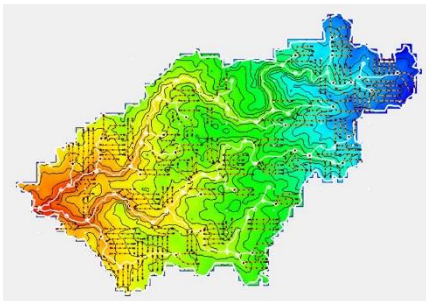
Cedar River Watershed Restoration and Protection Strategy Report



MINNESOTA POLLUTION CONTROL AGENCY

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CLEAN WATER LAND & LEGACY AMENDMENT

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Table of Contents

Table of Figures

Table of Tables

Key Terms

Assessment Unit Identifier (AUID): The unique water body identifier for each river reach comprised of the USGS eight-digit HUC plus a unique three-character code within each HUC. For example, the Cedar River from Turtle Creek to Rose Creek, a three-mile reach in length, is uniquely identified as 07080201-515.

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

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

Hydrologic Unit Code (HUC): A Hydrologic Unit Code (HUC) is assigned by the United States Geological Survey (USGS) for each watershed. HUCs are organized in a nested hierarchy by size. For example, the Cedar Basin and other adjacent watersheds that drain to the Mississippi River are assigned a HUC-4 of 0708, and the Upper Cedar River Watershed is assigned a HUC-8 of 07080201.

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

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

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

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 non-pollutant sources or factors (e.g., altered hydrology, dams preventing fish passage) that adversely impact aquatic life.

Total Maximum Daily Load (TMDL): A calculation of the maximum amount of a pollutant a receiving water body can assimilate while still achieving water quality standards. 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.

Summary

Minnesota has adopted a “watershed approach” to address water quality within the state’s 80 major watersheds. The watershed approach follows a 10-year cycle where water bodies are 1) monitored for chemistry and biology and assessed to determine if they are fishable and swimmable, 2) pollutants and stressors and their sources are identified, and then local partners and citizens are engaged to help 3) develop strategies to restore and protect water bodies, and 4) plan and implement restoration and protection projects. The Cedar River Watershed Restoration and Protection Strategy (WRAPS) Report (Report) summarizes work done in Steps 1 - 3 above in this first cycle of the Watershed Approach in the Cedar River Watershed (CRW).

The CRW area drains 454,029 acres and is part of the greater Cedar – Iowa Rivers system, which drains to the Mississippi River in Iowa. Located in Southeast Minnesota, the CRW covers portions of Dodge, Freeborn, Mower, and Steele Counties. Land use in the watershed is dominated by cultivated crops with 88% of the acreage used for agricultural purposes. Livestock production is prevalent in the watershed with 135,556 animal units (AUs) located within the watershed. Swine is the dominant livestock species, making up approximately 80% of the total AUs.

The condition monitoring, trend analysis and field investigations that comprise a foundation of this document are detailed in Chapters 1 and 2. Overall, streams and lake monitoring and assessment show mixed results of the water quality in the CRW.

- 39% of the stream reaches that were assessed are not supporting of aquatic life. 18% of the stream reaches do support aquatic life; the remaining 43% of the stream reaches needed additional information to make an assessment.
- 85% of the sites sampled for fish showed fair to good populations of fish. However, only 45% of the sites sampled for macroinvertebrates showed fair to good populations of macroinvertebrates. The reason for this is not entirely known, but may be due to the general robustness of fish (relative to macroinvertebrates) and/or the greater sensitivity to habitat quality or water chemistry of the macroinvertebrates.
- Of the 18 stream reaches assessed for aquatic recreation, no assessed stream reaches were supporting of aquatic recreation use designation because of high indicator bacteria populations.
- Of the seven lakes in the CRW, only Geneva Lake had sufficient data for a lake assessment and was found to be non-supporting of aquatic recreation due to high lake nutrient concentration and low transparency.
- Long term monitoring (since 1967) shows significant decreases in TSSs, total phosphorus (TP), ammonia concentrations and biochemical oxygen demand in the CRW. Even with these significant decreases, many areas of the CRW are still impaired and further reductions are still needed. Recent trend analysis shows these declines in pollutant concentrations have leveled off and show an overall “no trend” for the years 1995 through 2009.
- Nitrite/Nitrate trends have seen a significant increase since 1967. The Cedar River has some of the highest nitrate-nitrogen concentrations in Minnesota’s streams, with the site downstream of

Austin increasing about 2% per year (1967 through 2009), and the Cedar River at Lansing increasing about 1% per year, from 1980 through 2010 (MPCA 2013).This significant increase has resulted in the CRW being the 10^{th} highest nitrate loading watershed in Minnesota.

Chapter 2 also describes the types and sources of pollutants and stressors causing impairments within the CRW. A summary of the common pollutants and stressors with their respective goals are listed below.

- **Altered hydrology**: Altered hydrology is the changes in the characteristics of the water cycle. Specifically, water conveyance (stream flow and evapotranspiration) and water storage features have been changed or altered. Altered hydrology harms aquatic life by affecting the amount of water in the stream, as both too little and too much stream flow have negative impacts. Because altered hydrology also increases the amount and movement of pollutants and stressors (nutrients, sediment, etc.) to water bodies, addressing altered hydrology should be a top priority for the watershed.
    - Altered hydrology was a commonly identified stressor to aquatic life in the CRW; found to affect all the investigated stream reaches.
    - Recent statistical analysis of historical runoff and runoff ratio shows that stream flows in the CRW have significantly increased during the timeframe of 1981 through 2010, when compared with the entire period of record dating back to 1910. Since 1979, there has been a significant increase in the runoff ratio in the CRW (Minnesota Department of Natural Resources; DNR)
    - Two studies have attempted to quantify the potential sources for altered hydrology in the CRW. Depending on the study, either a third or a half of the increase flow can be attributed to a wetter climate. The remaining portions are attributed to non-climatic factors involving land use and land management. This includes an increase in artificial drainage, reduced soil organic matter, loss of wetlands, and changes in cropping rotations
    - A goal of 25% reductions in total flow in the entire CRW was identified. The Cedar River Watershed District (CRWD) has also developed 100 year – 24 hour storm reduction goals for selected subwatersheds.
- **Phosphorus:** Excess phosphorus fuels algae growth that degrades habitat and recreation, and contributes to oxygen depletion problems.
    - Excess phosphorus was found to be a pollutant in Geneva Lake and a stressor in 7 of the 19 bio-impaired stream reaches.
    - Point sources and nonpoint sources each contribute about half of the TP load to the CRW.
    - Point sources contribute a significant amount to the overall phosphorus load of the river; however, their biggest effect is elevating the phosphorus concentrations during low flow periods.

- The two dominant nonpoint sources of phosphorus in the CRW are agricultural land runoff and stream bank erosion. The amount of phosphorus contributed from each source is heavily dependent on weather events that erode soil from fields or stream banks. Data from the Watershed Pollutant Load Monitoring Network (WPLMN) shows a significant portion of loading of phosphorus from nonpoint sources generally occurs over a very short time period each year. Based on six years of data, about 40% of the yearly phosphorus load is delivered from five separate weather events that together span a period of only 2 to 3 weeks. It is not unusual to have one large event usually contributing 20% or more of the annual phosphorus load.
- There are three phosphorus reductions goals for the CRW:
  - The Geneva Lake Total Maximum Daily Load (TMDL) indicates a 12.8% reduction in TP is needed in the lakeshed to achieve water quality goals in the lake;
  - A watershed wide phosphorus reduction goal of 12% to address downstream water quality goals as outlined in the Minnesota Nutrient Reduction Strategy (NRS); and
  - A significantly higher watershed wide reduction of 56% to address local issues such as elevated nutrient stressors and potential future River Eutrophication Standards.

- **Bacteria:** Fecal bacteria indicate sewage or manure in water, which makes water unsafe for swimming. All 16 of the analyzed stream reaches were found to be impaired by fecal bacteria.
  - With a robust animal agriculture sector throughout the watershed, manure is the largest source of the fecal bacteria. The common pathway for fecal bacteria from animal agriculture to reach water bodies is runoff from farm fields where manure has been surface-applied, runoff from non-permitted feedlots, and overgrazed pastures near streams.
  - Even though there is potentially a significant number of failing septic systems in the CRW, they are unlikely to contribute substantial amounts bacteria to the total annual loads in the CRW, when compared to other sources. However, the impacts of failing septic systems on water quality may be pronounced in areas with high concentrations of failing septic systems or at times of low precipitation and/or flow.
  - There are 16 bacteria TMDL in the CRW detailing needed bacteria reductions. The needed reductions range from 9% to 91% in the impaired reaches.
- **Nitrogen:** Excess nitrogen (N) is toxic to aquatic life and contributes to the Gulf of Mexico's hypoxic zone. High N levels were identified as a conclusive stressor in 15 bio-impaired stream reaches. N is only investigated when a bio-impairment is identified; so excessive N conditions may be more widespread than appears and are likely problematic in areas with high subsurface tile drainage.
  - Agricultural tile drainage and agricultural groundwater is the dominant pathway for most of the N to enter the CRW.
  - N from cropland groundwater, drainage and runoff comes from a variety of sources. Commercial fertilizer represents the largest source of N that is added to soil. Manure,

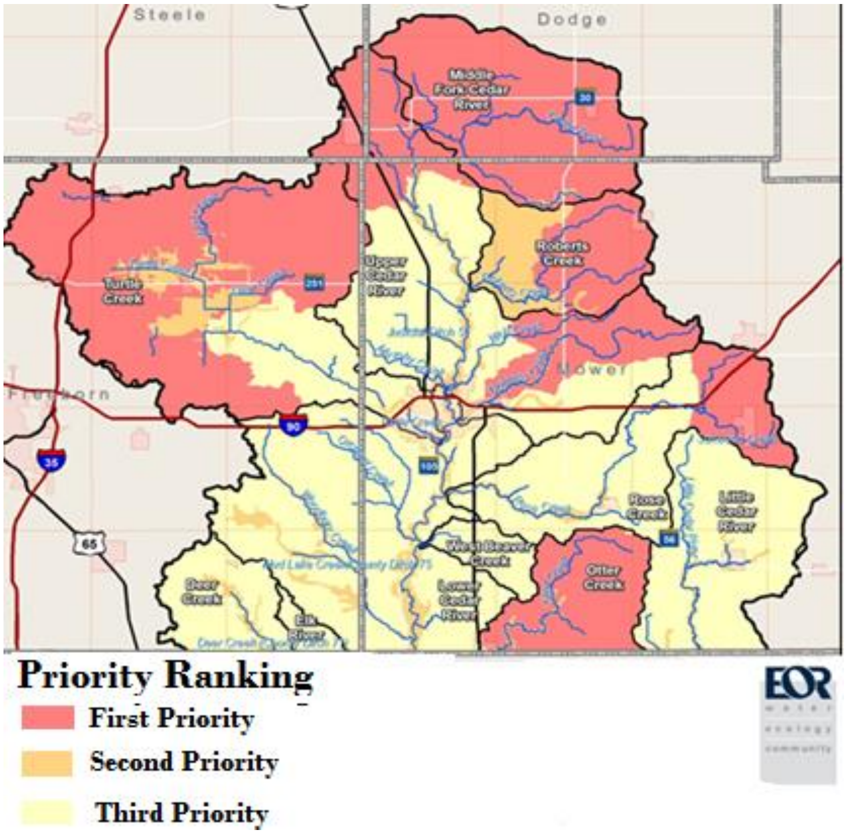
legumes, and atmospheric deposition are also significant sources, and when added together provide similar N amounts as the fertilizer additions. Mineralization of soil organic matter releases large quantities N annually, estimated to contribute about the same amount of N as commercial fertilizers and manure combined. While mineralization is an ongoing natural phenomenon, the increase in tile drainage has resulted in increased transport of this N to surface waters.

  - Point sources contribute only 6% of the total N load in the CRW. However, in low flow conditions point sources can be a major contributor of N, which results in elevated nitrate-nitrite concentrations in excess of 10 mg/L
  - The N reduction goal identified in the NRS call for a 45% reduction from the 1980 through 1996 conditions. However, the NRS recognizes the difficulty in achieving the 45% reduction and sets a milestone reduction of 20% by 2025.
  - The state of Iowa Cedar River Nitrate TMDL has indicated that a 35% reduction in total nitrate-N loading from the CRW is needed.

- **Sediment/Turbidity**: Sediment and other particles affect aquatic life by reducing habitat, suppressing photosynthesis, damaging gills, decreasing visibility and increasing sediment oxygen demand.
  - For the Cedar River's 54 stream miles in Minnesota, 45 miles are sediment-impaired. Sediment has been identified as a pollutant in 10 stream reaches. In four of the 10 stream reaches, sediment is a conclusive stressor to the biological communities.
  - Stream and ditch bank erosion account for an estimated 40% of the sediment load in the watershed; however, much of this is due to unnaturally accelerated erosion of stream banks caused by the altered hydrology.
  - Recent analysis has estimated that the increased runoff in the CRW has resulted in 15,000 tons of additional sediment being delivered to the CRW as a result of additional erosion from near channel sources
  - Cropland is the single largest source of sediment to the CRW. Each acre in the CRW potentially contributes up to 281 pounds of sediment load to the river, based on modeling. While each acre individually may not contribute a large amount of sediment, it is the totality of the nearly 400,000 acres of cropland in the CRW that causes cropland to be the largest source of sediment.
  - Monitoring within the CRW indicates most exceedence of the total suspended solid (TSS) standard occur at high and very high flows, and that streams meet water quality goals at lower flows. In many impaired reaches, a 80% to 90% reduction is needed to achieve water quality goals at very high flows.

Chapter 3 is the primary section of this report for local partner use in planning or project conception. It includes details and products that came from engagement with watershed stakeholders and local government units, aimed at prioritizing and implementing restoration and protection strategies. A general summary is as follows:

- Everyone within the watershed has a responsibility to transition to more sustainable practices to achieve clean water. Cultivated crop production accounts for approximately 80% of the land use in the watershed, with conventional farming practices leading to substantial contributions of all pollutants and stressors. Therefore, the greatest opportunity for water quality improvement is from land management changes to farm fields in the CRW. Likewise, cities, residents, animal operations, and other land uses must transition to more sustainable practices.
- There are 11 stream reaches that were fully supporting of aquatic life based on measures of fish and macroinvertebrate community health. Otter Creek was the top priority stream selected for protection in the CRW via the WRAPS committee process. However, with only 11 stream reaches fully supporting aquatic life in the CRW, all eleven stream reaches should be considered as potential priority areas for protection actions in the future.
- Prioritization of resources and implementation efforts in the CRW are based primarily on the importance of water retention in the headwaters to reduce stream flows, erosion, pollutant transport, loss of stream habitat and flooding. The identified prioritization strategy is:
    - **First priority**
        - Implementation of agricultural BMPs in the headwaters of the watershed, including the Dobbins Creek Subwatershed and upper part of the Roberts Creek and Turtle Creek Subwatersheds, all of which have existing best management practices (BMP) targeting models completed. Priority agricultural BMPs include buffers, soil health, cover crops, and erosion control practices.
        - Protection of water quality in the higher quality Otter Creek Watershed.
        - Upper Wolf Creek is also a high priority area. The entire Wolf Creek Subwatershed is an important implementation project area for the CRWD.
    - **Second priority**
        - A significant level of BMP implementation can also occur in second level priority subwatersheds. For example, this can involve work to reconnect the streams to their floodplains. Areas with flood insurance, such as near Austin can provide greater opportunities. The reconnection of streams to their floodplain anywhere in the watershed will be beneficial to improving water quality. Feasibility studies will be needed for design and implementation.
        - Implementation of agricultural BMPs in the lower part of the Roberts Creek Subwatershed.
    - **Third priority**
        - Implementation of BMPs in the downstream portions of the watershed.

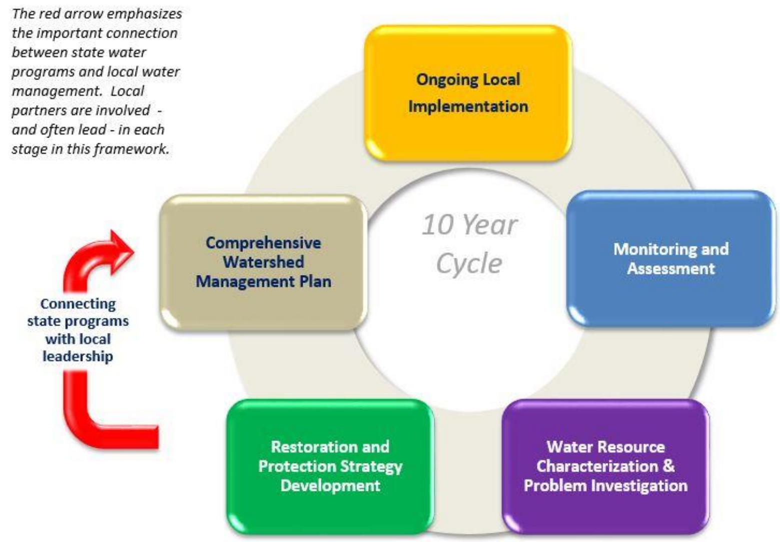


Chapter 3 concludes with a summary of restoration and protection strategies for the CRW. Progress and improvement in the CRW will be marked by implementation of these strategies. On-going measurement and condition monitoring will examine the fish and macroinvertebrate populations in streams, algae blooms in lakes, and the pollutant loads leaving the watershed. The value of the Cedar WRAPS going forward is in its summarization and listing of 1) various technical works and tools that were developed via significant time, resources and stakeholder input, and 2) examples of BMP combinations that can attain pollutant reduction goals. These tools and examples do not amount to a plan or prescription, but rather serve to inform future planning and support local partner efforts to acquire funds to do conservation work in the watershed.

What is the WRAPS Report?

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

Along with the watershed approach, the Minnesota Pollution Control Agency (MPCA) developed a process to identify and address threats to water quality in each of these major watersheds. This process is called Watershed Restoration and Protection Strategy (WRAPS) development. WRAPS reports have two parts: impaired waters have strategies for restoration, and waters that are not impaired have strategies for protection.



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

Purpose	• Support local working groups and jointly develop scientifically-supported restoration and protection strategies to be used for subsequent implementation planning • Summarize Watershed Approach work done to date including the following reports: • *Cedar River Watershed Monitoring and Assessment* • *Cedar River Watershed Biotic Stressor Identification* • *Cedar River Watershed Total Maximum Daily Load*
Scope	• Impacts to aquatic recreation and impacts to aquatic life in streams • Impacts to aquatic recreation in lakes
Audience	• Local working groups (local governments, Soil and Water Conservation Districts [SWCDs], watershed management groups, etc.) • State agencies (Minnesota Pollution Control Agency [MPCA], Department of Natural Resources [DNR], Board of Water and Soil Resources [BWSR], etc.)

1. Watershed Background & Description

The CRW covers approximately 709 square miles (454,029 acres) in southeast Minnesota in portions of Dodge, Freeborn, Mower, and Steele counties (Figure 1). The watershed is part of the greater Cedar-Iowa Rivers system, a major tributary system of the Mississippi River, a majority of which is located in Iowa. The Minnesota portion of Cedar River includes the headwaters of the greater Cedar River system. This WRAPS report focuses solely on the CRW in Minnesota.

The State of Iowa, the CRW coalition, and numerous Iowa-based agencies and groups are addressing water quality assessments, water quality goals, pollutant source identification, and implementation strategies for the Iowa portion of the Cedar Watershed.

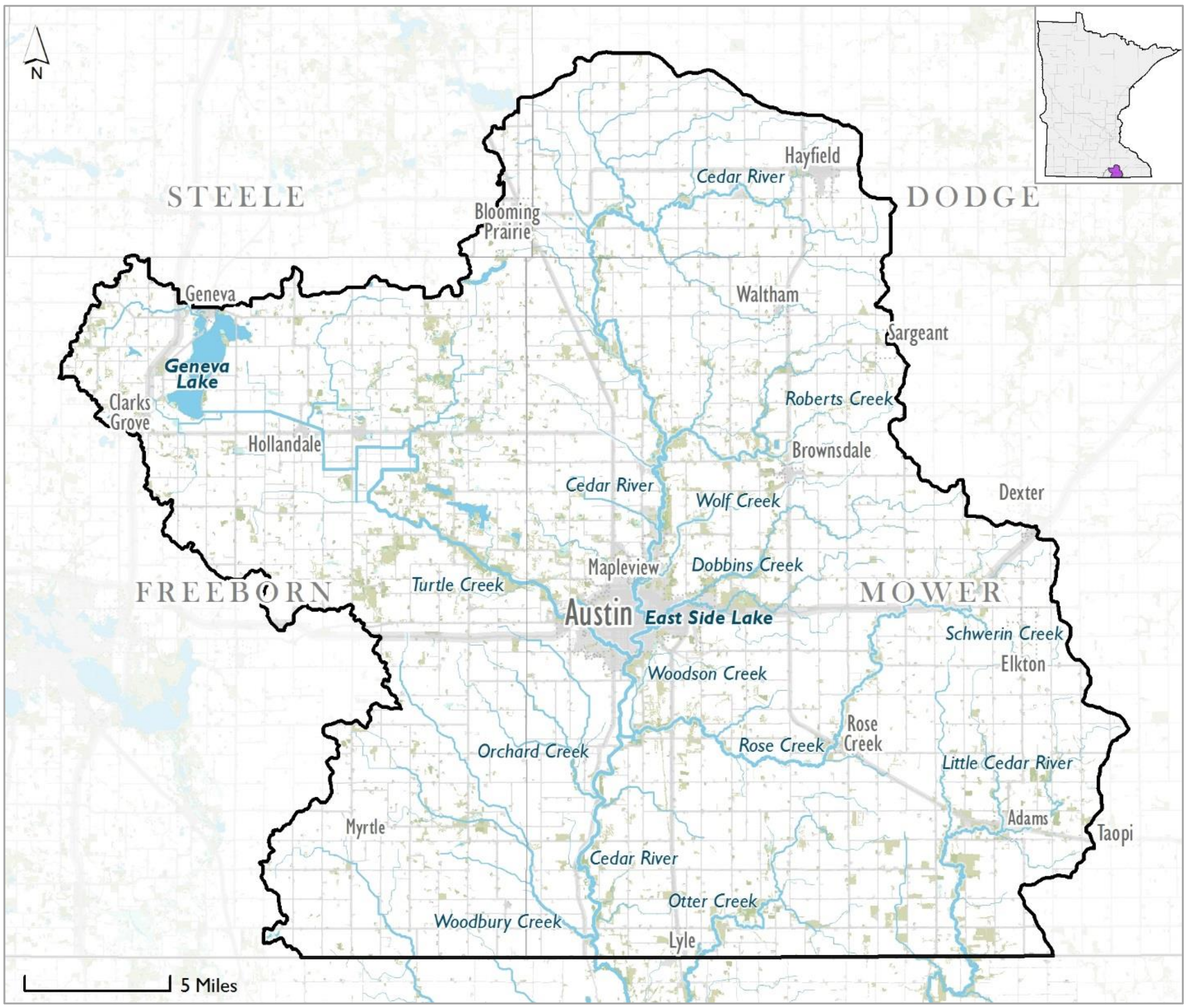


Figure 1. Cedar River Watershed

Historically, land cover in the CRW was comprised of tall grasslands, wetlands, oak savanna, and maple-basswood woodlands. European settlers and western expansion converted much of the area to agriculture during the late 1800s. This conversion to farmland required significant drainage of existing wetlands in the watershed. A particularly large wetland complex in the Turtle Creek Watershed, located in the northwest quadrant of the Cedar Watershed, experienced extensive drainage through construction of open ditches and underground tile lines (MPCA 2012; Register 2016).

Today approximately 80% of the CRW acreage is used for agricultural purposes, primarily corn and soybean crops (Figure 2). Urban development accounts for approximately 8.5% of land use, with the largest population center in Austin, Minnesota. Open water and wetlands make up about 2.1% of the watershed. The majority of the remaining land is grasslands or pastures.

Three dams are located in the CRW restricting the flow of the Cedar River and its tributaries. These dams create the Ramsey Mill Pond reservoir north of Austin, and Austin Mill Pond and East Side Lake in Austin.

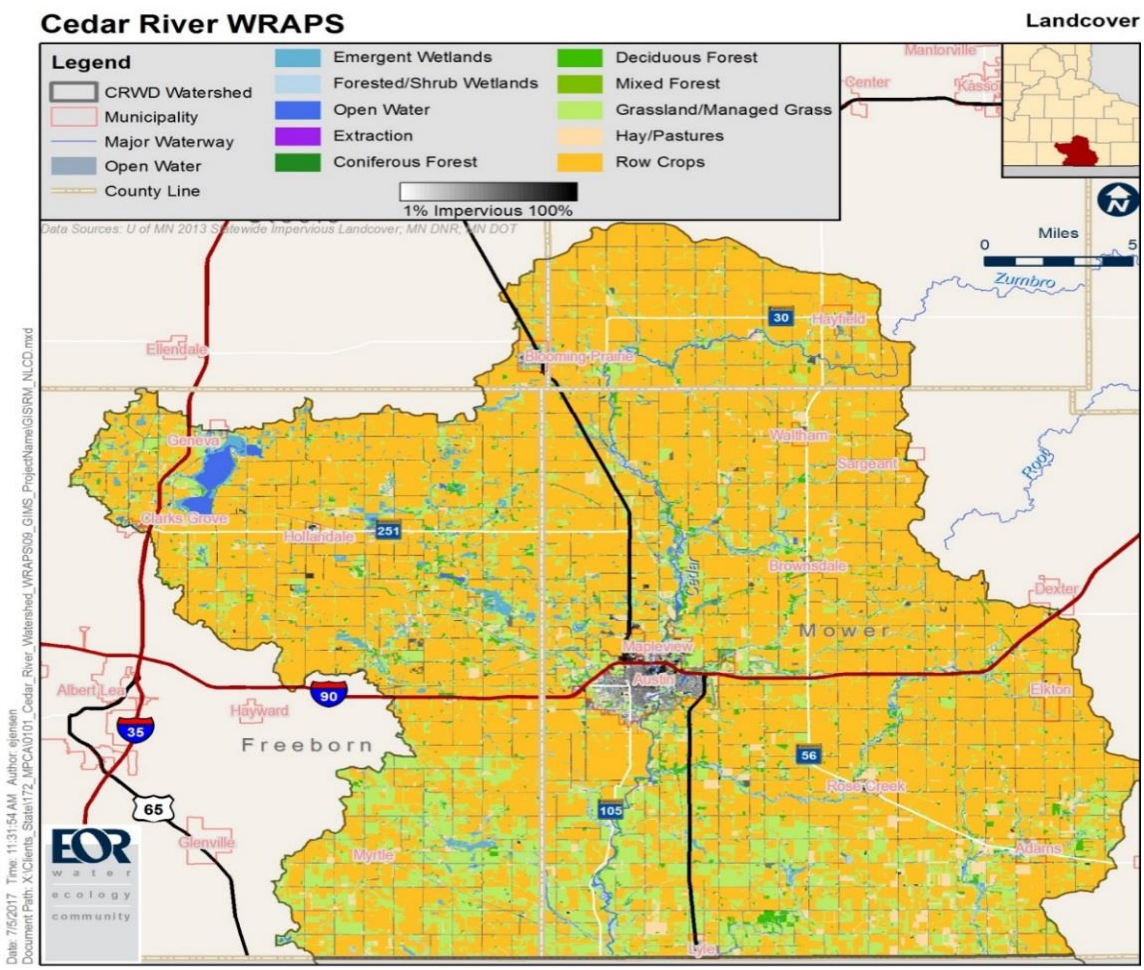


Figure 2. Cedar River Watershed land cover

The CRW is located in the western portion of the karst region of Minnesota (Figure 3). The karst in the CRW ranges from active karst features near the surface to covered karst that has 275 feet of overlying sediment. Numerous karst springs are located along the central corridor of the Cedar River and many of its tributaries (MPCA 2012). Historical records indicate that many of these spring-fed streams supported Brook Trout and other sensitive aquatic species. In the 1950s, the Minnesota DNR attempted to stock many of these steams with Brown Trout. Unfortunately, neither native Brook Trout nor introduced Brown Trout have been documented as captured in the watershed since 1982. However, sensitive fish, mussels, and aquatic invertebrate species in select tributaries of the Cedar River presently exist and indicate good water quality and habitat (MPCA 2012). These tributaries are worthy of additional protections in order to preserve these valuable aquatic resources.

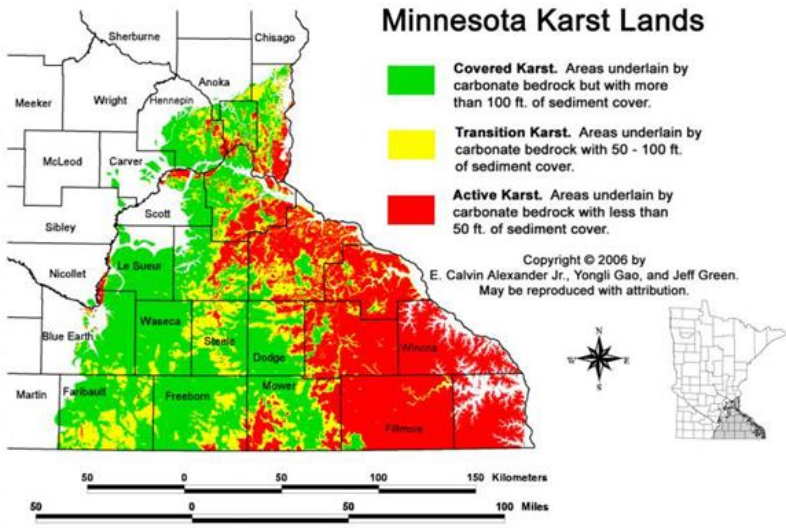


Figure 3. Minnesota karst lands

The active karst region south of the city of Austin is considered a source of “young water” for the Cedar River. This water has spent a short amount of time in the aquifer and in some cases travels directly from the surface into the aquifer without filtration. This source water is at higher risk of being contaminated with salts, petroleum products and agricultural chemicals.

Additional Cedar River Watershed Resources

There are several factors that play a role in the health of a watershed in addition to land use that have been assessed and recorded elsewhere. Refer to the following resources for further information on the Cedar River Watershed.

Cedar River Watershed Monitoring and Assessment Report. June 2012. Prepared by the Minnesota Pollution Control Agency.

Cedar River Watershed Stressor Identification Report. June 2016. Prepared by the Minnesota Pollution Control Agency.

Cedar River Watershed Total Suspended Solids, Lake Eutrophication, and Bacteria Total Maximum Daily Load. 2019. Prepared by the Minnesota Pollution Control Agency.

DNR Watershed Health Assessment Framework: http://mndnr.gov/whaf

USDA Natural Resources Conservation Service (NRCS) Rapid Watershed Assessment for the Upper Cedar River Watershed: https://www.nrcs.usda.gov/Internet/FSE_DOCUMENTS/nrcs142p2_022279.pdf

Minnesota Department of Natural Resources (DNR) Watershed Assessment Mapbook for the Cedar River Watershed:
http://files.dnr.state.mn.us/natural_resources/water/watersheds/tool/watersheds/wsmb48.pdf

Minnesota Nutrient Reduction Strategy: http://www.pca.state.mn.us/index.php/water/water-types-and-programs/surface-water/nutrient-reduction/nutrient-reduction-strategy.html

Minnesota Nutrient Planning Portal: http://mrbdc.mnsu.edu/mnnutrients/minnesota-major-watersheds

Cedar River Watershed District website: http://www.cedarriverwd.org/aboutus/10_year_plan.html

Turtle Creek Watershed District website: http://www.turtlecreekwd.org/

Cedar River Watershed District Management Plan. October 2009. Prepared by Barr Engineering.

Cedar River Watershed Surface Water Monitoring Reports (annual 2008-2013). Prepared by Cedar River Watershed District.

Turtle Creek Watershed District Management Plan. September 2003. Prepared by Barr Engineering

Revised Regional Total Maximum Daily Load Evaluation for Fecal Coliform Bacteria Impairments in the Lower Mississippi River Basin in Minnesota. January 2006. Prepared by Minnesota Pollution Control Agency.

Watershed Context Report: Cedar River. April 2016. Prepared by Minnesota Department of Natural Resources.

Additional Information on the Cedar River Watershed including the Monitoring and Assessment Report and the Stressor Identification Report can be found on the MPCA Cedar River Watershed website: https://www.pca.state.mn.us/water/watersheds/cedar-river

2. Watershed Conditions

In 2009, the MPCA undertook the intensive watershed monitoring (IWM) effort of the CRW's surface waters. Sixty-one sites were sampled for biology at the outlets of variable sized subwatersheds within the CRW. These locations included the mouth of the Cedar River at the Iowa border, the upstream outlets of major tributaries, and the headwater outlets of smaller streams. As part of this effort, the MPCA staff joined with the CRWD to complete stream water chemistry sampling at the outlets of seven of the Cedar River's major subwatersheds. In 2011, a holistic approach was taken to assess all of the watershed's surface water bodies for support of aquatic life, recreation, and fish consumption, where sufficient data was available. Thirty-five streams and one lake were assessed in this effort. (Not all lake and stream Assessment Unit Identifications [AUIDs] were able to be assessed due to insufficient data, modified channel condition or their status as limited resources waters.)

Throughout the watersheds, 11 stream AUIDs are fully supporting aquatic life. Thirty AUIDs are non-supporting of aquatic life and/or recreation. Of those AUIDs, 21 are non-supporting of aquatic life, and nine are non-supporting of aquatic recreation. Aquatic biological impairments occur along the main stem of the Cedar River and many tributaries. Bacterial impairments are common, with no streams classified as fully supporting aquatic recreation for their entire length. Aquatic consumption (fish tissue contamination with mercury) impairments span the entire length of the Cedar River.

Two AUIDs were not assessed due to their classification as limited resource waters. Twenty-three AUIDs were not assessed for aquatic biology because the reach or AUID is >50% channelized. Channelized reaches in the CRW are currently being assessed using the TALU standards, with any new biological impairments being proposed for the 2020, 303(d) Impaired Waters List. Biological quality at channelized streams was generally rated good to fair for fish and fair to poor for macroinvertebrates. Three additional AUIDs were not assessed due to local factors that make conditions not appropriate for stream assessment.

