (see Table 7) as no TSS data have been collected for this reach. Therefore, reductions are based on HSPF simulated TSS loads/concentrations.
***The permitted wastewater design flows exceed the stream flow in the indicated flow zone(s). The allocations are expressed as an equation rather than an absolute number: allocation = (flow contribution from a given source) x (65 mg/L or NPDES permit concentration) x (conversion factors). The LA is the remainder after the WLA is applied.
**** Although a small portion of the city of Marshall falls within the drainage area for this reach, reductions are not required.

Figure B-5. Dutch Charley Creek Reach 517 TSS load duration curve and monitored loads and exceedances.

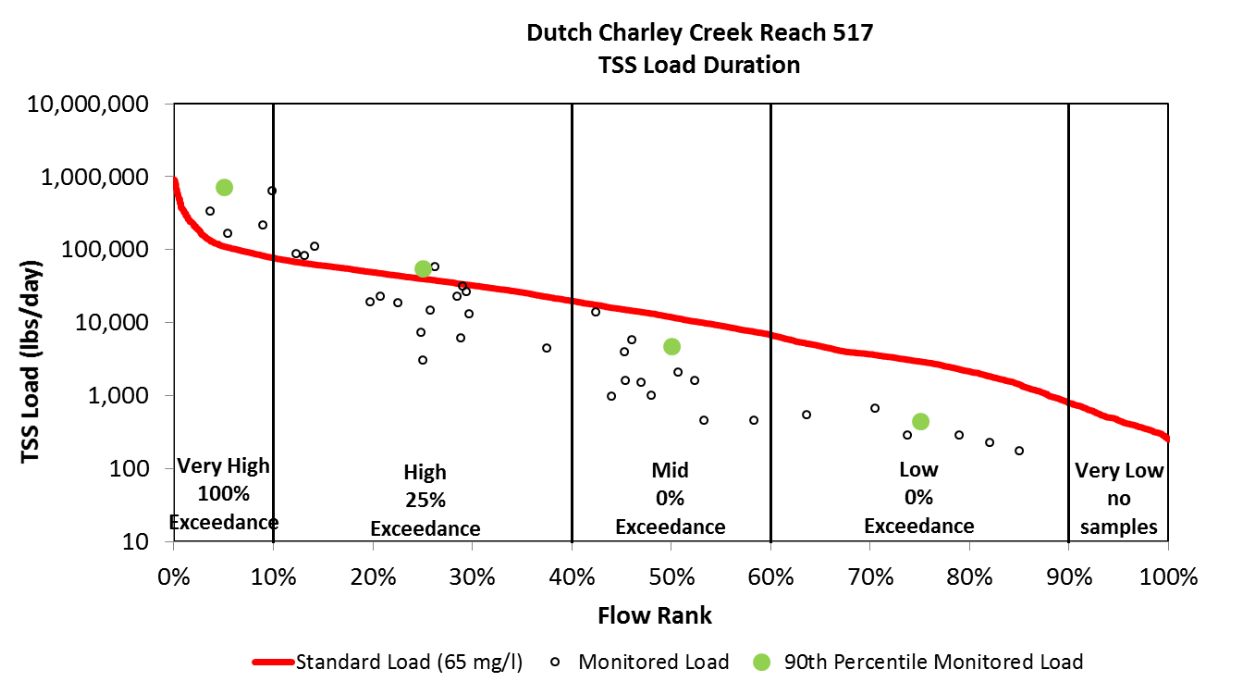


Table B-5. TSS TMDL summary for Dutch Charley Creek Reach 517.

Total Suspended Solids		Flow zones*				
		Very high	High	Mid-range	Low	Very low
Sources		TSS load (lbs/day)				
Wasteload	Storden WWTP (MNG580106)	99	99	99	99	**
	Westbrook WWTP (MNG580127)	611	611	611	611	**
	Lamberton WWTP (MNG580100)	489	489	489	489	**
	Construction/Industrial SW	165	59	18	4	**
	Total WLA	**1,364**	**1,258**	**1,217**	**1,203**	**
Load	**Total LA**	**104,035**	**36,612**	**10,094**	**1,589**	**
MOS		**5,547**	**1,993**	**595**	**147**	**23**
Total load		**110,946**	**39,863**	**11,906**	**2,939**	**456**
Existing 90th percentile concentration (mg/L)* **		**79**				
Overall estimated percent reduction* **		**18%**				

* Model simulated flow for HSPF reach 281 (2008-2017) was used to develop the flow zones and LCs for this reach.
** The permitted wastewater design flows exceed the stream flow in the indicated flow zone(s). The allocations are expressed as an equation rather than an absolute number: allocation = (flow contribution from a given source) x (65 mg/L or NPDES permit concentration) x (conversion factors).
*** Water quality monitoring station(s) used to estimate reductions: S001-915.

Figure B-6. Dutch Charley Creek Reach 518 TSS load duration curve and monitored loads and exceedances.

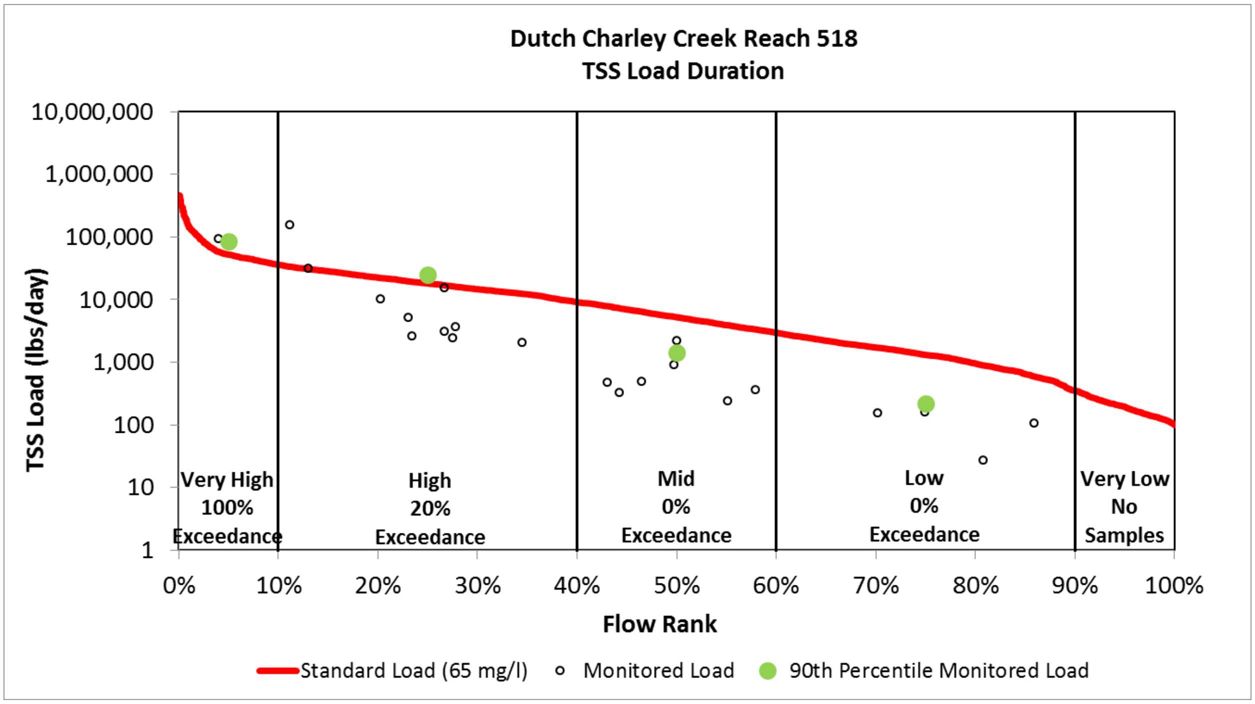


Table B-6. TSS TMDL summary for Dutch Charley Creek Reach 518.

Total Suspended Solids		Flow zones*				
		Very high	High	Mid-range	Low	Very low
Sources		TSS load (lbs/day)				
Wasteload	Lamberton WWTP (MNG580100)	489	489	489	489	**
	Construction/Industrial SW	78	27	8	2	**
	Total WLA	**567**	**516**	**497**	**491**	**
Load	**Total LA**	**49,303**	**16,749**	**4,468**	**756**	**
MOS		**2,625**	**909**	**261**	**66**	**10**
Total load		**52,495**	**18,174**	**5,226**	**1,313**	**194**
Existing 90th percentile concentration (mg/L)* **		****				
Overall estimated percent reduction* **		**5%**				

* Model simulated flow for HSPF reach 267 (2008-2017) was used to develop the flow zones and LCs for this reach.
** The permitted wastewater design flows exceed the stream flow in the indicated flow zone(s). The allocations are expressed as an equation rather than an absolute number: allocation = (flow contribution from a given source) x (65 mg/L or NPDES permit concentration) x (conversion factors).
*** Water quality monitoring station(s) used to evaluate reductions: S004-879.
**** The 90th percentile flow-zone corrected monitored TSS concentration is at or below 65 mg/L and therefore a 5% load reduction is recommended to ensure the TSS standard is met. There were 22 TSS measurements collected in this reach from 2008-2017 and therefore more monitoring would help determine if reductions beyond 5% are needed.

Figure B-7. Highwater Creek Reach 519 TSS load duration curve and monitored loads and exceedances.

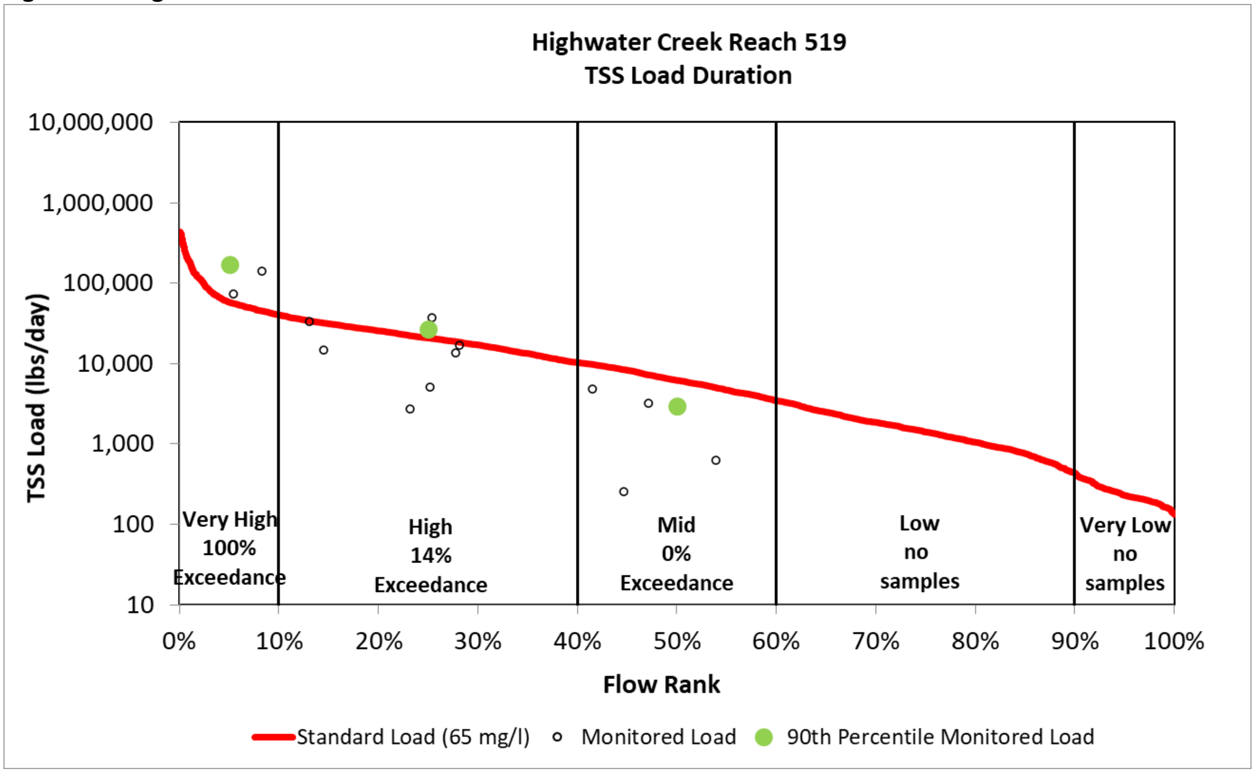


Table B-7. TSS TMDL summary for Highwater Creek Reach 519.

Total Suspended Solids		Flow zones*				
		Very high	High	Mid-range	Low	Very low
Sources		TSS load (lbs/day)				
Wasteload	Storden WWTP (MNG580106)	99	99	99	99	**
	Westbrook WWTP (MNG580127)	611	611	611	611	**
	Construction/Industrial SW	86	31	9	2	**
	Total WLA	**796**	**741**	**719**	**712**	**
Load	**Total LA**	**53,847**	**18,990**	**5,136**	**622**	**
MOS		**2,876**	**1,038**	**308**	**70**	**11**
Total load		**57,519**	**20,769**	**6,163**	**1,404**	**229**
Existing 90th percentile concentration (mg/L)* **		****				
Overall estimated percent reduction* **		**5%**				

* Model simulated flow for HSPF reach 279 (2008-2017) was used to develop the flow zones and LCs for this reach.
** The permitted wastewater design flows exceed the stream flow in the indicated flow zone(s). The allocations are expressed as an equation rather than an absolute number: allocation = (flow contribution from a given source) x (65 mg/L or NPDES permit concentration) x (conversion factors).
*** Water quality monitoring station(s) used to evaluate reductions: S009-443.
**** The 90th percentile flow-zone corrected monitored TSS concentration is at or below 65 mg/L and therefore a 5% load reduction is recommended to ensure the TSS standard is met. There were 22 TSS measurements collected in this reach from 2008-2017 and therefore more monitoring would help determine if reductions beyond 5% are needed.

Figure B-8. Pell Creek Reach 535 TSS load duration curve and monitored loads and exceedances.

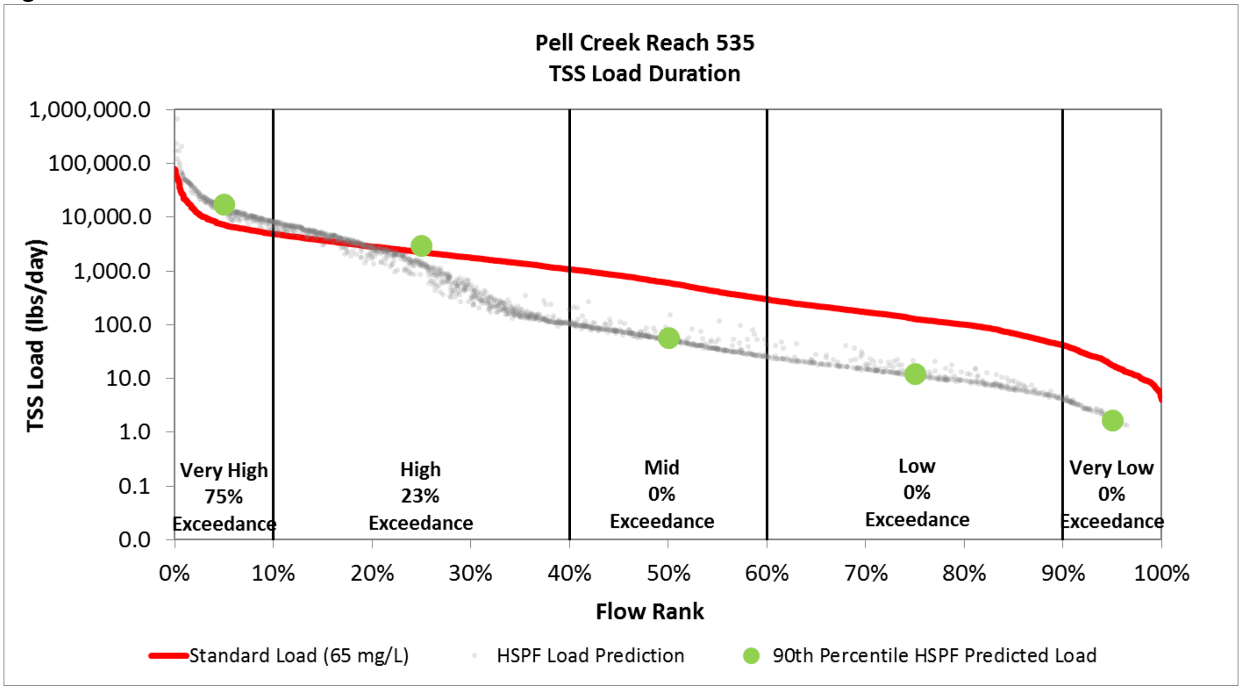


Table B-8. TSS TMDL summary for Pell Creek Reach 535.

Total Suspended Solids		Flow zones*				
		Very high	High	Mid-range	Low	Very low
Sources		TSS load (lbs/day)				
Wasteload	Construction/Industrial SW	11	3	0.9	0.2	0.03
	Total WLA	**11**	**3**	**0.9**	**0.2**	**0.03**
Load	**Total LA**	**6,789**	**2,113**	**569**	**121**	**17**
MOS		**358**	**111**	**30**	**6**	**0.9**
Total load		**7,158**	**2,227**	**600**	**127**	**18**
Existing 90th percentile concentration (mg/L)**		***				
Overall estimated percent reduction**		**5%**				

* Model simulated flow for HSPF reach 211 (2008-2017) was used to develop the flow zones and LCs for this reach.

** The impairment listing for this reach is based on Secchi Tube data (see Table 7) as no TSS data have been collected for this reach. Therefore, reductions were evaluated using HSPF simulated TSS loads/concentrations.

*** The 90th percentile flow-zone corrected HSPF simulated TSS concentration is at or below 65 mg/L and therefore a 5% load reduction is recommended to ensure the TSS standard is met. No TSS measurements have been collected in this reach. Future monitoring would help determine if reductions beyond 5% are needed.

Figure B-9. Sleepy Eye Creek Reach 599 TSS load duration curve and monitored loads and exceedances.

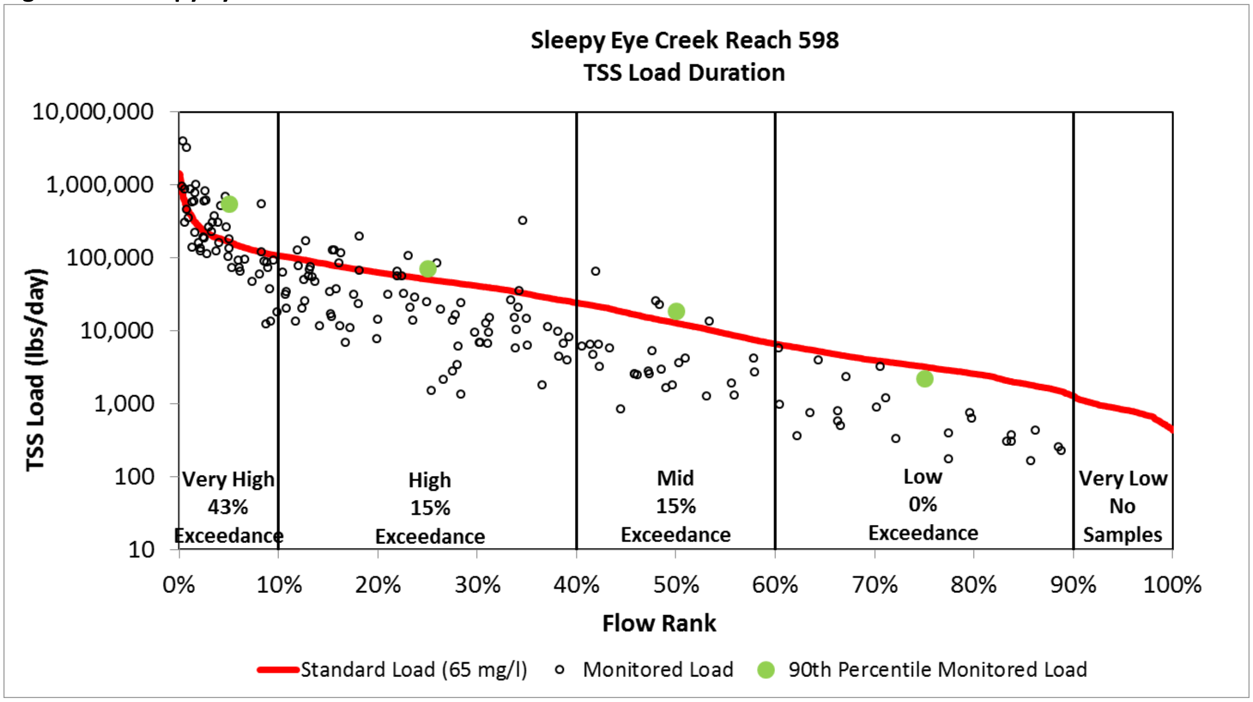


Table B-9. TSS TMDL summary for Sleepy Eye Creek Reach 599.

Total Suspended Solids		Flow zones*				
		Very high	High	Mid-range	Low	Very low
Sources		TSS load (lbs/day)				
Wasteload	Clements WWTP (MNG580094)	61	61	61	61	61
	Lucan WWTP (MNG580112)	86	86	86	86	86
	Wabasso WWTP (MN0025151)	28	28	28	28	28
	Wanda WWTP (MNG580126)	67	67	67	67	67
	Construction/Industrial SW	246	75	19	5	1
	Total WLA	**488**	**317**	**261**	**247**	**243**
Load	**Total LA**	**156,489**	**47,540**	**11,772**	**2,790**	**537**
MOS		**8,262**	**2,519**	**633**	**160**	**41**
Total load		**165,239**	**50,376**	**12,666**	**3,197**	**821**
Existing 90th percentile concentration (mg/L)**		**85**				
Overall estimated percent reduction**		**24%**				

* Model simulated flow for HSPF reach 407 (2008-2017) was used to develop the flow zones and LCs for this reach.

** Water quality monitoring station(s) used to estimate reductions: S001-919.

Figure B-10. Plum Creek Reach 602 and 603 TSS load duration curve and monitored loads and exceedances.

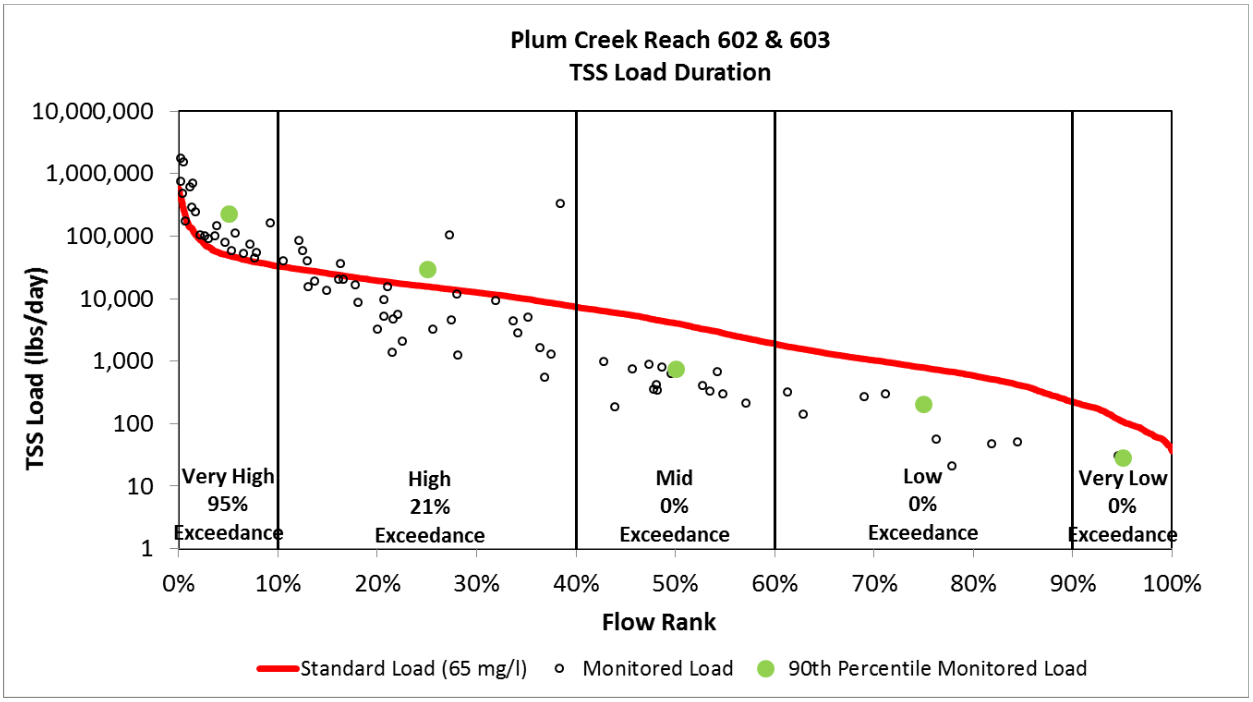


Table B-10. TSS TMDL summary for Plum Creek Reach 602 and 603.

Total Suspended Solids		Flow zones*				
		Very high	High	Mid-range	Low	Very low
Sources		TSS load (lbs/day)				
Wasteload	Construction/Industrial SW	73	23	6	1	0.2
	Total WLA	**73**	**23**	**6**	**1**	**0.2**
Load	**Total LA**	**46,565**	**14,829**	**3,827**	**747**	**103**
MOS		**2,455**	**782**	**202**	**39**	**5**
Total load		**49,093**	**15,634**	**4,035**	**787**	**108**
Existing 90th percentile concentration (mg/L)**		**77**				
Overall estimated percent reduction**		**16%**				

* Model simulated flow for HSPF reach 191 (2008-2017) was used to develop the flow zones and LCs for this reach.

** Water quality monitoring station(s) used to estimate reductions: S001-913.

Figure B-11. Cottonwood River Reach 502 *E. coli* load duration curve and monitored loads and exceedances.

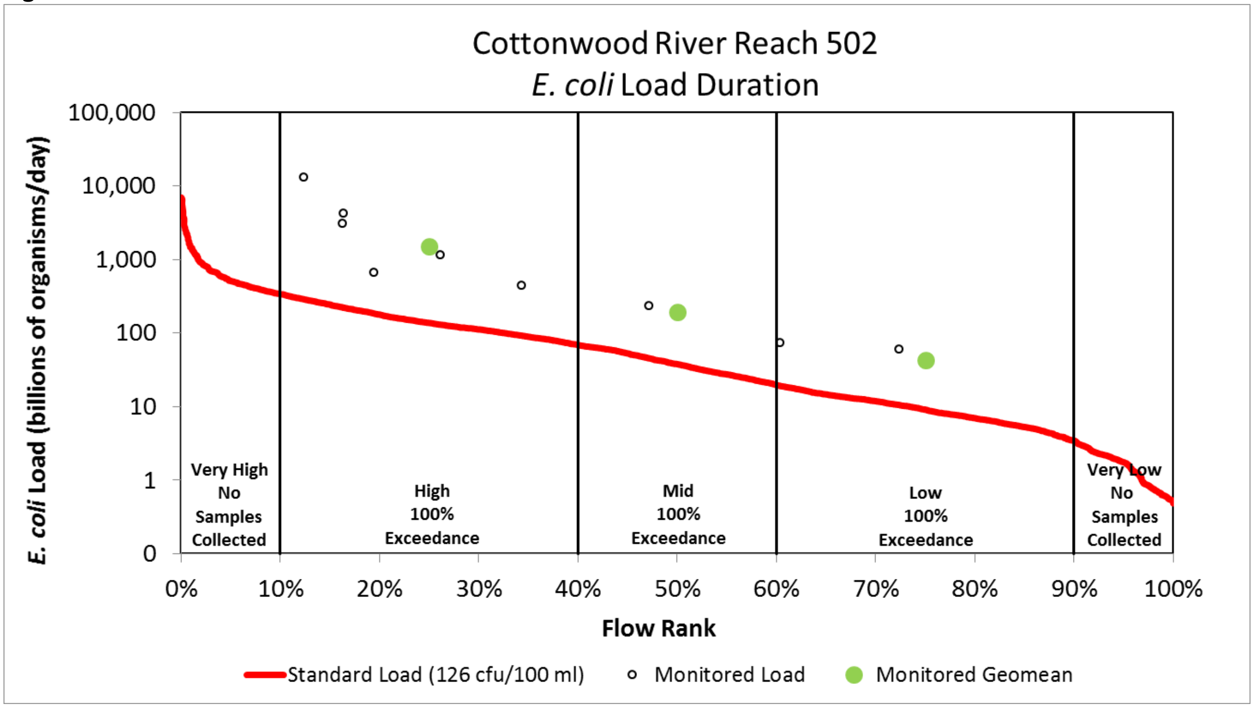


Table B-11. *E. coli* TMDL summary for Cottonwood River Reach 502.

E. coli		Flow zones*				
		Very high	High	Mid-range	Low	Very low
Sources		*E. coli* load (billions of orgs/day)				
Wasteload	Balaton WWTP	4	4	4	4	**
	Garvin WWTP	0.8	0.8	0.8	0.8	**
	Total WLA	**5**	**5**	**5**	**5**	**
Load	**Total LA**	**743**	**197**	**51**	**9**	**
MOS		**39**	**11**	**3**	**0.7**	**0.1**
Total load		**787**	**213**	**59**	**15**	**3**
Existing Concentration, Apr-Oct (org/100 mL)* **		**1,063**				
Maximum Monthly Geometric Mean (org/100mL)* **		**1,859**				
Overall Estimated Percent Reduction* **		**93%**				

* Model simulated flow for HSPF reach 90 from April-October (2008-2017) was used to develop the flow zones and LCs for this reach.

** The permitted wastewater design flows exceed the stream flow in the indicated flow zone(s). The allocations are expressed as an equation rather than an absolute number: allocation = (flow contribution from a given source) x (126 org per 100 mL) x conversion factors.

*** Water quality monitoring station(s) used to estimate reductions: S009-440.

Figure B-12. Judicial Ditch 30 Reach 511 *E. coli* load duration curve and monitored loads and exceedances.

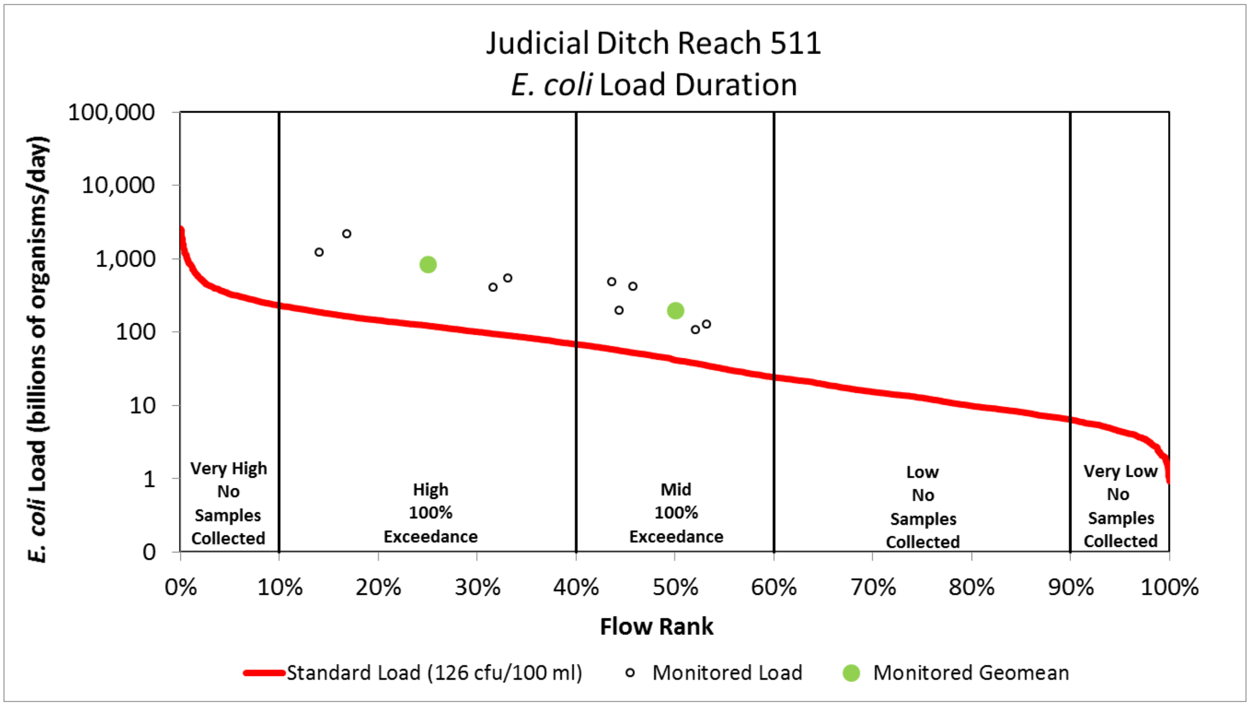


Table B-12. *E. coli* TMDL summary for Judicial Ditch 30 Reach 511.