2.1 Water Quality Assessment

This report addresses waters for protection or restoration of water quality in the entire CRW in Minnesota (HUC 07080201). This includes aquatic life uses based on the fish and macroinvertebrate communities, and suspended sediment/turbidity levels in the streams. This report also includes aquatic recreation uses based on bacteria levels in streams, and nutrient levels/water clarity in Geneva Lake. Waters that are listed as impaired will be addressed through restoration strategies and a TMDL study. Waters that are not impaired will be addressed through protection strategies to help maintain water quality and beneficial uses (see Section 2.5 and Section 3).

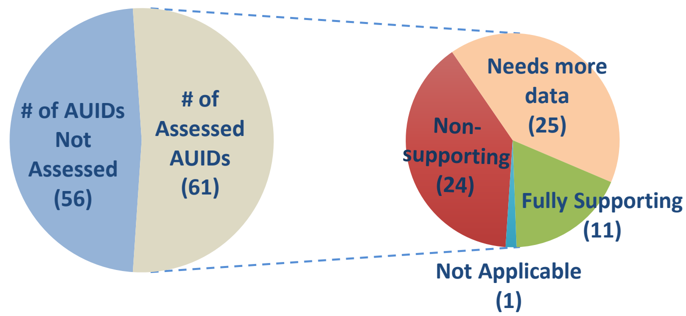
Some of the water bodies in the CRW are impaired by mercury; however, this report does not cover toxic pollutants. For more information on mercury impairments, see the statewide mercury TMDL at: http://www.pca.state.mn.us/index.php/water/water-types-and-programs/minnesotas-impaired-waters-and-tmdls/tmdl-projects/special-projects/statewide-mercury-tmdl-pollutant-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

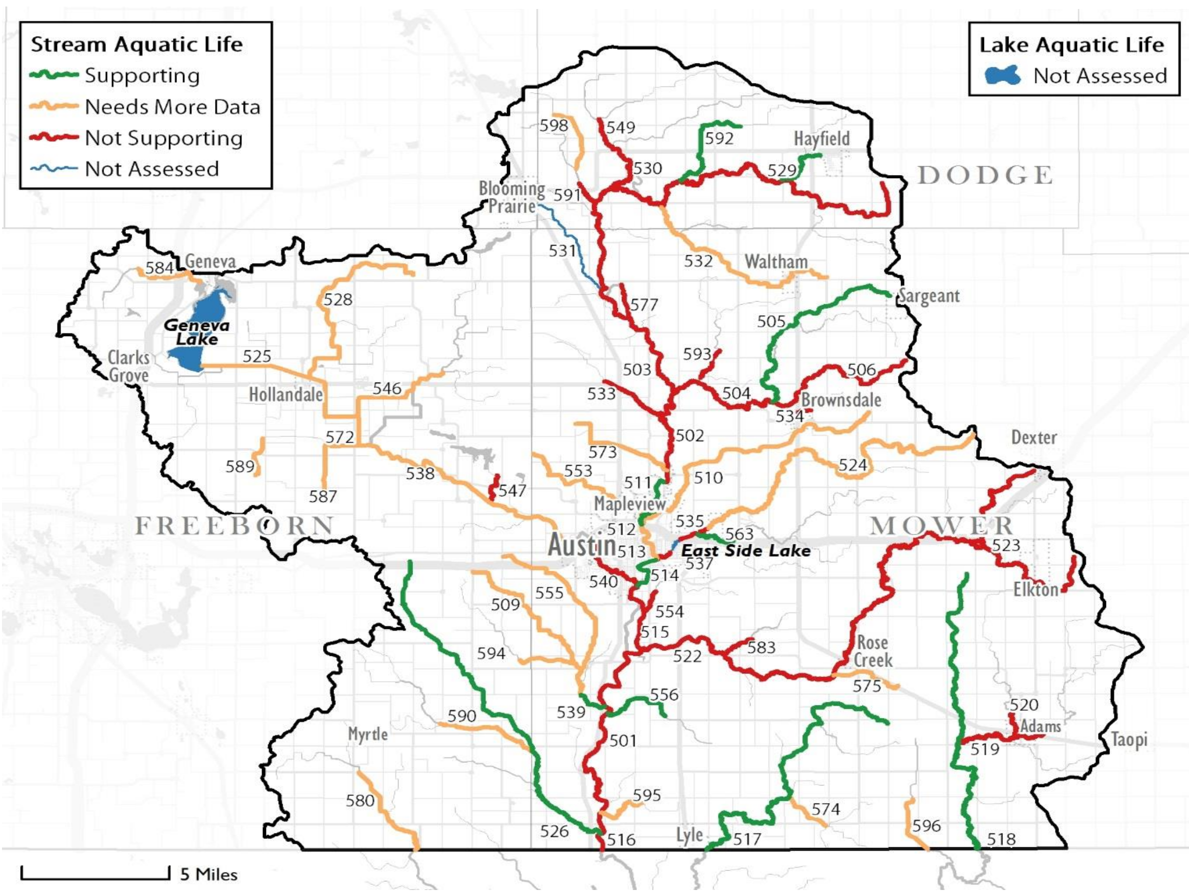
Streams

Streams were assessed for aquatic life and aquatic recreation designated uses. The CRW contains a total of 117 stream reaches with unique AUIDs. Sixty-one AUIDs were assessed for aquatic life with 11 AUIDs fully supporting aquatic life, 24 AUIDs not supporting aquatic life and 25 AUIDs needing more data to make an assessment. Figure 4 identifies the location of each of the AUIDs assessed for aquatic life.

Figure 4. Aquatic life use assessments

Aquatic life use impairments (non-supporting assessments) include Low Fish IBI; which means an unhealthy fish community is present, or low M IBI; which means an unhealthy macroinvertebrate community is present, or total suspended solids (TSS)/turbidity levels too high to support aquatic life.





Context for Aquatic Life Use Support

As part of the IWM, stream reaches were scored using the Index of Biological Integrity (IBI). The IBI provides a framework for translating biological community data into information regarding ecological integrity. The process utilizes a variety of metrics of the biological community, which responds in a predictable way to anthropogenic disturbances. These metrics are then scored numerically to quantify deviation from least-disturbed conditions. There are two types of IBI. Fish IBI (F-IBI) and Macroinvertebrate IBI (M-IBI). Macroinvertebrates are animals without a backbone that are large enough to be seen with the naked eye, and spend at least part of their life cycle in an aquatic environment. These animals may be as small as midges or mayflies, and as large as crayfish and mussels.

In the CRW and in southeast Minnesota regionally, IWM has documented many F-IBI values that are high relative to their corresponding M-IBI values. Figure 5 and Figure 6 show this phenomenon. Note that greater than 85% of the F-IBI values in the CRW are good or fair/good, while only ~45% of the invertebrate IBI values are good or fair/good. This may be due to general robustness of fish (relative to macroinvertebrates) and/or greater sensitivity to habitat quality or water chemistry in the case of macroinvertebrates. Both IBI values (when available) were used as lines of evidence in aquatic life use support decisions. In general, if one of the values is below the threshold or "goal" the stream is categorized as not supporting.

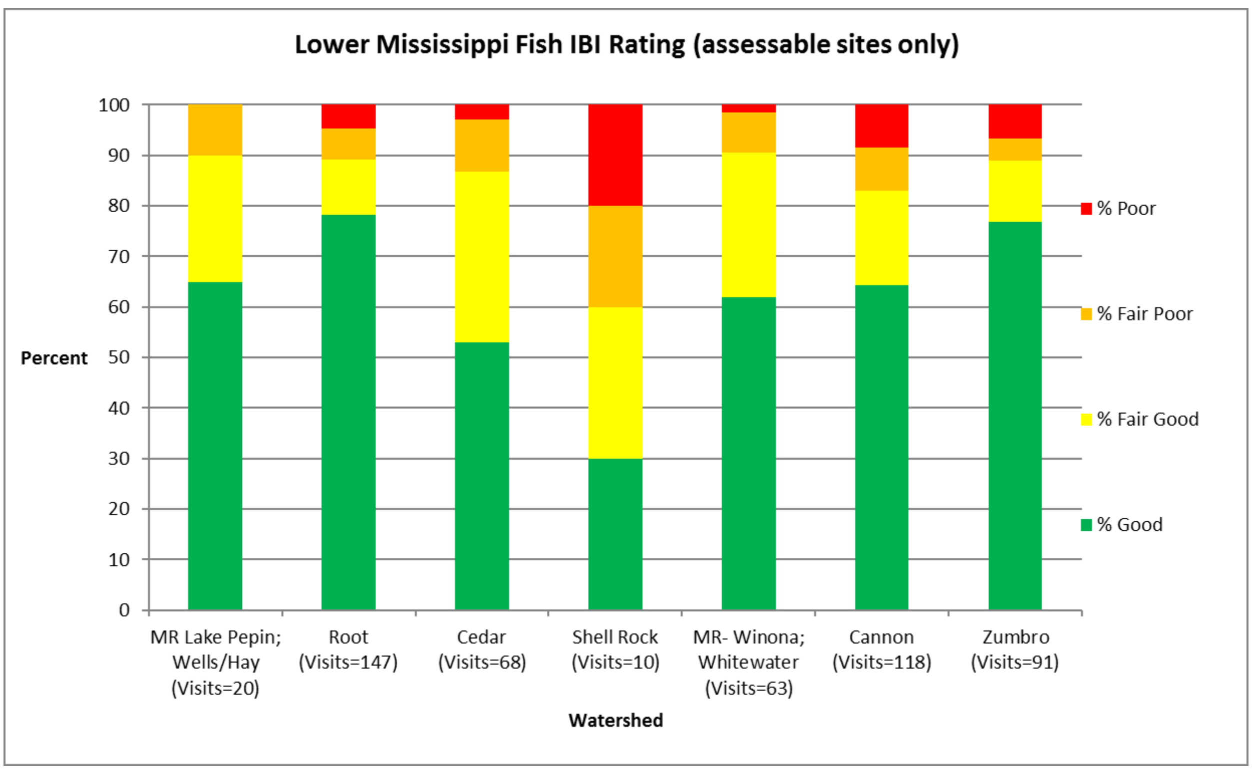


Figure 5. Lower Mississippi watersheds Fish Index of Biotic Integrity (F-IBI) Ratings

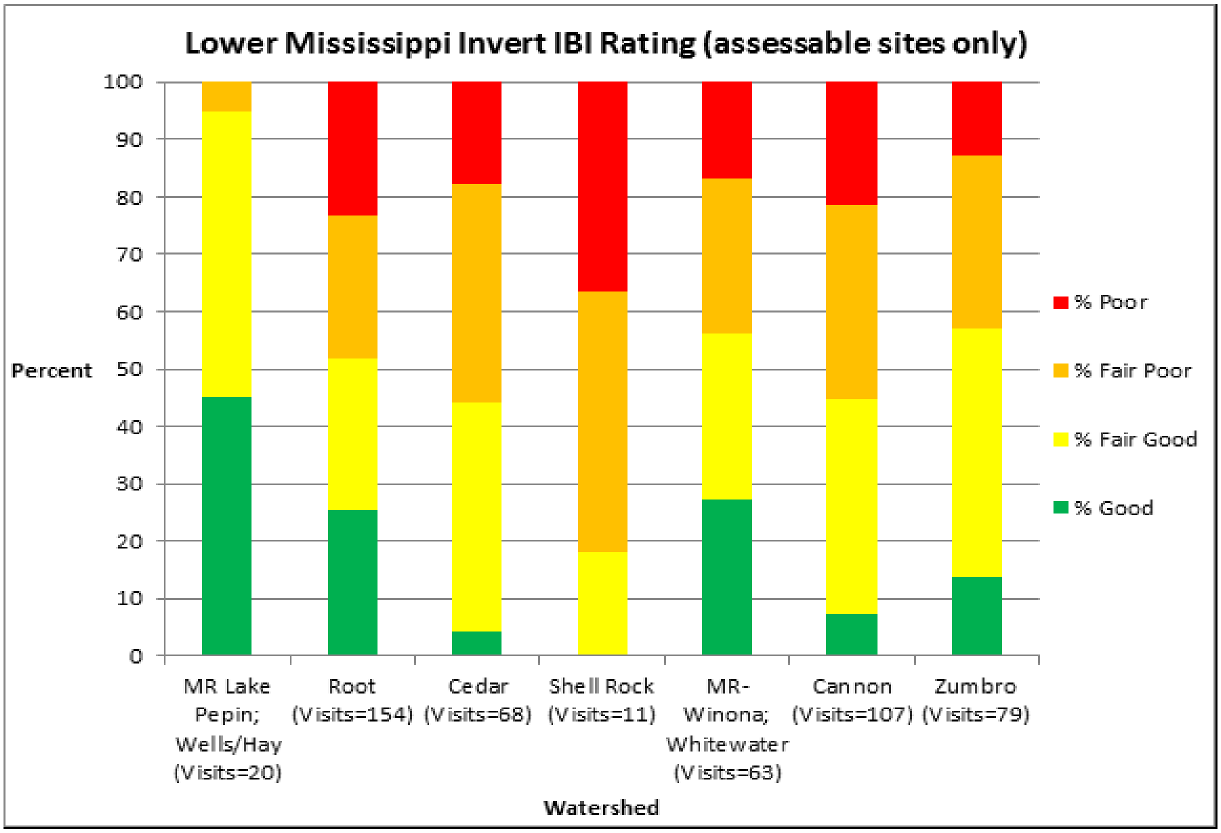


Figure 6. Lower Mississippi watersheds Macroinvertebrate Index of Biotic Integrity (M-IBI) Ratings

The impaired waters status for a number of streams in the CRW will be changing based on an assessment of the tiered aquatic life use (TALU) thresholds. This is scheduled to formally take place in 2020, with updating of Minnesota's 303(d) impaired waters list. Appendix A includes a table of proposed changes to stream reaches that were initially deferred from assessment, as TALU was developed. Now that TALU is complete and in place, streams that were deferred in Cycle 1, are to be designated into a tier, and then assessed with the thresholds within that tier. For affected stream reaches in the CRW, this means that the stream segment will either be a modified use, or a general use designation. Modified use streams have a channelized condition in more than 50% of the stream length, and have limiting habitat conditions. Modified use streams have a lower IBI threshold than general use streams (i.e. general use streams are held to a higher biological community threshold, as habitat is not strictly limiting).

Of the 18 AUIDs assessed for aquatic recreation, sixteen are not supporting aquatic recreation use. Two AUIDs need more data to make an assessment. No assessed stream reaches showed full support for aquatic recreation use designation. For stream aquatic recreation assessments, the MPCA tests for *E. coli* bacteria, which are commonly found in fecal waste and are easy to measure. *E. coli* is often used as “indicator organisms” to denote the potential presence of fecal waste.

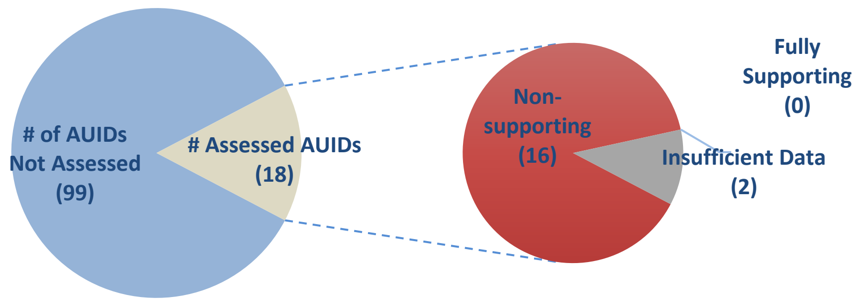
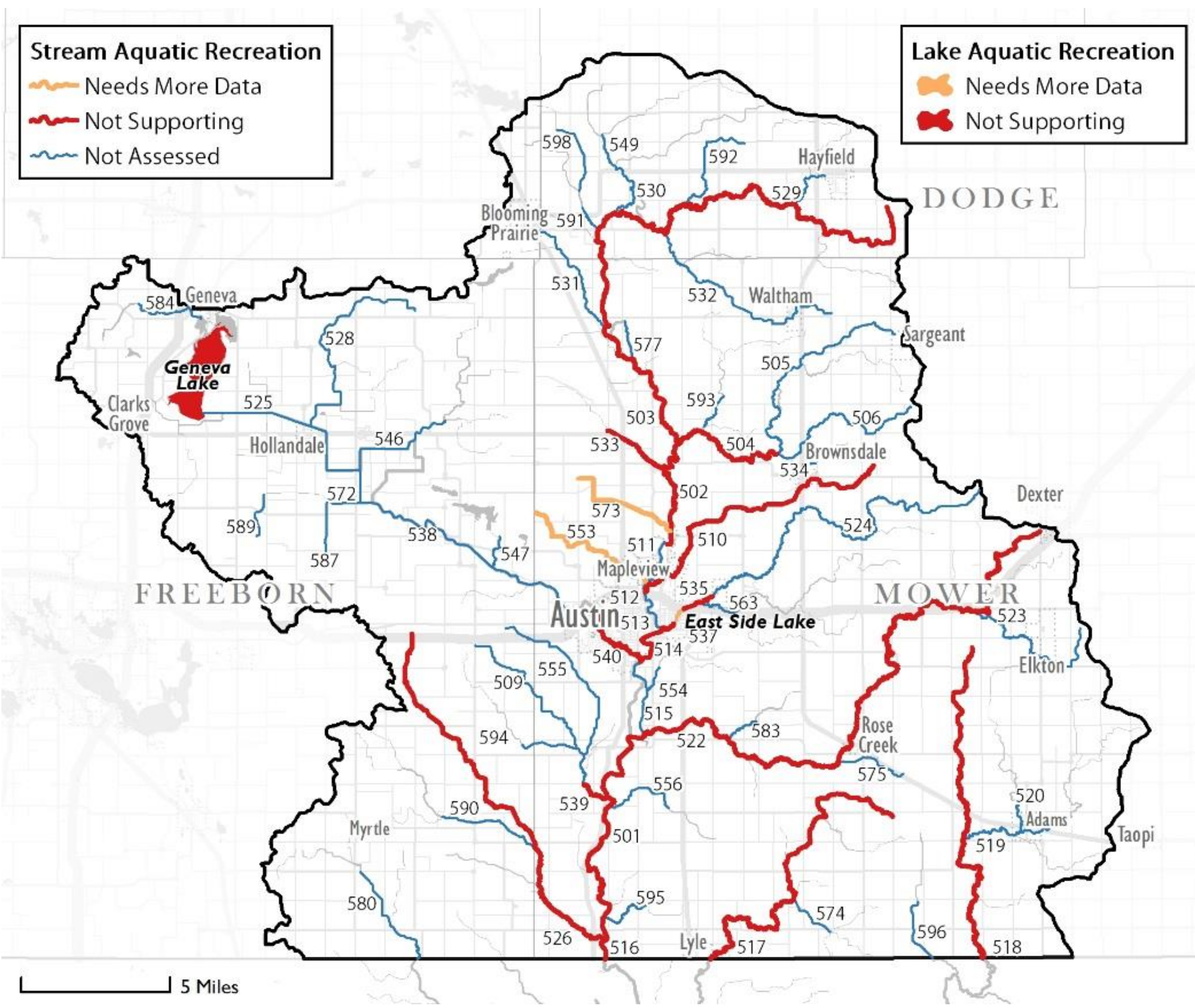


Figure 7. Aquatic recreation assessments

Aquatic recreation use impairments (non-supporting assessments) include Escherichia coli (E. coli); a bacteria, found in the intestinal tracts of warm-blooded animals, which is an indicator of fecal pollution levels that are too high for safe human contact (wading or swimming).



Using indicator bacteria to assess the presence of pathogens in not a perfect process, though it is the best available at this time. Higher levels of *E. coli* in the water may be accompanied by higher levels of pathogens and an increased risk of harm; varying survival rates of bacteria make is impossible to definitively state when pathogens are present. Figure 7 identifies the location of each of the AUIDs assessed for aquatic recreation.

Lakes

Lakes are assessed for aquatic recreation uses 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. To be listed as impaired, a lake must not meet water quality standards for TP and either chl-*a* or Secchi depth.

There are seven lakes in the CRW. The Upper Cedar River Subwatershed has East Side Lake and the Ramsey Mill Pond (on Cedar River mainstem in Austin). The Turtle Creek Subwatershed has an Unnamed (Hickory) Lake, and Geneva Lake. The Deer Creek Subwatershed has three small unnamed lakes/ponds (DOW 24-0079-00, 24-0070-00, 24-0072-00).

Of the seven lakes in the CRW, only Geneva Lake, a large shallow lake in the headwaters of Turtle Creek, had sufficient data for assessment. Geneva Lake was found to be non-supporting of aquatic recreation due to lake nutrient concentrations and low transparency (Table 1).

Table 1. Lake aquatic recreation use assessment and impairment summary

Watershed	Area (acres)	Total Lakes or Reservoirs	Lakes >10 Acres	Lake <10 Acres	Full Support	Non-support	Insufficient Data
Cedar River **HUC 8**	416,064	**7**	**7**	**0**	**0**	**1**	**6**
Middle Fork Cedar River	6,720	0	0	0	0	0	0
Roberts Creek	16,000	0	0	0	0	0	0
Upper Cedar River	21,376	2	2	0	0	0	2
Turtle Creek	24,960	2	2	0	0	1	1
Rose Creek	30,592	0	0	0	0	0	0
West Beaver Creek	37,568	0	0	0	0	0	0
Lower Cedar River	42,304	0	0	0	0	0	0
Otter Creek	46,272	0	0	0	0	0	0
Deer Creek	60,928	3	3	0	0	0	3
Little Cedar River	63,552	0	0	0	0	0	0
Elk River	65,792	0	0	0	0	0	0

2.2 Water Quality Trends

Table 2 displays water chemistry concentration data that were analyzed for trends for the long-term period of record (1967 through 2009) and near term period of record (1995 through 2009), for the Cedar River at Lansing, and the Cedar River below Austin (MPCA 2014). Trends that are statistically significant are based on a 90% confidence level. The designation of "no trend" means that there is no statistically significant trend, which can result from high variability or a small data set. Caution must be used when interpreting that decreasing concentration trends indicate overall improvement in the water quality, as water chemistry is one component of broader water quality conditions.

With those factors in mind, these data indicates decreasing overall trends in TSS, TP, BOD, and ammonia in the CRW. There was no trend in the near-term period for these four pollutants. No trend was observed for chloride; however, this may be the result of insufficient data, especially within the most recent time period. In general, these trends in the Cedar River are similar to what has been observed in other Southern Minnesota streams.

To illustrate the decreasing concentration trend for TSS, the Cedar River below Austin had a median (June through August as a summer median) TSS concentration of 42 mg/L from 1967 through 1976, while the median TSS concentration from 2000 through 2009 was 34 mg/L.

Even with the significant decreases in TSS, many segments of the CRW remain impaired and further reductions are required.

However, because of increase in river flows in the CRW, it is not known if decreasing concentration trends are related to less pollutants (total mass) entering the river, or if this is a result of dilution from additional water in the CRW. Further details can be found in both the CRW Monitoring and Assessment Report (MPCA 2012) and the Milestone Stream Sites trend report (MPCA 2014).

There were significant increases in nitrite/nitrate concentrations during the long-term period of record for both stations, and additionally for the short-term period for the Cedar River below Austin. During the first 10 years of the time period, NO3/NO2 median concentration (June through August as a summer median) were 2 and 3 mg/L, while the median concentrations for the most recent 10-year period, were 8 and 9 mg/l, respectively.

Table 2. Water quality trends in the Cedar River Watershed

Trend Period	Total Suspended Solids	Total Phosphorus	Nitrite/Nitrate	Ammonia	Biochemical Oxygen Demand	Chloride
At CSAH-2, 0.5 Miles E of Lansing (CD-24)						
Overall trend (1967 - 2009)	Decrease -71%	Decrease -58%	Increase + 294%	Decrease -50%	Decrease -83%	No trend
Recent trend (1995 - 2009)	No trend	No trend	No trend	No trend	No trend	Little data
At CSAH-4, 3 Miles S of Austin (CD-10)						
Overall trend (1967 - 2009)	Decrease -71%	Decrease -72%	Increase +193%	Decrease -90%	Decrease -82%	No trend
Recent trend (1995 - 2009)	No trend	No trend	Increase +53%	No trend	No trend	Little data

In another assessment of N and phosphorus transport in the Cedar River Basin (both Minnesota and Iowa), USGS (2018) reports an average annual runoff of 11.4" for the Cedar River in Minnesota (2000 through 2015), which carries an average annual nitrate-N yield of 24.5 lbs/acre, and an average annual total P yield of 0.981 lbs/acre (both yields are for 2007 through 2015 only). This report concluded that the amount of N and P transported from the Minnesota portion of the Cedar watershed did not change significantly ($p>0.05$) during 2000 through 2015.

When assessing these water chemistry reports, keep in mind that the MPCA report used only concentration data, while the USGS methods calculated pollutant loads – and different time periods were employed for each effort.

Longer-term trends at biological monitoring stations are another means of tracking stream water quality. The MPCA's South Biological Monitoring Unit maintains two long-term biological monitoring (LTBM) stations in the CRW, Roberts Creek and Woodbury Creek. These stations are monitored every other year on average, collecting fish and macroinvertebrate community data as well as physical habitat and some limited water chemistry data. For biological data, lower scores mean poorer water quality, and higher scores are better water quality. When scores fall below a threshold value, biological impairment is indicated. These stations are part of a statewide network that represent examples of least-disturbed watershed conditions across a framework of regional and stream type classifications (e.g., *Southern Streams Glide-Pool*). Where possible, these stations are co-located with existing flow monitoring gages to provide further context for the observed variability in biological communities over time. Roberts Creek at 550th Avenue is a LTBM site established in 2013 and is co-located with Mower SWCD station S001-182. Preliminary results indicate that this station consistently scores in the high 40s for the F-IBI (just below the impairment threshold –i.e. is impaired) and in the 60s for the M-IBI (well above the threshold, i.e. is not impaired). This station is classified as a *Southern Stream* for the F-IBI and as a *Southern Forest Streams – Glide Pool* for the M-IBI. The other LTBM station in this watershed is

Woodbury Creek at 110th Street, and it was established in 2014 and is co-located with Mower SWCD station S004-868. In 2009, this station scored well on the M-IBI (57, not impaired) but has since dipped into the 30s (i.e. this would result in a biological impairment, if consistently maintained) during the last two monitoring visits. F-IBI scores have remained above the impairment threshold on a stream that was considered fully supporting of aquatic life during the 2011 IWM assessments, and thus no F-IBI impairment would be called for

2.3 Stressors and Sources

In order to develop appropriate strategies for restoring or protecting waterbodies, the stressors and sources impacting or threatening them must be identified and evaluated.

A **stressor** is something that adversely impacts or causes fish and macroinvertebrate communities in streams to become unhealthy. Biological stressor identification (SID) is done for streams with either fish or macroinvertebrate biota impairments, and encompasses both evaluation of pollutants (such as nitrate- N, phosphorus, and/or sediment) and non-pollutant-related factors as potential stressors (e.g., altered hydrology, fish passage, dissolved oxygen (DO), habitat).

Pollutant source assessments are completed where a biological SID process identifies a pollutant as a stressor, as well as for typical pollutant impairment listings such as TSSs. Pollutants to lakes and streams include point sources (such as permitted sewage treatment plants) or nonpoint sources (such as runoff from the land).

Stressors of Biologically-Impaired Stream Reaches

A SID study (MPCA 2016) was conducted to identify the factors (i.e., stressors) that are causing the fish and macroinvertebrate community impairments in the CRW, including both pollutants and non-pollutants. Table 4 summarizes the primary stressors identified in streams with aquatic life impairments in the CRW. The most prevalent stressors were habitat/bedded sediment, nitrate- N, and flow alteration – each summarized below:

- **Lack of Habitat/Bedded Sediment:** excess fine sediment that deposits on the bottom of stream beds negatively impacts fish and macroinvertebrates that depend on clean, coarse stream bottoms for feeding, shelter, and reproduction. Throughout the CRW, qualitative habitat was measured with the Minnesota Stream Habitat Assessment (MSHA) (Figure 8). The MSHA is useful in describing the aspects of habitat needed to obtain an optimal biological community. It includes five subcategories: land use, riparian zone, substrate, cover, and channel morphology. The total score can be broken up into poor (<45), fair (45-66) and good (>66) categories.

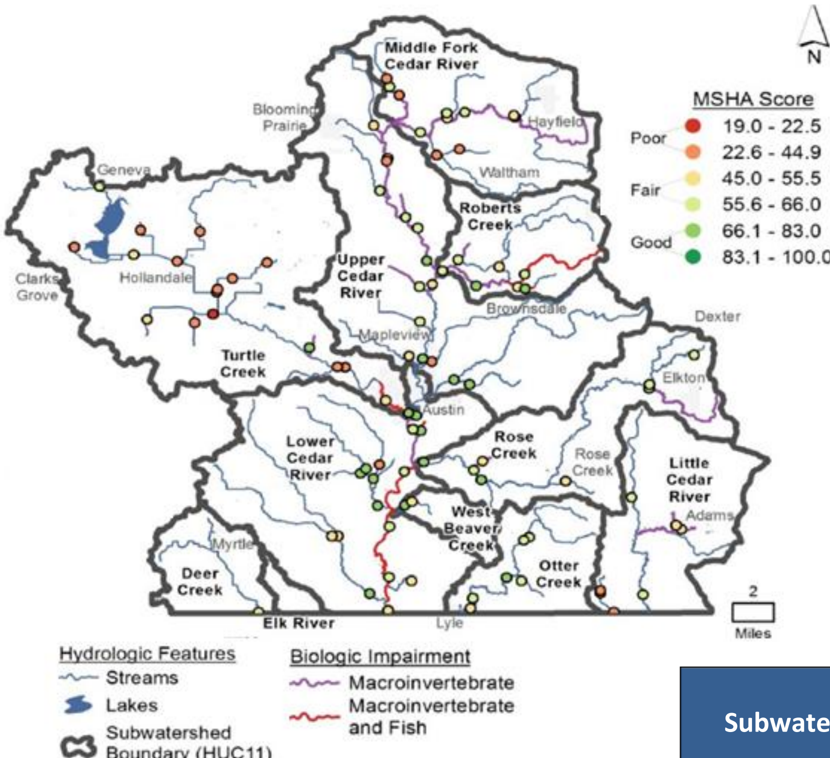


Figure 8. MSHA score and assessment locations

The Turtle Creek watershed is the only subwatershed to have an overall MSHA rating of poor. A significant portion of the subwatershed is ditched and many of the channelized reaches were rated poor habitat.

Subwatershed	Average MSHA Score	MSHA Rating
Middle Fork Cedar	49.8	Fair
Robert Creek	59.5	Fair
Upper Cedar River	58.6	Fair
Turtle Creek	43.9	Poor
Rose Creek	64.5	Fair
West Beaver Creek	61.2	Fair
Lower Cedar River	59.1	Fair
Otter Creek	61.1	Fair
Deer Creek	87	Good
Little Cedar River	45.5	Fair

At each of the biological monitoring sites, stream channel stability information is evaluated and a Channel Condition and Stability Index (CCSI) rating is determined. The CCSI rating provides an indication of stream channel geomorphic stability and loss of habitat quality, which may be related to changes in watershed hydrology, stream gradient, sediment supply, or sediment transport capacity. The CCSI rates three regions of the stream channel (upper banks, lower banks and bottom). Table 3 provides the average CCSI rating for each HUC-11 in the Cedar along with the number of locations with individual ratings.

Table 3. Cedar River Watershed Channel Condition and Stability Index ratings

		Number of locations within HUC-11 by CCSI rating				
HUC -11 name	CCSI Average for HUC-11	stable	fairly stable	moderately unstable	severely unstable	extremely unstable
Middle Fork Cedar River	moderately unstable	0	2	6	0	0
Roberts Creek	moderately unstable	0	1	5	0	0
Upper Cedar	moderately unstable	0	6	6	1	0
Turtle Creek	moderately unstable	0	2	10	0	0
Rose Creek	moderately unstable	0	1	2	2	0
West Beaver Creek	fairly stable	0	1	0	0	0
Lower Cedar River	moderately unstable	0	5	5	2	0
Otter Creek	moderately unstable	0	0	2	1	0
Deer Creek	severely unstable	0	0	0	1	0
Little Cedar River	moderately unstable	0	2	2	2	0

- **Elevated nitrate-nitrogen:** elevated levels of nitrate in streams can be toxic to fish and macroinvertebrates, especially for certain species of caddisflies, amphipods, and salmonid fishes. Nitrate toxicity to freshwater aquatic life is dependent on concentration and exposure time, as well as the overall sensitivity of the organism(s) in question. Camargo et al (2005) cited a maximum level of 2 mg/L nitrate-N as appropriate for protecting the most sensitive freshwater species, although in the same review paper, the authors also offered a recommendation of NO_3 concentrations under 10 mg/L as protective of several sensitive fish and aquatic macroinvertebrate taxa. Further discussion of N occurs in the SID report (MPCA 2016) and in Section 2.4 of this report.
- **Flow Alteration/Altered hydrology**: Flow alteration is the change of a stream's flow volume and/or flow pattern (low flows, intermittent flows, increased surface runoff, and highly variable flows) typically caused by anthropogenic activities, which can include channel alteration, water withdrawals, land cover alteration, wetland drainage, agricultural tile drainage, urban stormwater runoff, and impoundment. Increasing surface water runoff and seasonal variability in stream flow have the potential for both indirect and direct effects on fish populations (Schlosser 1990). Indirect effects include alteration in habitat suitability, nutrient cycling, production processes, and food availability. Direct effects include decreased survival of early life stages and potentially lethal temperature and oxygen stress on adult fish (Bell 2006). Increased channel shear stress, associated with increased flows, results in increased scouring and bank destabilization. The fish and macroinvertebrate communities may be influenced by the negative changes via loss of habitat and increased sediment. Further discussion of altered hydrology occurs in Section 2.4 of this report.

Table 4. Summary of stressors causing biological impairment in Cedar River Watershed streams by location (AUID). MPCA 2016.