E. coli		Flow zones*				
		Very high	High	Mid-range	Low	Very low
Sources		*E. coli* load (billions of orgs/day)				
Wasteload	Sleepy Eye WWTP	31	31	31	**	**
	Total WLA	**31**	**31**	**31**	**	**
Load	Total LA	**451**	**149**	**30**	**	**
MOS		**25**	**10**	**3**	**1**	**0.3**
Total load		**507**	**190**	**64**	**20**	**7**
Existing Concentration, Apr-Oct (org/100 mL)***		**710**				
Maximum Monthly Geometric Mean (org/100mL)***		**921**				
Overall Estimated Percent Reduction***		**86%**				

* Model simulated flow for HSPF reach 435 from April-October (2008-2017) was used to develop the flow zones and LCs for this reach.

** The permitted wastewater design flows exceed the stream flow in the indicated flow zone(s). The allocations are expressed as an equation rather than an absolute number: allocation = (flow contribution from a given source) x (126 org per 100 mL) x conversion factors.

*** Water quality monitoring station(s) used to estimate reductions: S009-438.

Figure B-13. Highwater Creek Reach 519 *E. coli* load duration curve and monitored loads and exceedances.

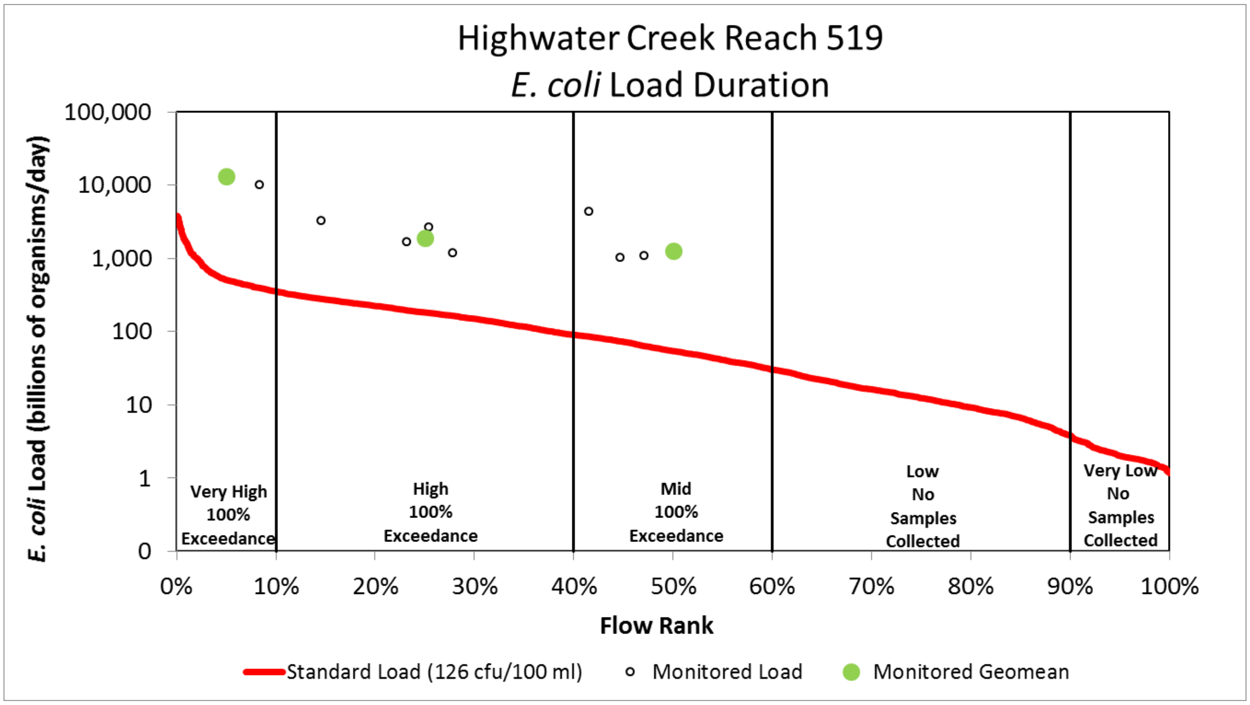


Table B-13. *E. coli* TMDL summary for Highwater Creek Reach 519.

E. coli		Flow zones*				
		Very high	High	Mid-range	Low	Very low
Sources		*E. coli* load (billions of orgs/day)				
Wasteload	Storden WWTP	1	1	1	1	**
	Westbrook WWTP	8	8	8	8	**
	Total WLA	9	9	9	9	**
Load	Total LA	735	259	71	9	**
MOS		39	14	4	1	0.2
Total load		783	282	84	19	3
Existing Concentration, Apr-Oct (org/100 mL)***		1,897				
Maximum Monthly Geometric Mean (org/100mL)***		2,729				
Overall Estimated Percent Reduction***		95%				

* Model simulated flow for HSPF reach 279 from April-October (2008-2017) was used to develop the flow zones and LCs for this reach.

** The permitted wastewater design flows exceed the stream flow in the indicated flow zone(s). The allocations are expressed as an equation rather than an absolute number: allocation = (flow contribution from a given source) x (126 org per 100 mL) x conversion factors.

*** Water quality monitoring station(s) used to estimate reductions: S009-443.

Figure B-14. Dry Creek Reach 520 *E. coli* load duration curve and monitored loads and exceedances.

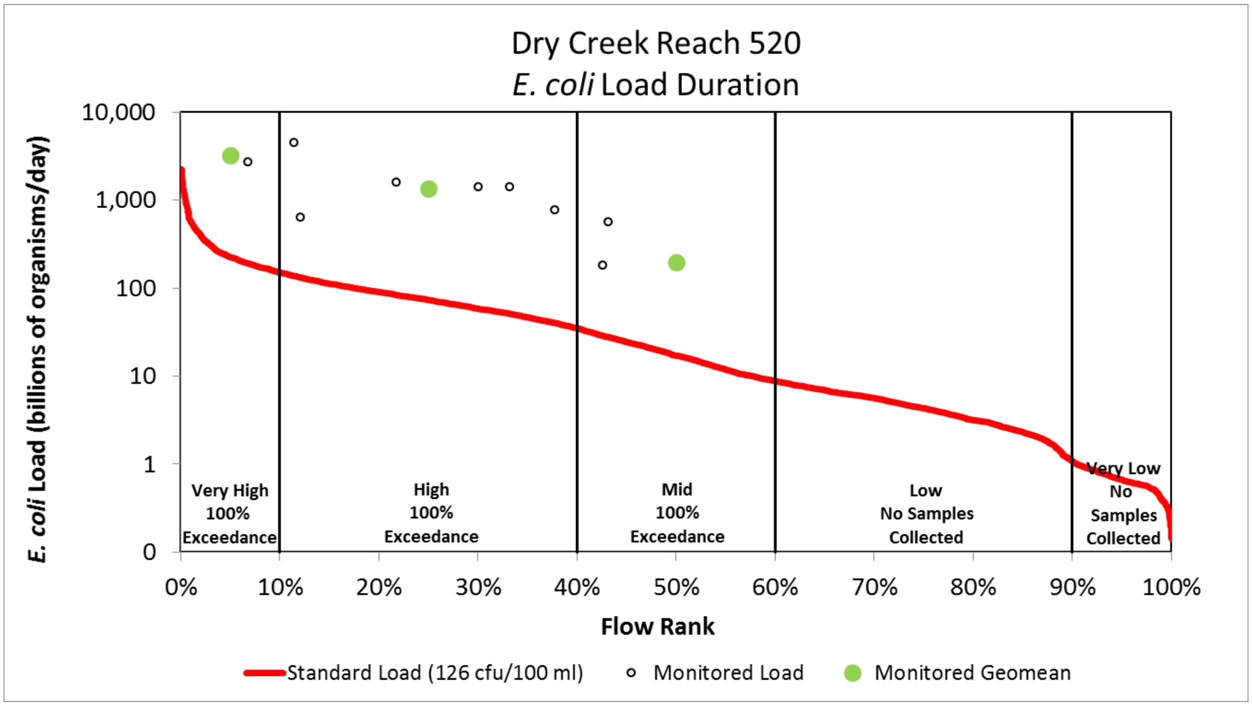


Table B-14. *E. coli* TMDL summary for Dry Creek Reach 520.

E. coli		Flow zones*				
		Very high	High	Mid-range	Low	Very low
Sources		*E. coli* load (billions of orgs/day)				
Load	Total LA	329	108	25	6	1
	MOS	17	6	1	0.3	0.1
	Total load	346	114	26	6	1
	Existing Concentration, Apr-Oct (org/100 mL)**	2,033				
	Maximum Monthly Geometric Mean (org/100mL)**	3,248				
	Overall Estimated Percent Reduction**	96%				

* Model simulated flow for HSPF reach 291 from April-October (2008-2017) was used to develop the flow zones and LCs for this reach.

** Water quality monitoring station(s) used to estimate reductions: S009-442.

Figure B-15. Mound Creek Reach 521 *E. coli* load duration curve and monitored loads and exceedances.

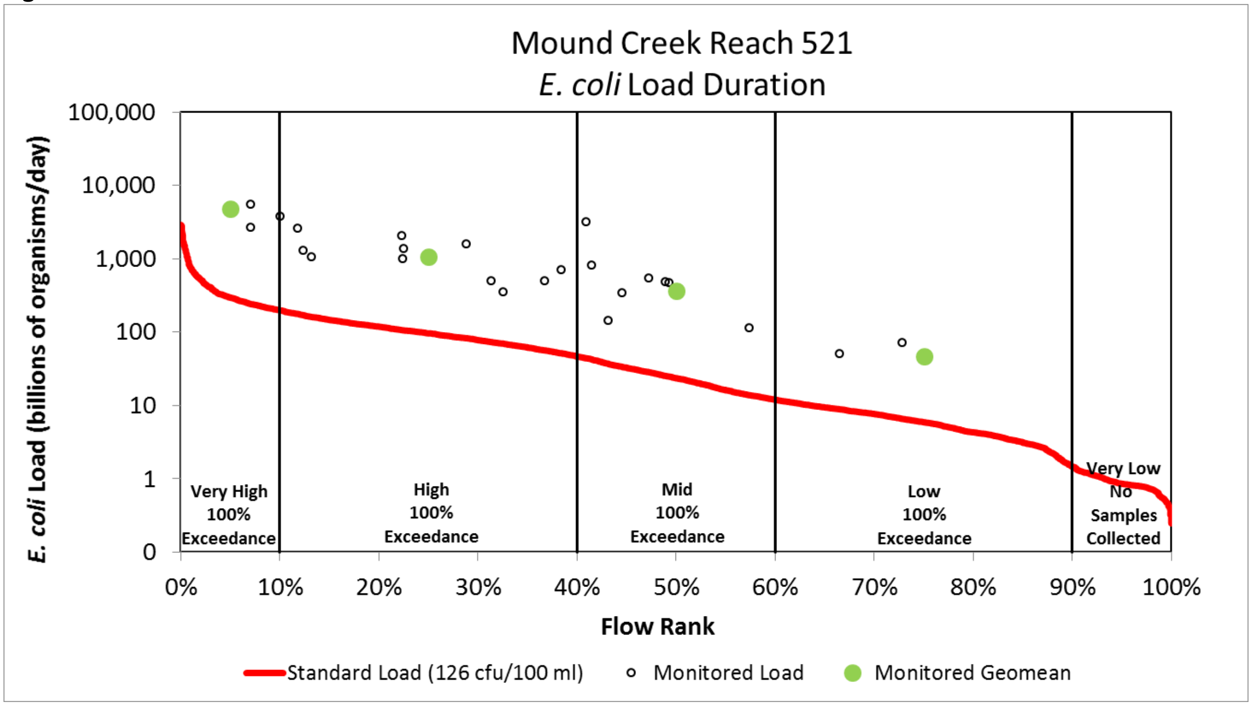


Table B-15. *E. coli* TMDL summary for Mound Creek Reach 521.

E. coli		Flow zones*				
		Very high	High	Mid-range	Low	Very low
Sources		*E. coli* load (billions of orgs/day)				
Load	Total LA	433	142	35	9	1
	MOS	23	7	2	0.5	0.1
	Total load	456	149	37	10	1
	Existing Concentration, Apr-Oct (org/100 mL)**	1,553				
	Maximum Monthly Geometric Mean (org/100mL)**	1,709				
	Overall Estimated Percent Reduction**	93%				

* Model simulated flow for HSPF reach 311 from April-October (2008-2017) was used to develop the flow zones and LCs for this reach.

** Water quality monitoring station(s) used to estimate reductions: S005-690.

Figure B-16. Pell Creek Reach 523 *E. coli* load duration curve and monitored loads and exceedances.

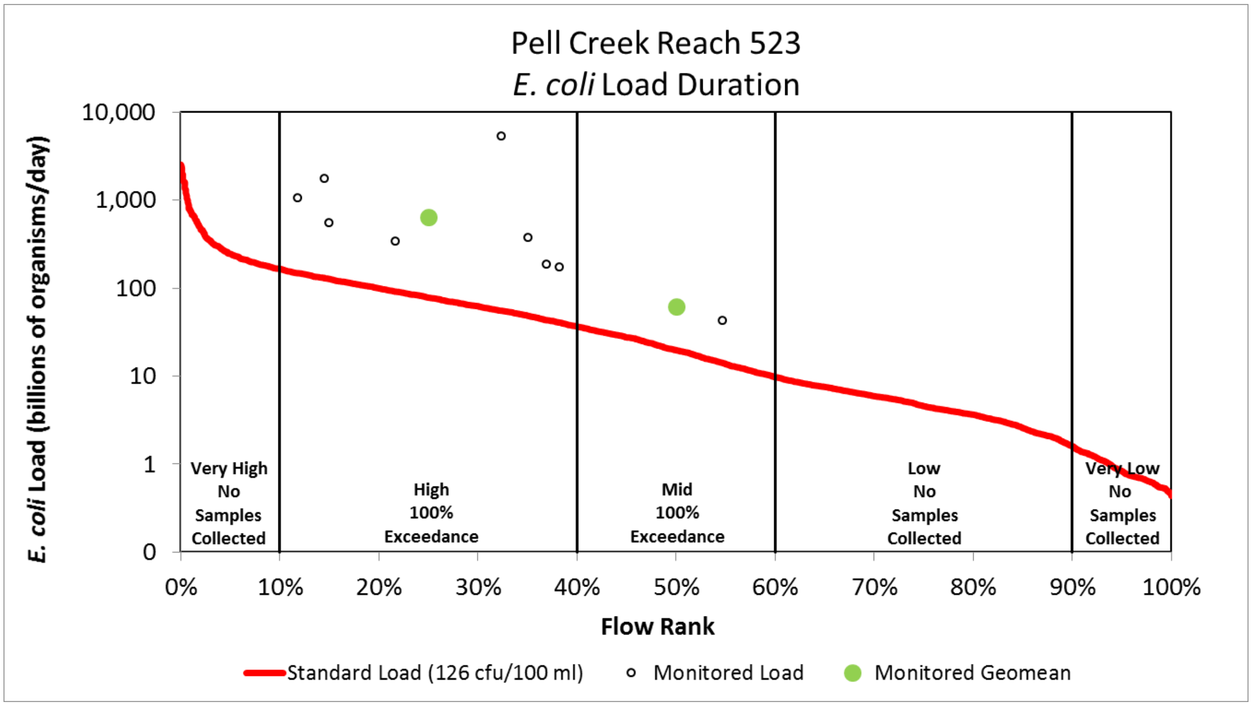


Table B-16. *E. coli* TMDL summary for Pell Creek Reach 523.

E. coli		Flow zones*				
		Very high	High	Mid-range	Low	Very low
Sources		*E. coli* load (billions of orgs/day)				
Wasteload	Walnut Grove WWTP	1	1	1	1	**
	Revere WWTP	0.7	0.7	0.7	0.7	**
	Total WLA	**2**	**2**	**2**	**2**	**
Load	**Total LA**	**358**	**113**	**27**	**5**	**
MOS		**19**	**6**	**2**	**0.4**	**0.1**
Total load		**379**	**121**	**31**	**7**	**1**
Existing Concentration, Apr-Oct (org/100 mL)* **		**937**				
Maximum Monthly Geometric Mean (org/100mL)* **		**2,005**				
Overall Estimated Percent Reduction* **		**94%**				

* Model simulated flow for HSPF reach 215 from April-October (2008-2017) was used to develop the flow zones and LCs for this reach.
** The permitted wastewater design flows exceed the stream flow in the indicated flow zone(s). The allocations are expressed as an equation rather than an absolute number: allocation = (flow contribution from a given source) x (126 org per 100 mL) x conversion factors.
*** Water quality monitoring station(s) used to estimate reductions: S009-444.

Figure B-17. Coal Mine Creek Reach 604 *E. coli* load duration curve and monitored loads and exceedances.

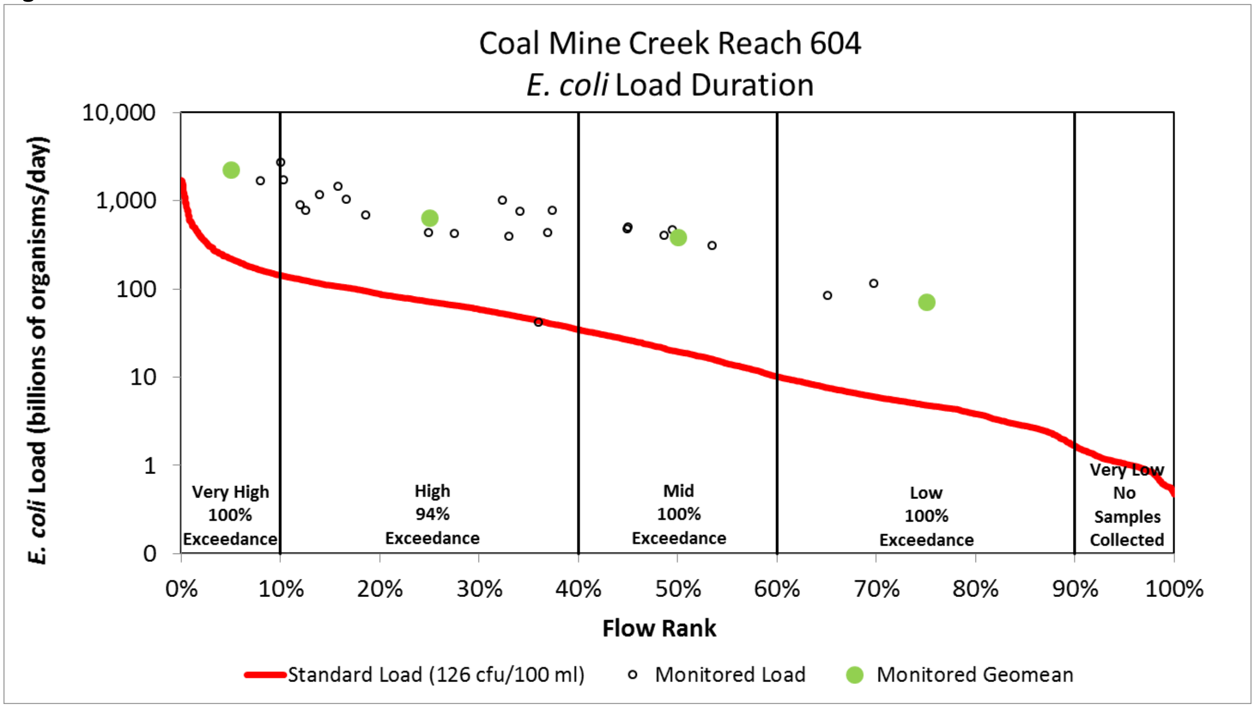


Table B-17. *E. coli* TMDL summary for Coal Mine Creek Reach 604.

E. coli		Flow zones*: Very high	High	Mid-range	Low	Very low
Sources		*E. coli* load (billions of orgs/day)				
Load	Total LA	321	105	29	7	2
	MOS	17	6	2	0.4	0.1
	Total load	338	111	31	7	2
	Existing Concentration, Apr-Oct (org/100 mL)**	1,401				
	Maximum Monthly Geometric Mean (org/100mL)**	1,740				
	Overall Estimated Percent Reduction**	93%				

* Model simulated flow for HSPF reach 335 from April-October (2008-2017) was used to develop the flow zones and LCs for this reach.

** Water quality monitoring station(s) used to estimate reductions: S005-691 and S009-439.

Figure B-18. Judicial Ditch 30 Reach 609 *E. coli* load duration curve and monitored loads and exceedances.

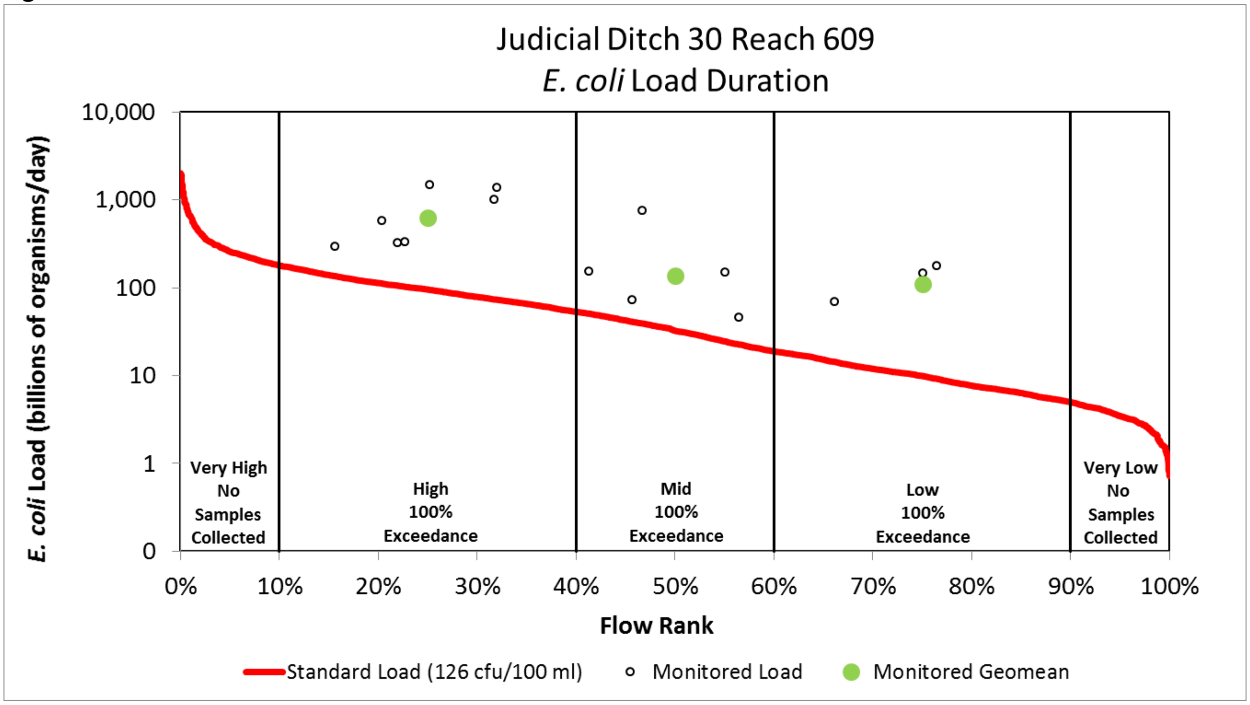


Table B-18. *E. coli* TMDL summary for Judicial Ditch 30 Reach 609.

E. coli		Flow zones*				
		Very high	High	Mid-range	Low	Very low
Sources		*E. coli* load (billions of orgs/day)				
Load	Total LA	378	140	48	15	5
MOS		20	7	3	0.8	0.3
Total load		398	147	51	16	5
Existing Concentration, Apr-Oct (org/100 mL)**		787				
Maximum Monthly Geometric Mean (org/100mL)**		2,064				
Overall Estimated Percent Reduction**		94%				

* Model simulated flow for HSPF reach 435 from April-October (2008-2017) was used to develop the flow zones and LCs for this reach.

** Water quality monitoring station(s) used to estimate reductions: S005-688.

Table B-19. Rock Lake (42-0052-00) phosphorus TMDL.

Phosphorus Sources		Existing TP load*		Allowable TP load		Estimated load reduction	
		lbs/year	lbs/day	lbs/year	lbs/day	lbs/year**	%
Wasteload	Construction/Industrial SW	3	0.01	3	0.01	0	0%
	Total WLA	**3**	**0.01**	**3**	**0.01**	**0**	**0%**
Load	Watershed runoff	1,699	4.65	841	2.30	858	50%
	SSTS	15	0.04	9	0.03	6	39%
	Atmospheric deposition	91	0.25	91	0.25	0	0%
	Internal load	3,722	10.19	496	1.36	3,226	87%
	Total LA	**5,527**	**15.13**	**1,437**	**3.94**	**4,090**	**74%**
MOS				**160**	**0.44**		
Total load		**5,530**	**15.14**	**1,600**	**4.39**	**4,090**	**71%**

* Model calibration year(s): 2002, 2007 & 2017.
** Net reduction from current load to TMDL is 3,930 lbs/yr; but the gross load reduction from all sources must accommodate the MOS as well, and hence is 3,930 + 160 = 4,090 lbs/yr.

Figure B-19. Rock Lake phosphorus source reductions to meet TMDL.

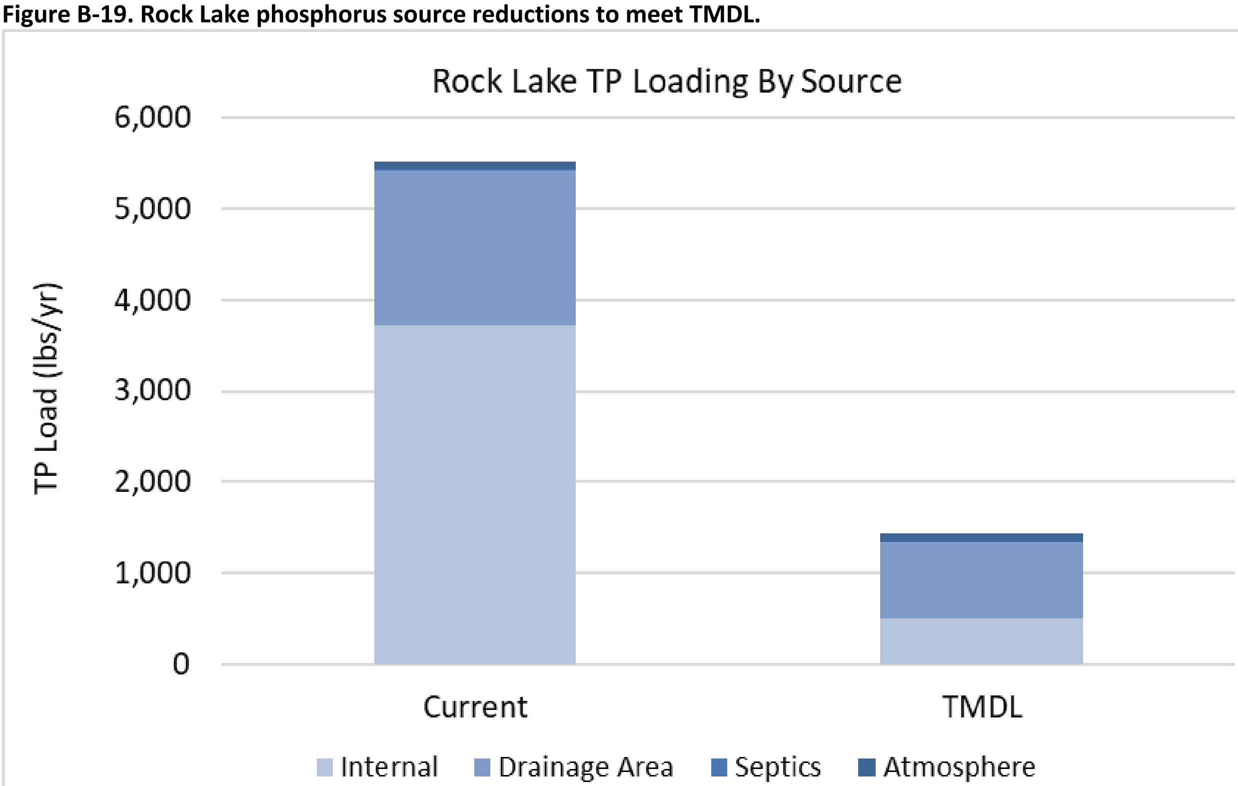


Table B-20. Bean Lake (08-0011-00) phosphorus TMDL.

Phosphorus		Existing TP load*		Allowable TP load		Estimated load reduction	
Sources		lbs/year	lbs/day	lbs/year	lbs/day	lbs/year**	%
Wasteload	Construction/Industrial SW	0.5	0.001	0.5	0.001	0.0	0%
	Total WLA	**0.5**	**0.001**	**0.5**	**0.001**	**0.0**	**0%**
Load	Watershed runoff	326.0	0.893	211.6	0.579	114.4	35%
	SSTS	2.5	0.007	1.2	0.003	1.3	54%
	Atmospheric deposition	39.2	0.107	39.2	0.107	0.0	0%
	Internal load	1,191.8	3.263	591.2	1.619	600.6	50%
	Total LA	**1,559.5**	**4.270**	**843.2**	**2.308**	**716.3**	**46%**
MOS				**93.7**	**0.257**		
Total load		**1,560.0**	**4.271**	**937.4**	**2.566**	**716.3**	**40%**

* Model calibration year(s): 2007, 2008 & 2017.

** Net reduction from current load to TMDL is 622.6 lbs/yr; but the gross load reduction from all sources must accommodate the MOS as well, and hence is 622.6 + 93.7 = 716.3 lbs/yr.

Figure B-20. Bean Lake phosphorus source reductions to meet TMDL.

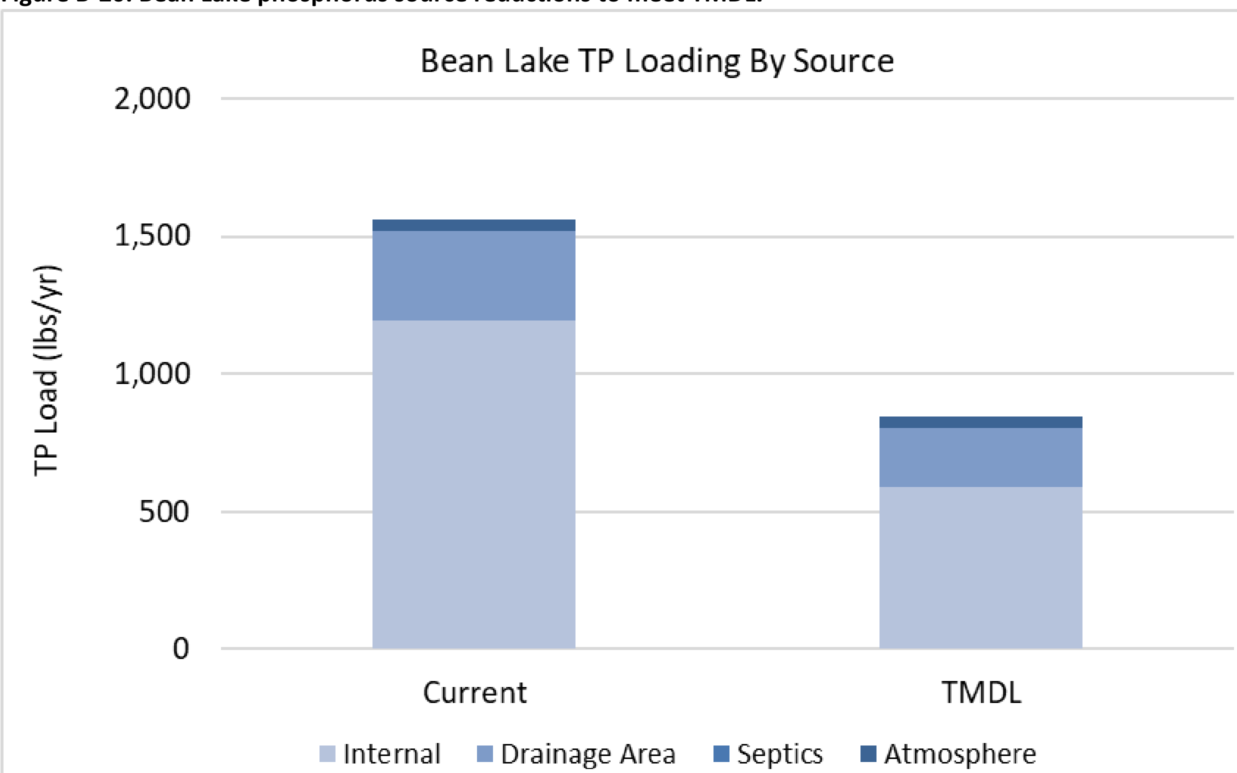


Table B-21. Double (North Portion) Lake (17-0056-01) phosphorus TMDL.