HUC-11 Subwatershed	Stream	AUID Last 3 digits	Biological Impairment	Stressor: Lack of Habitat/ Bedded Sediment	Stressor: Elevated Nitrate	Stressor: Low Dissolved Oxygen	Stressor: Elevated Nutrients Phosphorus	Stressor: Sediment/Turbidity	Stressor: Altered Hydrology
● Determined to be a direct stressor		O Inconclusive candidate cause		■ Not an identified stressor					
Middle Fork Cedar River	Cedar River, Middle Fork	549	Macroinvertebrates	●	O	O	O	O	●
	Cedar River, Middle Fork	530	Macroinvertebrates	●	●	●		O	●
Roberts Creek	Unnamed creek	531	Fish, Macroinvertebrates	●	●	O	O	O	●
	Roberts Creek	506	Fish, Macroinvertebrates	●	●	O		O	●
	Unnamed creek	593	Macroinvertebrates	●	●	O	O	O	●
	Roberts Creek	504	Macroinvertebrates	●	●	O	●	O	●
Upper Cedar River	Unnamed creek (Cedar River, West Fork)	591	Macroinvertebrates		O	O	O	O	●
	Unnamed creek	577	Macroinvertebrates	●	●	O	O	O	●
	Cedar River	503	Macroinvertebrates	●	●	●	●	●	●
	Unnamed creek	533	Macroinvertebrates	●	●		●	●	●
Turtle Creek	Unnamed creek	547	Macroinvertebrates		O	O	O	O	●
	Turtle Creek	540	Fish, Macroinvertebrates	●	●	●	●	●	●
Rose Creek	Schwerin Creek	523	Macroinvertebrates	●	●	O	O	O	●
	Unnamed creek	583	Macroinvertebrates	●	●	O	●	●	●
Lower Cedar River	Unnamed creek	554	Fish, Macroinvertebrates	●			O	O	●
	Cedar River	515	Macroinvertebrates	●	●	●	●	O	●
	Cedar River	501	Fish, Macroinvertebrates	●	●		●	●	●
Little Cedar River	Unnamed creek	520	Macroinvertebrates	●	●	O	O	O	●
	Unnamed creek	519	Macroinvertebrates	●	●	O	O	O	●

2.4 Pollutants and Sources

Point Sources

Point sources are defined as regulated facilities that discharge stormwater or wastewater to a lake or stream and have a National Pollutant Discharge Elimination System (NPDES) or State Disposal System (SDS) permit. There are 10 municipal wastewater facilities, 3 industrial wastewater facilities and 1 large subsurface wastewater treatment system that require NPDES permitting located in the CRW (Table 5 and Figure 9).

Table 5. Point Sources in the Cedar River Watershed

HUC-10 Subshed	Point Source Name	Permit #	Type	Receiving water body	Receiving water impaired
Headwaters Cedar River	Austin Utilities - Northeast Power Plant	MN0025810	Industrial Wastewater	Cedar River	Yes
	Arkema	MN0041521		Unnamed ditch	No
	Hormel Foods Corp	MN0050911		Cedar River	Yes
	Austin WWTP	MN0022683	Municipal Wastewater	Cedar River	Yes
	Blooming Prairie WWTP	MN0021822		Unnamed creek	No
	Brownsdale WWTP	MN0022934		Roberts Creek	yes
	Sargeant WWTP	MNG580214		Unnamed creek	No
	Lansing Township WWTP	MN0063461		Cedar River	Yes
	Waltham WWTP	MN0025186		Unnamed Creek	No
Turtle Creek	Hollandale WWTP	MN0048992	Municipal Wastewater	Mud Creek Branch of Judicial Ditch No. 24	No
Rose Creek	Beaver Trails Campgrounds & RV Park Inc	MN0064840	Large Subsurface Treatment System	No surface Discharge	NA
	Elkton WWTP	MNG580013	Municipal Wastewater	Schwerin Creek	Yes
Lower Cedar River	Oakland Sanitary District WWTP	MN0040631	Municipal Wastewater	Unnamed ditch	No
Little Cedar River	Adams WWTP	MN0021261	Municipal Wastewater	Little Cedar River	Yes

* See the CRW TMDL Study for specific NPDES permit requirements

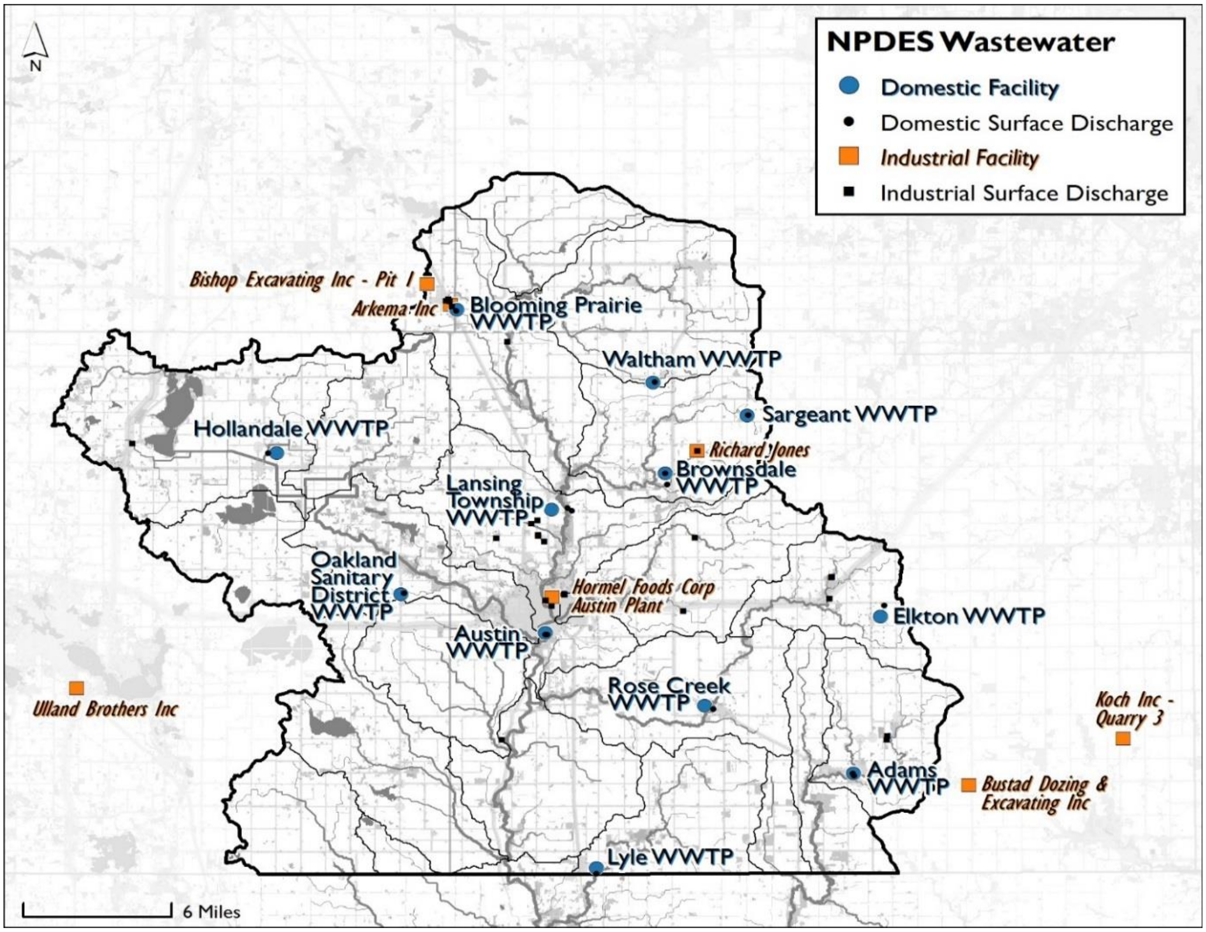


Figure 9. Point source locations in the Cedar River Watershed

Construction Stormwater

Construction activities cause soil disturbance and result in the removal of protective vegetation. While construction sites are localized, and temporary in nature, significant erosion and sediment loss can occur from improperly managed sites. From 2008 through May 2018, about 100 construction stormwater permits were issued within Mower County, with 58 of those in the city of Austin.

Septic Systems

Septic systems that are not maintained or failing can contribute excess phosphorus, N, and bacteria. The MPCA collects data yearly from local government units on subsurface sewage treatment systems (SSTS). Estimations are made on the number of: total SSTS systems, the number of compliant systems, number of systems failing to protect ground water (failing) and the number of imminent public health threats (IPHT) which may include straight pipes. Data is reported only to the county level, or to the township level if the township has elected jurisdiction, so data specific to the CRW is not available. Without site-specific data, it is difficult to provide SSTS data specific to the CRW. However, using overall county data could indicate potential SSTS compliance percentage within the watershed. Figure 10 provides countywide estimates for SSTS compliance for counties in the CRW.

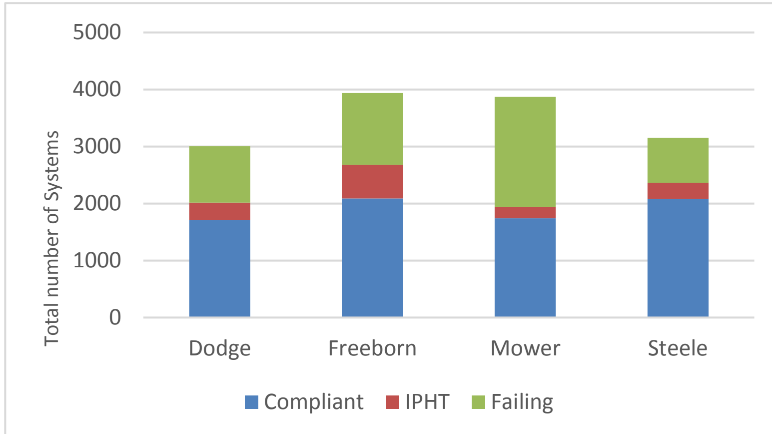


Figure 10. SSTS compliance rate estimates by county

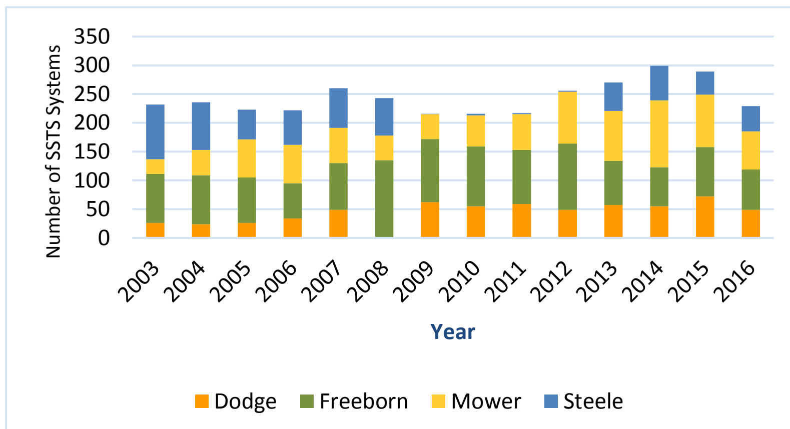


Figure 11. SSTS repaired or replaced each year within each county

Each of the counties within the CRW, at a minimum, have a "Point of Sale" inspection requirement within their local ordinance indicating that a SSTS compliance inspection is required at property transfer. On average, the four counties in the CRW inspect 1% to 3% of the SSTS yearly within their respective counties. Even though there is potentially a significant number of failing and IPHT systems in the CRW, they are unlikely to contribute substantial amounts of pollutants and stressors to the total annual loads in the CRW, when compared to other sources. However, the impacts of failing SSTS on water quality may be pronounced in areas with high concentrations of failing SSTS or at times of low precipitation and/or flow. A watershed wide SSTS inventory with compliance inspections would help quantify the potential impact SSTS have on the CRW. Progress on replacing failing and IPHT systems is occurring within the four counties. Since 2003, on average 243 systems are replaced or repaired each year within the four counties (Figure 11).

Undersewered/Unsewered Communities

Undersewered/unsewered community is defined as a cluster of five or more houses or businesses that are each situated on one-acre lots or less that have inadequate wastewater treatment. This may range from a community having failing individual systems to small cities with inadequate collection and treatment infrastructure. An inventory of these communities located in the CRW was completed for the Lower Mississippi River Basin Regional Fecal Bacteria TMDL in 2002. The inventory identified 16 communities, which were considered undersewered/unsewered. Since this inventory, 11 communities have been corrected via annexation into a city, community development of a proper wastewater system, or evaluation of individual systems that determined compliance. The five remaining communities are at various stages of becoming “sewered” and continued local support is needed to ensure the completion of the projects.

Feedlots and manure application

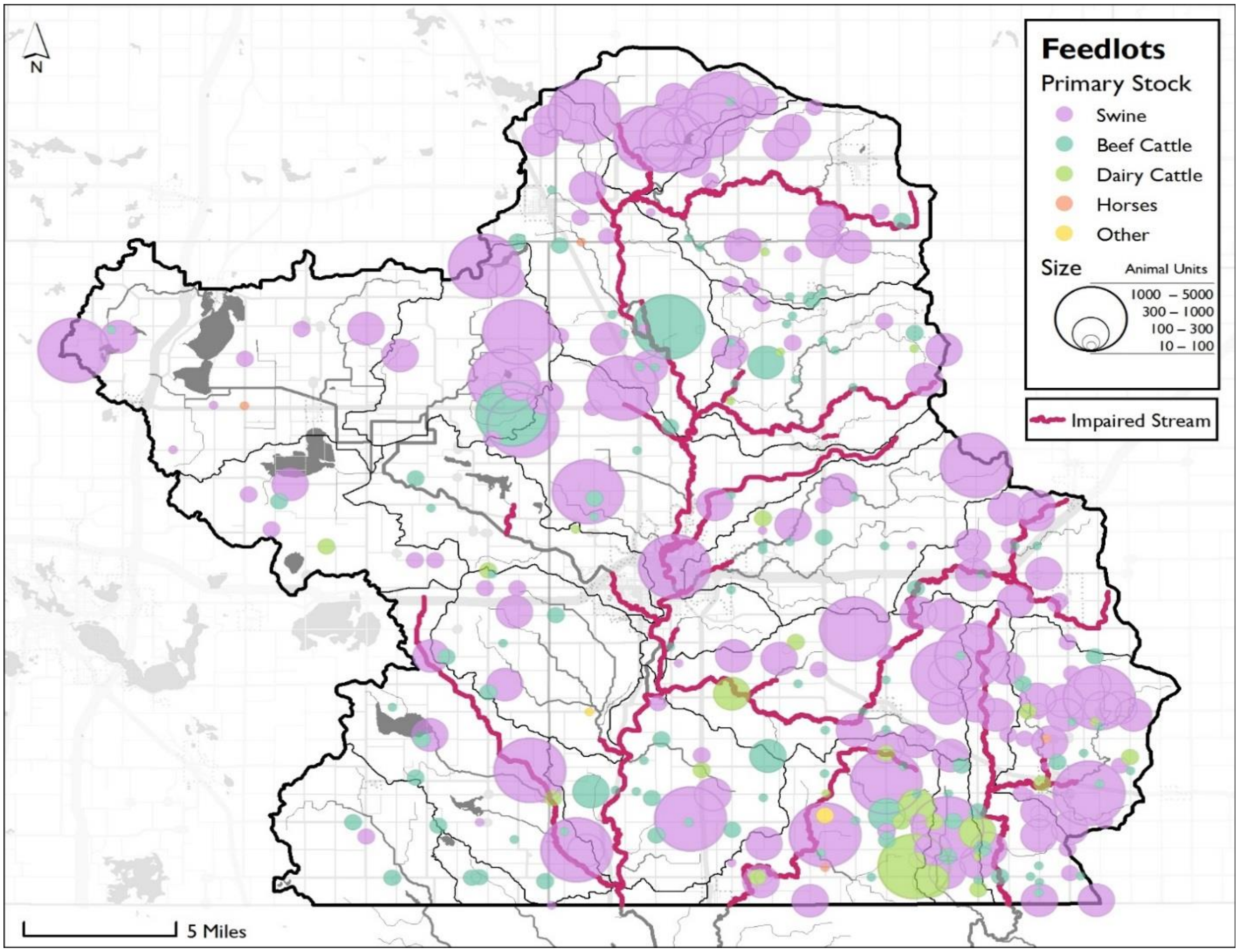


Figure 12. Feedlot locations with approximate feedlot size and animal type

Manure contains high concentrations of phosphorus, N, and bacteria that can runoff into lakes and streams when not properly managed. Of the 375 feedlots in the CRW (Figure 12), there are 38 active NPDES permitted operations, 35 of which are Concentrated Animal Feeding Operations (CAFOs). The MPCA currently uses the federal definition of a CAFO in its regulation of animal feedlots. In Minnesota, the following types of livestock facilities are issued, and must operate under, a NPDES Permit: a) all federally defined CAFOs, some of which are under 1000 AUs in size; and b) all CAFOs and non-CAFOs, which have 1000 or more AUs. These feedlots must be designed to totally contain runoff, and manure management planning requirements are more stringent than for smaller feedlots. In accordance with the state of Minnesota’s agreement with EPA, CAFOs with state-issued General NPDES Permits must be inspected twice during every five-year permitting cycle and CAFOs with state issued Individual NPDES Permits are inspected annually. Freeborn, Mower and Steele counties are “delegated” counties to implement and enforce the MPCA feedlot rules Minn. R. 7020.

While feedlot sites are not considered one of the major sources of phosphorus to the Cedar River (MPCA 2014), local impacts to water resources in the CRW could in some cases be significant. Data indicate that there are 41 feedlots located in shoreland (within 1,000 feet of a lake or 300 feet of a river/stream). Of the 41 feedlots in shoreland, 29 have open lots and of those, four feedlots have Open Lot Agreements (OLA). Feedlots in shoreland with an open lot with or without an OLA should be a priority for feedlot inspections, and feedlot fixes if necessary, as they present the highest potential for runoff pollution.

Swine are approximately 80% of the 135,556 AUs in the CRW (Figure 13). Of that number, 87% are located on facilities with 300 or more AUs. This information would indicate that the majority of the manure within the CRW is applied as liquid manure that is generally injected or immediately incorporated. Properly injected/incorporated manure presents a lower risk for runoff containing phosphorus and bacteria. Beef (14%), dairy (6%) and turkey (<1%) make up the majority of the remaining AUs in the CRW. Generally, these types of manure are handled as solid manure and additional steps are needed in the application process to ensure the manure is incorporated. Solid manure left on the surface and not incorporated into the soil prior to a rainfall or a runoff event presents an elevated risk for contaminated runoff.

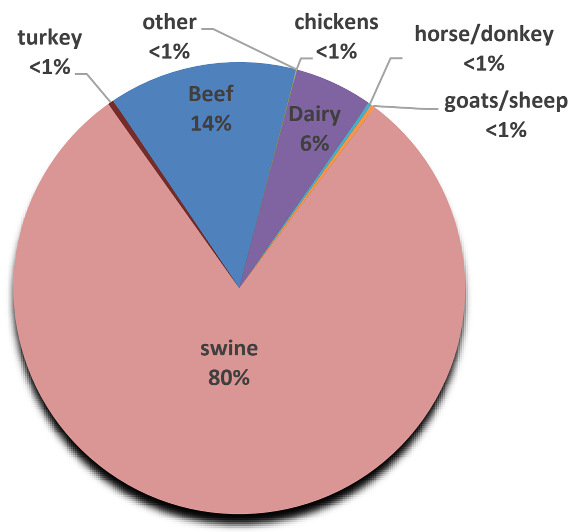


Figure 13. Animal types in the Cedar River Watershed

The Minnesota Department of Agriculture (MDA) has recently developed an interactive model to assist livestock producers to evaluate the potential runoff risk for manure applications, based on weather forecasts for temperature and precipitation along with soil moisture content. The model can be customized to specific locations. It is advised that all producers applying manure utilize the model to determine the runoff risk, and use caution when the risk is “medium” and avoid manure application during “high” risk times. For more information and to sign up for runoff risk alerts from the MDA Runoff Risk Advisory Forecast, please see the MDA website.

Commercial fertilizer use in combination with manure is an issue for consideration in the CRW. The MDA has partnered with the National Agricultural Statistics Service (NASS) to survey Minnesota corn growers to assess the status of N use and BMPs awareness on corn acres throughout Minnesota. The most recent survey was conducted in early 2015 to assess the N use on corn grown in 2014. The survey evaluated N use from commercial sources and manure. In 2017 the MDA released two companion documents: Commercial Nitrogen and Manure Fertilizer Selection and Management Practices Associated with Minnesota 2014 Corn Crop and Commercial Nitrogen and Manure Fertilizer Application on Minnesota 2014 Corn Crop Compared to the University of Minnesota Nitrogen Guidelines detailing the findings of the survey. The results were aggregated to either the county level or the MDA defined BMP region. All the counties within the CRW were associated with the South Central BMP region, which has a total of 18 counties in south central Minnesota. The number of respondents to the survey and number of corn acres operated by the respondents are shown in Table 6.

	Manure Applied (main nitrogen source)		Acres Where Nitrogen Was Applied (all sources)	
County	**Number of Respondents**	**Total Corn Acres (in survey)**	**Number of Respondents**	**Total Corn Acres (in survey)**
Dodge	7	843	28	11,120
Freeborn	19	2,187	47	15,105
Mower	11	2,431	30	11,560
Steele	11	1,273	28	11,120
SC Region total (18 counties)	236	28,372	580	171,613

Table 6. Number of respondents and corn acres under the control of the respondents

Figure 14 and Figure 15 show the range of N rates when manure is applied, with or without additional commercial N fertilizer, in the South Central BMP region. In 2014, the University of Minnesota Extension Service (UMN-ES) recommendation for N fertilizer on corn following corn was 155 lbs N/acre with an acceptable range of 130 – 180 lb N/acre. For corn following soybeans, the recommendation is 120 lbs

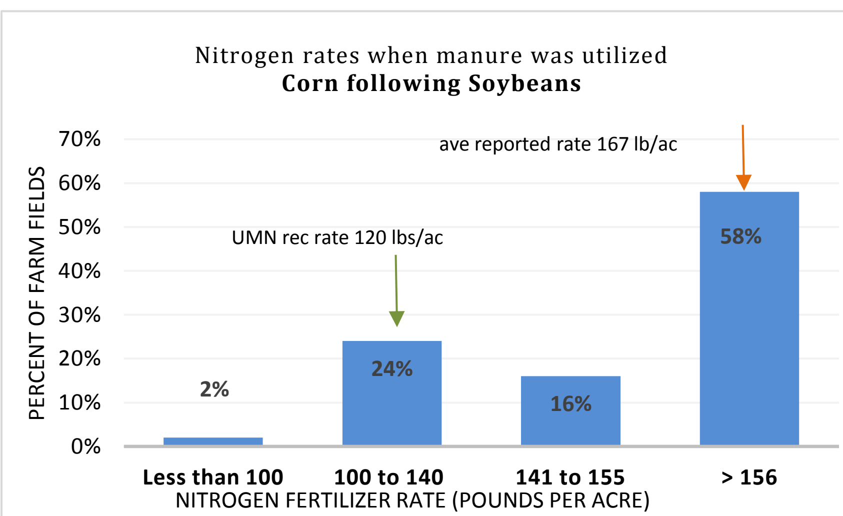


Figure 14. Nitrogen rates when manure was utilized as a nitrogen source (Corn following Soybeans)
74% of the fields, that were part of the survey, had a nitrogen rate that was above the UMN-ES recommended rate with the average reported rate of 167 pounds of nitrogen per acre. Nitrogen rates included nitrogen from manure and any additional commercial nitrogen fertilizer.

N/acre with an acceptable range of 100 – 140 lbs N/acre. Survey results indicate that 74% of the acres, that were part of the survey, had above the UMN-ES N recommendation when corn followed soybeans. This percent dropped to 39% when corn followed corn. While this survey data is not specific to the CRW, nor does it indicate all manure applications, it does indicate that there is a potential that over application of N may be occurring when manure is being used as a N source. County Feedlot Officers, and other personnel working with livestock farmers, should continue to educate feedlot producers of proper manure management planning, and continue to review feedlot manure application records in the CRW to ensure application of manure is in compliance with Minn R. 7020.

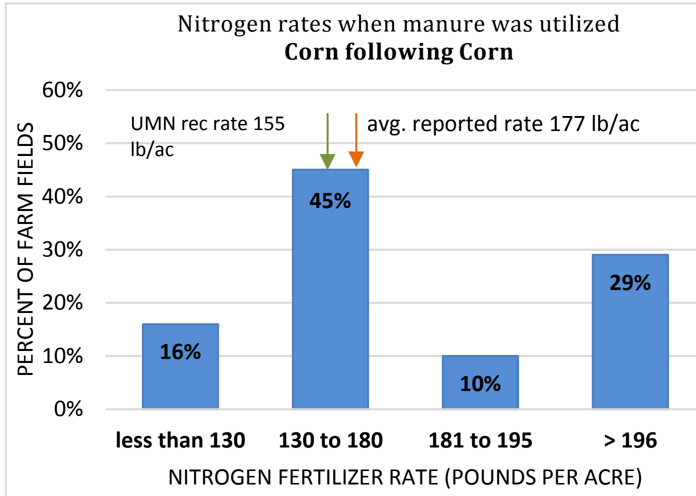


Figure 15. Nitrogen rates when manure is utilized (Corn following Corn)
39% of the fields, that were part of the survey, had a nitrogen rates that was above the UMN-ES recommendation. The average rate of 177 pounds per acre of nitrogen was within the recommended rate. Nitrogen rates included nitrogen from manure and any additional commercial nitrogen fertilizer.

Nonpoint Sources

Nonpoint sources of pollution, unlike pollution from industrial and sewage treatment plants come from many diffuse sources. Nonpoint source pollution is caused by rainfall or snowmelt moving over and through the ground. As the runoff moves, it picks up and carries away natural and human-made pollutants, where they affect the quality of lakes and streams. The common nonpoint pollutants of phosphorus, bacteria, N and sediment are summarized below. Altered hydrology, normally a biological stressor and not a pollutant, is also discussed in this section, as it is often greatly influences the pollutants common in the CRW.

Altered Hydrology

Hydrology is the study of the distribution and circulation of water on and below the earth's surface and in the atmosphere (USGS 2014b). Hydrology is interconnected in a landscape; for example, the rate of evapotranspiration on the land impacts the amount of water reaching a stream. Changes in river flow are the result of other hydrologic alterations. Altered hydrology refers to changes in hydrologic parameters including: river flow, precipitation, drainage, impervious surfaces, wetlands, river paths, vegetation, soil conditions, evaporation, evapotranspiration, etc. Altered hydrology can directly harm aquatic life by affecting the amount of water in the water body. Both too little and too much stream flow can harm aquatic life. Stream flow naturally varies over time, which is good for the plants and animals that are in the aquatic environment, but when this pattern is altered too much it has been found to negatively impact aquatic life (Caddis). Furthermore, altered hydrology accelerates the movement and amount of other pollutants and stressors (nutrients, sediment, etc.) to water bodies.

Status

Altered hydrology was a commonly identified stressor to aquatic life in the CRW, found to affect all the investigated stream reaches (Table 4). Both high and low river flow conditions were identified as problematic in the watershed. Since altered hydrology is not a pollutant by itself, it is only investigated when a bio-impairment is identified. The sources of altered hydrology are common across the watershed. Therefore, altered hydrology is likely negatively impacting water quality watershed-wide.

A long term (since about 1910) stream flow record is available for the Cedar River below Austin, at the stream monitoring site maintained by the USGS (Gage # 0457000). Data from this station was used to calculate the runoff ratio, which is a measure of the amount of precipitation that ends up as runoff. A runoff ratio provides an estimation of the amount of rainfall that does not infiltrate nor is taken up by evapotranspiration, and thus ends up as runoff. Runoff ratio is controlled to some extent by natural factors. Soil type and slope have the largest natural influence on the runoff ratio. Soils containing clay or silt absorb less water than sandy soils and thus produce higher runoff ratios. Watersheds with steep slopes tend to shed more water and infiltrate less due to rapid runoff and will also have higher runoff ratios. These natural factors affecting the runoff ratio are stable and should not change much over time. However, human alteration of the landscape also affects runoff ratio and these changes can be seen in variations in runoff and runoff ratio over time. The runoff ratio for the CRW when using data from 2008 to 2012 is calculated at 0.33 (10.49” of runoff with 31.03” of precipitation), which is higher than many

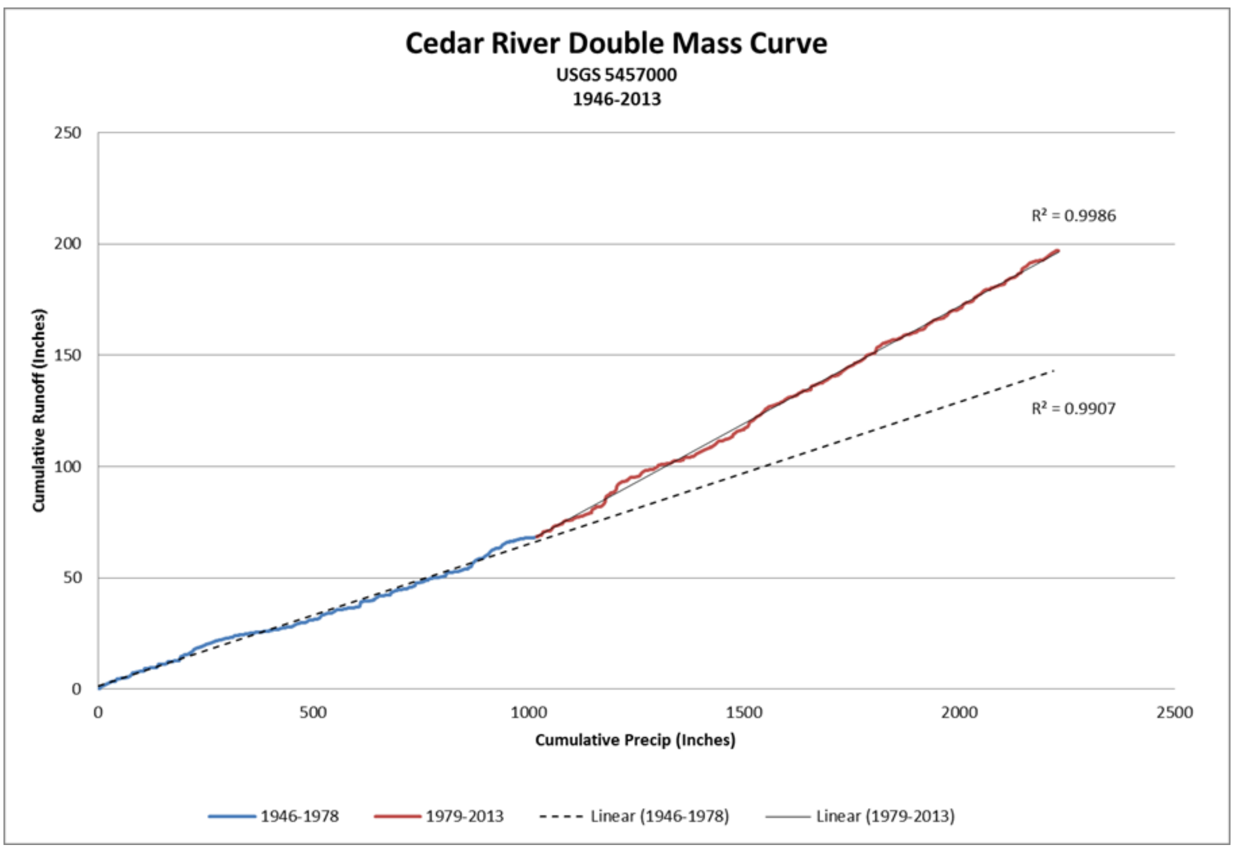


Figure 16. Cedar River runoff ratio double mass curve
In 1979, a distinct change is seen in the slope when comparing runoff to precipitation, indicating that the rate of runoff is increasing faster than the increase in precipitation (prepared by MDNR).

watersheds in Minnesota but consistent with other watersheds in southeast Minnesota. Recent statistical analysis of historical runoff and runoff ratio shows that stream flows in the CRW have significantly increased during the timeframe of 1981-2010, when compared with the entire period of record. Since 1979, there has been a significant increase in the runoff ratio in the CRW (DNR) (Figure 16).

The change in slope relationship indicates runoff from the watershed is increasing relative to the amount of rain. Within the entire data set, both low and high annual precipitation volumes were recorded, suggesting that a period of wet or dry conditions does not affect this relationship. Looking at overall trends for the Cedar River (Figure 17), the discharge and precipitation values show the precipitation trend is fairly flat, while the discharge trend is increasing, thus supporting the analysis.

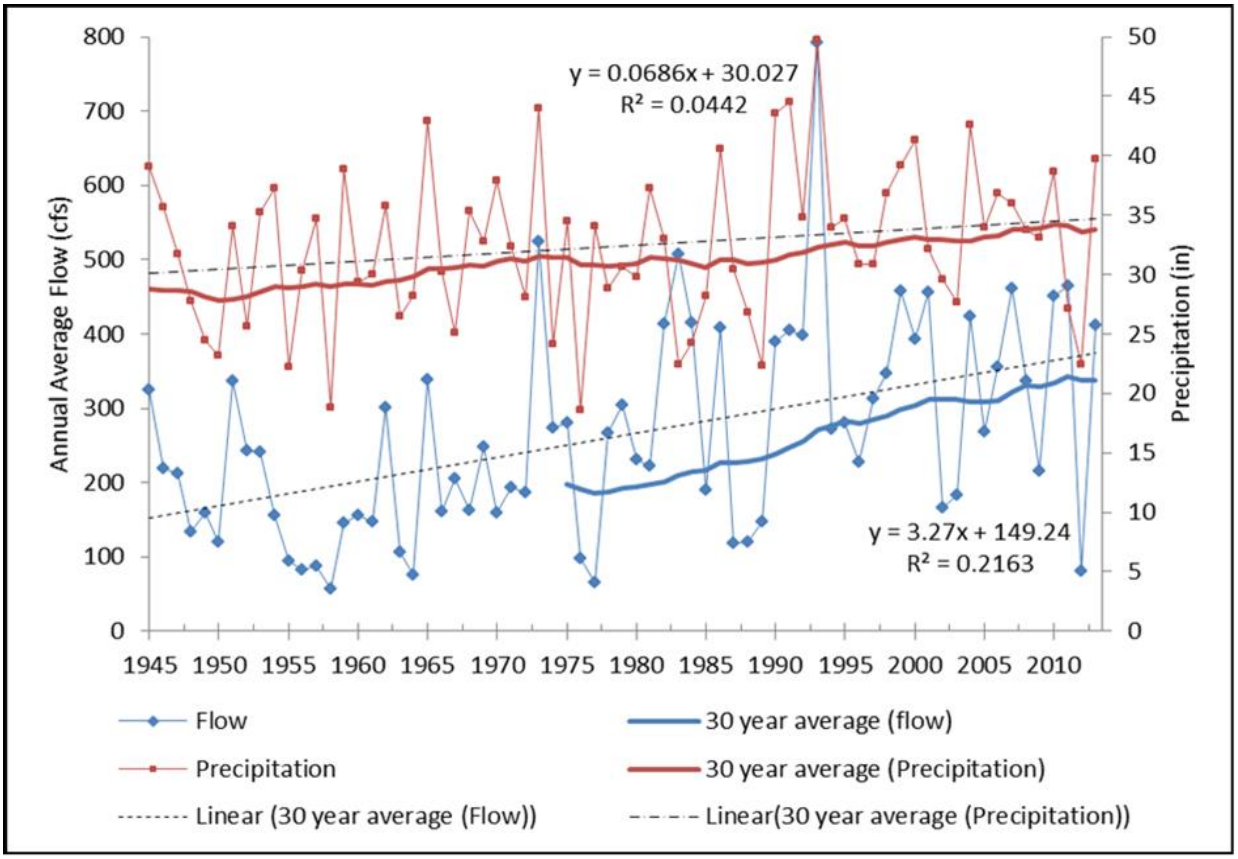


Figure 17. Cedar River Watershed precipitation and annual average river flows

Causes

Two recent studies have attempted to quantify the potential sources for altered hydrology. Barr Engineering completed a technical memorandum regarding the hydrologic trends, sources of additional runoff and implications for streambank erosion for each of the Minnesota watersheds (including the CRW), as a follow-up to the Detailed Phosphorus Assessment (Barr Engineering Company 2004). In their work, Barr determined that 50% of the trend can be attributed to climatic factors, while the remaining contribution is due to non-climatic factors attributed to changes within the watershed (such as drainage, urbanization and shifts in cropping). In the study titled "Twentieth Century Agricultural Drainage Creates More Erosive Rivers," Schottler et al. (2013) found a mean change in water yield for the Cedar River (at the USGS gauge near Austin) of 10 cm, when comparing two time periods (1940 through 1974, and 1975 through 2009). And comparing the same periods, the annual precipitation had a mean change of +7.4 cm. Through their analysis, the researchers hypothesized that about 3.5 cm is the result of a wetter climate, 6.3 cm for artificial drainage changes, and about 0.3 cm for crop conversion in the CRW. Of the 21 watersheds in the study, the CRW was one of the watersheds with the highest change in river flow (Figure 18).