Phosphorus Sources		Existing TP load*		Allowable TP load		Estimated load reduction	
		lbs/year	lbs/day	lbs/year	lbs/day	lbs/year**	%
Wasteload	Construction/Industrial SW	0.5	0.001	0.5	0.001	0.0	0%
	Total WLA	**0.5**	**0.001**	**0.5**	**0.001**	**0.0**	**0%**
Load	Watershed runoff	365.2	1.000	103.8	0.284	261.4	72%
	SSTS	10.9	0.030	5.2	0.014	5.7	52%
	Upstream lake (Bean)	145.8	0.399	97.8	0.268	48.0	33%
	Atmospheric deposition	32.5	0.089	32.5	0.089	0.0	0%
	Internal load	468.2	1.282	329.0	0.901	139.2	30%
	Total LA	**1,022.6**	**2.800**	**568.3**	**1.556**	**454.3**	**44%**
MOS				**63.2**	**0.173**		
Total load		**1,023.1**	**2.801**	**632.0**	**1.730**	**454.3**	**38%**

* Model calibration year(s): 2007, 2008, 2017 and 2018.
** Net reduction from current load to TMDL is 391.1 lbs/yr; but the gross load reduction from all sources must accommodate the MOS as well, and hence is 391.1 + 63.2 = 454.3 lbs/yr.

Figure B-21. Double (North Portion) Lake phosphorus source reductions to meet TMDL.

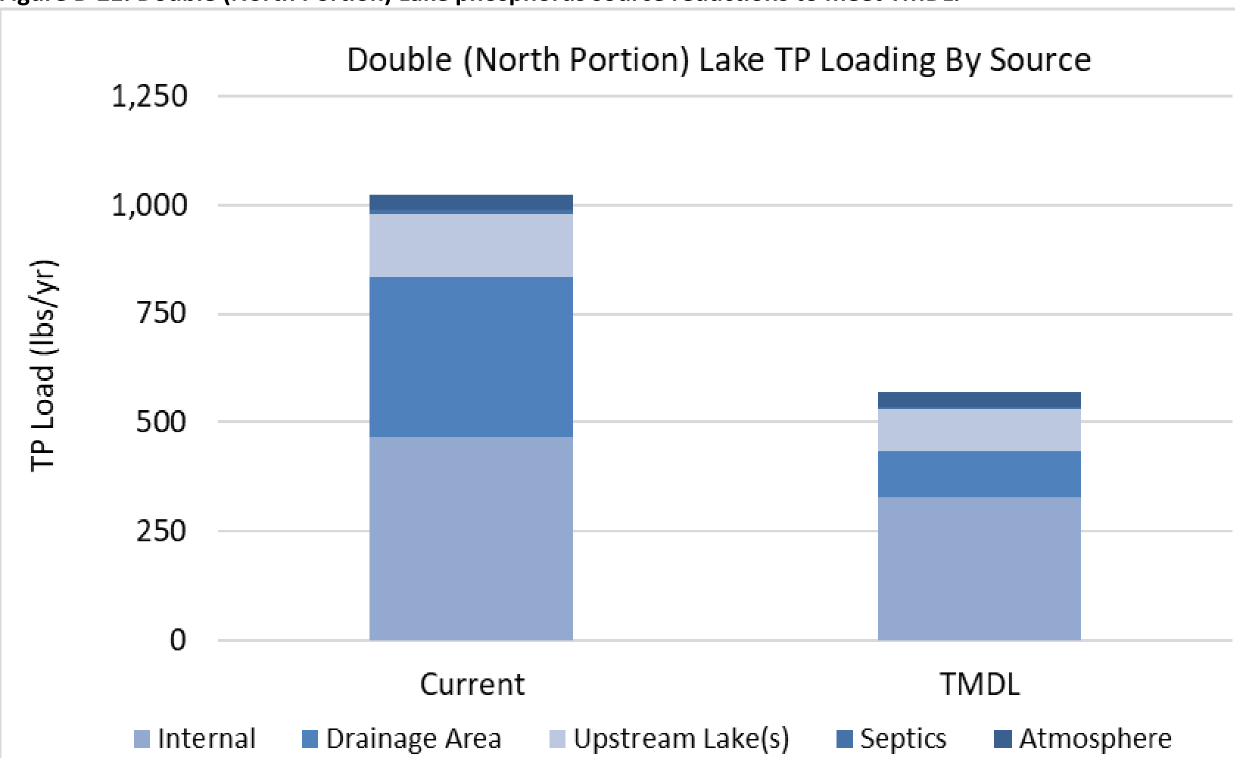


Table B-22. Clear Lake (08-0011-00) phosphorus TMDL.

Phosphorus Sources		Existing TP load*		Allowable TP load		Estimated load reduction	
		lbs/year	lbs/day	lbs/year	lbs/day	lbs/year**	%
Wasteload	Construction/Industrial SW	1.6	0.004	1.6	0.004	0.0	0%
	Total WLA	**1.6**	**0.004**	**1.6**	**0.004**	**0.0**	**0%**
Load	Watershed Runoff	1,055.8	2.891	605.3	1.657	450.5	43%
	SSTS	16.3	0.045	7.6	0.021	8.7	53%
	Atmospheric deposition	66.2	0.181	66.2	0.181	0.0	0%
	Internal load	1,289.0	3.529	344.6	0.943	944.4	73%
	Total LA	**2,427.3**	**6.646**	**1,023.7**	**2.802**	**1,403.6**	**58%**
MOS				**113.9**	**0.312**		
Total load		**2,428.9**	**6.650**	**1,139.2**	**3.118**	**1,403.6**	**53%**

* Model calibration year(s): 2009, 2010 and 2017.
** Net reduction from current load to TMDL is 1,289.7 lbs/yr; but the gross load reduction from all sources must accommodate the MOS as well, and hence is 1,289.7 + 113.9 = 1,403.6 lbs/yr.

Figure B-22. Clear Lake phosphorus source reductions to meet TMDL.

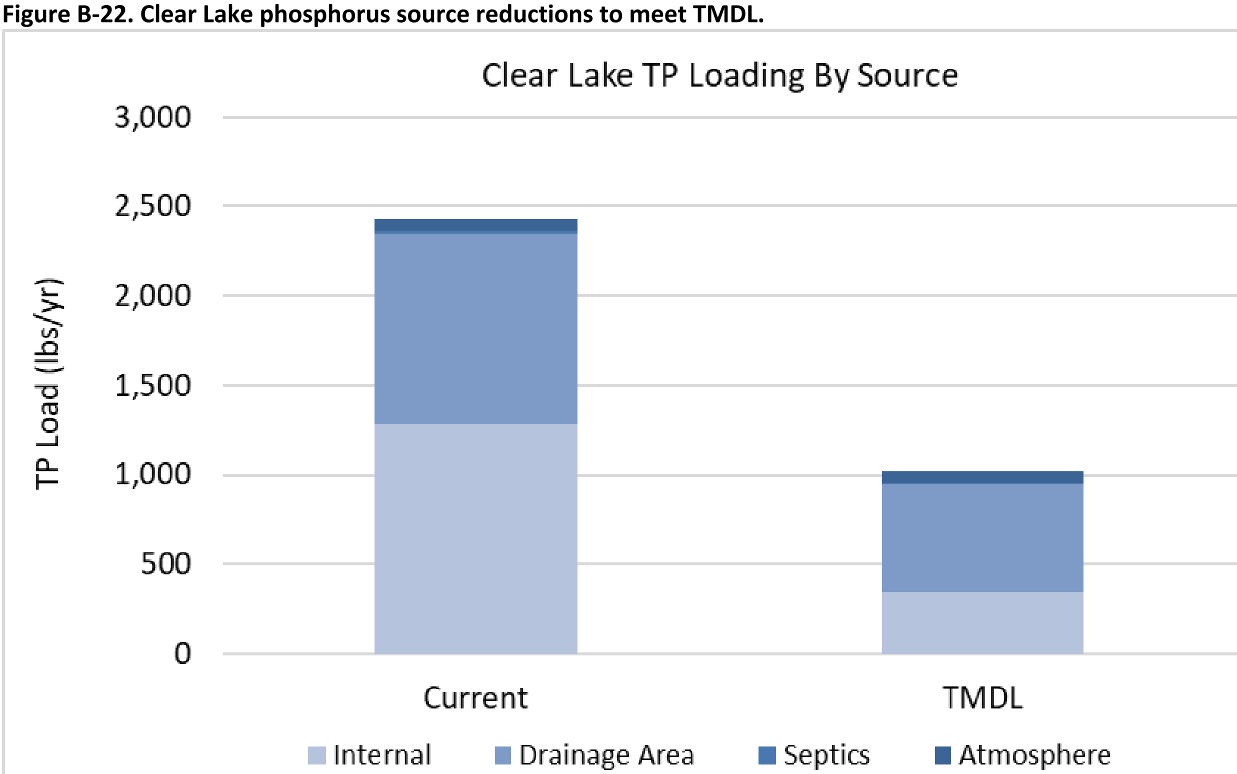


Table B-23. Altermatt Lake (08-0054-00) phosphorus TMDL.

Phosphorus Sources		Existing TP load*		Allowable TP load		Estimated load reduction	
		lbs/year	lbs/day	lbs/year	lbs/day	lbs/year**	%
Wasteload	Construction/Industrial SW	1	0.004	1	0.004	0	0%
	Total WLA	**1**	**0.004**	**1**	**0.004**	**0**	**0%**
Load	Watershed runoff	978	2.679	374	1.025	604	62%
	SSTS	9	0.026	4	0.012	5	54%
	Atmospheric deposition	29	0.080	29	0.080	0	0%
	Internal load	3,169	8.677	50	0.136	3,119	98%
	Total LA	**4,185**	**11.462**	**457**	**1.253**	**3,728**	**89%**
MOS				**51**	**0.140**		
Total load		**4,186**	**11.466**	**509**	**1.397**	**3,728**	**88%**

* Model calibration year(s): 2009 and 2010.

** Net reduction from current load to TMDL is 3,677 lbs/yr; but the gross load reduction from all sources must accommodate the MOS as well, and hence is 3,677 + 51 = 3,728 lbs/yr.

Figure B-23. Altermatt Lake phosphorus source reductions to meet TMDL.

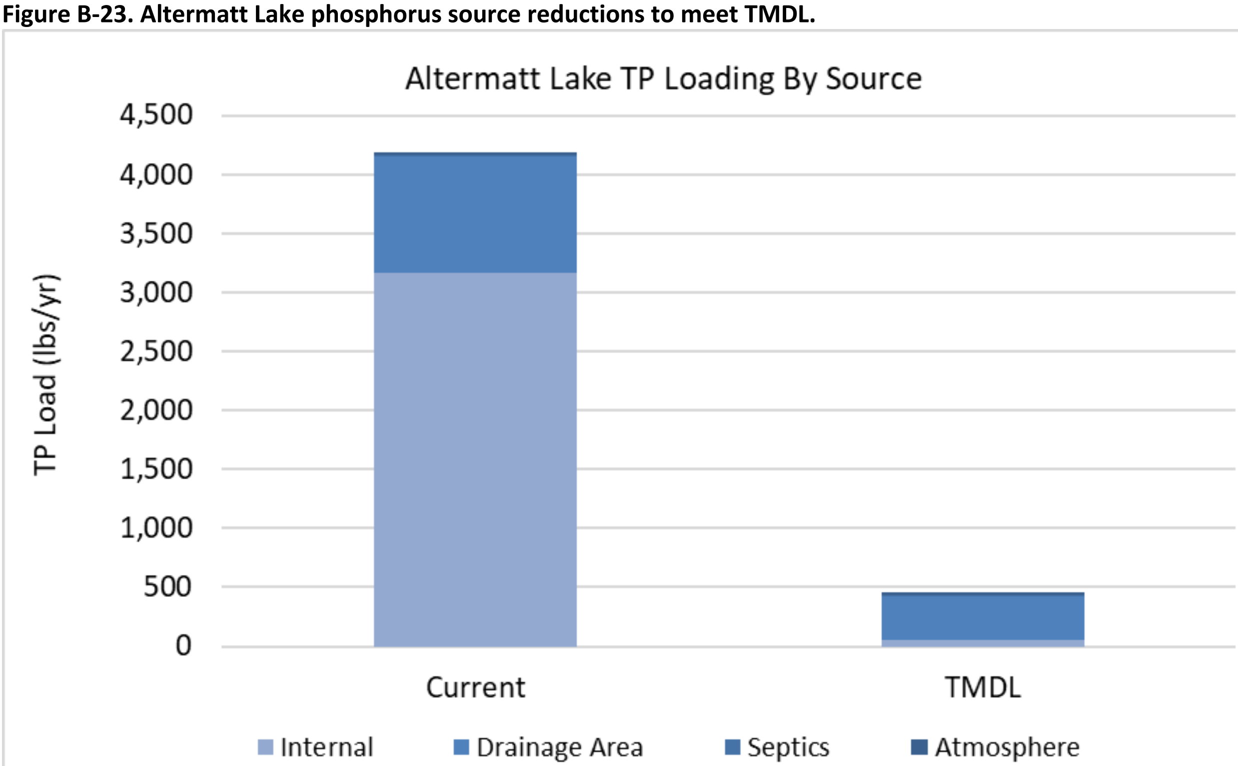


Table B-24. Boise Lake (08-0096-00) phosphorus TMDL.

Phosphorus Sources		Existing TP load*		Allowable TP load		Estimated load reduction	
		lbs/year	lbs/day	lbs/year	lbs/day	lbs/year**	%
Wasteload	Construction/Industrial SW	1	0.003	1	0.003	0	0%
	Total WLA	**1**	**0.003**	**1**	**0.003**	**0**	**0%**
Load	Watershed runoff	804	2.202	258	0.706	546	68%
	SSTS	8	0.023	4	0.010	4	50%
	Atmospheric deposition	42	0.114	42	0.114	0	0%
	Internal load	1,333	3.649	96	0.264	1,237	93%
	Total LA	**2,187**	**5.988**	**400**	**1.094**	**1,787**	**82%**
MOS				**44**	**0.122**		
Total load		**2,188**	**5.991**	**445**	**1.219**	**1,787**	**80%**

* Model calibration year(s): 2011 and 2012.

** Net reduction from current load to TMDL is 1,743 lbs/yr; but the gross load reduction from all sources must accommodate the MOS as well, and hence is 1,743 + 44 = 1,787 lbs/yr.

Figure B-24. Boise Lake phosphorus source reductions to meet TMDL.