Changes in cropping patterns affect hydrology by changing the landscape evapotranspiration rate (ET).

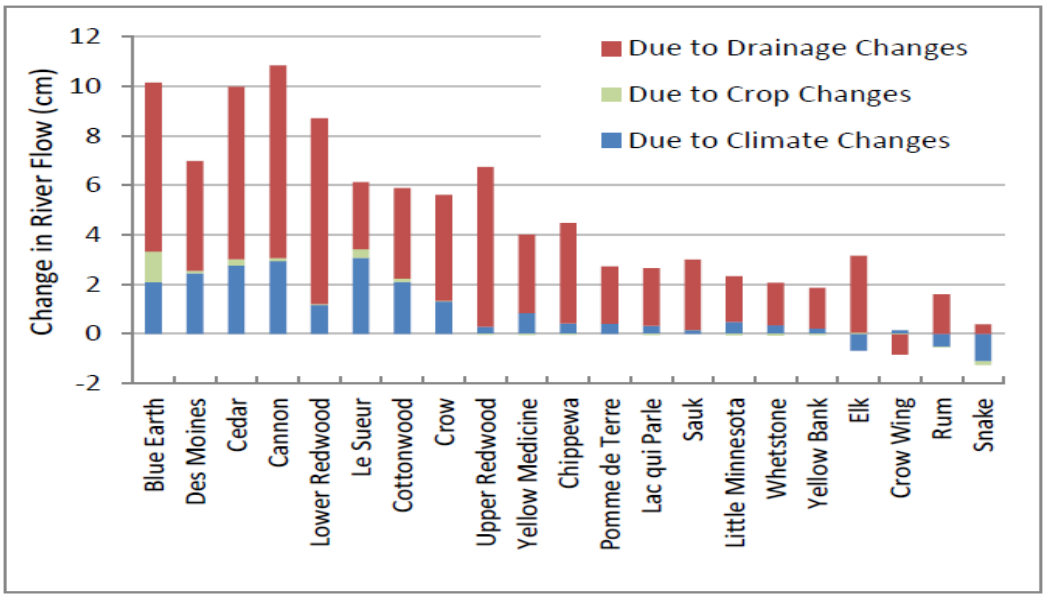


Figure 18. Reason for changes in river flow of various Minnesota Rivers.
The CRW has experienced a 10 cm increase in river flow when comparing two time periods (1940 through 1974, and 1975 through 2009). While some of the flow can be contributed to an increase in precipitation, the majority of the increase can be contributed to an increase in artificial drainage.

Figure 19 illustrates the monthly average ET of crops, grass, and wetlands and the monthly average precipitation (See Appendix C for details on how ET was calculated). The monthly average precipitation corresponds more closely to the ET of perennial crops such as hay and alfalfa. In contrast, corn and soybeans use much less water than precipitation supplies in the spring and much more than is supplied later in the summer. Therefore, a landscape that is almost exclusively corn and soybeans is less synced with historic precipitation patterns and more prone to exacerbate high flows in the spring and low flows in the later summer.

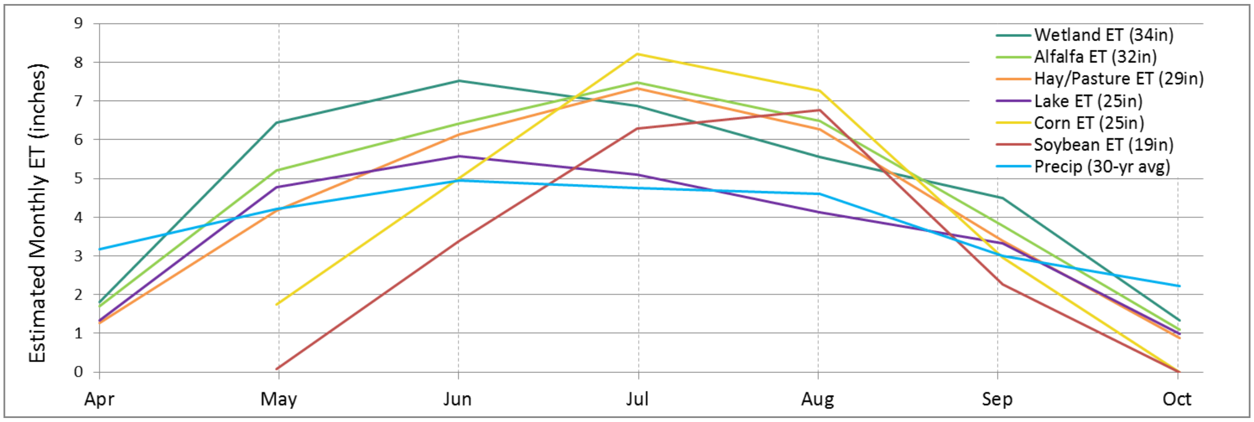


Figure 19. Estimated monthly evapotranspiration rates of various land covers

While there is some difference in the total yearly ET of alfalfa/hay/pasture and corn/soybeans, the biggest effects of changing crop patterns is the timing of the ET. Alfalfa, hay and pasture have significantly higher ET in spring (April, May and June) when compared to corn and soybeans. See Appendix C for information on how ET was calculated for various categories.

The CRW landscape has seen a significant shift to intensive row crop agriculture dominated by corn and soybeans over the past century. Moore et al. (2013) analyzed cropping shifts in the CRW for two 35-year time periods (1940 through 1974, and 1975 through 2009). The results in Table 7 show a doubling of acres in soybeans, an increase in corn acres and a reduction of more than half of the acres planted to alfalfa and small grains. Data from the 2016 United States Department of Agriculture (USDA) Crop Data Layer shows this trend continuing, with more corn and soybeans acres and less hay and small grains.

Time Period	% Agricultural	% Soybeans	% Corn	% Hay, Small Grains
1940-1974	66	14	27	25
1975-2009	77	31	38	8
2016	79.4	33.8	41.4	1.6

Table 7. Percent of acres by crop in the CRW

Agricultural drainage, by design, modifies the hydrology of a given area. The University of Minnesota outlines the potential impacts agricultural drainage may have on a watershed in the publication Fields to Streams, Managing Water in Rural Landscapes (2015):

- ***Reduce time that water is being stored in the soil.*** *Only drainable water is removed by tile and ditches. The amount of plant available water (i.e., water held by soil particles against the pull of gravity) is not affected by artificial drainage systems.*
- ***Change the pathway of water over land.*** *Some ditches and tile link streams to depressions (potholes) that were previously not connected, which could increase peak flows.*
- ***Reduce overland flow*** *(and soil erosion) if water instead moves through soil and subsurface tile. Overland flow still occurs on tiled land if surface soil structure is poor, blocking infiltration, or if the soil is saturated.*
- ***Decrease evaporation*** *by removing areas of standing water.*
- ***Increase annual transpiration*** *if rooting depth and productivity increase.*

- ***Increase the total amount of water that reaches streams*** *(annual yield). Models show that tiling increases the annual amount of water leaving the field.*
- ***Reduce, delay, and extend the peak flow in a stream*** *after a precipitation or snowmelt event (if water is moving through tile systems instead of overland). Water takes longer to travel through soil to a tile system than to move overland or through ditches. This means rainfall will reach a stream later than if it only flowed overland. Soil continues to drain long after an event, so elevated stream flow lasts longer than if the rain all reached the stream overland.*

The publication notes that while tile impacts within the field or at the field edge are understood, extrapolating to the watershed scale increases uncertainty of the overall impact of tile drainage. The hydrology of a watershed involves complex variables that under certain circumstances tile may increase and at other times may moderate. With so many variables, the overall impact of agricultural drainage systems on watershed hydrology are site specific and vary greatly based on the interplay of six important factors as identified in the publication:

- ***Type of drainage.*** *For example, drainage ditches may increase the rate of overland flow, while subsurface tile may reduce the amount of overland flow in favor of subsurface flow.*
- ***Scale of impacts.*** *The hydrologic impact at the edge of a field may not add up to the same effect in a stream. Watershed-wide impacts on a stream are much more complex than field-edge impacts and vary with different runoff events.*
- ***Precipitation patterns.*** *The amount of water in the soil before a snowmelt or rain event will determine the downstream impact of a drainage system – the more water in the soil before an event, the more surface runoff and tile flow. The size of the event also matters. Even with drainage tile, a short, heavy rainfall will generate more runoff than the same amount of precipitation in several lighter events.*
- ***Field conditions.*** *The soil management practices in a tiled field will affect flow to the tile.*
- ***The rest of the watershed.*** *The impact of ditches and tile may be large or small relative to other influences on hydrology in the watershed including the amount of lakes, wetlands, and other water storage; the amount of impervious surfaces; channelization of streams; the presence of dams and culverts; and climatic patterns.*
- ***System design and landscape details.*** *The type of soil and the capacity of the system – determined by tile size, spacing, depth, and outlet characteristics – have known hydrologic effects. Sands and Canelon (2013) modeled significant variation in ET, water yield, and surface runoff depending on the type of soil, precipitation, and drain spacing and depth*.

To assess the extent of subsurface tiles in the CRW, estimates were made using a common GIS analysis. Tile drainage areas were predicted using land cover (row crop) and soil hydrologic class (C and D). This method indicated that cropland with tile drainage accounted for 84% of all cropland acres in the CRW. When assessed from an entire watershed scale, about 65% of the overall watershed has tile drainage (Barr 2014).

A significant amount of watercourses, in the CRW, have been ditched or straightened for agricultural drainage. This altering of watercourses leads to an increase of speed water leaves the landscape. In its work for the Minnesota Statewide Altered Watercourse Project the MPCA, Minnesota Geospatial Information Office and DNR determined that 63.3% (635.5 miles) of the watercourses in the CRW are considered altered. 1.4% (13.6 miles) are considered impounded and 19.1% (191.7 miles) remained natural. The remaining 16.3% (163.6 miles) had no definable channel. Figure 20 provides a GIS interpretation of locations of streams, lakes and wetland prior to settlement of the CRW. Figure 20 also depicts the current state of watercourses in the CRW, showing significant watercourse alterations.

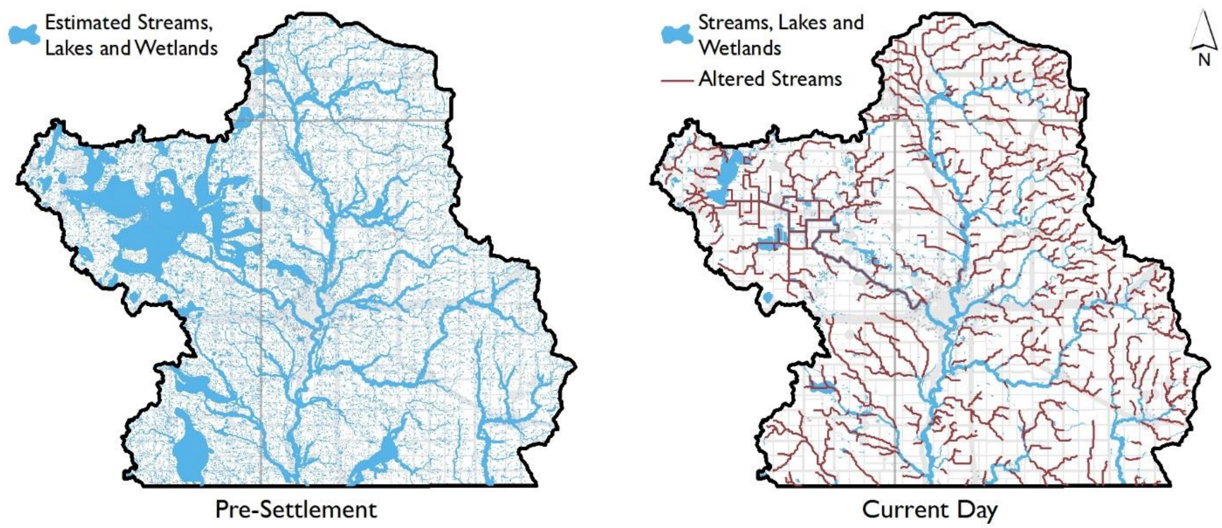


Figure 20. Pre-settlement (estimation) and current location of streams, lakes and wetlands in the Cedar River Watershed
Several large wetland complexes were located along the western edge of the CRW prior to the late 1800's. In 1919, the Albert Lea Farms Company purchased 15,000 acres of wetlands in the northwest corner of the CRW and constructed a network of drainage ditches. Once drained, this area was planted to vegetables such as celery, potatoes, onions, carrots and cabbage.

Soil Organic Matter (SOM) plays a significant role in the ability of the soil to allow water infiltration and to hold water. The National Resource Conservation Service (NRCS) estimates that for every 1% increase in SOM in the top six inches of soil, an additional 27,000 gallons of water per acre could be held in the soil profile (USDA-NRCS Beman Hudson 2013). This equates to roughly 1" of water per acre per 1% of SOM. Soils in southern Minnesota and within the CRW have some of the highest SOM levels of all mineral soils, historically ranging from 4% to 7% of the total soil mass (Overstreet & DeJong-Hughes). Agricultural practices, such as tillage, crop rotation and fertilization all have an effect on SOM. Aggressive tillage has the largest effect on SOM, and most organic matter losses in soil occurred in the first decade or two after land was cultivated. In some cases more than 50% of the SOM was lost in the first 25 years of aggressive land cultivation (i.e. moldboard plowing) (Lewandowski 2000). GIS analysis completed for the DNR Watershed Health Assessment Framework provides a current estimation of SOM in the CRW (Figure 21).

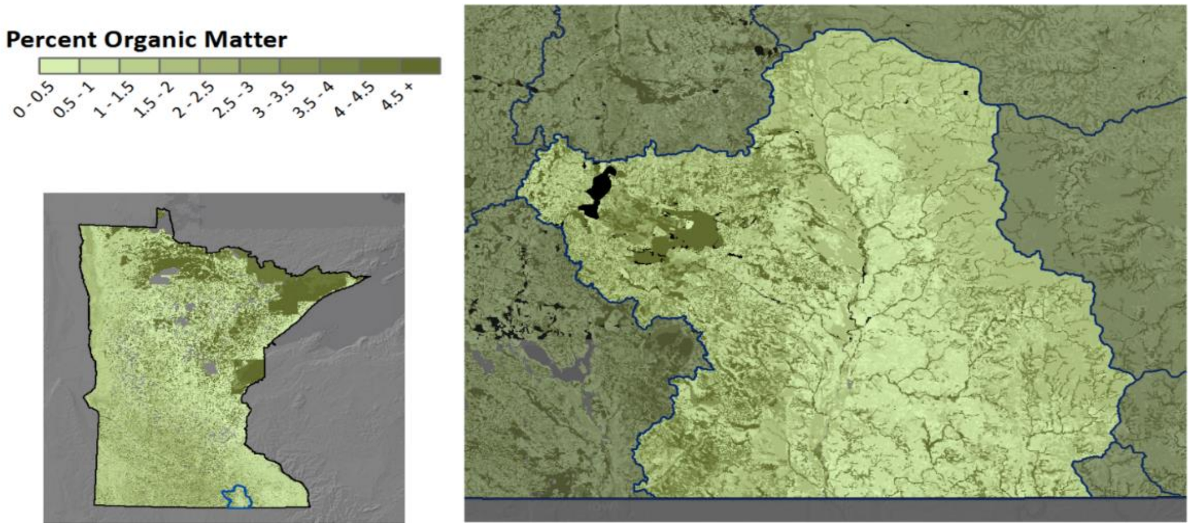


Figure 21. Percent soil organic matter, DNR Watershed Health Assessment Framework
Historically, SOM levels in the CRW were between 4% and 7%. With continued yearly tillage over the last 100 years, many areas of the CRW now average between 1% and 3% SOM.

Tillage Transect Surveys (TTS) are a method to estimate the tillage practices of farmland. TTS were conducted in Minnesota counties from around 1989 to the mid-2000s and associated with funding from various sources. In 2007, the Minnesota Board of Water and Soil Resources (BWSR) coordinated with the Water Resources Center at Minnesota State University to compile previous TTS data (1989 through 2007) into one location at the Minnesota Tillage Transect Survey Data Center. Although the TTS is reported by county, it does provide a good indication of tillage practices that are occurring within the CRW. From 1989 to 2007 the overall trend is less intensive tillage and more reduced or conservation tillage (Figure 22).

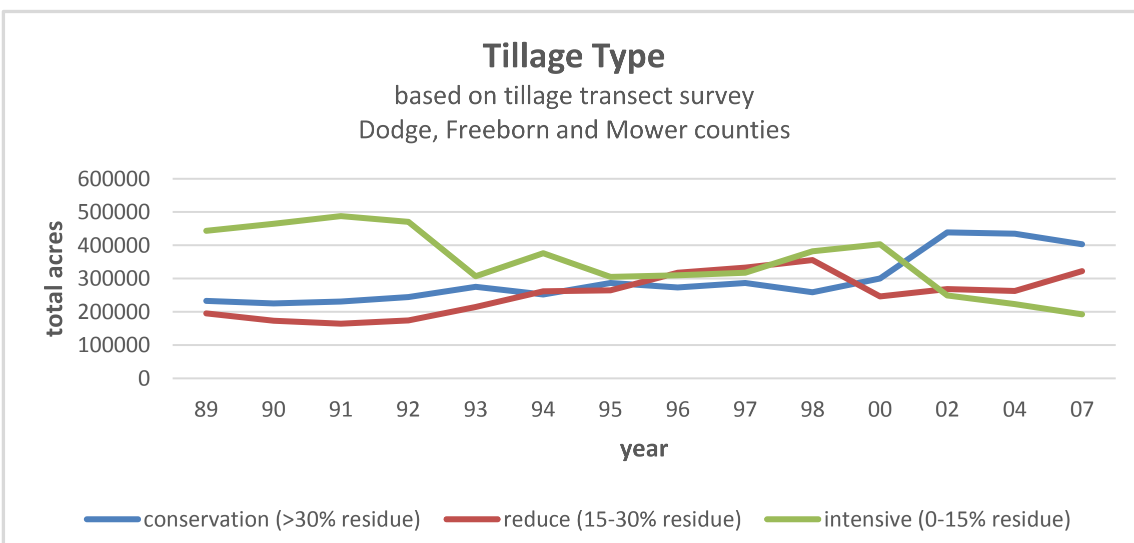


Figure 22. Tillage Transect Survey 1989 – 2007 for Dodge, Freeborn, Mower and Steele counties.

More recent TTS, specific to the CRW, potentially shows this trend reversing (Figure 23). However, caution must be used when comparing the two sets of data, as the TTS viewer subjectivity of residue cover may be the cause of the significant shift in tillage practices. In any case, numerous variables affect a farmer's decision on tillage, so it is important to look at long-term trends when evaluating overall tillage methods in an area.

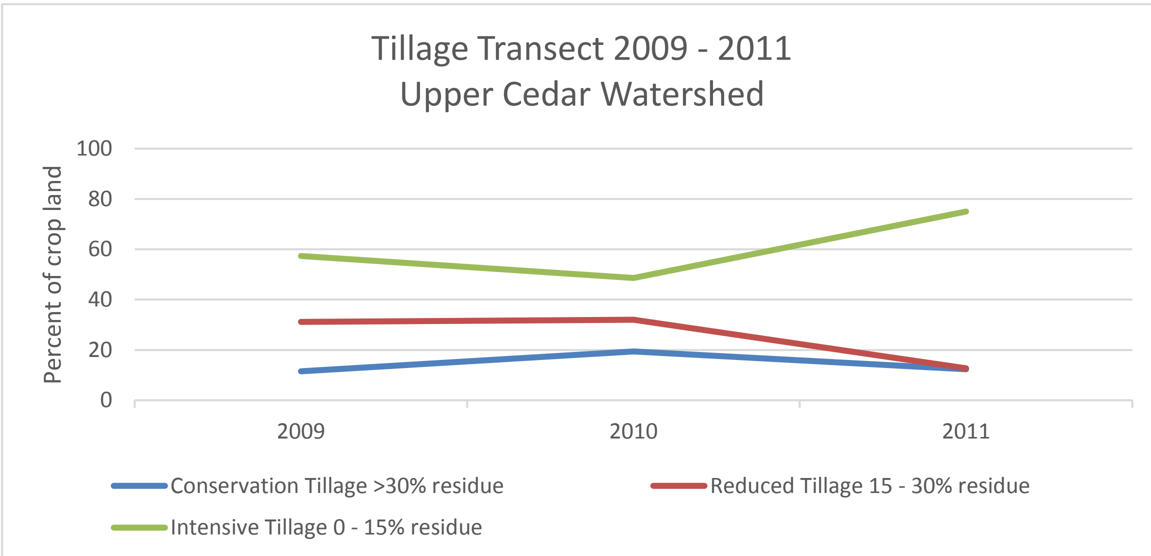


Figure 23. Tillage Transect Survey results specific to the CRW 2009 - 2011

Changes needed

Because altered hydrology is not a pollutant, there is not a water quality standard to address it. The easiest way to quantify altered hydrology is by the runoff ratio. The current runoff ratio is 0.33, which equates to a current average annual flow of 239,257-acre feet (approximately 78 million gallons) for the years 2008 through 2015 from the CRW. Because of the significant change in the runoff ratio around the year 1979, efforts should be made to transform the runoff ratio to a pre-1979 level, which was 0.27, and result in a flow of 179,442 acre feet (approximately 58 million gallons) based on current precipitation amounts. This amounts to a 25% reduction in the total flow of the CRW. However, the hydrologic conditions need changes on "both ends" of the flow spectrum, meaning both high flows, and low base flows. Stream base flow conditions can also be a critical to aquatic life, as the SID process also identified extreme low base flows also as a stressor. While it is important to decrease the peak and overall flows of the CRW, strategies that also have the capacity to increase base flow while decreasing peak flows and total volume should have a higher priority for implementation. The CRWD has also developed 100 year - 24-hour storm flow reduction goals for selected subwatersheds. These important goals identified by the CRWD can be found in the individual HUC – 11 descriptions in Section 3.2 and at the CRWD website: https://www.cedarriverwd.org/wp-content/uploads/2018/11/CedarRiverWMP-CompletePlan.pdf.

Phosphorus

Phosphorus is an important nutrient for plants and animals. It is frequently the limiting nutrient for algae and aquatic plants. It impacts aquatic life by changing food chain dynamics, impacting fish growth and development, increase algae, and increasing the DO variation (i.e. high and low DO). High phosphorus impacts aquatic recreation in lakes by fueling excessive algae growth, making waters undesirable or even dangerous to swim in due to the potential presence of toxic blue-green algae. High phosphorus can also elevate TSS through total suspended volatile solids (TSVS), by production of more algae and plant material, and DO can be lowered due to the eventual algae decay.

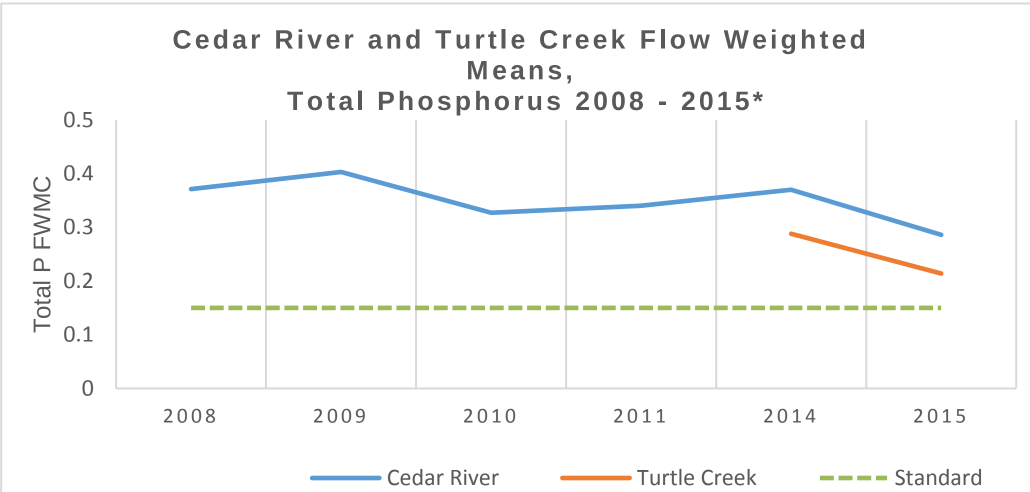
Status

The CRW was formally assessed for water quality impairments in 2012. This pre-dated the adoption of the River Eutrophication Standards (RES). , Therefore, no rivers or streams were examined in the context of water quality standards for eutrophication, at that time. Subsequently, the MPCA determined that the Cedar River below Austin exceeded the TP threshold, but there was insufficient information for an impairment designation, based on the response variables. The RES states that waters that show high phosphorus concentrations (above 0.15 mg/L) and exceedance of at least one response variable (chl-*a* 0.35 mg/L or higher; or diel (daily) DO flux of 4.5 mg/L or higher; or biochemical oxygen demand of 3.0 mg/L or higher) could be added to the impaired waters list.

In addition to RES, the SID monitoring found 7 of the 19 bio-impaired stream reaches are stressed by phosphorus (i.e. the fish and macroinvertebrate populations indicate problems attributed to excess phosphorus) (Table 4).

Regarding lake water quality and TP, of the six analyzed lakes, one was impaired by phosphorus (Geneva Lake), and the remaining five needed more data to make a scientifically-conclusive finding (Table 3).

Data from the two WPLMN sites in the CRW (Cedar River near Austin and Turtle Creek at Austin) consistently show that the river annual flow weighted mean concentrations (FWMC) exceed the new RES standard for phosphorus of 0.15 mg/L. The Cedar River near Austin has a FWMC TP concentration of 0.35 mg/L from 2008 through 2015 and the Turtle Creek at Austin has a concentration of 0.25 mg/L from 2014 through 2015 (Figure 24). From a statewide perspective, the phosphorus concentration and TP yield per acre of watershed area are high in the Cedar River.



*Because of inconsistency in the collected data, calendar year 2012 and 2013 are not reported

Figure 24. Average annual flow weighted mean concentrations for Phosphorus

Geneva Lake was also evaluated using the Tropic State Index (TSI). This index provides a number that summarizes a lake's overall nutrient richness. Nutrient richness ranges from lakes low in nutrients (oligotrophic) to very productive lakes, with very high nutrient levels (hypereutrophic). Three water quality parameters are used to determine a lake's TSI: transparency, chl-*a*, and TP. Geneva Lake's TSI is

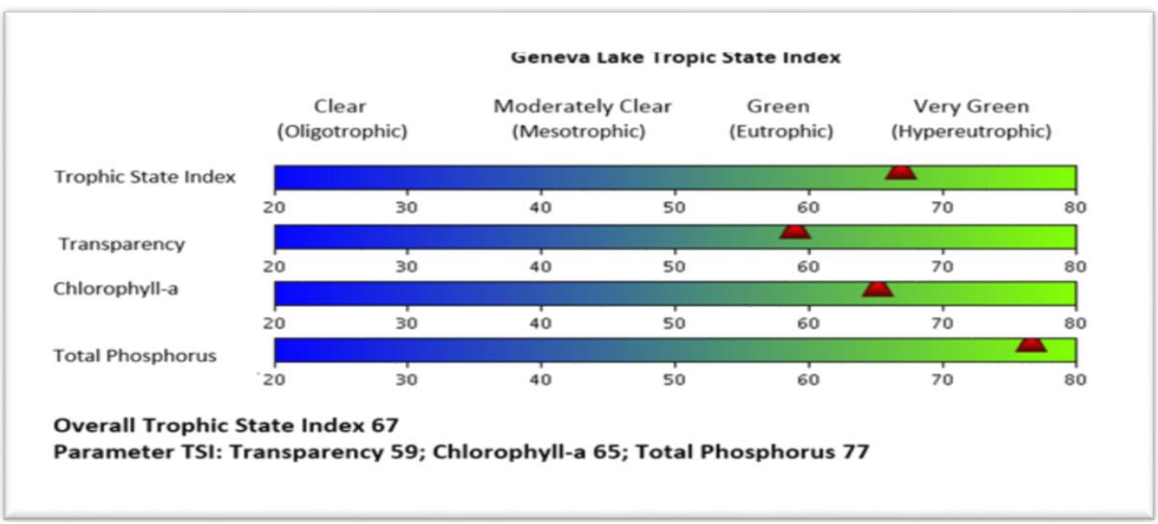


Figure 25. Geneva Lake Tropic State Index

A TSI score of 67 would indicate that Geneva Lake would experience blue-green algae dominance, possible scums, and extensive macrophyte growth. A lake with a TSI score of 70 – 80 would experience heavy algal blooms throughout the summer and dense macrophyte beds. A lake with score over 80 would experience algal scum and summer fish kills.

67 indicating a hypereutrophic lake (Figure 25).While water quality and trophic state concepts are related, they should not be used interchangeably. “Water quality” is a term used to describe a water body’s conditions in relationship to human needs or designated uses, while “trophic state” is a measure of a water body’s fertility based on algal growth.

Sources

In 2004 the MPCA released the report Detailed Assessment of Phosphorus Sources to Minnesota Watersheds completed by Barr Engineering. This report identified the sources and amount of phosphorus entering Minnesota surface waters for each of the 10 major basins (including the Cedar River Basin) from point and nonpoint sources during low (dry), average and high (wet) flow conditions. Figure 26 and Figure 27 represent the finding of the 2004 report related to sources in the Cedar River Basin. The report indicates that river flows dictate which source is the dominant source of phosphorus. In low flow years, point source becomes the dominant source of phosphorus for the CRW, whereas in high flow years nonpoint sources (namely ag land runoff and streambank) become the dominant source. Data collected in the CRW from the WPLMN and point sources for the years 2008 through 2011 and 2014 through 2015

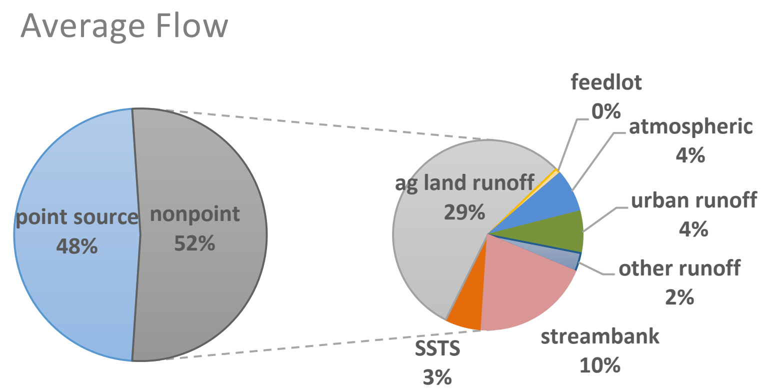


Figure 26. Cedar River Basin Phosphorus Sources for average flow conditions.

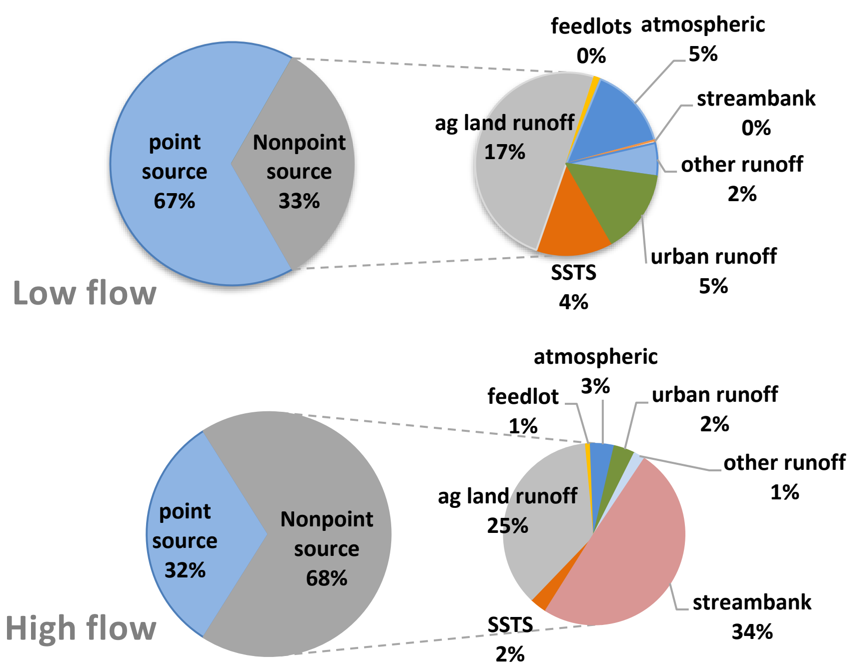


Figure 27. Cedar River Basin Phosphorus source for low and high flows

There is distinct difference in what is the dominant source of phosphorus based on low and high river flows in the Cedar River Basin. At low flows, point sources are 67% of the phosphorus load and nonpoint is 33%. This ratio reverses in high flows years, where nonpoint sources become 68% of the phosphorus load and point sources account for only 32%.

validate the findings of the phosphorus report (Figure 28). However, it should be noted that the amount of phosphorus orginating from point sources has remained relatively constant (to slightly decreasing).