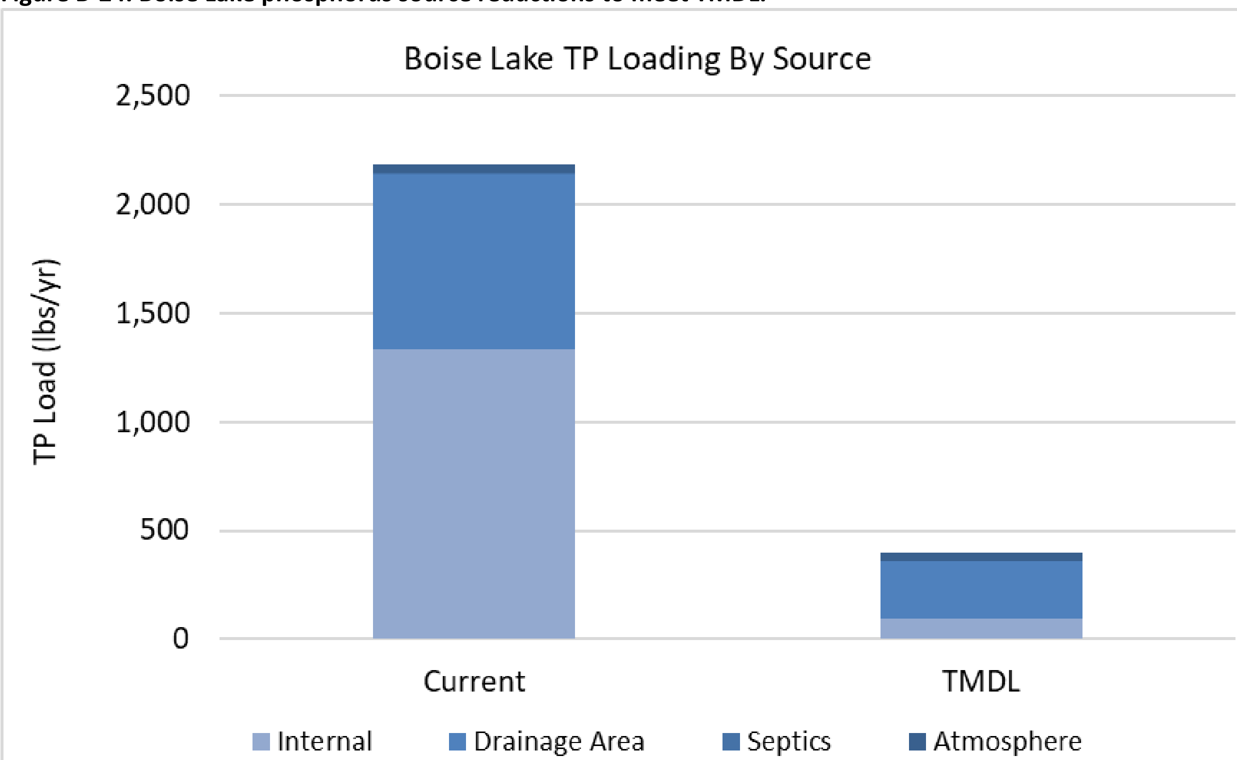
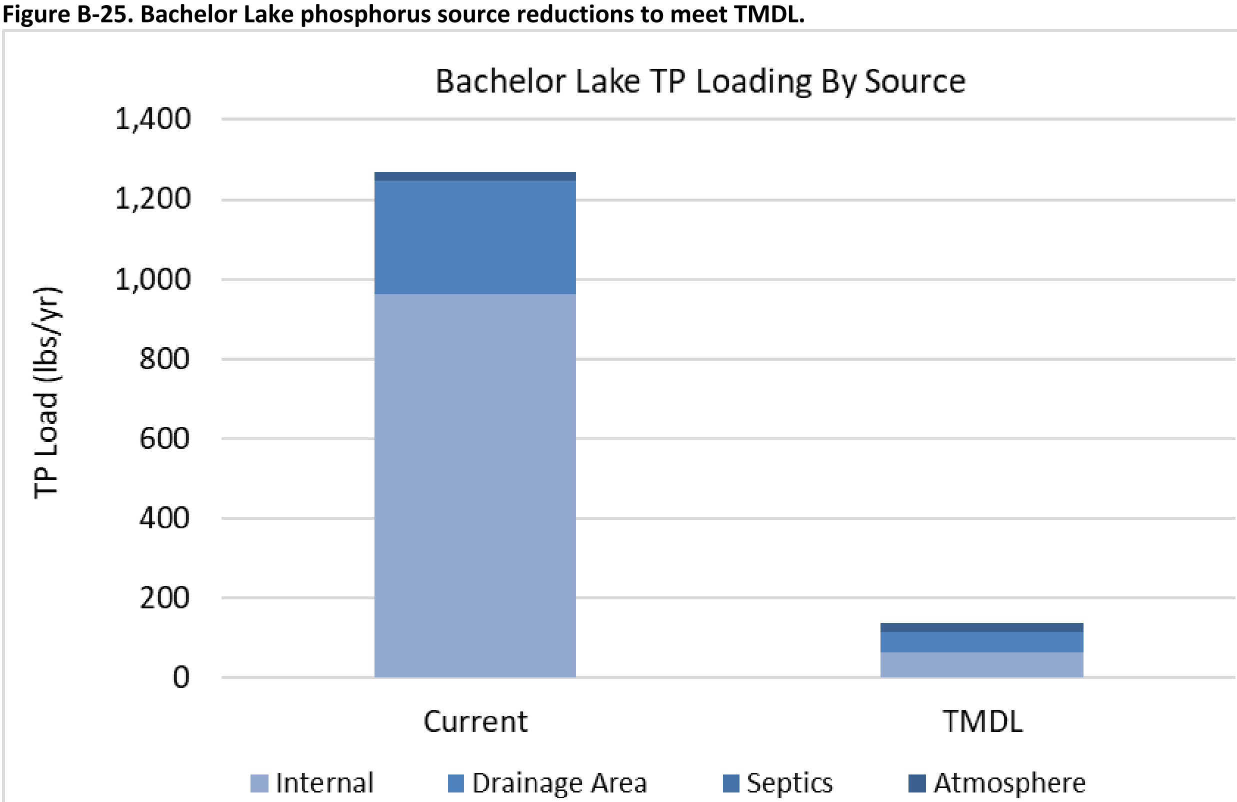


Table B-25. Bachelor Lake (08-0029-00) phosphorus TMDL.

Phosphorus Sources		Existing TP load*		Allowable TP load		Estimated load reduction	
		lbs/year	lbs/day	lbs/year	lbs/day	lbs/year**	%
Wasteload	Construction/Industrial SW	0.4	0.001	0.4	0.001	0.0	0%
	Total WLA	**0.4**	**0.001**	**0.4**	**0.001**	**0.0**	**0%**
Load	Watershed runoff	282.2	0.773	50.5	0.138	231.7	82%
	SSTS	0.6	0.002	0.4	0.001	0.2	33%
	Atmospheric deposition	23.3	0.064	23.3	0.064	0.0	0%
	Internal load	962.8	2.636	63.6	0.174	899.2	93%
	Total LA	**1,268.9**	**3.475**	**137.8**	**0.377**	**1,131.1**	**89%**
MOS				**15.4**	**0.042**		
Total load		**1,269.3**	**3.476**	**153.6**	**0.420**	**1,131.1**	**88%**

* Model calibration year(s): 2011 and 2012.
** Net reduction from current load to TMDL is 1,115.7 lbs/yr; but the gross load reduction from all sources must accommodate the MOS as well, and hence is 1,115.7 + 15.4 = 1,131.1 lbs/yr.

Figure B-25. Bachelor Lake phosphorus source reductions to meet TMDL.



Appendix C: Precipitation Data

Figure C-1. Monthly precipitation at the Lamberton Southwest Research and Outreach Center.

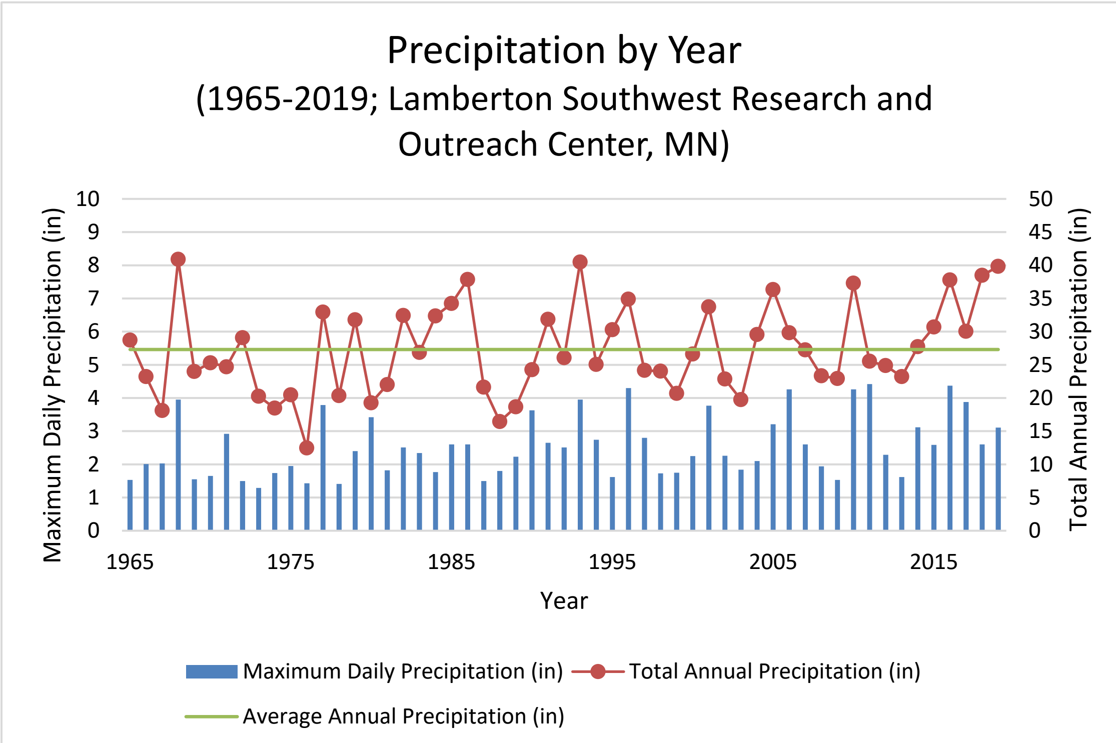


Figure C-2. 24-hour rain events at the Lamberton Southwest Research and Outreach Center.

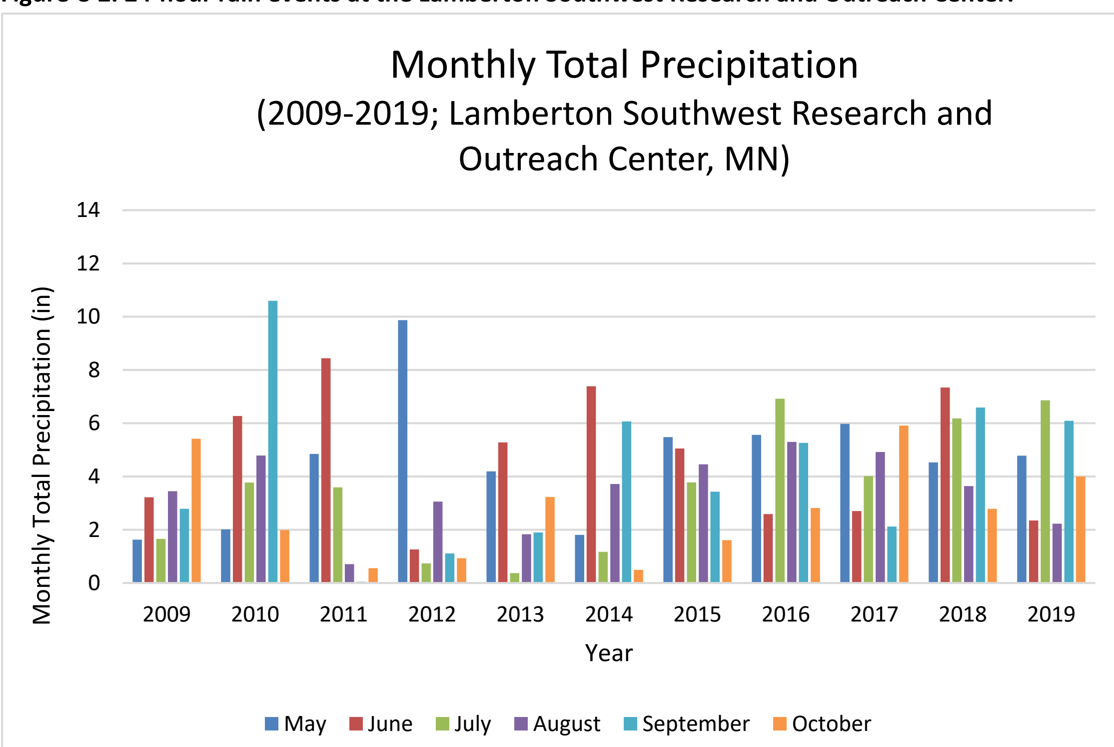


Figure C-3. Annual precipitation at the Marshall station (USC00215204).

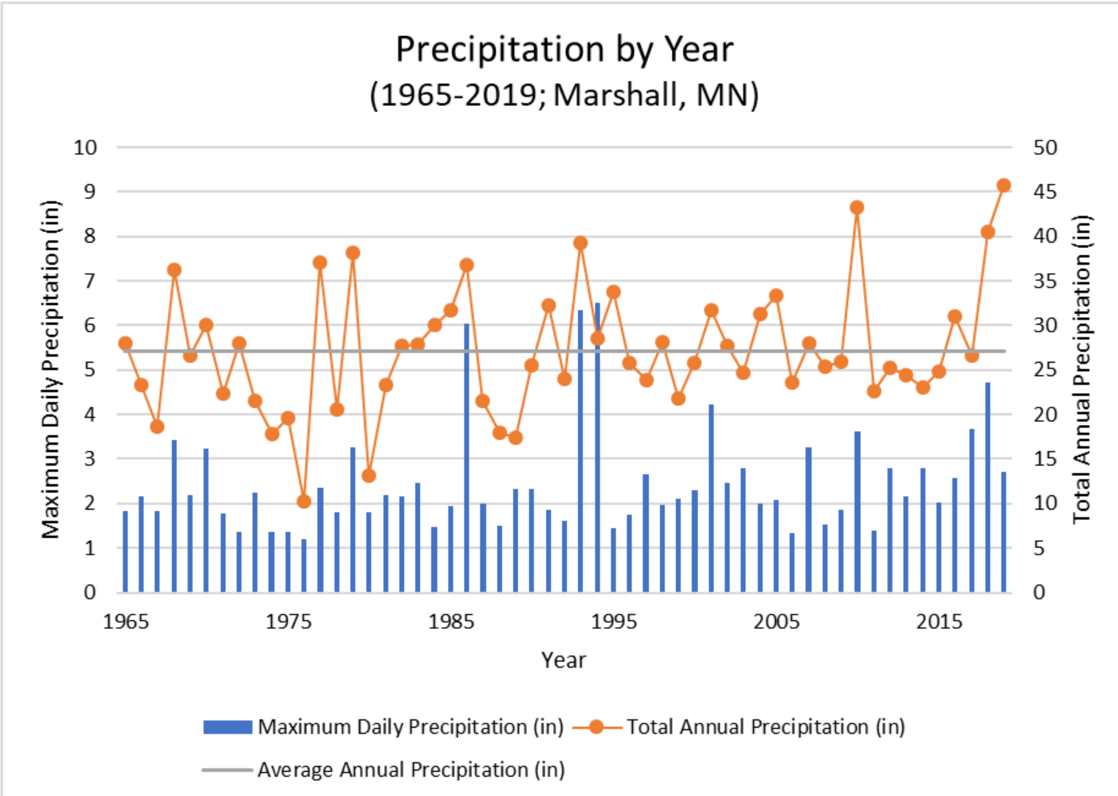


Figure C-4. Monthly precipitation at the Marshall station (USC00215204).

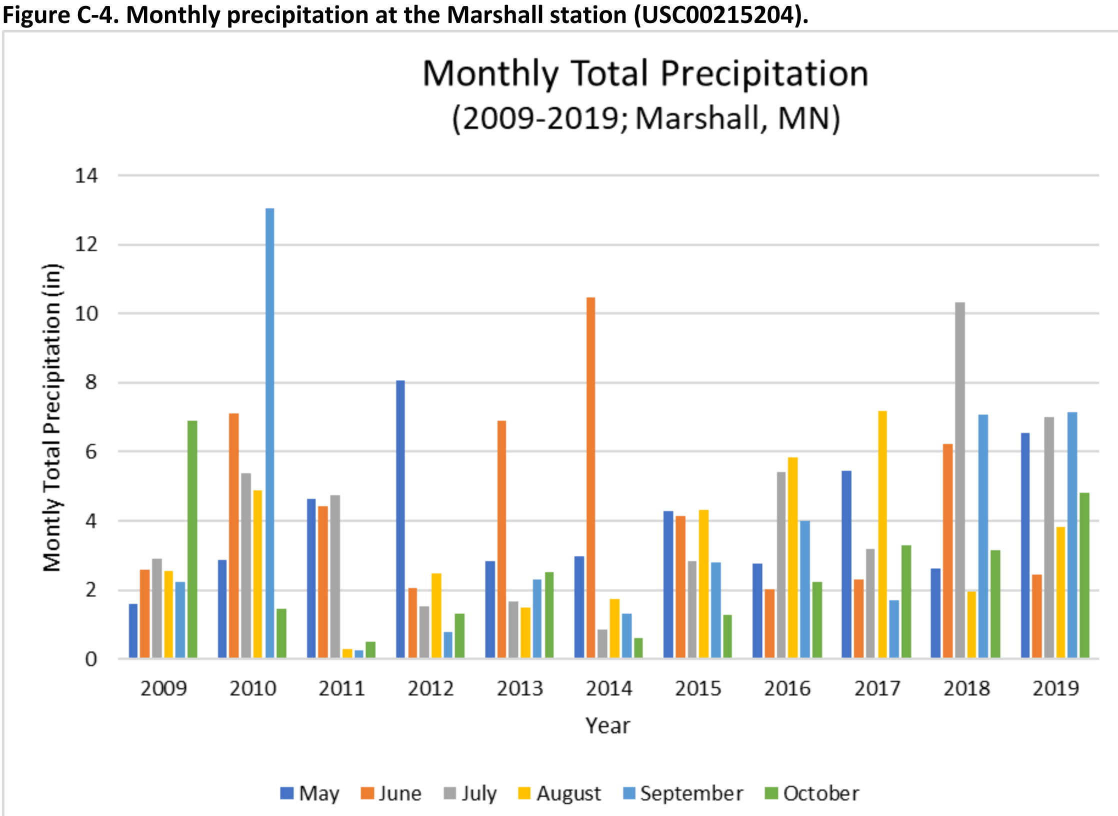


Figure C-5. Monthly precipitation at the Minneota station (USC00215482).