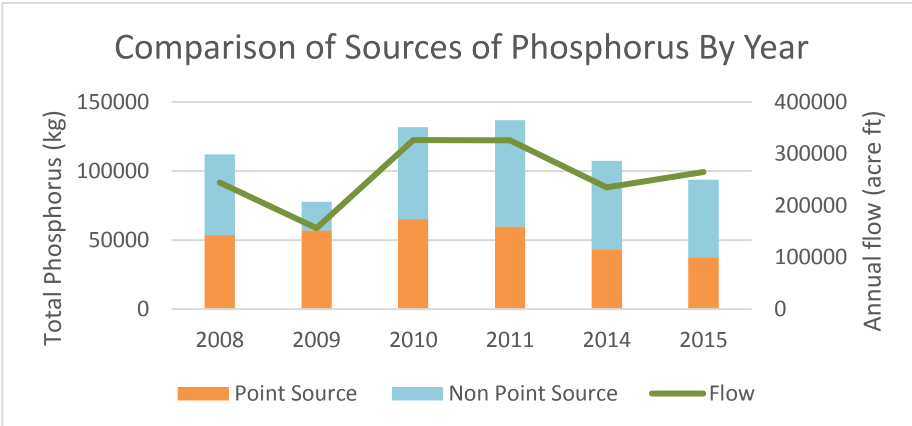


Figure 28. Comparison of Phosphorus source in the CRW

Point sources are a major contributor of phosphorus to the Cedar River (Figure 29). While they do contribute a significant amount to the overall phosphorus load of the river, their biggest effect is elevating the phosphorus concentrations during low flow periods. This effect can be seen in the WPLMN data (Figure 30). When river flows are at their lowest the concentration of phosphorus are at their highest, indicating a strong point source influence. Once the river flows increase, the concentration decreases as the additional water in the river dilutes the concentration. The city of Austin WWTP is the largest single source of phosphorus to the Cedar River in the CRW. If the city were to upgrade the WWTP to meet a 1 mg/L of TP discharge limit, this would reduce its contributions by an estimated 80% and would reduce the overall phosphorus load of the CRW by approximately 29% (based on 2015 Austin WWTP discharge reports and 2015 Cedar River WPLMN data). This improvement would take a considerable amount of effort in both time and money (potentially tens of millions of dollars). If this

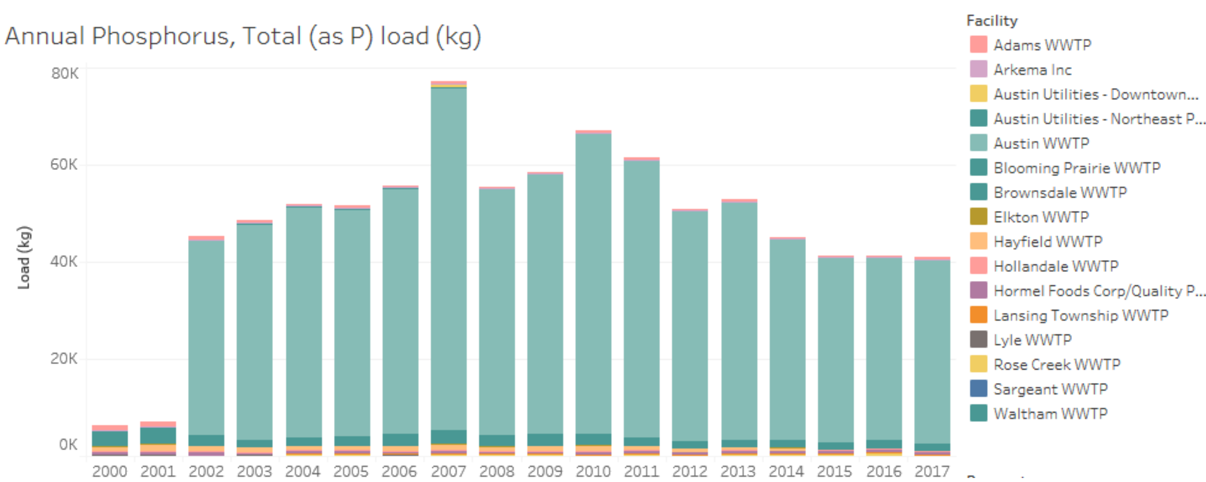


Figure 29. Annual reported phosphorus discharge to the CRW from wastewater treatment plants.

Note not all facilities were required to submit discharge information to the MPCA in 2000 and 2001 were to occur, a significant reduction in phosphorus loading would result. This is especially important during periods with lower stream flows, and would be expected to improve conditions for stream biota. Other significant improvements throughout the CRW will be needed if water quality goals are to be achieved.

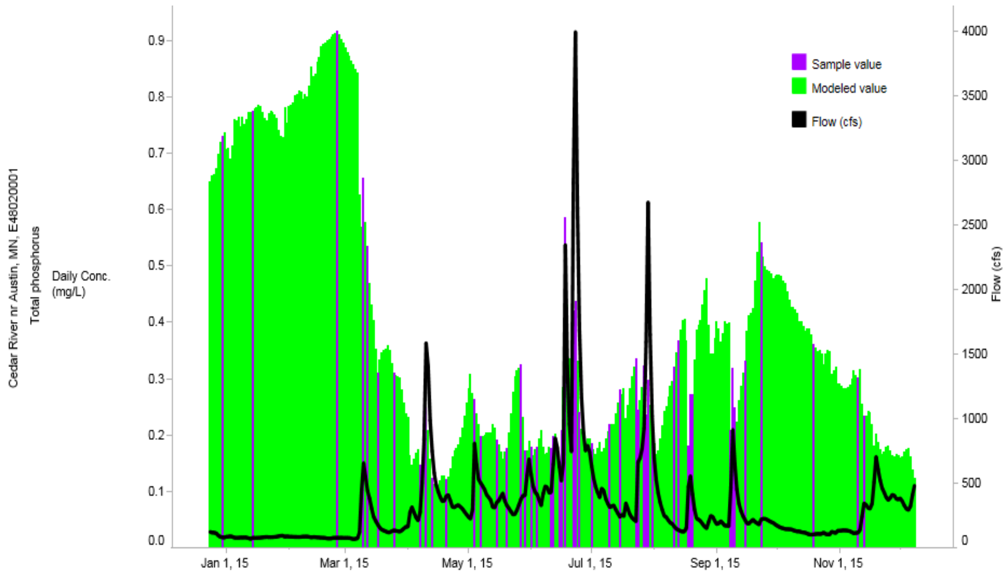


Figure 30. Daily phosphorus concentrations in the Cedar River near Austin
Note: the green zones between measured values are modeled or interpolated conditions.

The two dominant nonpoint sources of phosphorus in the CRW are agricultural land runoff and stream bank erosion. The amount of phosphorus contributed from each source is heavily dependent on weather events that erode soil from fields or stream banks. Data from the WPLMN for the years 2008 through 2011 and 2014 through 2015 indicate that, on average, roughly half of the TP loading to the CRW occurs in months of March through June, when crop land is at its most vulnerable with newly planted fields that have been recently tilled and crops that have not developed a "canopy" over the soil. In the neighboring Root River Watershed, the Root River Field to Stream Partnership has found, via five years of monitoring at numerous field edges in rural southeast Minnesota, that approximately 90% of the runoff and associated nutrient and sediment losses often occur together over the four-month span of March through June (Kuehner 2016).

Also based on WPLMN data, a significant portion of loading of phosphorus from nonpoint sources generally occurs over a very short time period each year. Based on six years of data, about 40% of the yearly load is delivered from five separate weather events that together span a period of only two to three weeks. It is not unusual to have one large event usually contributing 20% or more of the annual TP load (Table 8). Figure 31 from the WPLMN data provides an example of this event in 2014 where one event in late June contributed 23% of the annual load.

Table 8. Timing of significant phosphorus loading events to the CRW

2008	June 12th - 15th	45,217	40%	5	16	61%	81%
2009	June 17th - 20th	6,670	9%	4	14	23%	41%
2010	September 23rd - 28th	29,628	22%	3	16	41%	39%
2011	March 18th - 25th	33,155	24%	6	19	44%	60%
2014	June 18th - 23rd	24,451	23%	4	19	43%	72%
2015	June 17th - 23rd	10,256	11%	5	16	29%	45%
Average		24,896	21.50%	4.5	16.7	40%	56%

Review of historical weather data when compared to the WPLMN data, shows that most significant phosphorus loading events (events that result in more than 1,000 kg of phosphorus loading to the river per day) are either the result of spring snow melt or a greater than one inch precipitation event in the months of March through June. Later in the year, after crop canopy, rain events usually must exceed higher amounts to obtain similar loading results in the river.

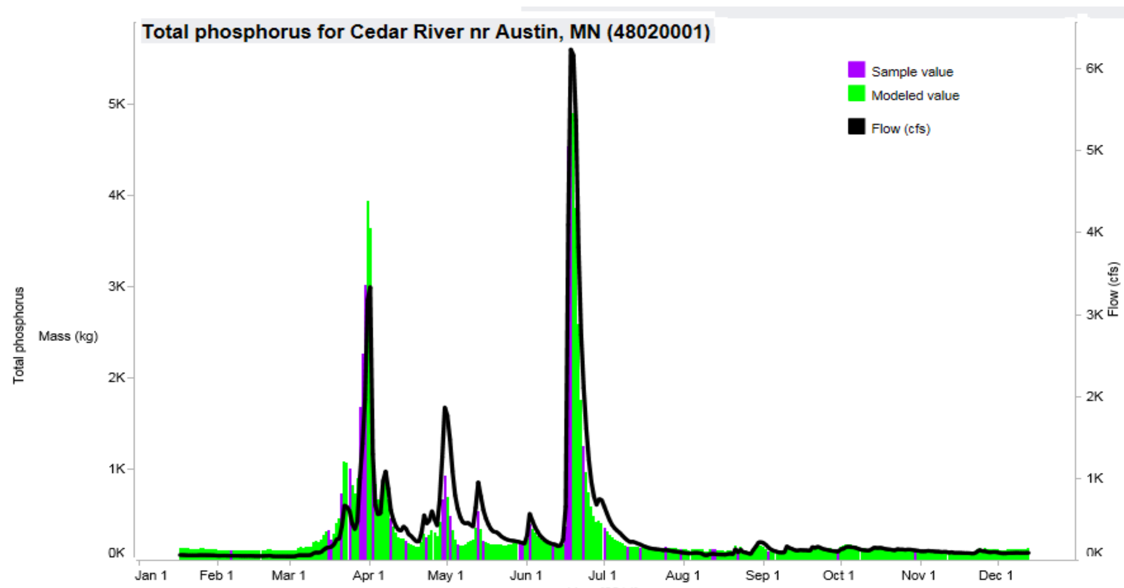


Figure 31. Daily Phosphorus loading of the Cedar River near Austin (2014)
The majority of the phosphorus loading in the CRW occurs during a few events every year. For example, in just two days in 2014 (June 18 and 19th) 10,042 kg (22,138 pounds) of phosphorus was deposited in the river from one rain event.

Reductions

There are three phosphorus reductions goals for the CRW: The Geneva Lake TMDL provides specific phosphorus reductions needs to achieve to water quality goals in the lake; a watershed wide phosphorus reduction goal related to potential future RES standards, which would address many of the elevated nutrient stressors; and reductions needed to achieve the statewide NRS goals.

The Geneva Lake TMDL indicates a current loading of 18,946 pounds of phosphorus per year (51.8 lbs/day) to Geneva Lake. Modeling indicates a reduction of 12.8% of phosphorus to 16,523 pounds per year (or about 45 lbs/day) is needed to achieve water quality goals (Table 9).

Allocation	Seasonal TP, lbs/day	Seasonal TP, lbs/year
TMDL	45.27	16,524
Margin of Safety	4.527	1,652
Atmospheric Load	2.30	840
Construction and Industrial Stormwater	0.0192	7
Loading Allocation (internal loading and upland)	38.423	14,024

Table 9. Geneva Lake TMDL summary

With no wastewater treatment facilities (WWTF) in the subwatersheds that discharge to Geneva Lake and only limited construction and industrial storm water inputs, the majority of the reductions are needed from nonpoint sources. Hydrologic Simulation Program Fortran (HSPF) modeling indicates the upland phosphorus loading from subwatersheds total 2,891 pounds per year (of the 18,099 total pounds of load allocation attributed to nonpoint sources), indicating a large internal load of phosphorus within the lake.

Internal phosphorus loading is important to understand in the context of “unaccounted for” loads. With Geneva Lake, as was the case for several lakes in the Cannon River Watershed TMDL, predicted model results of in-lake phosphorus concentrations were still not meeting water quality standards even when tributary loads were set to zero. Heiskary and Martin (2015) found that in these cases, the “unaccounted for” portion can be assigned to internal loading. Internal phosphorus loading in lakes typically occurs through wind-driven sediment resuspension, bioturbation (e.g. sediment disturbance by benthic-dwelling fish), macrophyte senescence (e.g. curly-leaf pondweed) and/or diffusive sediment flux under anoxic conditions (Sondergaard et al. 2003). Geneva Lake is a relatively shallow lake that does not typically stratify for prolonged periods. Its fish community is dominated by benthic-dwelling species that are tolerant of hypoxia and warm water temperatures. To more accurately budget for phosphorus in Geneva Lake, in the future, a collection of sediment cores and determination of phosphorus release through laboratory incubation and measurement would need to be done to accurately account for internal loading. The DNR’s Shallow Lakes Program is actively conducting an assessment of phosphorus “pools” (ex. sediments, or biotic pools, for example), and phosphorus interactions in numerous shallow lakes, and information from these efforts would also be important for future work on Geneva Lake (Hansel-Welch 2018).

To achieve the needed reduction to meet the Geneva Lake TMDL (and to account for the 10% margin of safety) both the upland nonpoint and the internal loading of phosphorus in the lake needs to be reduced by 27% (upland reduction by 780 pounds and internal loading by 4,106 pounds). The internal load of phosphorus in Geneva Lake is a key driver of water quality and management strategies that focus on internal nutrient cycling will need to be implemented. Recent in-lake activities in the form of lake drawdowns and efforts to control rough fish will have positive effects on the lake. Additional conservation efforts in the upper subwatersheds that drain to Geneva Lake have also been implemented and their effectiveness will also need to be further evaluated.

During the normal course of RES assessment in 2016, the MPCA determined that the Cedar River below Austin exceeded the TP threshold, but there was insufficient information for an impairment designation, based on the response variables. This determination involved a second year of DO data collection during 2017. In addition to RES, the SID monitoring has found that 7 of the 19 bioimpairments (watershed-wide) are linked to phosphorus (i.e. the fish and macroinvertebrate populations indicate problems attributed to excess phosphorus), as well as one stream reach where low DO was a conclusive stressor (Table 4). It is acknowledged that weather and river flow play a significant role in the amount of phosphorus load in any given year. Because TP reductions are needed, the O.15 mg/L RES TP standard is used as a target to estimate necessary reductions. This analysis is based on the Cedar River below Austin, for 2008 through 2011 and 2014 through 2015, and uses data from WPLMN. An average reduction (over the six years previously noted) of 136,710 pounds of TP is needed to achieve water quality goals, which represents a 56% decrease. Because the Cedar River reach below Austin is influenced by point source contributions, reductions should be split between point sources and nonpoint sources. Any WWTP discharging into or above this reach, would be required to comply with Minn. R. ch. 7053.0255, and meet a 1 mg/L TP limit, if existing facilities expand the design flows.

Using a similar set of factors for the Turtle Creek Subwatershed, a 41% TP reduction is needed with an average reduction of 22,150 pounds of phosphorus per year. Because there are limited point source contributions in the subwatershed, all the reductions would be targeted towards nonpoint sources.

In 2014, the state of Minnesota completed the Minnesota NRS in response to the 2008 Gulf of Mexico Hypoxia Action Plan. The NRS provides the information and collective objectives needed to address watershed nutrient goals downstream of the HUC-8 watersheds. Minnesota has assumed a nutrient reduction goal that is proportional to the load reductions needed in the Gulf of Mexico drainage area as a whole, as a percentage of baseline loads. In the future, it is possible that states could be allocated a nutrient load to meet the Gulf of Mexico goals. In the meantime, Minnesota will strive to reduce nutrient loads by applying an equitable “fair-share” approach using a proportional reduction of the baseline load (NRS 2014). The phosphorus reduction goal identified in the NRS calls for a 45% reduction from the 1980 through 1996 conditions for watersheds that drain to the Mississippi River. Because of previous phosphorus reduction achieved across the state, the current goal calls for a 12% reduction from current conditions. In the CRW, according to modeling done for the NRS, a reduction of 44,753 pounds of phosphorus is needed to achieve the downstream goals that were outlined. The NRS acknowledges that local water quality goals may require additional reductions than those outlined by the NRS and this is the case for the CRW.

HSPF modeling indicates areas with elevated TP loading (Figure 32) that should be areas initially targeted for prioritized improvements.

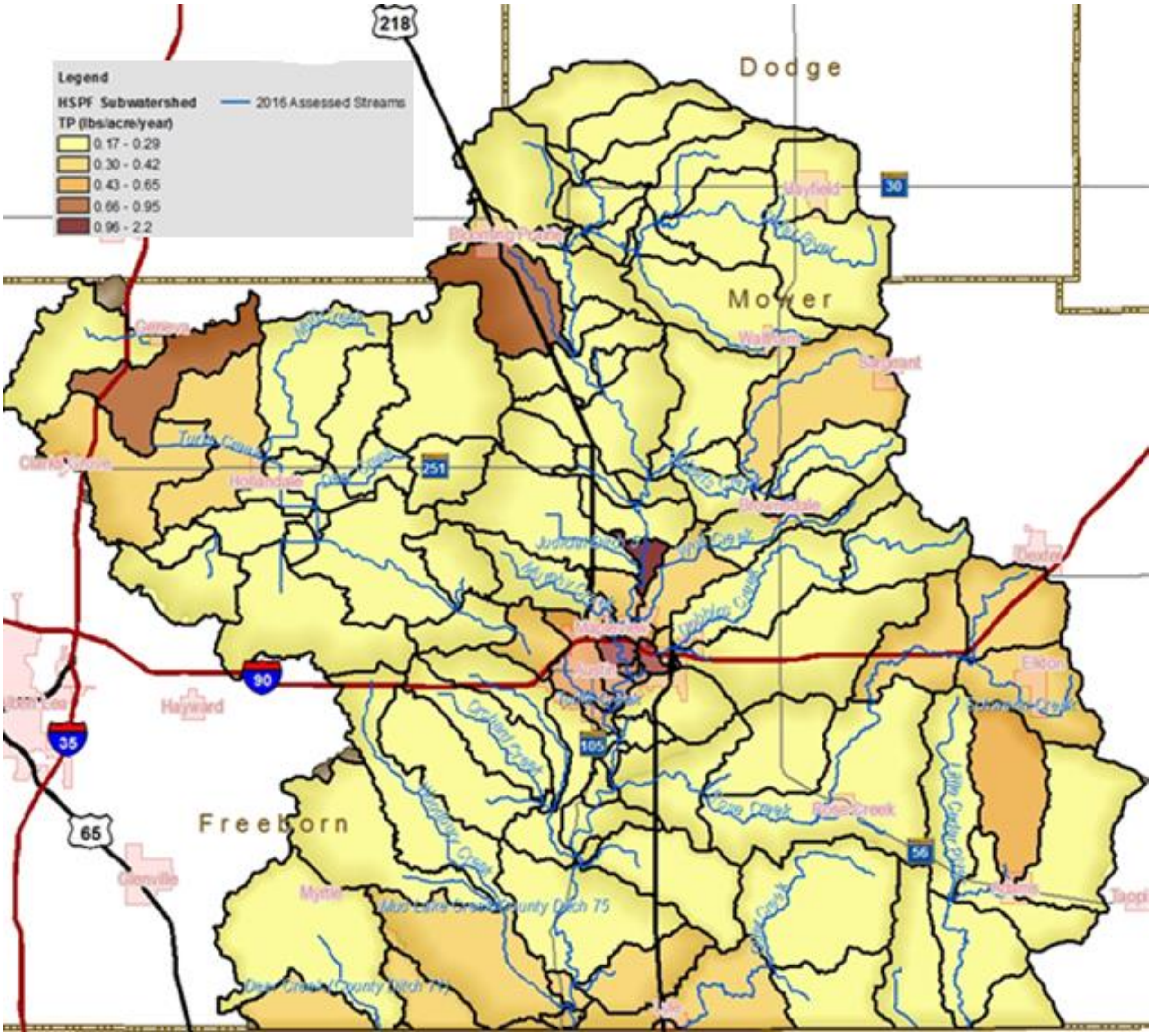


Figure 32. Nonpoint phosphorus loading rates based on HSPF modeling

Bacteria

Fecal bacteria (*E. coli* or fecal coliform) are indicators of animal or human fecal matter and potentially other pathogens in waters. Fecal matter impacts the safety of aquatic recreation because contact with fecal material and other pathogens can lead to potentially severe illnesses. Fecal bacteria are living organisms that can be present in upstream locations due to upstream sources, yet die before reaching downstream waters where they may not be detected.

Status

Fecal bacteria is problematic across much of the watershed and across the entire region. Fecal bacteria has been identified as a pollutant in 16 stream reaches (14 for *E. coli* and 2 additional stream reaches had previously identified fecal coliform as a pollutant). The two reaches identified as impaired by fecal coliform were included in the Revised Regional TMDL Evaluation of Fecal Coliform Bacteria Impairments in the Lower Mississippi River Basin in Minnesota (MPCA 2006). None of the sampled stream reaches were found to be supporting of fecal bacteria standards, and five stream reaches needed more data.

Sources

The following text, which provides an overview of nonpoint sources of fecal coliform and *E. coli* bacteria and associated pathogens, is excerpted and adapted from *the Revised Regional TMDL Evaluation of Fecal Coliform Bacteria Impairments in the Lower Mississippi River Basin in Minnesota* (MPCA 2006). Additional research conducted by Chandrasekaran et al. (2015) is also noted. At the time the MPCA 2006 study was conducted, Minnesota's water quality standard was described in terms of fecal coliform colonies as indicators of fecal pathogens; it has since changed to make use of *E. coli* counts (the water quality standard used in these TMDLs) for the same purpose.

The relationship between land use and fecal coliform concentrations found in streams is complex, involving both pollutant transport and rate of survival in different types of aquatic environments. Intensive sampling at numerous sites in southeastern Minnesota shows a strong positive correlation between stream flow, precipitation, and fecal coliform bacteria concentrations. In the Vermillion River Watershed, storm-event samples often showed concentrations in the thousands of organisms per 100 mL, far above non-storm-event samples. A study of the Straight River Watershed divided sources into continuous (failing individual sewage treatment systems, unsewered communities, industrial and institutional sources, WWTFs) and weather-driven (feedlot runoff, manured fields, urban stormwater) categories. The study hypothesized that when precipitation and stream flows are high; the influence of continuous sources is overshadowed by weather-driven sources, which generate extremely high fecal coliform concentrations. However, during drought (low-flow conditions), continuous sources can generate high concentrations of fecal coliform, the study indicated. Besides precipitation and flow, factors such as temperature, livestock management practices, wildlife activity, fecal deposit age, and channel and bank storage also affect bacterial concentrations in runoff (Baxter-Potter and Gilliland 1988). Source assessment for the Lower Mississippi River Bacteria TMDL, which includes segments in the CRW, indicate similar findings. During wet periods, bacteria sources from animal agriculture is the dominant source. Whereas, during dry periods, sources that directly supply bacteria to the water become the dominant source of bacteria (Figure 33).

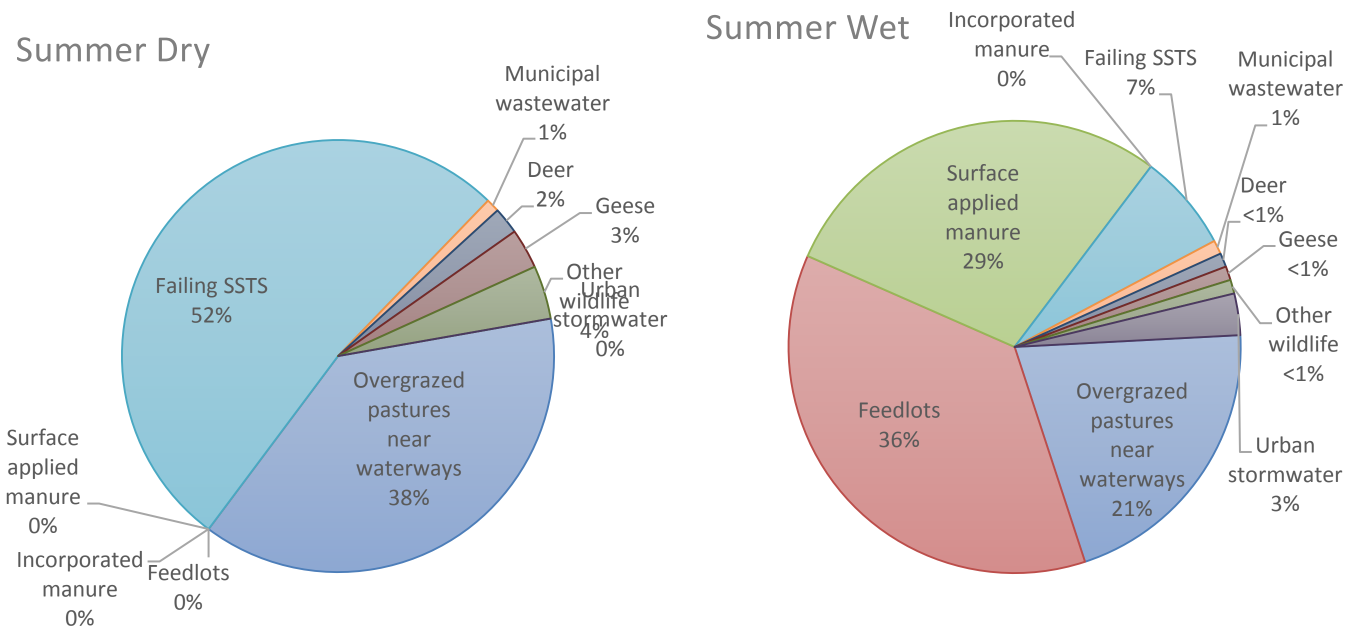


Figure 33. Lower Mississippi River Basin bacteria sources

A bacteria source assessment was conducted for the Lower Mississippi River Basin Bacteria TMDL. The CRW was part of the area of study for the TMDL. The dominant source of bacteria is highly dependent on precipitation. In dry years, sources that discharge directly into the river become the dominant source. In wet years, bacteria contaminant runoff (feedlot and land applied manure) become the dominant sources.

Fine sediment particles in the streambed can serve as a substrate harboring fecal coliform bacteria. "Extended survival of fecal bacteria in sediment can obscure the source and extent of fecal contamination in agricultural settings," (Howell et al. 1996). Sadowsky etal. (2010) studied reproduction and survival of *E. coli* in ditch sediments and water in the Seven Mile Creek Watershed; their work concluded that while cattle are likely major contributors to fecal pollution in the sediments of Seven Mile Creek, it is also likely that some *E. coli* strains reproduce in the sediments and thus some sites probably contain a mixture of newly acquired and resident strains (Sadowsky et al. 2010). A study published in 2015 by Chandrasekaran et al. (Sadowsky being a co-author), continued research in the Seven Mile Creek Watershed. Results from this study concluded that populations of *E. coli* can exist in ditch sediments as temporal sinks and be a source of bacteria to streams. The authors highlight the issue with using only livestock manure operations as an indicator of source impacts to water quality.

Hydrogeological features in southeastern Minnesota may favor the survival of fecal coliform bacteria. Cold groundwater, shaded streams, and sinkholes (where they are present) may protect fecal coliform from light, heat, drying, and predation (MPCA 1999). Sampling in the South Branch of the Root River Watershed showed concentrations of up to 2,000 organisms/100 mL coming from springs, pointing to a strong connection between surface water and ground water (Fillmore County 1999 and 2000). The presence of fecal coliform bacteria has been detected in private well water in southeastern Minnesota. However, many detections have been traced to problems of well construction, wellhead management, or flooding, not from widespread contamination of the deeper aquifers used for drinking water. Finally, fecal coliform survival appears to be shortened through exposure to sunlight. This is purported to be the reason why, at several sampling sites downstream of reservoirs, fecal coliform concentrations were markedly lower than at monitoring sites upstream of the reservoirs.

Monitoring of various subwatersheds of the CRW (Figure 34) indicate that bacteria levels are elevated at all flows, potentially indicating that different sources are affecting the streams at different times.

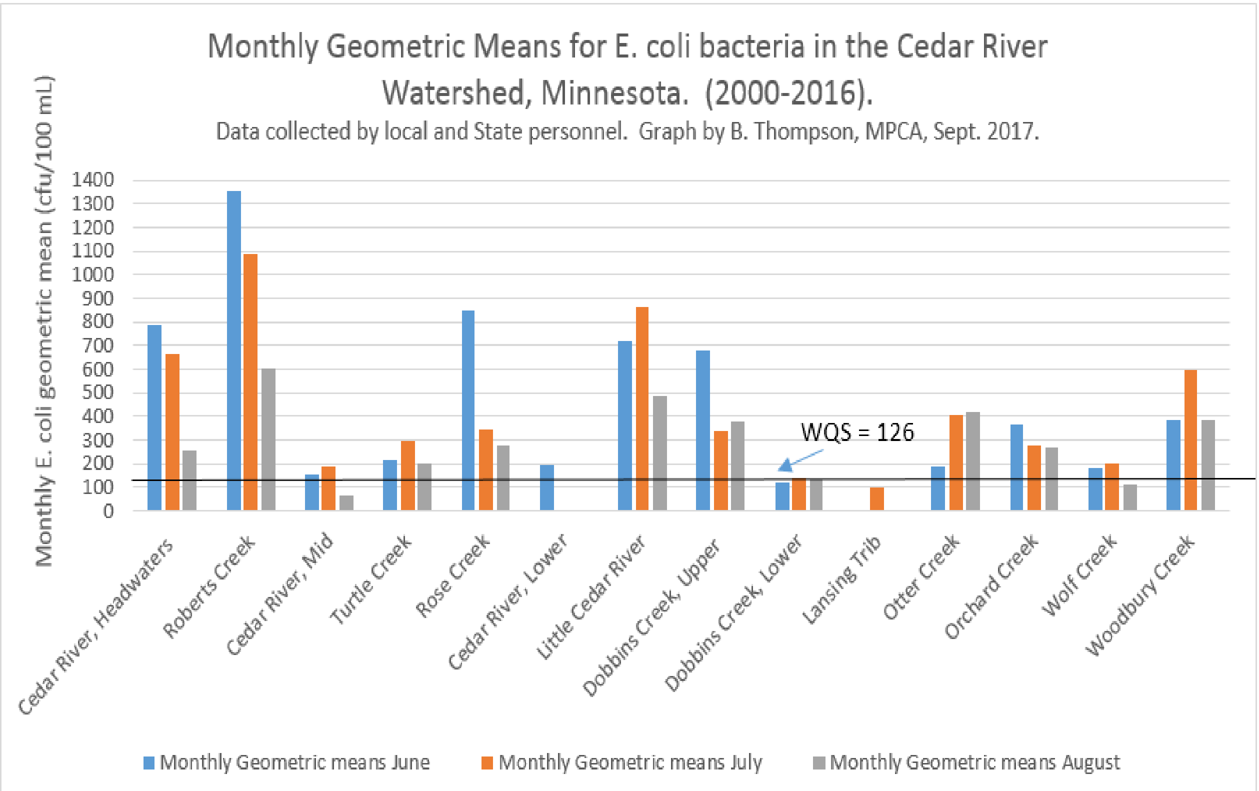


Figure 34. Monthly E. coli geometric means for various subwatersheds of the CRW

Reductions

At monitoring sites that have sufficient data available, bacteria loads exceed the water quality goals under all flow conditions. Stream reaches that show bacteria exceedances across all flow zones include the Upper Cedar River, Roberts Creek and Woodbury Creek. Table 10 indicates the reductions needed across each of the flow zones for the identified stream reaches and Figure 35 shows the locations.