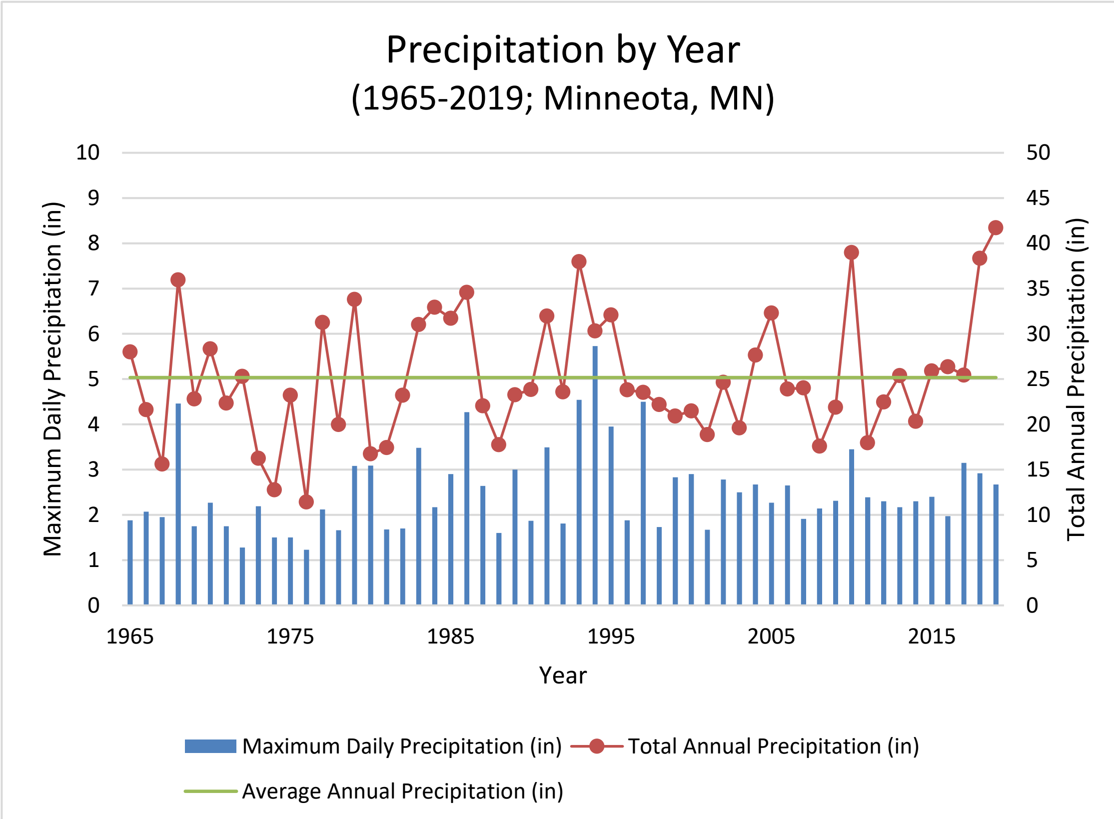


Figure C-6. Monthly precipitation at the Minneota station (USC00215482).

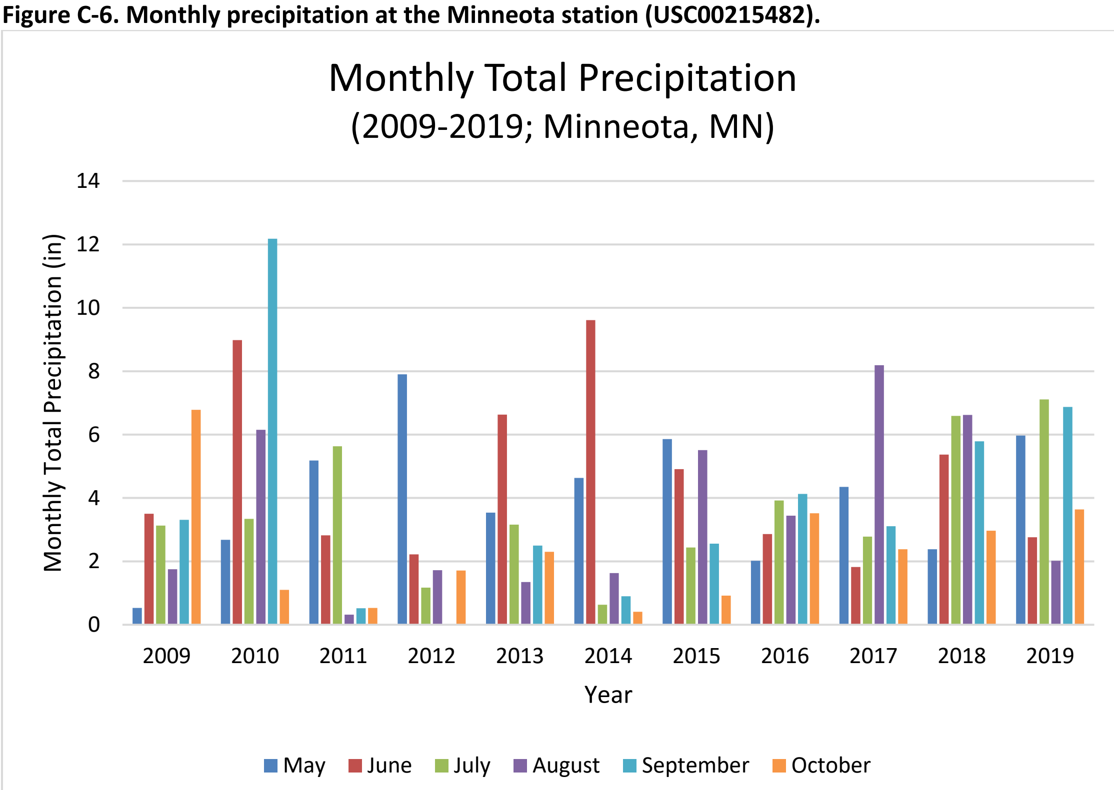


Figure C-7. Yearly precipitation at the Redwood Falls Municipal Airport station (USW00014992).

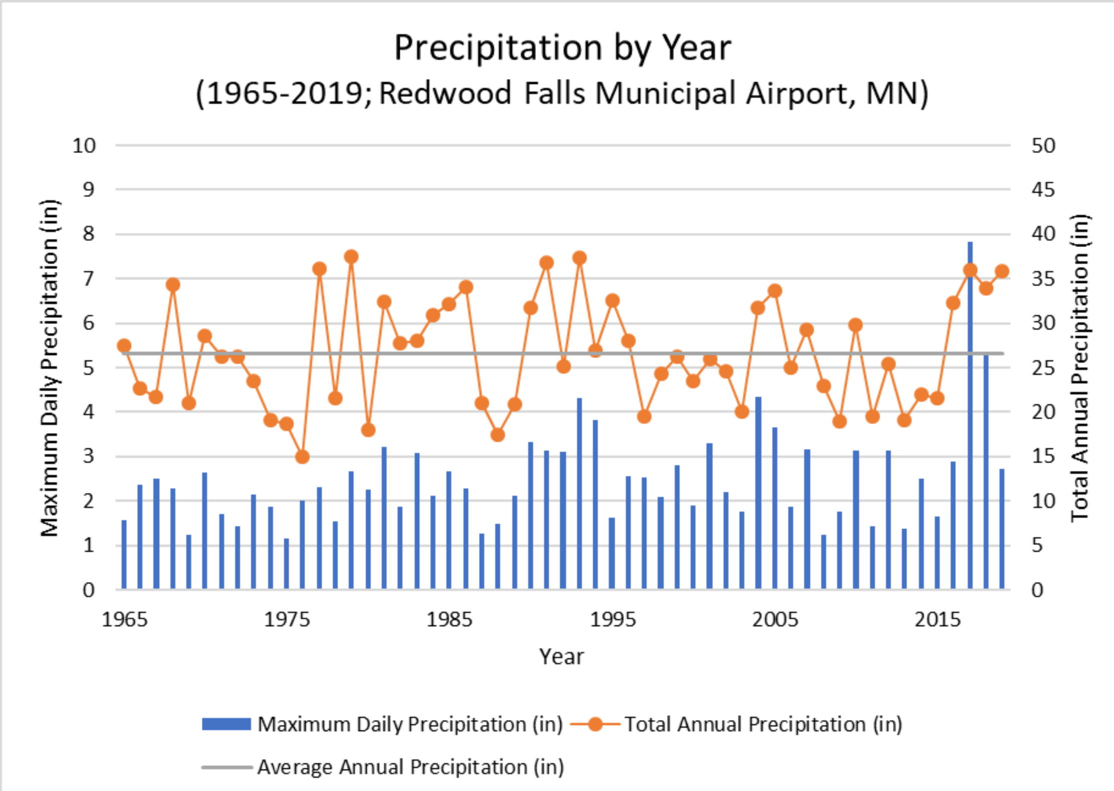


Figure C-8. Monthly precipitation at the Redwood Falls Municipal Airport station (USW00014992).

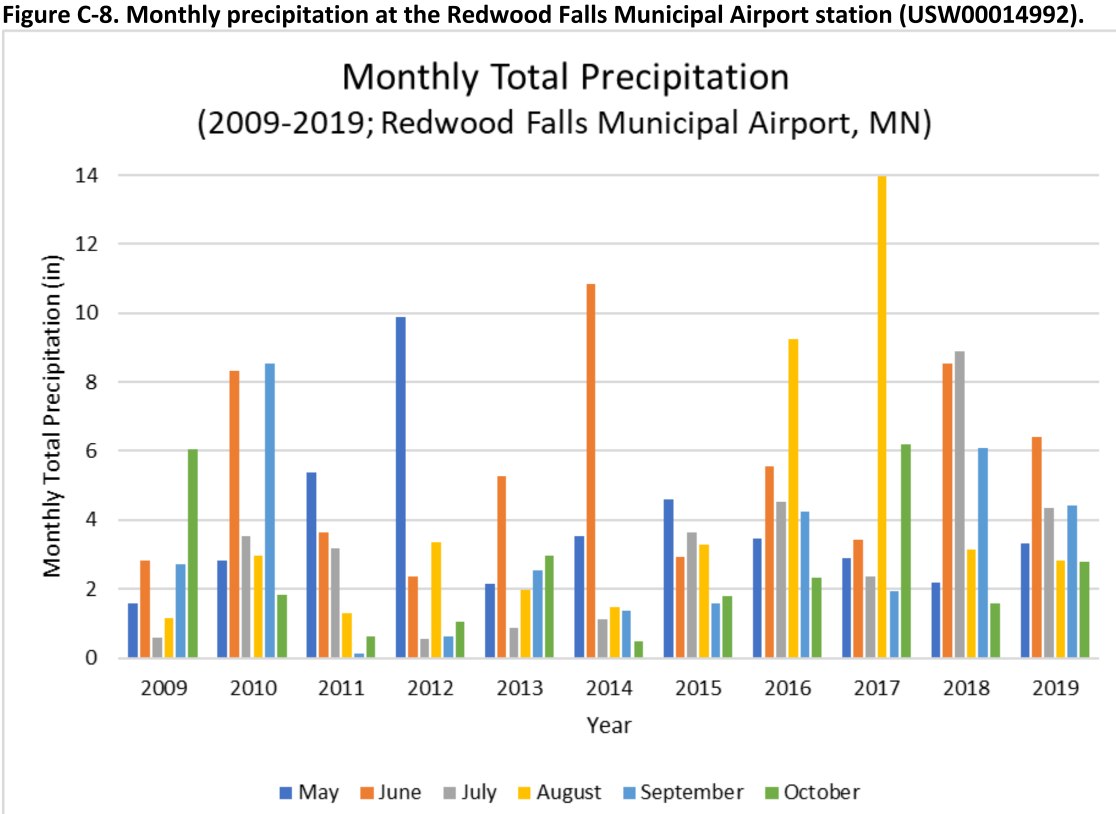


Figure C-9. Yearly precipitation at the Tracy station (USC00218323).

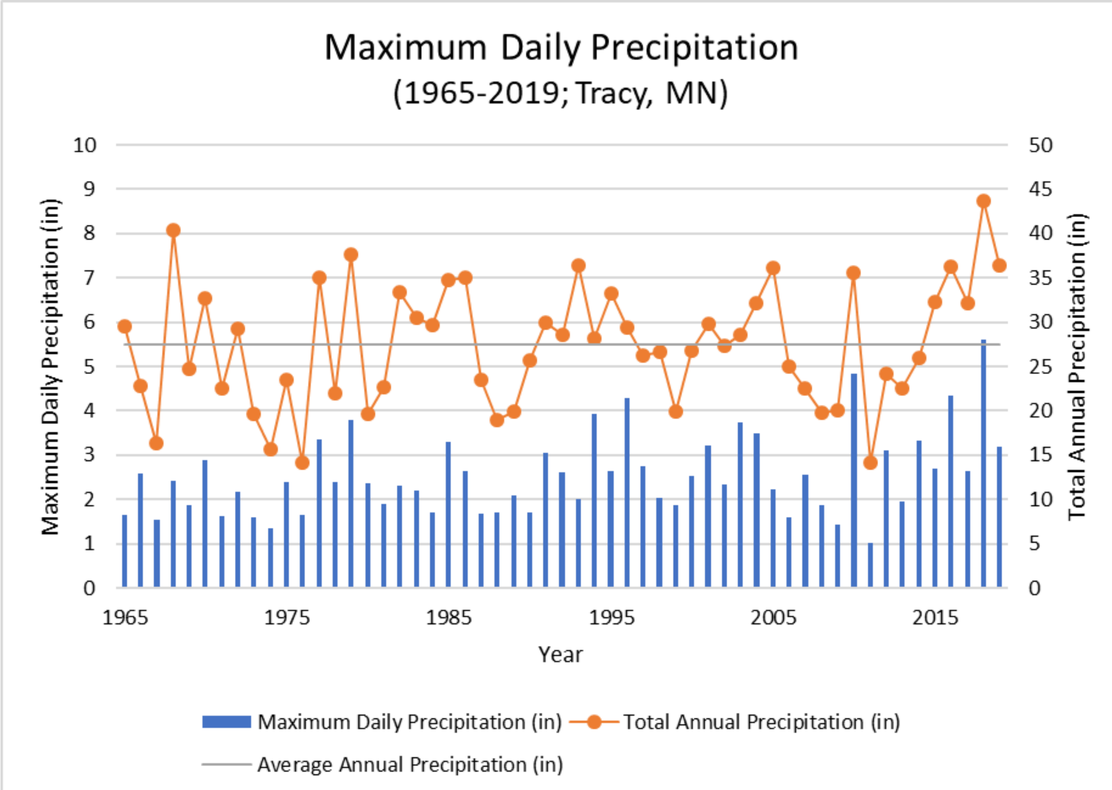


Figure C-10. Monthly precipitation at the Tracy station (USC00218323).