Reach name	AUID	June		July		August	
		org/100 ml	Reduction needed	org/100 ml	Reduction needed	org/100 ml	Reduction needed
Cedar R Rose Creek to Woodbury Cr	-501	486*	56%*	486*	56%*	486*	56%*
Cedar R Roberts Cr to Upper Austin	-502	486*	56%*	486*	56%*	486*	56%*
Cedar R Headwaters to Roberts Cr	-503	788	84%	667	81%	255	51%
Roberts Creek	-504	1352	91%	1089	88%	605	79%
Wolf Creek	-510	180	30%	204	38%	115	0%
Cedar R, Dobbins to Turtle Creek	-514	154	18%	185	32%	65	0%
Cedar R, Woodbury Cr to Iowa	-516	193	35%	No data	No data	No data	No data
Otter Creek	-517	191	34%	406	69%	422	70%
Little Cedar River	-518	717	82%	863	85%	486	74%
Rose Creek	-522	852	85%	344	63%	278	55%
Woodbury Creek	-526	385	67%	599	79%	386	67%
Lansing tributary	-533	145	13%	304	59%	598	79%
Dobbins Creek (upper reach)	-535	677	81%	336	63%	377	67%
Dobbins Creek (below East Side Lake)	-537	117	0%	139	9%	133	9%
Orchard Creek	-539	366	66%	279	55%	270	54%
Turtle Creek	- 540	216	42%	300	58%	201	37%

Table 10. Bacteria reductions needed for each impaired reach of the CRW
* indicates data was from 2006 Lower Mississippi River Basin Regional Fecal Coliform TMDL where geometric mean was calculated for “summer months” and not individual months. Because this was a Fecal Coliform TMDL, the water quality standard was 200 colonies/100 ml

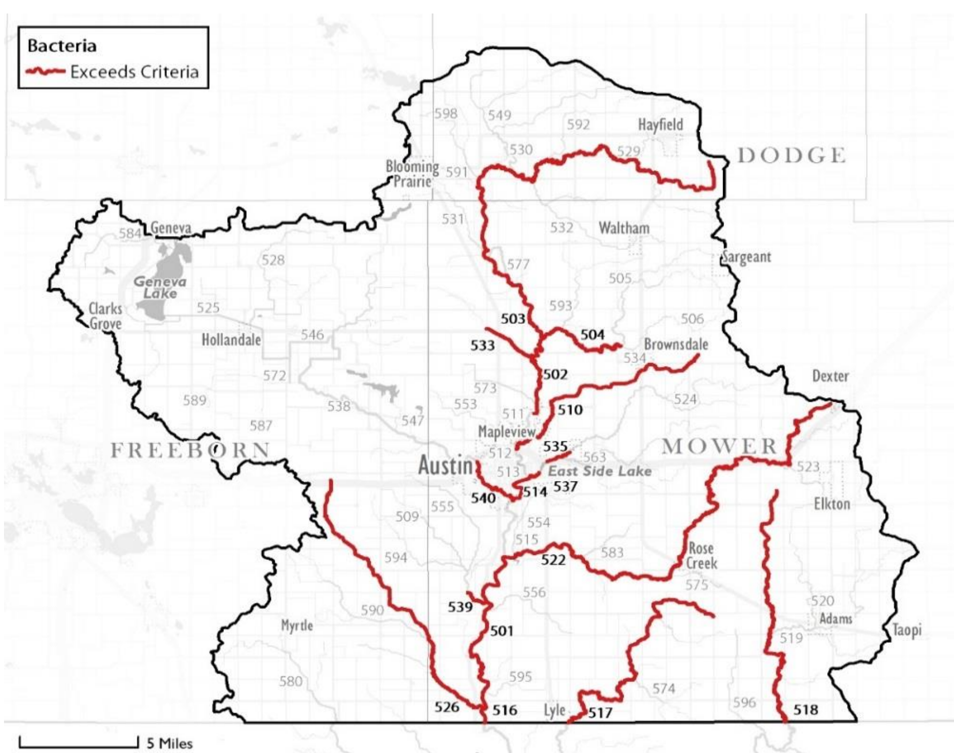


Figure 35. Location of bacteria impaired reaches
All stream reaches that were assessed for bacteria impairments were determined to be impaired

Nitrogen

Excessive N can be directly toxic to fish and macroinvertebrates. N can also increase the acidity of waters, limiting sensitive species. Excessive N contributes to eutrophication and is implicated as the main cause for the Gulf Hypoxic Zone (NOAA 2015). N is also a major human health concern, as excessive N consumption via drinking water causes blue baby syndrome (WHO 2015). Due to this health risk, excessive N in drinking water can necessitate expensive treatments.

Status

From 2008 through 2015, the Cedar River at Austin had a total nitrogen (TN) FWMC of 11.18 mg/L (inorganic N 10.0 mg/L plus 1.18 mg/L Total Kjeldahl nitrogen [TKN]), while Turtle Creek at Austin for the years 2013 through 2015 had TN FWMC of 12.62 mg/L (11 mg/L inorganic nitrogen plus 1.62 mg/LTKN). The Cedar River has some of the highest nitrate-nitrite concentrations in Minnesota's streams, with the site downstream of Austin increasing about 2% per year (1967 through 2009), and the Cedar River at Lansing increasing about 1% per year, from 1980 through 2010 (MPCA 2013). Using monitoring data, it is estimated that TN yield is 29.59 pounds per acre for the CRW. Modeling completed for the statewide NRS project shows similar TN yields, at 24.6 pounds per acre with an estimated 10,169,400 pounds of N delivered to the streams yearly. To assess downstream issues on the Mississippi River, it was estimated that the Cedar River (in Minnesota) accounts for about 4.4% of the TN load at Keokuk, Iowa (MPCA 2013). This places the Cedar River at about the 10th highest load for Minnesota streams (the Cannon River and Root River, which are both significantly larger watersheds, both are at 5.2%, for comparison). Work completed for the State of Iowa, Cedar River Nitrate TMDL (which includes the Minnesota CRW) indicates a loading of 5,811 tons N per year from the CRW to the greater Cedar River Basin (Iowa DNR 2006).

High N was identified as a conclusive stressor (Table 4) in 15 bio-impaired stream reaches. N is only investigated when a bio-impairment is identified, so excessive N conditions may be more widespread than they appear, and are likely problematic in highly tiled areas.

Sources

In 2013, the MPCA, in collaboration with the University of Minnesota and U.S. Geological Survey, released the report [Nitrogen in Minnesota Surface Waters, conditions, trends, sources and reductions]() This report allows a better understanding of N conditions in Minnesota's surface waters, along with the sources, pathways, trends and potential ways to reduce N in Minnesota's waters. This report identified the sources and amount of N entering Minnesota surface waters for

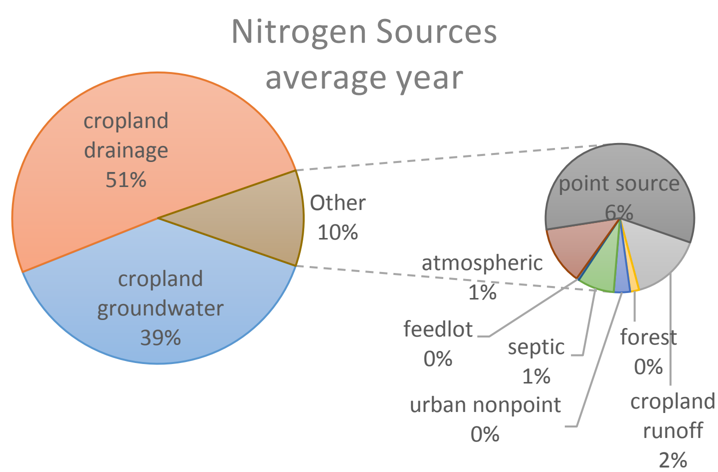


Figure 36. Nitrogen sources in the Cedar River Basin (average flow year)

each of the 10 major basins (including the Cedar River Basin) from point and nonpoint sources during low (dry), average and high (wet) flow conditions. Figure 36 and Figure 37 represent findings of the report related to pathways in the Cedar River Basin (which includes the CRW, along with the Shell Rock River, Winnebago River and Upper Waspsispinicon River). Cropland drainage and cropland groundwater are the dominant pathways of N in the Cedar River Basin and when combined contribute 79% to 92% of N in the basin depending on flow conditions.

Weather has a significant effect on nonpoint source N loading to surface waters in the Cedar River Basin.

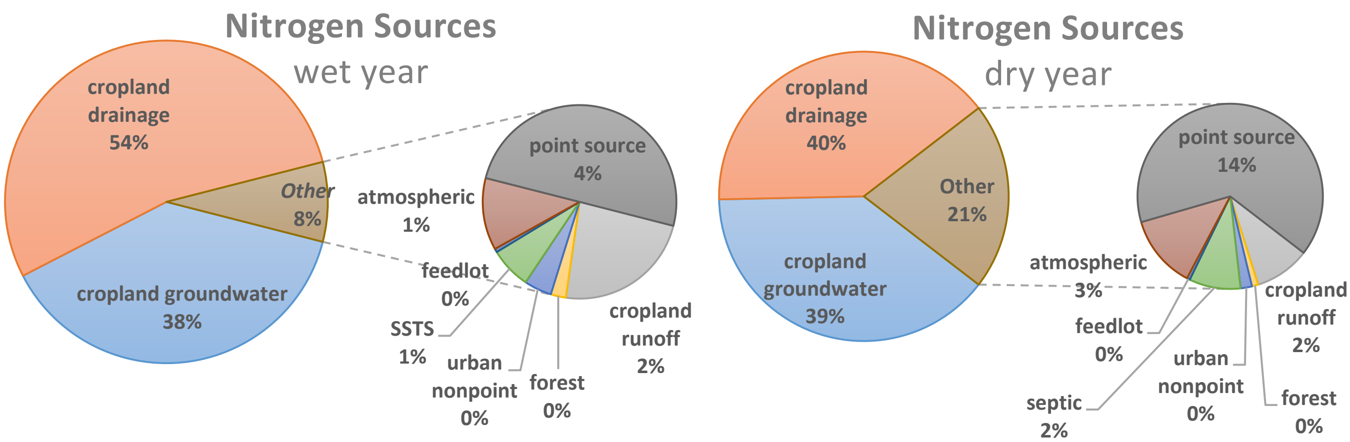


Figure 37. Nitrogen sources in the Cedar River Basin (wet and dry years)

Total loading of N to surface water in a dry year, according to modeling, is nearly 4.8 million pounds of N. This number more than triples to 15.9 million pounds of N in a wet year (Figure 38). Monitoring data for the years 2008 -2015 in the Cedar River at Austin confirms this modeling and shows that the average loading is 7.5 million pounds of TN (6.76 million pounds of inorganic N and 788,000 pounds of TKN). Monitoring data for the years 2013 through 2015 in Turtle Creek at Austin indicate the average loading is 2.97 million pounds of TN (2.61 million pounds of inorganic N and 366,000 pounds of TKN). Regardless of flow, nonpoint sources dominate as the source of N in the Cedar River Basin.

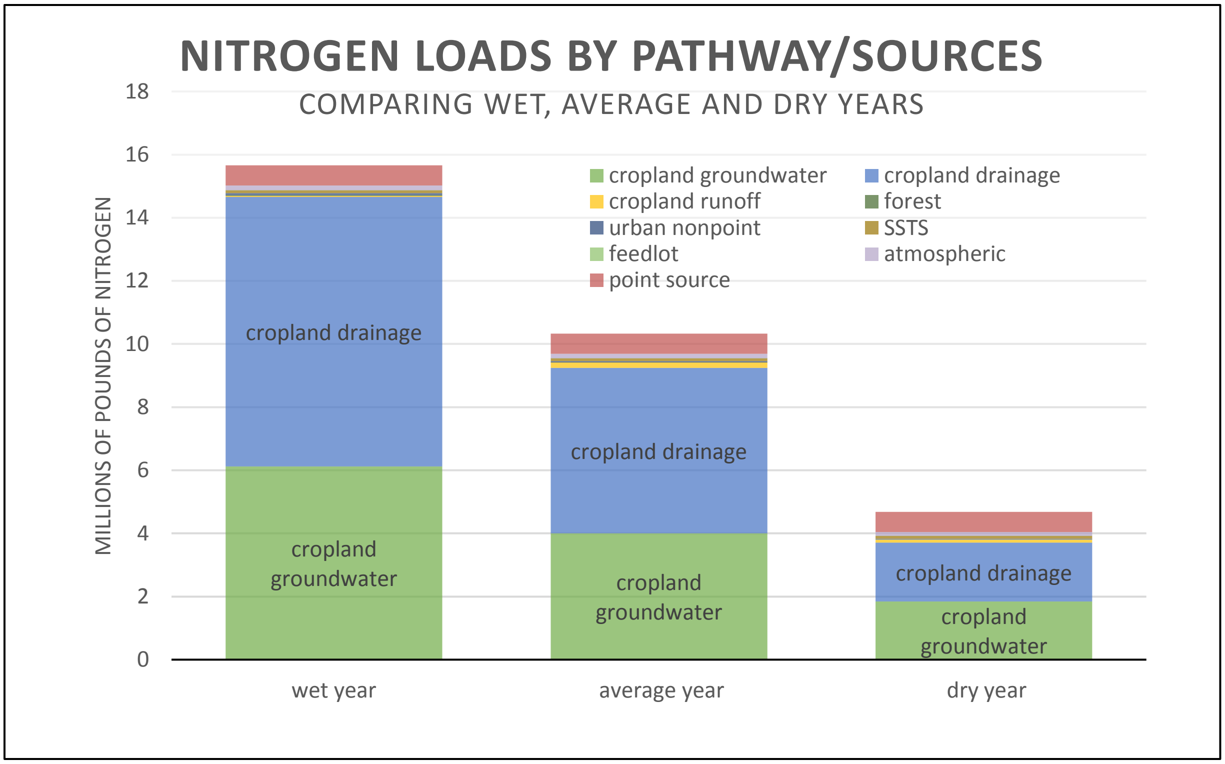


Figure 38. Comparing nitrogen loads by pathway and sources in wet, average and dry years
The amount of precipitation in a year has a direct correlation to the amount of nitrogen loading to the CRW. The amount of nitrogen delivered to the river more than triples when comparing a dry year to a wet year.

N from cropland groundwater, drainage and runoff comes from a variety of sources (Figure 39). The MPCA (2013) determined that statewide, commercial fertilizer represents the largest source of N that is added to soil. Manure, legumes, and atmospheric deposition are also significant sources; and when added together provide similar N amounts as the fertilizer additions. SOM mineralization is not a N source in itself but rather a process that mobilizes large quantities of N from the soil bank. While mineralization is an ongoing natural phenomenon, the increase in tile drainage has resulted in an increase transport of this N to surface waters. Septic systems, lawn fertilizers and municipal sludge add comparatively small amounts of N to soils statewide (less than 1% of added N).

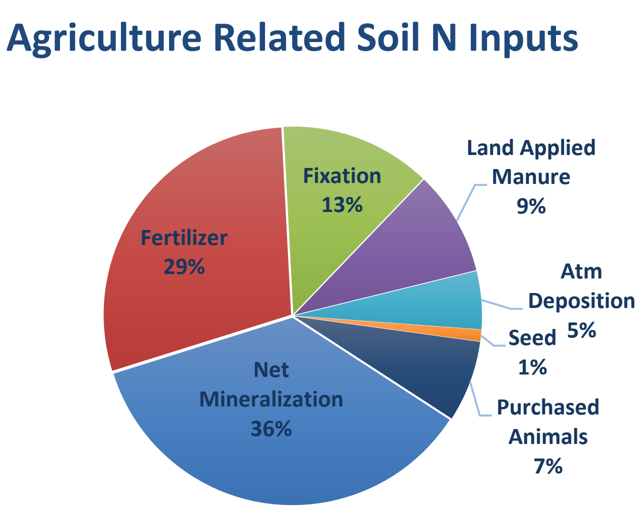


Figure 39. Nitrogen inputs to agricultural soils (statewide)

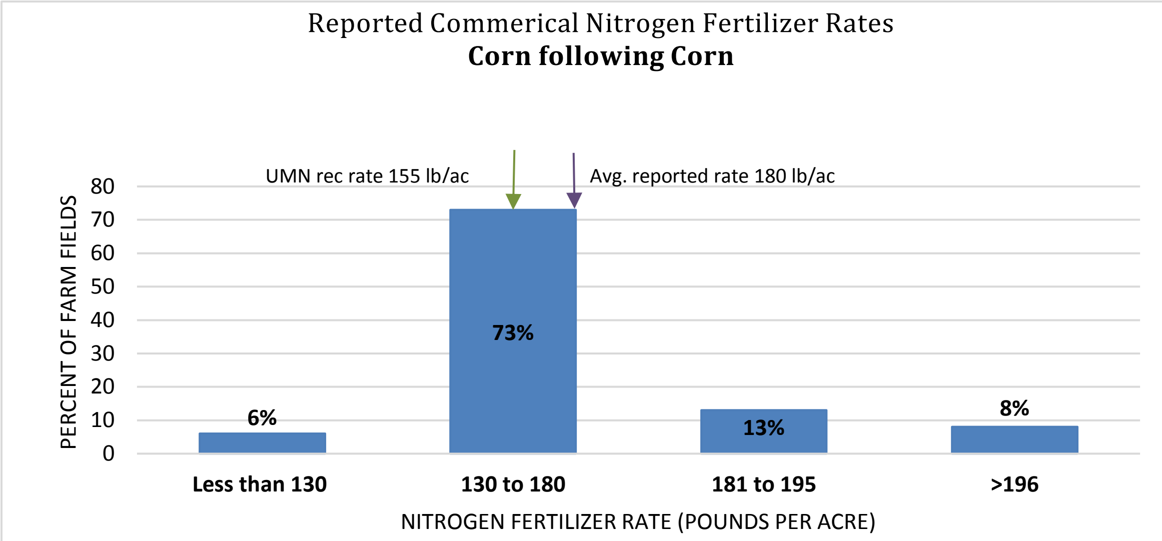


Figure 40. Reported nitrogen rates when commercial fertilizer is utilized (corn following soybeans)
21% of the fields, that were part of the survey, had nitrogen rates above the UMN-ES recommended rates. However, the overall average reported rate of 180 lbs/acre of nitrogen was within the recommended rates.

Figure 40 and Figure 41 provide the results of the 2015 MDA N use survey of corn growers in South Central Minnesota for the 2014 growing season. While this survey was not specific to the CRW it does provide some indication of N use in the region. Seventy-nine percent of farm fields, that were part of the survey, received N at or below the UMN-ES N recommendations when utilizing commercial fertilzer for corn following corn. However, when corn follows soybeans this number drops to just 32% of the fields at or below the UMN-ES N recommendations when utilizing commerical fertilzer. So, assuming this is a common regional condition for fields in a corn-soybean rotation, there is a high likihood that a significant number of acres are receiving excessive amounts of N fertilizer in the watershed. Figure 13

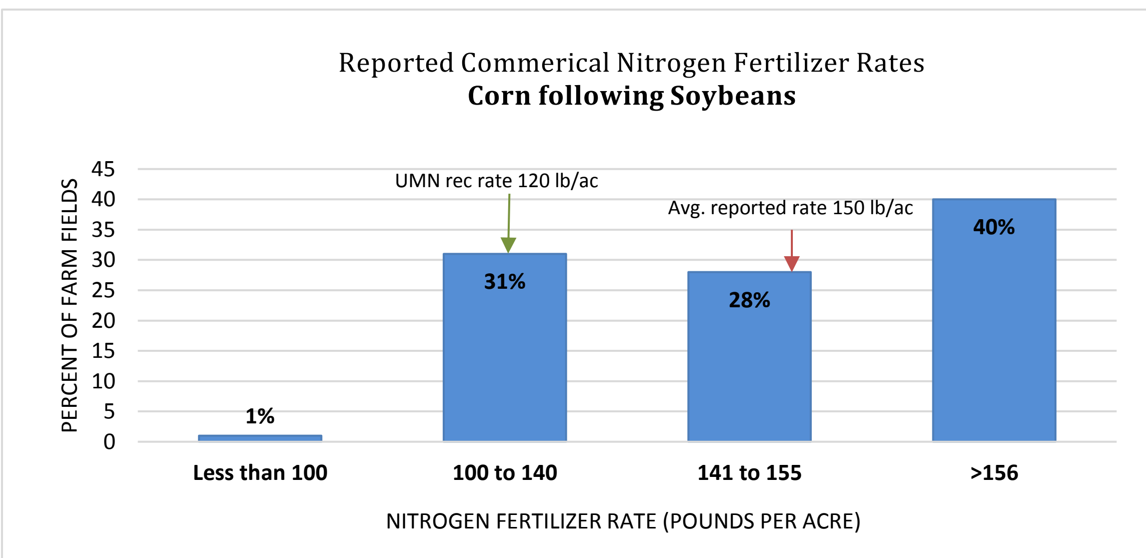


Figure 41. Reported nitrogen rates when commercial fertilizer is utilized (corn following corn)
21% of the fields, that were part of the survey, had nitrogen rates above the UMN-ES recommended rates. However, the overall average reported rate of 180 lbs/acre of nitrogen was within the recommended rates.

and 14 (in the feedlot section) provide the survey results for when manure is the main N source. It should be noted since this survey was conducted, the UMN-Extension has modified its N recommendation based on its own research. For corn following corn the new recommendation is 180 pounds of N per acre and for corn following soybeans the recommendation is 140 pounds of N per acre.

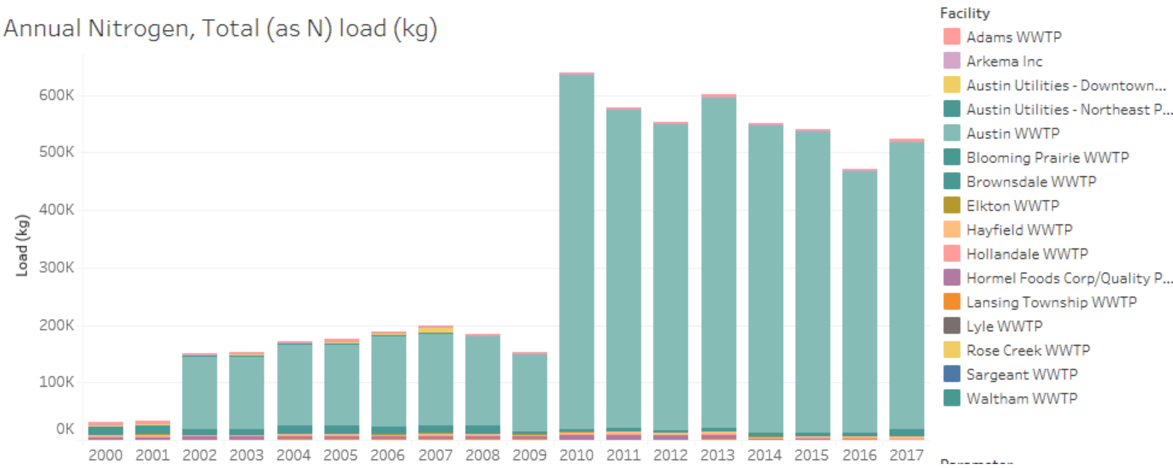


Figure 42. Annual reported nitrogen discharges to the CRW from point sources
From 2000 to 2009 amounts reported were only estimated amounts. In 2010, actual amounts of nitrogen discharged were reported.

Field and plot-scale work by the University of Minnesota has documented nitrate- N loading rates (measured via sampling of subsurface tiles) for various cropping systems and other land covers (Figure 42). Over the course of four years of monitoring, continuous corn showed the highest loading rate and Conservation Reserve Program (CRP) showed the lowest loading rate – approximately 50 times less than that of continuous corn. Corn and soybeans themselves are not the root cause of the nitrate-N loses. Instead, it is more of the lack of an actively growing crop during the spring and fall when 45% to 85% of the annual nitrate-N loss occurs through subsurface drainage (Bjorneberg 1996). This points to a need for widespread adoption of cover crops.

Overall, point sources (Figure 43) contribute only 6% of the total N load in the CRW. However, in low flow conditions point sources can be a major contributor of N which results in elevated nitrate-nitrite concentrations in excess of 10 mg/L. Figure 44 from the WPLMN demonstrates these conditions, where during higher flows and higher loading of N displayed in the lower graph (April through July), the daily concentration in the upper graph exceeds 10 mg/L. However, during lower flows (August through March) the N concentration remains near 10 mg/L, even when the actual load to the CRW is extremely low.

Effect of CROPPING SYSTEM on drainage volume, NO_3-N concentration, and N loss in subsurface tile drainage during a 4-yr period (1990-93) in MN.

Cropping System	Total discharge	Nitrate-N Conc.	Nitrate-N Loss
	Inches	ppm	lb/A
Continuous corn	30.4	28	194
Corn – soybean	35.5	23	182
Soybean – corn	35.4	22	180
Alfalfa	16.4	1.6	6
CRP	25.2	0.7	4

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Figure 43. Effects of cropping system on nitrogen loss (Graphic from Gyles Randall, UMN)

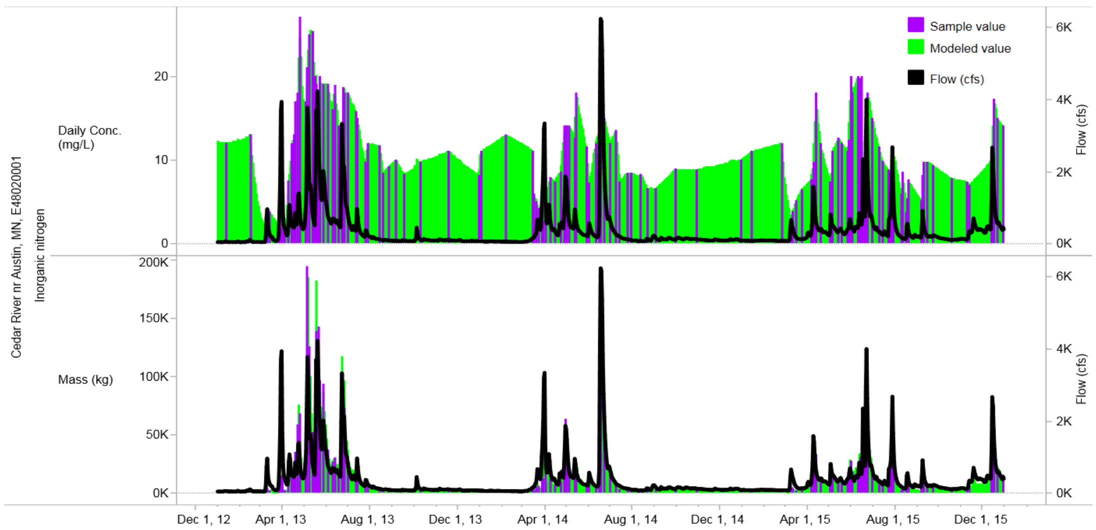


Figure 44. CRW inorganic nitrogen concentration and loads (2013 – 2015)
The high nitrate concentration (top) and low loading (bottom) during the period of August 2013 through April 2014 and then again August 2014 through April 2015 indicate a strong point source influence during low flow conditions in the CRW. Even though the concentrations are significantly higher during this timeframe, the actual amount of nitrates is relatively low.

Reductions

In the CRRW, the two key strategies to reduce N will be following the UMN recommendations, and the adoption of cover cropping. The N reduction goal identified in the NRS call for a 45% reduction from the 1980 through 1996 conditions. However, the NRS recognizes the difficulty in achieving the 45% reduction and sets a milestone reduction of 20% by 2025. The NRS indicates, "*While progress can be made with existing BMPs for nitrogen reduction, achieving nitrogen goals for the Mississippi River will also require research and development of new BMPs and adjustment to some current BMPs to make them more widely applicable. As a result, a longer timeframe is proposed for nitrogen reduction implementation. In addition, nitrate standards for aquatic life that are currently being considered will require several years for approval and implementation. For nitrogen in the Mississippi River Major Basin, a milestone reduction of 20 percent is established with a target date of 2025. Future milestones for nitrogen reduction will be established based on progress toward the milestone, along with adaptations that integrate new knowledge and needs for continued improvement. The timeframe for achieving the provisional goal is likely between 2035 and 2045 and will be refined after the success of future BMP research is evaluated, and as the Gulf of Mexico Hypoxia Task Force further considers timeframes for reaching goals. For now, a projected target date for achieving the NRS provisional goal of 45 percent reduction is 2040."* The NRS estimates the reductions needed in the CRW to achieve the 20% reduction would equate to 2,055,000 pounds of N. To achieve the 45% goal, a reduction of 4,624,000 pounds of N is required.

The Cedar River Nitrate TMDL in Iowa has indicated that a 35% reduction in total nitrate-nitrogen loading from the CRW is needed. Based on the TMDL estimated loading of 5,811 tons of N per year from the CRW, a reduction of 4,068,000 pounds of N is needed if the Cedar River is to achieve water quality standards in Iowa. Minnesota will coordinate with the State of Iowa, and the U.S. EPA, regarding cross border pollution issues.

Figure 45 depicts the HSPF modeled output for areas of high N loading from nonpoint sources. Many areas in the eastern half of the CRW are contributing in excess of 28 pounds per acre of TN to the CRW and should be targeted for reductions.

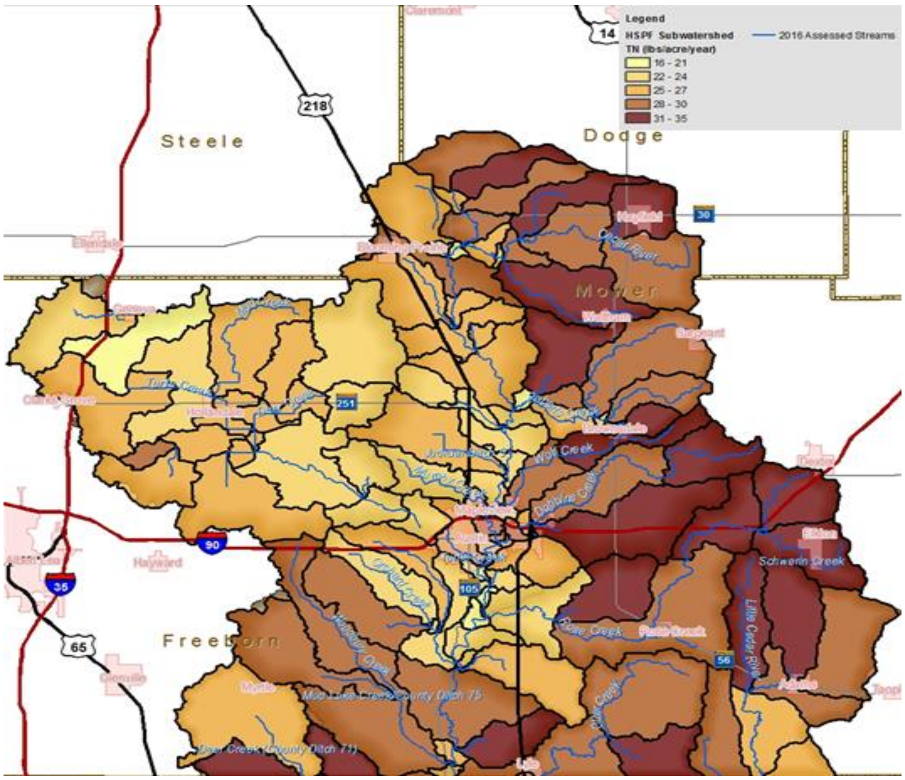


Figure 45. Nitrogen loading rates from nonpoint sources estimated from HSPF
HSPF modeling outputs indicate that the majority of the CRW is contributing at least 20 lbs/acre/year of nitrogen. With over half of the watershed contributing at least 25 lbs/acre/year.

Sediment

Sediment in rivers and streams can be in both a suspended form (pollutant) and/or an embedded form (stressor). The result is a decline in conditions for stream biota, with a degradation of aquatic habitats in both the water column, and the stream channel. Sediment that is suspended in the rivers and streams impacts aquatic life by reducing visibility that reduces feeding, clogging or damaging gills that impairs respiration, and smothering substrate that limits reproduction. Sediment that fills in between larger rocks in the channels is called embedded sediment, where it degrades conditions, such as for spawning, filling in spaces between larger rocks. These coarser sediments also affect downstream waters used for recreation and navigation (on larger rivers).

Status

For the Cedar River's 54 stream miles in Minnesota, 45 miles are sediment-impaired. Sediment has been identified as a pollutant in 10 stream reaches. In four of the 10 stream reaches, sediment is a conclusive stressor to the biological communities. From 2008 through 2015, the Cedar River at Austin had a TSS FWMC of 46 mg/L. Turtle Creek at Austin for the years 2013 through 2015 had TSS FWMC of 63 mg/L. While the average annual FWMC was below the 65 mg/L water quality standard at both locations, many times during high and very high flow the standard was exceeded. Similar to phosphorus, the majority of TSS loading is the result of three to five precipitation events a year. Figure 46 shows data from the WPLMN and how the daily TSS concentrations exceed the water quality standard only at certain times each year.

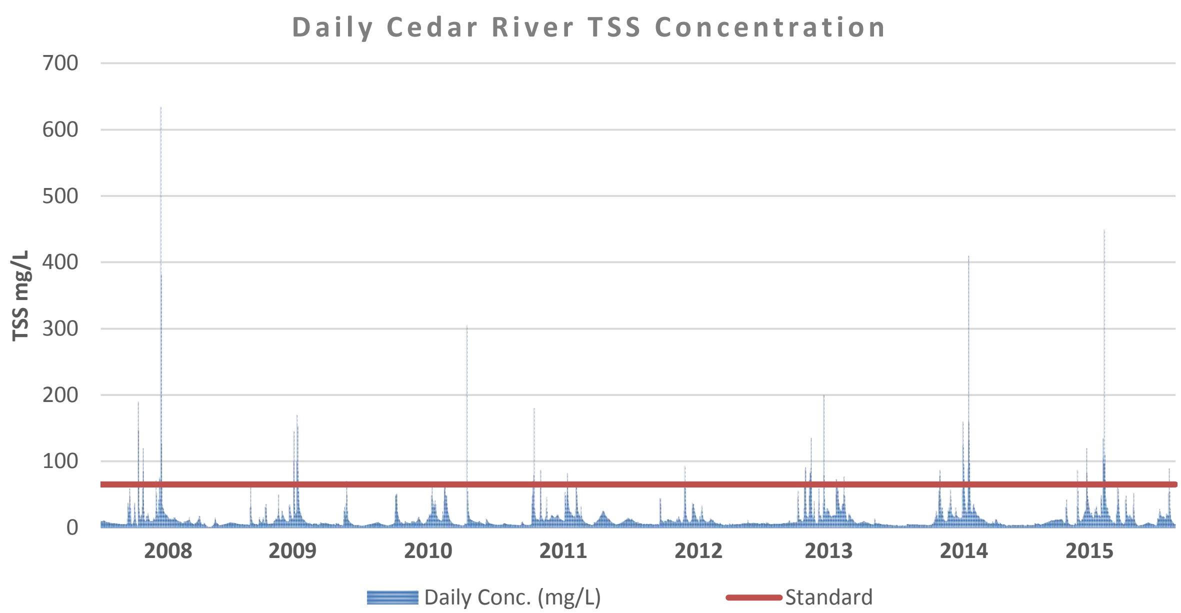


Figure 46. Daily Cedar River TSS concentrations (2008 – 2015)
Much like phosphorus, the TSS exceedances only occur a few times each year. However, when exceedance do occur they result in significant loading to the river as was the case in 2008 when one event was 10 times the 65 mg/L standard.

Sources

Multiple modeling efforts in the CRW have estimated the amount of sediment from each source. Figure 47 symbolizes the merger of these efforts. It should be noted that because there has not been a comprehensive gully and ravine inventory completed in the CRW indicating the number of ravines and the erosion rate, sediment from this soure can not accurately be modeled seperately. Therefore, sediment from gully and ravines is accounted for within the land use that the gully or ravine is located.