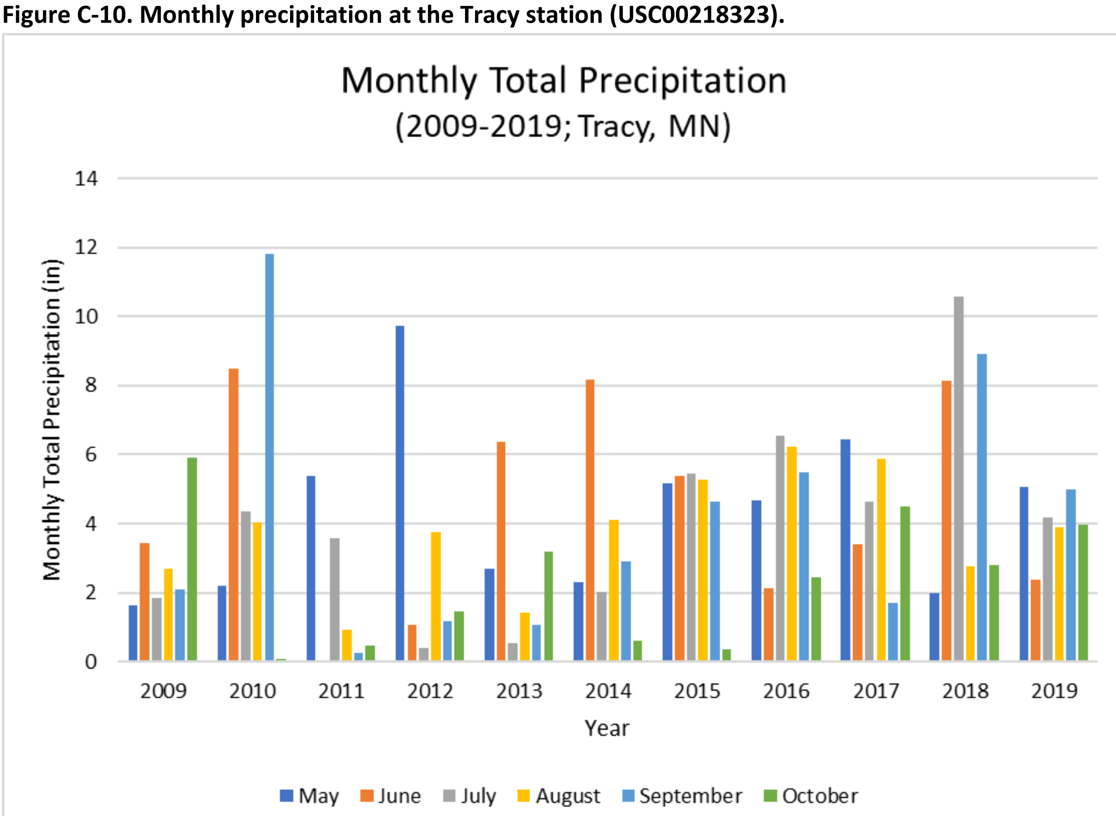
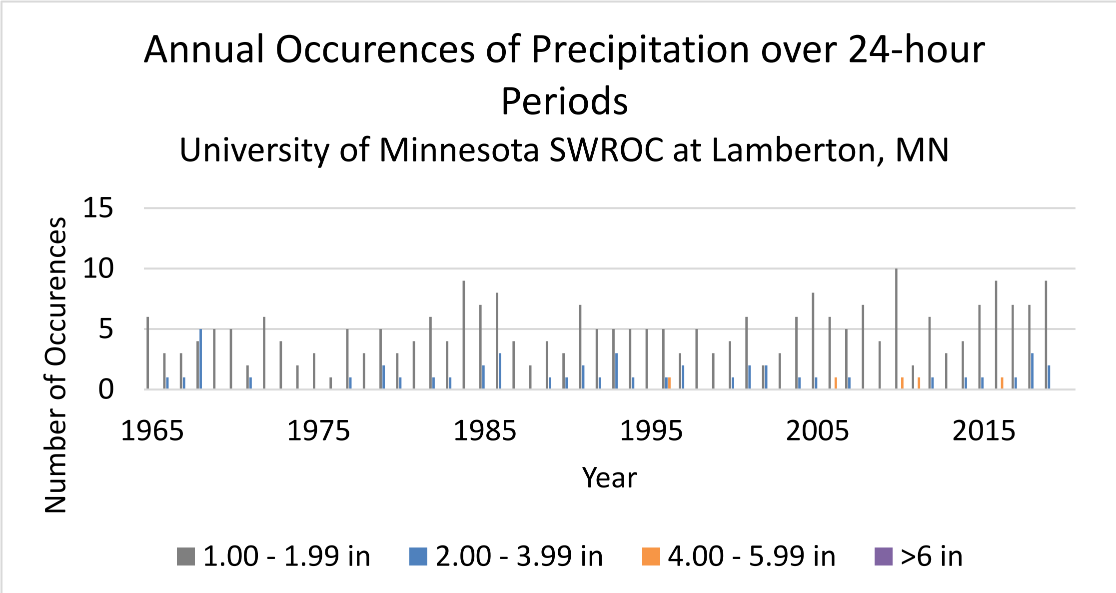


Figure C-11. 24-hour rain events at the University of Minnesota Southwest Research and Outreach Center (SWROC) at Lamberton, MN.



Appendix D: Subwatershed Summaries – description and example

As described in Section 3.1, the purpose of the WRAPS subwatershed analyses was to provide a tool and framework to help local stakeholders and resource managers evaluate and compare the subwatersheds throughout the Cottonwood River Watershed. During the WRAPS process, a tabular database was constructed that included descriptive watershed statistics and other information for each HUC-12 subwatershed. The final product of the analysis was a two-page summary for each HUC-12 subwatershed that consists of an overview map (page one) and a descriptive summary (page two) of the subwatershed. The two-page summaries cand be reviewed on the RCRCA web page, or the MPCA's Cottonwood River Watershed webpage. The Plum Creek HUC-12 is included below as an example of the subwatershed summaries.

Overview Map

The overview map is intended to provide a closer, detailed look at the subwatershed. The map shows the location of the subwatershed within the greater Cottonwood River Watershed, the upstream contributing subwatersheds, elevation change of the subwatershed, as well as water bodies, WMAs, impairments, and townships within the subwatershed.

Descriptive Summary

The subwatershed descriptive summary (page two) contains a column for quick facts about the subwatershed including watershed area, contributing/upstream HUC-12 watersheds and their areas, elevation change within the HUC-12, and known longitudinal barriers identified in the DNR's Watershed Characterization Report. The descriptive summary also contains a list of the watershed impairments, reductions needed to meet TMDLs, and general strategies for addressing the impairments. Finally, four small maps from the DNR's WHAF were included to highlight health scores for key watershed pollutant sources/stressors which can be compared to other subwatersheds throughout the Cottonwood River Watershed. Regardless of the variable, WHAF scores range from 0 to 100, with 0 representing the least healthy condition and 100 representing the healthiest condition. An overview of the WHAF tool and detailed information on how each watershed health score was calculated can be found online here. The four WHAF maps presented in the descriptive summaries are summarized below.

Altered Watercourse

The Altered Watercourse metric is the ratio of the length of altered watercourses in the catchment to the total length of watercourses. Data from the Altered Watercourse Project were used to classify all streams in the state to major classes of natural, altered, impounded, or no definable channel. The score ranges from 0 to 100 with low scores representing the worst condition of all streams being altered and high scores represent the best condition of all streams being natural. See here for more information on how the Altered Watercourse score was developed.

Livestock Animals

The Livestock Animals metric totals the number of AUs in registered feedlots within each catchment. The AU count is normalized for the watershed area to calculate an AU/acre. The score ranges from 0 to 100 with low scores indicating an AU/acre density of >0.75 and high scores indicating no registered feedlots within the catchment. See here for more information on how the Livestock Animals score was developed.

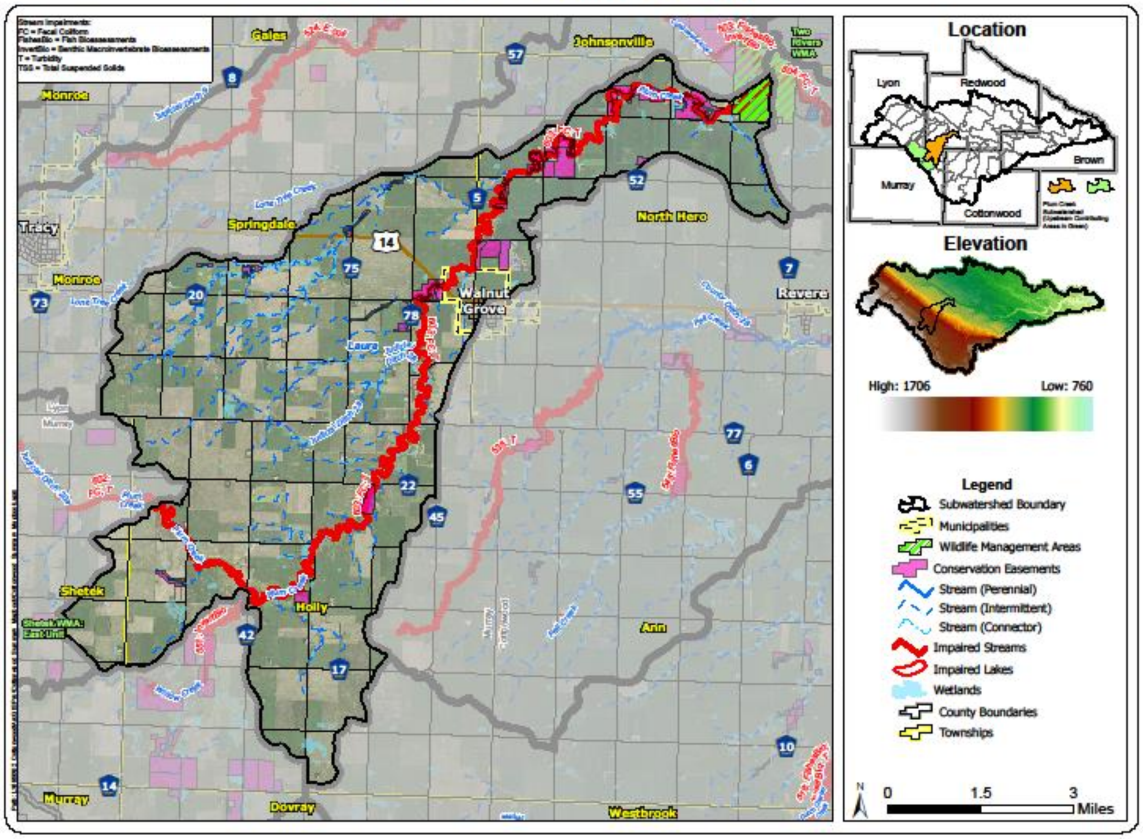
Steep Slopes Near Streams

Spatial data used to calculate the Steep Slopes Near Streams health score include the DNR Hydrography Streams with Strahler Stream Order, 30-meter buffer of streams with a Strahler Stream Order ≤3, and 100-meter buffer and 30-meter buffer or streams with Strahler Stream Order >3. Spatial data layers were used to identify areas of steep slopes found in close proximity to streams. The score ranges from 0-100 and ranks the risk that erosion from steep slopes will impact streams. A high density of steep slopes results in a low score, whereas a low density of steep slopes results in a high score. See here for more information about how the Steep Slopes Near Streams score was developed.

Wetland Loss

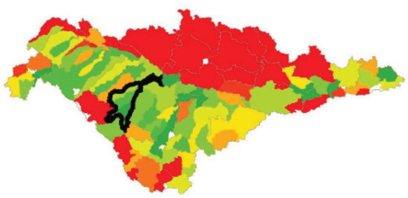
The Wetland Loss metric calculates the ratio of current water storage capacity to pre-settlement water storage capacity. Pre-settlement water storage was approximated using hydric soils information from county (SSURGO) and state (STATSGO) soil surveys. Current water storage was approximated using the National Wetland Inventory (NWI). The score ranges from 0-100, with low scores indicating a high proportion of land within the catchment has been converted out of water storage and high scores indicating a high proportion of land has been preserved as water storage area. See here for more information on how the Wetland Loss score was developed.

Plum Creek Subwatershed

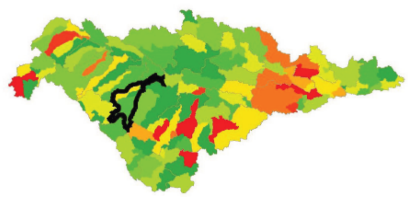


Plum Creek
HUC-12 ID 70200080303

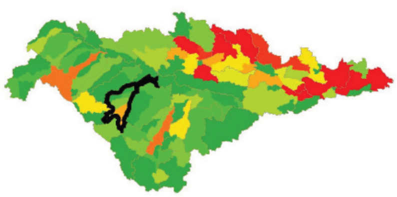
Altered Watercourses



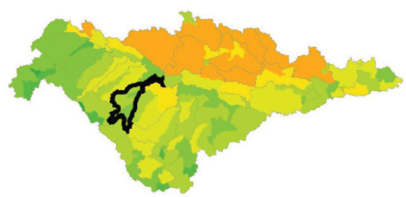
Livestock Animals



Slopes Near Streams



Wetland Loss



High Score Healthiest — **Low Score** Least Healthy

Strategies:
Primary pollutant addressed by strategy type noted in italics.

Soil Health *Sediment*	Implement cover crops, no-till, and/or low-till management techniques to improve soil health and increase water storage capacity of soils
Storage *Sediment*	Implement practices such as grassed waterways, wetland restoration, and water and sediment control basins to store and slow down the flow of water
Slope Stabilization *Sediment*	Implement slope stabilization and riparian buffer practices in high slope areas to address soil loss and slow overland runoff
Manure & Septic Management *Bacteria*	Implement appropriate combination of education, inspections, BMP construction, and upgrades with individual producers and owners

Cottonwood River

Quick Facts:

Subwatershed Size:
30,286 acres

Upstream Subwatersheds:
Willow Creek (8,931 acres)
Judicial Ditch No. 20A (18,478 acres)

Counties:
56% Redwood
44% Murray

Cities:
Walnut Grove

Major Waterbodies:
Plum Creek
Judicial Ditch No. 28
Lake Laura

Elevation Change:
Maximum Elevation: 1,511 ft
Minimum Elevation: 1,075 ft

Longitudinal Barriers:
1 Significant Barrier
2 Partial/Seasonal Barriers

Impairments:

Sediment:
63% Reduction in sediment is required for Plum Creek Reach 603 to meet TMDL

Bacteria:
88% Reduction in bacteria is required for Plum Creek Reach 603 to meet TMDL

Appendix E. Additional Resources

Additional Cottonwood River Watershed resources

Hydrologic Condition and Terrain Analysis Report for the Cottonwood River Watershed: Cottonwood River Watershed Characterization Report | WRL Digital Asset Management (mnpals.net)

Cottonwood County Local Water Management Plan: https://www.cottonwoodswcd.org/wp-content/uploads/2018/02/CCCLWP_-__FINAL_APPROVED.pdf

Brown County Comprehensive Local Water Management Plan: http://brownswcdmn.org/wp-content/uploads/2016/03/FINAL_DRAFT_WATER_PLAN_Aug_2013.pdf

Lyon County Comprehensive Local Water Management Plan: https://www.lyonco.org/departments/lyon-county-soil-water-conservation-district/reports-and-plans/-folder-1112#docan2403_3404_2333

Minnesota Department of Natural Resources (DNR) Climate Summary for Watersheds: Cottonwood River: http://files.dnr.state.mn.us/natural_resources/water/watersheds/tool/watersheds/climate_summary_major_29.pdf

Minnesota Department of Natural Resources (DNR) Cottonwood River Watershed Characterization Report: https://wrl.mnpals.net/islandora/object/WRLrepository%3A3615/datastream/PDF/view

Minnesota Department of Natural Resources (DNR) Cottonwood River Watershed Context Report: https://files.dnr.state.mn.us/natural_resources/water/watersheds/tool/watersheds/context_report_major_29.pdf

Minnesota Department of Natural Resources (DNR) Watershed Health and Assessment Framework (WHAF) Cottonwood River Watershed Report Card: http://files.dnr.state.mn.us/natural_resources/water/watersheds/tool/watersheds/ReportCard_Major_29.pdf

Minnesota Nutrient Planning Portal for Cottonwood River Watershed: https://mrbdc.mnsu.edu/mnnutrients/watersheds/cottonwood-river-watershed

Minnesota Pollution Control Agency (MPCA) Cottonwood River Watershed Monitoring and Assessment Report: https://www.pca.state.mn.us/sites/default/files/wq-ws3-07020008.pdf

Minnesota Pollution Control Agency (MPCA) Cottonwood River Watershed Total Maximum Daily Load (TMDL) Study for Total Suspended Solids, *E. coli*, Chloride, and Lake Nutrients: Cottonwood River | Minnesota Pollution Control Agency (state.mn.us)

Minnesota Pollution Control Agency (MPCA) Cottonwood River Fecal Coliform Total Maximum Daily Load Report: https://www.pca.state.mn.us/sites/default/files/wq-iw7-20e.pdf

Minnesota Pollution Control Agency (MPCA) Cottonwood River Watershed Stressor Identification Report: available upon request

Murray County Local Water Management Plan: www.murrayswcd.org/Reports/Murray County Water Plan.pdf Redwood County Comprehensive Local Water Management Plan: https://c9c11c37-9889-4c8b-b0ac-4022c0d3a130.filesusr.com/ugd/4af85c_e82127e3bb994e0ca42f9dcfea6429cd.pdf

United States Department of Agriculture and National Resources Conservation Service (NRCS) Rapid Watershed Assessment Resource Profile Cottonwood HUC: 07020008: https://www.nrcs.usda.gov/Internet/FSE_DOCUMENTS/nrcs142p2_022270.pdf