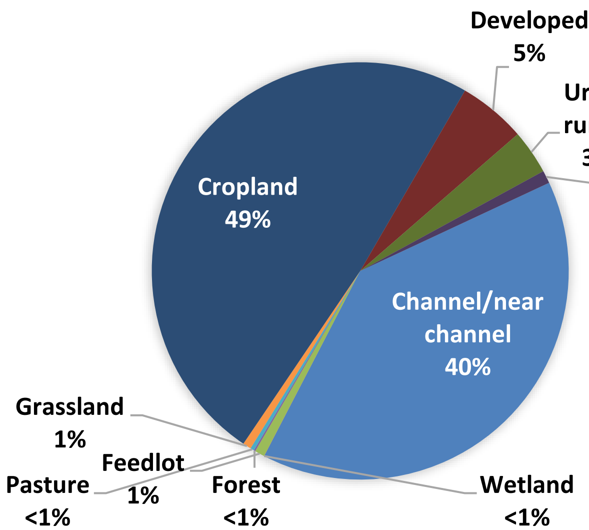


Figure 47. TSS sources in the CRW

Cropland (rill and sheet erosion) and near channel sources (bluffs, steambanks and channel) are the two largest sources of sediment in the CRW at 49% and 40% repectfully. Data from the WPLMN demonstrates (Figure 48) that these two sources are highly influenced by precipitation and river flow. Barr Engineering (2004) determined that increased runoff in the CRW has resulted in 15,000 tons of

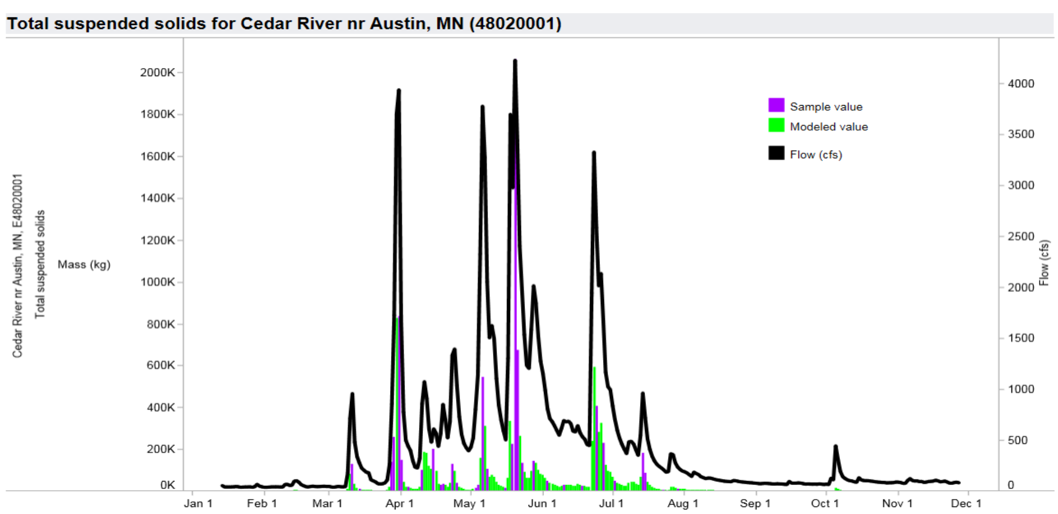


Figure 48. Daily TSS loading to the Cedar River near Austin (2013)

additional sediment being delivered to the CRW as result of additional erosion from near channel sources.

Cropland is the single largest source of sediment to the CRW. Each acre in the CRW potentially contributes between a few pounds up to 281 pounds of sediment load to the river based on HSPF modeling (Figure 49). This rate indicates the amount of sediment that actually reaches water, and is significantly lower than soil erosion rates that may be experienced within the field. While each acre individually may not contribute a large amount of sediment, it is the totality of the nearly 400,000 acres of cropland in the CRW that causes cropland to be the largest source of sediment.

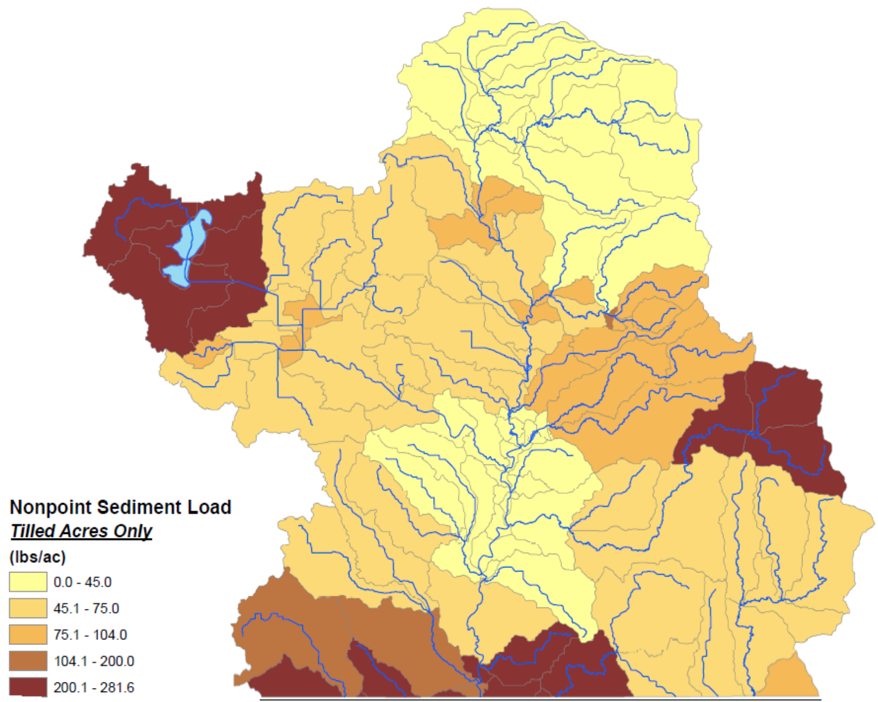


Figure 49. TSS loading rates from agricultural acres based on HSPF modeling.

While the vast majority of the TSS impairments are related to sediments such as silts and clays, in certain conditions algae growth and decay could also contribute to TSS impairments. This condition is more pronounced in low flow conditions, downstream from impoundments such as Ramsey Mill Pond and East Side Lake, and also downstream of Geneva Lake. These conditions are also present in some low gradient drainage ditches and was also noted in Turtle Creek at mid and low flow zones.

Municipal WWTF are a minor contributor of TSS to the CRW. Figure 50 provides the past 17 years of reported data from WWTF in the CRW. The average 131,326 kg per year discharged is 0.9% of the total load monitored by the WPLMN near Austin, closely approximating the modeled amount of 1% for point sources.

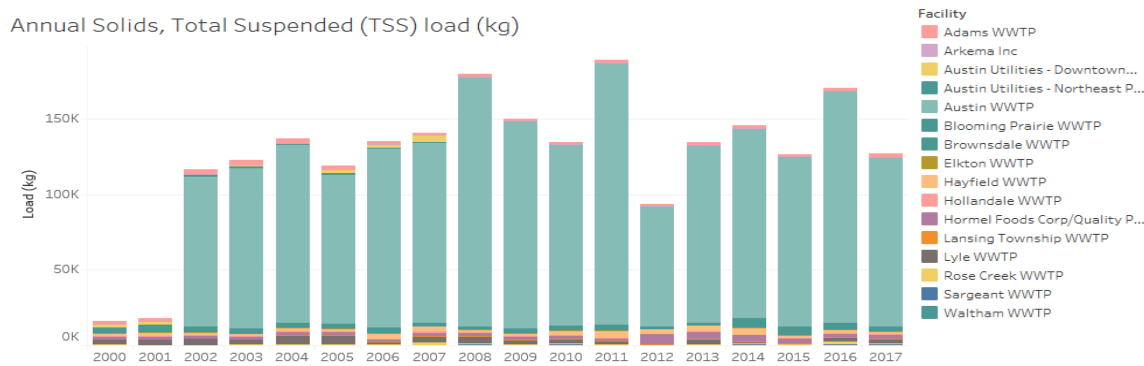


Figure 50. Annual reported TSS discharges to the CRW from wastewater treatment plants
Note not all facilities were required to submit discharge information to the MPCA in 2000 and 2001

Reductions

Water monitoring within the CRW indicates most exceedence of the TSS standard occur at very high and high flows, and most streams meet water quality goals at lower flows. Table 11 summarizes developed information from the TMDL Report, which utilizes the load duration curve method. This method identifies stream segments requiring reductions, based on the five flow zones. Figure 51 shows the location of each stream segment. In many impaired reaches, within the 'very high flow' category, a 80% to 90% reduction is needed to achieve water quality goals. It must also be understood that the TSS goals are for aquatic life use support, which also includes methods associated with the SID process. This is to say that the biological "endpoints" are important as we interpret the TSS reductions based on the standard TMDL methods that were employed.

Table 11. TSS TMDL reduction summary
All impaired reaches require reductions at very high flows. The headwaters of the Cedar River and Rose Creek also require reductions at high flows and Turtle Creek requires reductions in all flows except very low flows

Reaches name	AUID	Very High Flow	High Flow	Mid Flow	Low Flow	Very Low Flow
Cedar River, *Rose Creek to Woodbury Cr*	**-501**	**95%**	0%	0%	0%	0%
Cedar River, *Roberts Cr to Upper Austin*	**-502**	**81%**	0%	0%	0%	0%
Cedar River, *Headwaters to Roberts Cr*	**-503**	**93%**	**34%**	0%	0%	0%
Cedar River *Turtle Creek to Rose Creek*	**-515**	**79%**	0%	0%	0%	0%
Cedar River, *Woodbury Cr to Iowa*	**-516**	**41%**	0%	0%	0%	0%
Rose Creek	**-522**	**96%**	**41%**	0%	0%	0%
Lansing tributary	**-533**	**94%**	0%	0%	0%	0%
Dobbins Creek *(upper reach)*	**-535**	**91%**	0%	0%	0%	0%
Dobbins Creek *(below East Side Lake)*	**-537**	**91%**	0%	0%	0%	0%
Turtle Creek	**-540**	**86%**	**15%**	**18%**	**23%**	0%
Unnamed tributary to Rose Creek	**-583**	**94%**	0%	0%	0%	0%

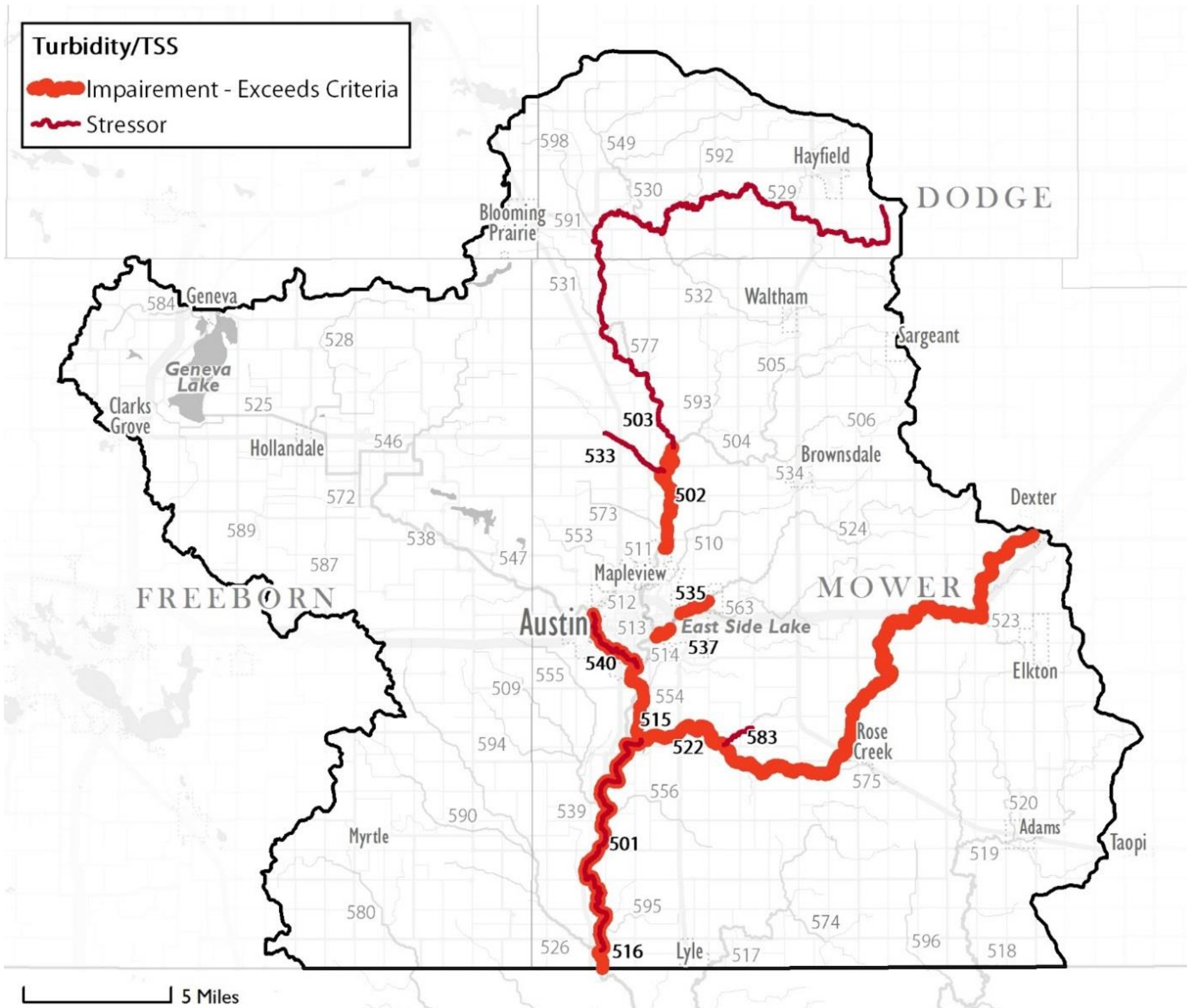


Figure 51. Location of TSS impaired reaches and reaches where TSS is a conclusive stressor

2.5 Protection Considerations

For the surface waters with sufficient data to assess for support of aquatic life, there are 11 AUIDs that were fully supporting of aquatic life based on measures of fish and macroinvertebrate community health (see **Appendix A**). These streams included several unnamed creeks, small sections of the Cedar River, Orchard Creek, Woodbury Creek, Otter Creek, and the Little Cedar River. However, all of these streams were still impaired with high levels of bacteria and other pollutants. Otter Creek was the top priority stream selected for protection in the CRW via the WRAPS committee process. However, with only 11 AUIDs fully supporting aquatic life in the CRW, all 11 AUIDS should be considered as potential priority areas for protection actions in the future.

While these 11 AUIDs were fully supportive of aquatic life, during the assessment it was noted that each AUID had potential issues, which if not addressed, could potentially lead to the stream reach becoming impaired in the future. A summary of the CRW Monitoring and Assessment report for each AUID is found in Section 3.3 within each HUC – 11 subwatershed description. Figure 52 shows the location of each of the AUIDs that fully support aquatic life.

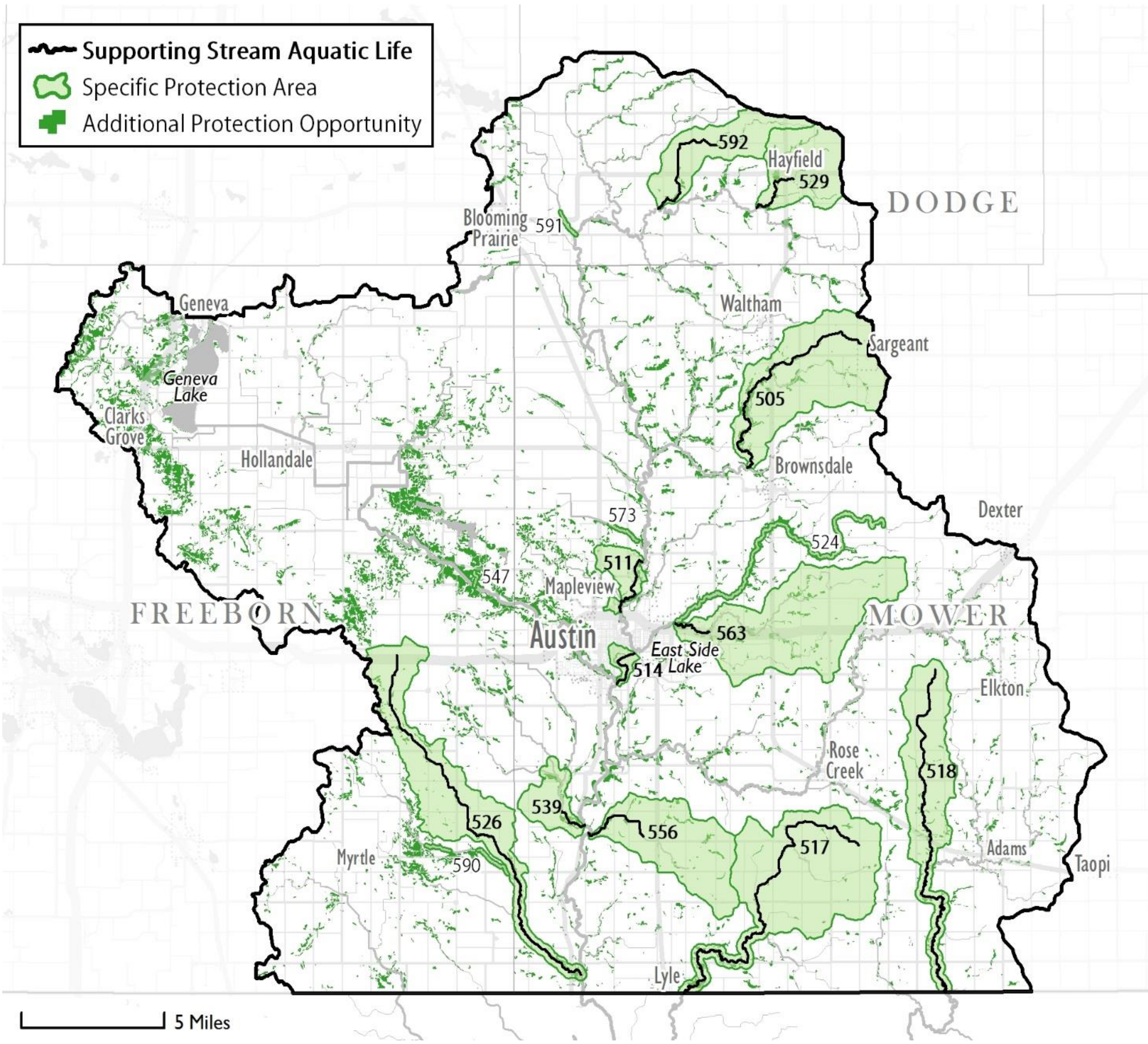


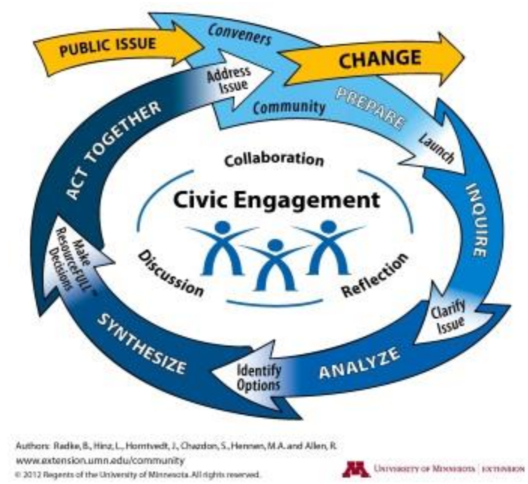
Figure 52. Streams fully supporting aquatic life based on fish and macroinvertebrate community health

3. Prioritizing and Implementing Restoration and Protection

The Clean Water Legacy Act (CWLA) requires that WRAPS reports summarize information and tools that help prioritize and target actions to improve water quality, and identify point sources and nonpoint sources of pollution with sufficient specificity to help prioritize and geographically locate watershed restoration and protection actions. In addition, the CWLA requires including an implementation table of example strategy combinations that are capable of cumulatively achieving needed pollution load reductions for point and nonpoint sources.

This section provides the results of such prioritization and strategy development. Because much 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 a critical part of the overall approach for moving forward.

3.1 Civic Engagement



A key prerequisite for successful strategy development and on-the-ground implementation is meaningful civic engagement. This is distinguished from the broader term 'public participation' in that civic engagement encompasses a higher, more interactive level of involvement. The MPCA has coordinated with the University of Minnesota Extension Service for years on developing and implementing civic engagement approaches and efforts for the watershed approach. Specifically, the University of Minnesota Extension's definition of civic engagement is "Making 'resourceFULL' decisions and taking collective action on public issues through processes that involve public discussion, reflection, and collaboration." Extension defines a resourceFULL decision as one based on diverse sources of information and supported with buy-in, resources (including human), and competence. Further information on civic engagement is available at:

https://extension.umn.edu/community-development/leadership-and-civic-engagement

Civic Engagement

The MPCA along with the local partners and agencies in the CRW recognize the importance of public involvement in the watershed process. Table 12 outlines the opportunities used to engage the public and targeted stakeholders in the watershed.

Table 12. Cedar River Watershed civic engagement meetings

Date	Location	Focus
July 10, 2008	Hollandale	TMDL development meeting
Feb. 19, 2008	Hollandale	Turtle Creek Watershed District
December 15, 2011	Austin	Mower Co. Water Planning
March 19, 2012	Austin	City of Austin, work session
March 20, 2012	Hollandale	Turtle Creek Watershed District

Date	Location	Focus
March 21, 2012	Austin	Cedar River Watershed District
November 12, 2012	Austin	Mower SWCD Board
March 7, 2016	Austin, JC Hormel Nature Center	Izaak Walton League

Additional information related to work conducted by the Mower SWCD and CRWD in 2011-2013 on civic engagement, is contained in Appendix F of the CRW TMDL Report. This appendix to the TMDL contains a report titled "Cedar River Watershed Strategy and Implementation Plan – Phase 1. Final Project Report, August 2013."

From 2015 to the present, exceptional efforts to engage both groups and the general public in CRW improvement efforts have been made by the Mower SWCD/CRWD. These efforts have affected a new level of interest and awareness about water quality, in the community as a whole. While these efforts occurred previously, they have increased in frequency, becoming more effective at reaching people, using a variety of formats. This has helped to bring forward a new initiative and partnership in the CRW, which includes private sector suppliers, landowners, and public entities working closely together (https://environmental-initiative.org/work/cedar-river-watershed-partnership/).

Technical Committee Meetings

The CRW includes numerous local/regional partners who have been involved at various levels throughout the project. The technical committee is made up of members representing the CRWD, Turtle Creek Watershed District, counties, the city of Austin, SWCDs, MPCA, DNR, BWSR, MDA, and MDH. Table 12 outlines the meetings that occurred regarding the CRW monitoring, TMDL development, and WRAPS development. The January 2014 meeting in Blooming Prairie was also attended by USDA-NRCS personnel from several counties in the watershed.

Date	Location	Meeting Focus
January 21, 2014	Blooming Prairie	Upper Cedar River Subwatersheds
January 28, 2014	Albert Lea	Turtle Creek and Freeborn County Subwatersheds
April 25, 2017	Austin	Prioritization of issues and resources; Identification of strategies

Table 13. Cedar River Watershed technical committee meetings

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 March 4, 2019 to April 3, 2019. There was one comment letter received and responded to, as a result of the public comment period.

3.2 Targeting of Geographic Areas

The following section describes the specific tools and methodologies that were used in the CRW to identify, locate and prioritize potential watershed restoration actions. The efforts to use these tools, especially for numbers 2 and 3, was locally defined – and meant to provide a high level of specificity for implementation efforts. The overall prioritization and targeting methodology was based upon the results of applying several tools, as presented separately below:

1. HSPF: Hydrologic Simulation Program Fortran
2. SWAT: Soil and Water Assessment Tool
3. Digital Terrain Analysis

HSPF and SWAT are large-scale watershed simulation models, developed and supported by U.S. EPA and USDA, respectively. Because of the importance of sediment (11 reaches), the focus is on subwatershed sediment erosion rates (pounds/acre), as shown by Figure 49 and Figure 53. Due to the different scales and timeframes, the results are different and variable for these two watershed models. Additional estimates are provided for TN (Figure 45) and TP (Figure 32) using the HSPF model, since there are 15 reaches with a confirmed nitrate stressor, and high phosphorus levels impact Geneva Lake and contribute to low DO levels in the lower Cedar River. Digital terrain analysis predicts locations of concentrated flow paths and subsequent field-scale erosion and concentrated flow paths. Local information from the WRAPS technical advisory committee was also very important for targeting.

The results from these tools provide a roadmap to guide BMP planning and implementation activities for stakeholders. It also provides rough estimates of the extent of BMP implementation needed to achieve practical reduction goals. Some of the initial output provided by these tools is summarized in the following section. Subsequent further application of the tools may be useful for planning purposes and other technical exercises.

Critical Area Identification Tools and Results

HSPF

HSPF is a large-basin, watershed model that simulates runoff and water quality in urban and rural landscapes. An HSPF watershed model was created for the CRW for use with TMDL analyses. HSPF focuses on a generalized, larger scale perspective of watershed processes. The HSPF model value lies in estimation of river flows and water quality in areas where limited or no observed data has been collected. It also provides estimations of the locations and proportions of watershed sources -- specific combinations of land use, slopes and soils -- comprising pollutant loading at downstream locations where more substantial observed data are available. The model development and calibration report for the HSPF model is available from the MPCA.

<u>Sediment, N, and phosphorus critical areas</u> identified from the HSPF model in the CRW are mapped in the source section in Figure 32 for phosphorus, Figure 45 for N and Figure 49 for TSS.

SWAT

SWAT is a physically-based watershed model developed by Dr. Jeff Arnold for the USDA Agricultural Research Service (ARS) in Temple, Texas (Arnold etal. 1993). SWAT was developed to predict the impact of land management practices on water, sediment, nutrients, DO, and agricultural chemical yields in large watersheds with varying soils, land use, and management conditions over long periods of time. SWAT is noted for accuracy in agricultural land management simulations. SWAT explicitly simulates crop management practices and urban impervious runoff. Simulated hydrologic processes include surface runoff, tile drainage, snow-melt runoff, infiltration, subsurface flow and plant uptake. The model allows for consideration of reservoirs and ponds/wetlands, as well as inputs from point sources.

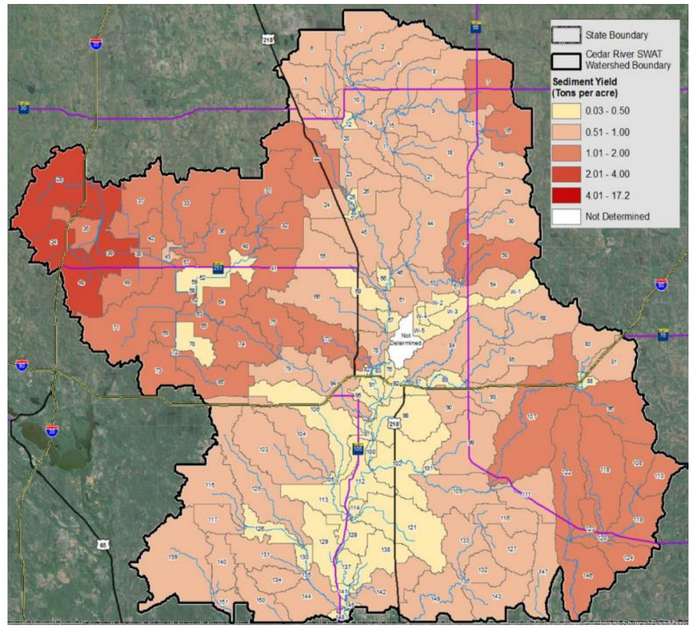


Figure 53. CRW updated SWAT Model. Modeling completed by Barr Engineering

An existing SWAT watershed model (created in 2014) for the Cedar River basin was updated with current information about soils data and locations of existing agricultural BMPs, based on data collected by Mower SWCD and watershed staff for the Cedar River and Turtle Creek Watershed Districts (Figure 53). Through these refinements, the model was used to provide greater insight into identifying and prioritizing the critical sediment source areas within each subwatershed, including a review of subwatershed sediment loads with and without the surveyed BMPs. Through inclusion of the surveyed BMPs, a sediment reduction of 25% was estimated using the SWAT, compared to modeling estimates that did not include the surveyed BMPs. Additional information on the development and application of the SWAT model is included in Appendix D of the TMDL Report.

Digital Terrain Analysis

Digital Terrain Analysis of high-resolution (3m) LiDAR DEM was performed for the CRW following guidelines developed by the MDA and the University of Minnesota. This analysis was completed as local efforts and the TMDL continued, and is described in detail in Appendix C to the TMDL report. The terrain analysis identified a large number of sites with concentrated water flow (including gullies or nick points), which may directly contribute sediment and other pollutants to surface waters in the CRW. This process involved the use of a terrain analysis index called the Stream Power Index (SPI), which provides information on areas of concentrated flow, where erosion is more likely occurring. (Note: The SPI is not restricted to stream channels, like the name implies, but rather is used in upland zones where slope length and topography are important factors for predicting erosion areas). This process narrowed down the number of SPI points, using a screening process. The final products were GIS maps that provided local staff with a series of high priority areas for both field inspection and follow-up BMP planning.

High Priority Potential Implementation Areas for erosion control BMPs identified from the digital terrain analysis in the CRW are mapped preceding the individual subwatershed strategy tables in Section 3.3. The number of high priority potential implementation sites identified within each HUC-11 subwatershed is summarized by reach AUID in the individual subwatershed strategy tables in Section 3.3, and as a whole in Table 15 below

Table 14. Number of potential high-priority sites for erosion control BMPs identified through digital terrain analysis by HUC-11 subwatershed

HUC-11 Subwatershed	Potential high-priority sites for erosion control BMPs
Middle Fork Cedar River	41
Roberts Creek	43
Upper Cedar River	75
Turtle Creek	79
Rose Creek	97
West Beaver Creek	2
Lower Cedar River	45

BMP Targeting Tools

The following tools and information were used to target various BMPs throughout the watershed. Further information regarding these targeting tools as well as the results of the analysis can be found in Appendix B. The leadership of local resource managers and soil conservation professionals also played a key part in understanding and assessing what practices would be most effective, and where/how to prioritize efforts.

Restorable Wetland Identification

Due to the extent of historical wetland drainage, restoring wetlands is a key strategy for the CRW. Water storage in the upper watershed areas in the CRW is an important implementation strategy.

Soil and Water Assessment Tool (SWAT) BMP Scenarios: Roberts Creek and Otter Creek Subwatersheds

A special application of SWAT model (using grids as the basic modeling unit) was combined with results from the digital terrain analysis (see description in previous section) to further identify and prioritize critical source areas throughout the CRW. A part of the Roberts Creek Subwatershed was a focus for restoration efforts, while the Otter Creek Subwatershed was modeled with a protection framework in mind.

Gridded Surface Subsurface Hydrologic Analysis (GSSHA): Dobbins Creek

GSSHA is a continuous, distributed-parameter, two-dimensional, hydrologic watershed model developed by the Hydrologic Systems Branch of the U.S. Army Corps of Engineers' Coastal and Hydraulics Laboratory. DNR staff have led the development of a GSSHA model for the 25,000-acre Dobbins Creek Subwatershed and at several smaller scales for the Upper North Branch of Dobbins Creek.

Prioritization

Prioritization of resources and implementation efforts in the CRW are based primarily on the importance of water retention in the headwaters to reduce stream flows, erosion, pollutant transport, loss of stream habitat and flooding. The prioritization strategy is:

- **First priority (red):**
    - Implementation of agricultural BMPs in the headwaters of the watershed, including the Dobbins Creek Subwatershed and upper part of the Roberts Creek and Turtle Creek Subwatersheds, all of which have existing BMP targeting models completed, as described in the previous section. Priority agricultural BMPs include buffers, soil health, cover crops, and erosion control practices.
    - Protection of water quality in the higher quality Otter Creek Watershed
    - Upper Wolf Creek is also a high priority area. The entire Wolf Creek Subwatershed is an important implementation project area for the CRWD.
- **Second priority (orange):**
    - While a good level of implementation can occur in second level priority subwatersheds, the greater benefit will be in headwaters zones. This can involve work to reconnect the streams to their floodplains. The reconnection of streams to their floodplain anywhere in the watershed will be beneficial to improving water quality. Feasibility studies will be needed for design and implementation.
    - Implementation of agricultural BMPs in the lower part of the Roberts Creek Subwatershed.
- **Third priority (yellow):**
    - Implementation of BMPs (rural and urban) in the downstream portions of the watershed.

An additional factor in developing the implementation strategies are the priorities of the Minnesota Nonpoint Source Funding Plan, which include: restoring impaired waters close to meeting water quality standards, protecting unimpaired waters, and restoring and protecting water resources for public use and public health, including drinking water.

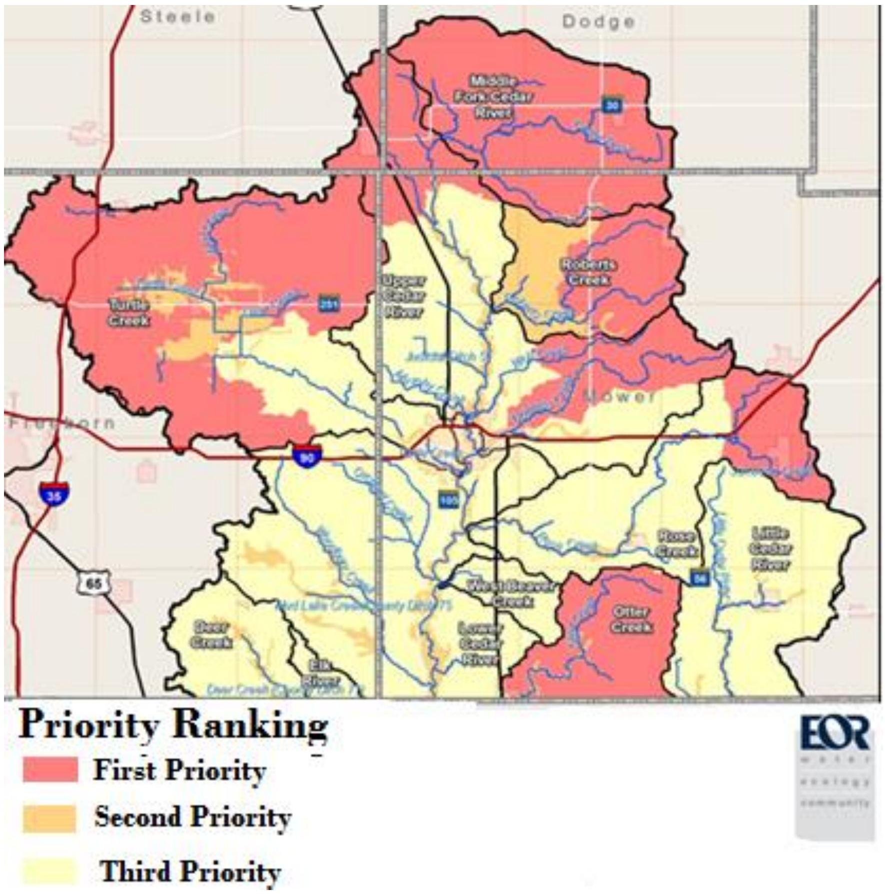


Figure 54. Priority areas

3.3 Restoration & Protection Strategies

This section provides detailed tables identifying restoration and protection strategies throughout the CRW including Geneva Lake and the individual streams in each subwatershed.

The dates contained in the table are associated with either a 10-year interim milestone or an anticipated year when water quality targets will be achieved. The first 10-year timeframe would be 2018 through 2028, and the quantity of recommended implementation is estimated for that period. The estimated time for BMP implementation, could vary considerably – as it depends upon many related factors (farm economy, technical and financial assistance, social acceptability, weather and climate, etc.).

The learning and application of techniques and information from the Dobbins Creek Subwatershed projects will continue to be a critical component in the CRW efforts. This “highest” priority project will help everyone involved learn about the relationship of BMP implementation and water quality/water quantity response.

The restoration and protection strategies are organized into key watershed-wide strategies and by HUC-11 subwatershed. Watershed-wide strategies represent a broad array of efforts and work, at various scales, that make good sense to implement broadly. They represent a core set of foundational goals that will help improve soils, waters, and habitats. The goals associated with the watershed-wide strategies come from Minnesota's NRS (MPCA 2014), the need for water storage throughout the watershed, and the need for onsite wastewater treatment for rural residences. The NRS goals for the Cedar are consistent with other large Minnesota watersheds, and cover N and phosphorus. Detailed water storage goals will be defined by the current One Watershed-One Plan process (BWSR, initiated in 2016) in the Cedar Watershed, and through ongoing work by the watershed districts and other units of government. There are 13 main strategy types included in the watershed-wide category. Many of these address runoff-driven pollutant loads, and thereby will help to reduce sediment, phosphorus, bacteria, and flow volume. N reductions are addressed by controlled drainage, nutrient management, wetland restorations, and saturated buffers. Aquatic habitat improvements will result from flow mitigation and stream channel restoration strategy types, as well as the implementation of a wide array of structural and management practices.

Subwatershed goals build upon the watershed-wide foundation, and add more specificity for water planners and implementers to utilize. Within each HUC-11 subwatershed section there is:

- Map of impaired water resources
- Map of high priority areas from the digital terrain analysis (see Section 3.2: Critical Area Identification Tools)
- A summary list of impairments
- Restorable wetland examples in several subwaterheds (see also Section 3.2: BMP Targeting Tools)
- Summary of:
    - Priority ranking
    - Subwatershed characteristics and notes
    - Stressors to stream biology Summary
    - Protection summary
    - Key strategies
- Table of Restoration and Protection Strategies for each assessed stream segment

Local Partner Input

The following list describes the major water quality concerns in the CRW based on input from local partners and regional land and water resource professionals, during the April 20, 2017, WRAPS Technical

Advisory Committee meeting in Austin, Minnesota. These water quality concerns were used to guide the identification and prioritization of restoration and protection strategies for the CRW, and are listed below, in no particular order:

- Near-channel sediment sources (streambank erosion, down-cutting of the bed, channel scour) is about 40% of the total sediment that is eroded and transported in the entire CRW according to modeling completed for the Cedar River Watershed TMDL
- Surface-groundwater interaction in karst and sandy areas
- High infiltration areas (sand)
- High nitrate- nitrogen levels in stream and drinking water
- Loss of stream bed (bottom) habitat for fish and macroinvertebrates
- Stream channelization
- Lack of water storage
- Change in stream flow following storm events
- Sediment accumulation in Geneva Lake
- Ditch maintenance and management – reduce cleanouts, and incorporate concepts such as two stage ditches and meanders into drainage ditch projects
- City of Austin floodplain and stormwater management
- Ramsey Mill Pond Dam habitat and recreational improvements
- Cedar River mainstem fish habitat
- Soil health, perennial cover, cover crops

Funding Sources

There are a variety of funding sources to help cover some of the costs to implement practices that reduce pollutants from entering our surface waters and groundwater. There are several programs listed below 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.

On November 4, 2008, Minnesota voters approved the Clean Water, Land & Legacy Amendment to the constitution. The Clean Water Fund has several grant and loan programs that could potentially be used for implementation of the BMPs and education and outreach activities. Additionally, there are various programs and sponsoring agencies related to clean water funding and other sources of funding. The following are funding sources available for clean water projects:

- Agriculture BMP Loan Program (MDA)
- Clean Water Fund Grants (BWSR)

- Clean Water Partnership Zero-interest Loans (MPCA)
- Environment and Natural Resources Trust Fund (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 (Minnesota Department of Health)
- Surface Water Assessment Grants (MPCA)
- Wastewater and storm water financial assistance (MPCA)
- Conservation Partners Legacy Grant Program (DNR)
- Environmental Quality Incentives Program (Natural Resources Conservation Service)
- Conservation Reserve Program (USDA)
- Clean Water State Revolving Fund (EPA)

Watershed-wide

Thirteen key strategies were identified for the CRW (Table 15), and would be implemented based on the subwatershed prioritization. Goals, interim 10-year milestones and responsible parties for these strategies in the CRW are listed in Table 16.

Table 15. Key strategies for the Cedar River Watershed

Strategy Scale	Strategy Type	Applicable Ag BMP Handbook Strategies (NRCS Code)
Agricultural BMPs: Build Soil Health	**Nutrient Management**	Nutrient Management (590)
	Tillage BMPs	Conservation Tillage (329, 345 and 346)
	Cover Crops	Cover Crops (340)
Agricultural BMPs: Control Water Within Fields	**Controlled Drainage**	Controlled Drainage (554)
	Incentives for Alternative Drainage	
Agricultural BMPs: Control Water Below Fields	**Wetland Restorations**	Wetland Restoration (651)
	Water Retention BMPs	Water and Sediment Control Basin (638) Constructed Wetlands Culvert Downsizing
Agricultural BMPs: Riparian Management	**Ditch Maintenance**	MN Public drainage manual
	Two Stage Ditches	Guidance from BWSR and DNR
	Stream Restoration	Riparian and Channel Vegetation (322/390)
	Buffers	Buffer law and BWSR website
Stormwater BMPs	**Urban & Municipal/Residential/Industrial**	Stormwater BMP Manual
Rural wastewater	**Upgrade septics, failing and threatening**	Onsite sewage treatment rules/program

Agricultural BMPs

Meeting the water quality standard for TSS in the CRW will involve implementing and sustaining land management activities throughout the watershed. Soil particles that are detached and transported from one event, can be remobilized during a later event, and move downstream to negatively affect water quality and habitats. At every scale, practices to reduce erosion and mitigate runoff and flow increases will need to be implemented and carefully maintained by the responsible parties.

For example, the Agricultural Conservation Planning Framework, developed by Mark Tomer of Iowa State University (Tomer et al. 2013) and others at the USDA-ARS National Laboratory for Agriculture and the Environment, is based on the concept that BMPs implemented at multiple scales, from in-field to edge-of-field to riparian, can achieve aggregate reductions without significant removal of productive agricultural land (Figure 55). This framework involves a series of decision-making steps to identify the most compatible BMPs at each implementation scale for different pollutants. The ACPF was developed and being used in the Dobbins Creek priority subwatershed.

Several other techniques and assessments have been developed, including the Prioritize, Target, and Measure Application (PTMApp), and the Minnesota Nutrient Reduction Strategy (MPCA 2013).

A small-scale modeling project was completed in the Roberts Creek Subwatershed of the CRW using a similar framework and illustrated that conservation tillage can reduce sediment loading by about 5% from existing conditions, but when filtration BMPs and controlled drainage are added with improved tillage, the total sediment reductions are in the 20% to 30% range. This demonstrates the need for a combination of practices to be implemented and sustained to meet water quality standards in the CRW.

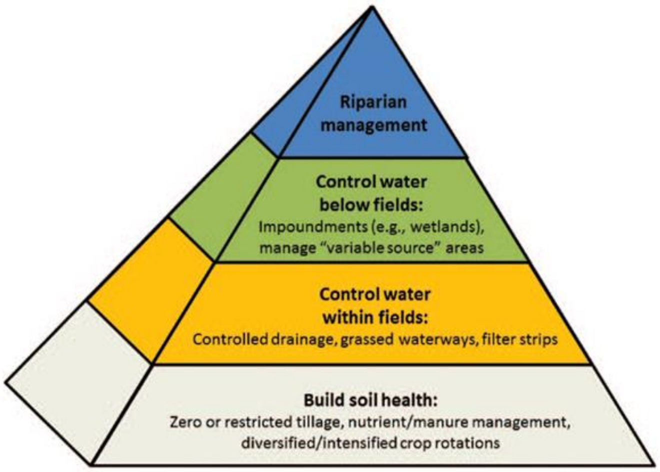


Figure 55. Agricultural Conservation Planning Framework

Conservation practices in a watershed, conceptualized as a pyramid. Healthy agricultural soils will improve the effectiveness of practices placed within fields, below fields, and in riparian zones (Tomer etal. 2013).

Ditch and Stream Strategies

For any given open channel project, a detailed site-specific survey, plan and design are required. There are numerous site-specific details such as drainage area, soils, dimensions, floodplain, slopes and ownership – to name a few – that will define how a project can be implemented. Figure 57 provides an example set of general criteria and guidance points, which should be reviewed by the project implementers, to guide the early project development stage for ditch and stream work in the CRW.

The streams in the CRW have been highly altered as shown in Figure 20 in the altered hydrology section. Consequently, a key concern for the CRW is ditch and stream management and restoration. Potential implementation strategies to address this concern include:

Self-formed two-stage ditches (TSD) are open channel ditches that have "self-formed" a low-flow channel and floodplain bench within the channel bed, without a specific construction project occurring. Often, a channel is starting to meander through a relatively wide ditch system, with the adequate slope and sediment supply to form natural channel features. As noted in Figure 57, the TSD approach is to allow as much of the natural features to remain intact.

Constructed TSD are constructed with a cross sectional area that supports a low-flow channel and floodplain bench within the channel bed. The private Mullenbach TSD demonstration project by Adams, in Mower County (Figure 56), provides the opportunity to learn from a local, on-the-ground project. This project is located in the Little Cedar River Subwatershed and was developed by the landowners, the UMN, and TNC.

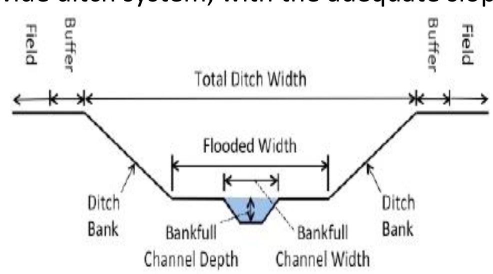


Figure 56. A two-stage drainage ditch cross-section (Figure 2.1 from Krider *et al.* 2014)

Stream restorations involve the restoration of natural stream channels with erosion, stability issues and/or poor aquatic habitat.

Figure 57. General criteria and guidance for ditch and stream management

Self-formed Two Stage Ditches

- Targeted cleanouts: If the flooded width interferes with tile drainage, only clean out the bank full channel to allow drainage while keeping the channel intact.
- Conduct a channel survey to better understand bank full channel dimensions and flooded width necessary for channel stability. Also, document channel slope, parent materials, sediment supply, and vegetation.
- Understand the natural hydrologic processes and succession of the channel.
- Consider vegetation on the bench that promotes nitrate reduction.
- Increase width of flooded width beyond the bank full channel.
- Minimize clean-out, excavate only if proven necessary for drainage.
- Work with local professional to manage and size the channel.

Public drainage systems

- Coordinate and work with drainage authorities.
- Select sites for pre-petition data collection.
- Work with drainage engineer for specifics on drainage management practices, including the need to address ongoing drainage maintenance and improvements.
- Engineer's reports for drainage projects must account for increased downstream flows.

Private ditch systems

- Coordinate and work proactively with resource professionals and private ditch groups.

Constructed Two Stage Ditches

- Most applicable for ditch improvement projects or new ditch construction.
- Include flood control or flow reduction projects upstream of the TSD.
- Consider with culvert management.
- Use tools for siting of TSDs, and culvert assessments and potential redesigns.
- Address comprehensive costs and benefits.
- May be more successful in locations where a two-stage channel has naturally formed in the past.
- Implement first in high priority areas (e.g., headwaters) to maximize downstream benefits.
- Size TSD based on drainage area and hydraulics to determine cross sectional area.

Selected Stream Restoration

- Restore stream reaches by creating a channel with proper shape, pattern, and slope.
- Consider developing a subwatershed plan to prioritize stream restorations that utilizes Natural Channel Design to restore form and function.
- Determine what is the stream's successional stage and if the channel can recover naturally.
- Prioritize streams restorations where hydrology is not altered (or minimal alteration).
- Stabilize/restore channels within the headwaters/upper parts of a given watershed first.
- Consider bank stabilization only when infrastructure involved OR when it's the only bank in the reach that is unstable (unlikely).
- Address physical habitat, channel geometry with restoration projects, not merely streambank patches.
- For bank stabilization, use natural materials (i.e., wood or field stone) vs riprap.

City of Austin Strategies

The city of Austin (population about 26,000) is located at the confluence of the Cedar River, Turtle Creek, and Dobbins Creek. Water management (drinking water and wastewater), flood mitigation, stormwater, floodplain management, and normal municipal services, are all critical items that the city is actively involved with.

Since 1983, Austin has had four major floods, including 2004 when the flood stage height was 25 feet, and maximum discharge was 20,000 cfs. Prior to 2004, six studies were conducted by either the U.S. Army Corps of Engineers (U.S. COE) or Federal Emergency Management Agency (FEMA), regarding flooding, flood insurance, or mitigation planning. The flood of 2004 resulted in a post-event mitigation study, and the city of Austin North Main Study, which assessed the feasibility of flood walls. Since 1978, about 300 structures have been bought-out and moved out of the flood plain, with local funding coming from a half-cent local option sales tax, which has provided about $13 million dollars. Austin's community goal is to remove or protect all structures in the flood plain (Flood Mitigation Plan 2006).

Austin's 2016 Comprehensive Plan recognizes the river corridors and surrounding agricultural lands as great natural assets. The city works to balance the built and natural environments. The City plans to respect and leverage the close proximity to the Cedar River through innovative stormwater management, and access to open spaces and nature.

Austin is an MS4 city, and provides public outreach and education on stormwater. This outreach and education includes webpage postings, newspaper items, meetings, trainings, and storm drain marking. The city of Austin requires that drainage design meet the requirements of the CRWD, U.S. COE, and the DNR. By City ordinance, post-construction stormwater is managed for volume, TSS and TP (City of Austin, SWPP).

Austin's WWTF are important infrastructures for the community and the regional economy. Due to the wastewater volumes and pollutant loads, the facilities are also important in river water quality below the discharge point. The existing Class A wastewater treatment system consists of two separate facilities (one industrial and one municipal), both owned and operated by the City, and are located on the same site. The industrial facility treats wastewater exclusively from Hormel Foods Corporation, while the municipal facility treats wastewater from other industries, businesses, and homes that are connected to the sanitary sewer system. The effluent from both facilities is combined for ammonia removal, clarification, and disinfection, prior to discharge into the Cedar River in the reach just upstream of the Turtle Creek tributary inflow. The Cedar River reach AUID where the discharge occurs is 07080201-514, which falls between Dobbins Creek (upstream) and Turtle Creek (downstream). This reach of the Cedar River is impaired by bacteria, and meets biological criteria for fish and macroinvertebrates.

The city of Austin is planning on a major WWTP renovation project, and is currently in the preliminary design phase.

The issue of failing septic systems along the edges of town have also been addressed by Austin, with cooperation from Austin Township and the Southeast Minnesota wastewater initiative. Annexations occurred in 2011 (142 parcels) and 2014 (28 parcels), with sanitary sewer extensions.

Table 16. Strategies and actions proposed for the entire Cedar River Watershed

Water Quality Goals/Targets and Estimated % Reduction	Strategy Scale	Strategy Type	Strategies	Pollutant / Stressors Addressed							Estimated Adoption Rate			Governmental Units with Primary Responsibility P = Project lead; X =Project partner									Estimated Year to Achieve Water Quality Target
				Nitrate	Phosphorus	Dissolved Oxygen	Altered Hydrology	Lack of Habitat	Turbidity/TSS	*E. coli*	Interim 10-yr Milestone	Suggested Goal	Units	Turtle Creek WD	Cedar River WD	SWCD	County	MPCA	DNR	BWSR	MDA	City	
Nitrogen and Phosphorus goals are from the 2014 [Minnesota Nutrient Reduction Strategy] **Nitrogen:** 20% load reduction by 2025 45% load reduction by 2040 **Phosphorus:** 12 % reduction by 2025 45% load reduction by 2025 **Water storage** Increase in surface detention areas, floodplains, and soil profile	**Agricultural BMPs:** **Build Soil Health**	**Nutrient Management**	Reduce fertilization rates to U of M agronomic fertilization rates	●	●	●					25%	50%	Corn/Soybean acres			x					P		2040
			Support and expand gridded soil testing coop programs through NRCS EQIP and private sector	●	●	●					50%	8-%	Cropland acres			x					P		
			Adopt spring N application	●	●	●					Consult NRS	Broadly	Cropland acres								x		
		Tillage BMPs	Improve soil health through improved crop residue management	●	●		●		●		5%	30%	Sediment reduction from croplands	x	x	P					x		2040
		Cover Crops	Cover crops, adding small grains/alfalfa to rotation	●	●		●		●		6%	50%	Cropland acres			x				x	x		2040
	Agricultural BMPs: **Control Water Within Fields**	**Controlled Drainage**	Water table control on flat fields	●			●				5%	25%	Cropland acres with slopes <1-2%	P	P	x				x	x		2040
		Obtain funding and apply for Alternative Drainage	Self-sustaining and pollutant trapping/mitigating designs	●			●				5	30	# of Projects			x	P		x	x			2040
	Agricultural BMPs: **Control Water Below Fields**	**Wetland Restorations**	Restore wetlands to mitigate hydrology	●			●		●		5 projects	Significant acres restored in priority area	Restorable wetlands	P	P	x			x	x		x	2035
		Water Retention BMPs (WASCOBs/ Constructed Wetlands CP 39/ Culvert Downsizing)	Implement BMPs in headwater subwatersheds	●	●	●	●	●	●		No increase	Decrease annual flow 20%	Peak flows and total discharge at Austin	P	P	x			x	x		x	2040
				●	●	●	●	●	●		Increase to 12 hours	Increase to 24 hours	Storm event storage time in headwaters										
			Reconnect floodplains and implement water retention BMPs in floodplains	●	●	●	●	●	●		Along Cedar River near Austin, MN and Otter Creek	Increase 20%	Floodplain storage										
	Agricultural BMPs: **Ditch Projects and Management**	**Ditch Maintenance**	Provide information to landowners on ditch stability, clean-out, and proper function	●			●	●	●		Annually	Annually	Workshops	P	x	x	P		x	x			2019
			Local workshops with drainage managers and U of M researchers on ditch maintenance recommendations	●			●	●	●		3 or 4	Annually	Workshops	P			P		x				

Water Quality Goals/Targets and Estimated % Reduction	Strategy Scale	Strategy Type	Strategies	Pollutant / Stressors Addressed							Estimated Adoption Rate			Governmental Units with Primary Responsibility P = Project lead; X =Project partner									Estimated Year to Achieve Water Quality Target
				Nitrate	Phosphorus	Dissolved Oxygen	Altered Hydrology	Lack of Habitat	Turbidity/TSS	*E. coli*	Interim 10-yr Milestone	Suggested Goal	Units	Turtle Creek WD	Cedar River WD	SWCD	County	MPCA	DNR	BWSR	MDA	City	
			Modernize ditch records	●			●	●	●		Digitize all	Update and maintain	# of drainage systems	P	x		P		x	x			
			Implement buffers	●			●	●	●		Meet buffer law	Preserve all natural features				P	x			x			
			Preplanning for petitions: collect data and utilize tools to determine opportunities for conservation implementation (water focus)	●			●	●	●		Select sites for pre-petition data collection; coordinate and work with drainage authorities	Continue	# of public drainage systems										
		Stream Restoration	Restore priority stream reaches by creating a channel with proper shape, pattern, slope, and floodplain	●	●	●	●	●	●		Headwaters; Develop subwatershed plan to assess and prioritize restorations	Two projects	Channels	x	x	x	x		P				2025
			Streambank stabilization as needed to protect infrastructure or for extreme erosion		●				●		A few in one priority subwatershed	A few in two priority subwatersheds	Channels										
		Buffers	Site, design, and install Saturated Buffers	●		●					100	250	# of saturated buffers	x	x	P			x				2038
			Install Side inlets on ditches		●				●		5	25	# of ditches	x	x	x	P		x	x			
		Two-Stage Ditches	Construct or promote self-formation	●	●		●	●	●		Develop one pilot project for each drainage authority	Two projects	Pilot studies	P	x		P		x	x			2030
			Use tools for siting, culvert assessments and potential redesigns; identify and rank ditches for TSD retrofits	●	●		●	●	●		High priority - some public and some private	All private	Ditches										
	Stormwater BMPs	Urban & Municipal/ Residential/ Industrial	Stormwater BMPs to reduce flows and trap pollutants	●	●		●		●	●	Follow SWPPP, model potential projects	20 projects	City storm sewer sheds						x			P	2032
	Septic systems	Rural residential	Upgrade failing systems and IPHT							●	Reduce by 50%	90 % compliance for failing, and 98% for IPHT	% of SSTS				P	x				x	2048

Individual HUC-11 subwatersheds

Middle Fork Cedar River Subwatershed

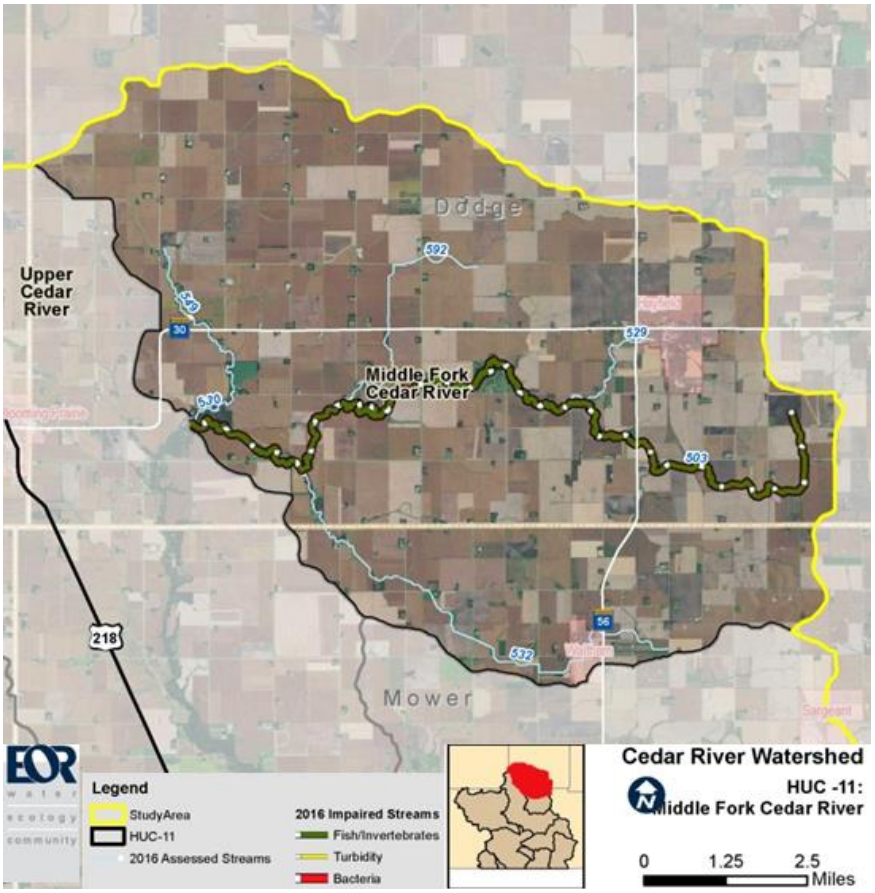


Figure 58. Middle Fork Cedar River Subwatershed

Priority Ranking: - High

Subwatershed Characteristics

- 72 square miles.
- 88% row crops.
- Includes the initial 28 miles of the Cedar River, and a series of channelized segments and drainage ditch tributaries.
- Higher nitrate-nitrogen (NO3-N) concentrations do occur.

Summary of Stressors to Biologically Impaired Streams

- 549 - Little Cedar River, Middle Fork/Westfield Ripley ditch to unnamed creek
    - Flow alteration from channelization of the headwaters results in high intensity flows during hydrologic events.
    - High flows lead to easy transport of nutrients, eroding stream banks, destruction of habitat, and sedimentation of the stream channel.

- High percentage of burrowers and legless macroinvertebrates indicate habitat stress.
- Fine sedimentation is a major driver to substrate embeddedness and habitat loss.
- Additional monitoring of water chemistry is needed.
- This reach is a general use channel under TALU. Habitat is not limiting at the channelized station.

- 530 – Unnamed Creek to Cedar River
    - Nitrate and habitat as main drivers.
    - Elevated nitrate with some of the highest concentrations in the CRW.
    - Additional TSS monitoring is needed.
    - River would benefit from habitat improvement and alterations to the surrounding landscape to control sedimentation and improve refuge for macroinvertebrates.

Summary of Other Impairments

- 503 – Cedar River, Headwaters to Roberts Creek
    - Bacteria
    - TSSs

Protection Summary

- Two unnamed creeks (– 529 and – 592)
    - In both of these stream segments, the habitat was rated as fair, however it was noted that habitat losses were occurring due to altered hydrology and unstable stream channels.
    - High nitrite-nitrate levels of 9 to 21 mg/L in the months of May and June were also observed.
    - Addressing the altered hydrology, which is creating unstable stream channels and the elevated nitrite-nitrate levels, is needed to prevent future impairment listings.

Key Strategies

- Subwatersheds with flow rate goals (as set by CRWD):

Subwatershed	Existing Flow * (cfs)	Targeted Flow (cfs)	Reduction %
Cedr - 13	3526	2258	36%
Cedr - 29	2030	1863	8%
Cedr - 34	4873	3994	18%
Cedr - 47	4873	3994	18%
Cedr - 60	1435	994	31%
Cedr- 61	1312	932	29%
UpCdr - 7	754	229	70%
UpCdr - 24	1533	787	49%

*Existing conditions and proposed conditions for a 100-year, 24-hour storm peak discharge in cubic feet per second (cfs), based on modeling results in the Upper Cedar River Surface Water Management Plan. Rates are for planning purposes and are subject to change with future study. (CRWD Watershed Mgt. Plan).

- 41 potential high priority sites for erosion control BMPs (green dots in Figure 59).
- Wetland restorations (potential areas identified in Figure 60).
- Improve soil health by reducing tillage and addition of cover crops.
- Continued management for buffers and riparian zones.
- CRP on marginal lands (wet and/or steep).

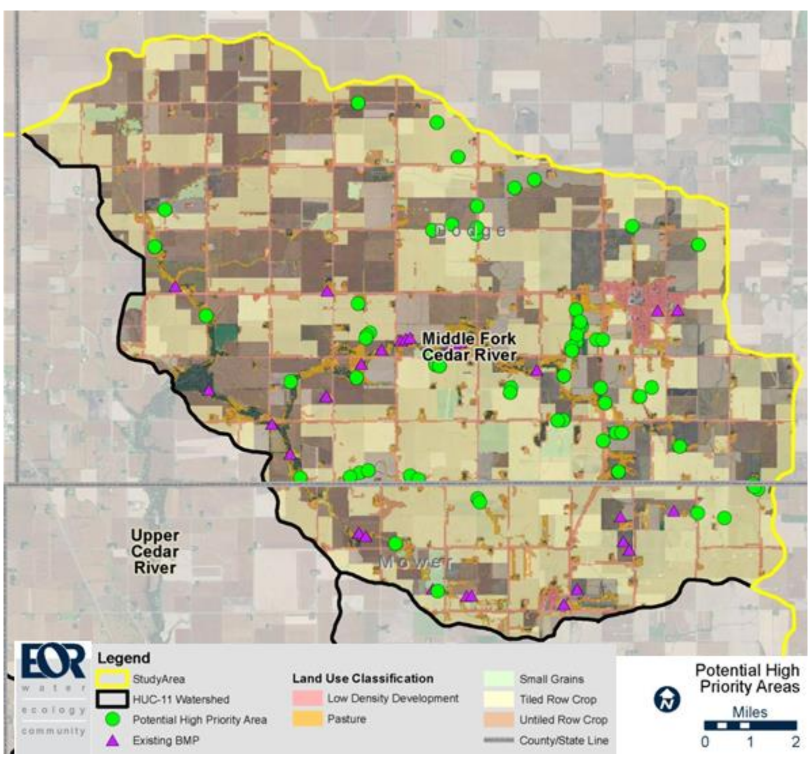


Figure 59. Middle Fork Cedar River existing BMP Locations and potential high priority areas

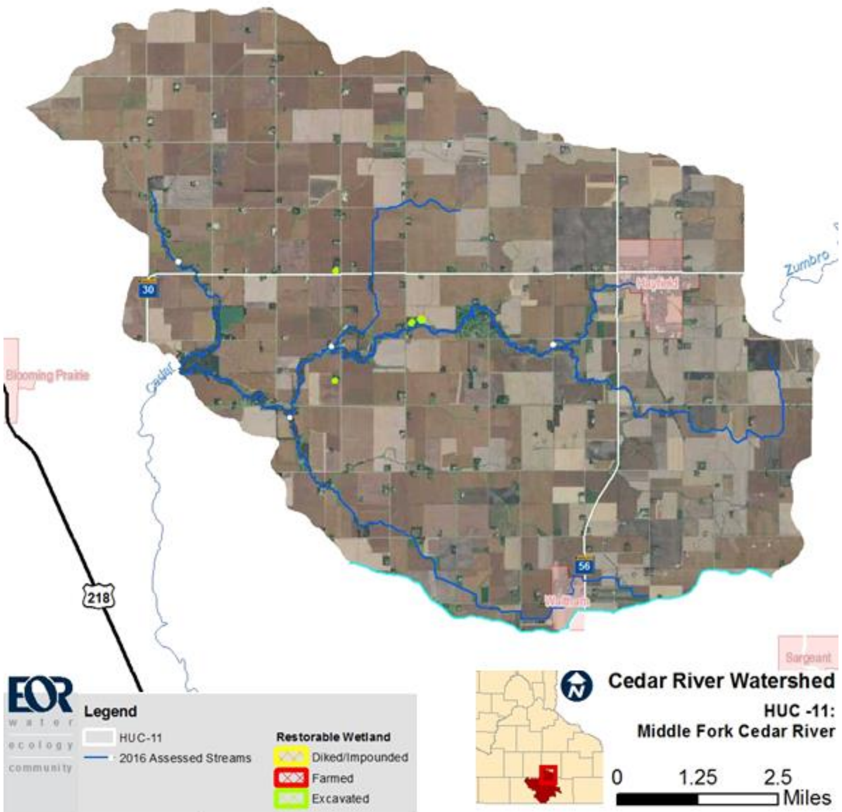


Figure 60. Middle Fork Cedar River potential restorable wetlands

Four areas were identified as having the potential to be restored wetlands. Further analysis is required to determine feasibility of the restorations.

Table 17. Strategies and actions proposed for the Middle Fork Cedar River Subwatershed

Priority Ranking	Waterbody and Location		Parameter (incl. non-pollutant stressors)	Water Quality		Strategy Type	Strategies	Pollutant / Stressors Addressed							Estimated Adoption Rate			Governmental Units with Primary Responsibility P = Project lead; X =Project partner									Estimated Year to Achieve Water Quality Target
	Waterbody (ID)	**Location** and Upstream Influence Counties		Current Conditions (load or concentration)	Goals / Targets and Estimated % Reduction			Nitrate	Phosphorus	Dissolved Oxygen	Altered Hydrology	Lack of Habitat	Turbidity/TSS	*E. coli*	Interim 10-yr Milestone	Suggested Goal	Units	Turtle Creek WD	Cedar River WD	SWCD	County	MPCA	DNR	BWSR	MDA	City	
High	Cedar River, Headwaters to Roberts Creek (503)	Dodge and Mower	***E. coli***	Average = 555 cfu/100ml, 3 of 17 samples > 1260 cfu/100ml	Monthly geometric means < 126cfu/100mL	Feedlot Improvements	Reduce/eliminate uncontrolled runoff from feedlot sites	●	●					●	30%	90%	Percent of prioritized feedlot sites			x	p	x			x		2027
						Manured Field and Riparian Pasture Management	Reduce runoff through tillage, soil management, rotational grazing, and buffers	●	●				●	●	30%	75%	Acres of manured fields with slopes >2% and grazed riparian areas			x	P	x					
						SSTS Upgrades	County programs to convert failing septics to conforming							●	Convert 75%	Convert 100% and maintain compliance	Percent of noncompliant systems				P	x			x		
			M-IBI Stressors: Nitrate Phosphorus Lack of Habitat Altered Hydrology	M-IBI below threshold	M-IBI above threshold	Erosion Control Projects*	Implement BMPs where feasible at high priority sites identified through GIS terrain analyses to reduce erosion and filter pollutants (e.g., filter strips, gully stabilization)	●	●				●		Field verify all 2 high priority sites for feasibility; implement 1	Implement all feasible sites	# high priority sites and drainage areas treated		x	P			x	x			
High	Cedar River - Middle Fork, Unnamed Creek to Cedar River (530)	Dodge & Mower	**M-IBI Stressors:** Nitrate Lack of Habitat Altered Hydrology	M-IBI below threshold	M-IBI above threshold	Erosion Control Projects*	Implement BMPs where feasible at high priority sites identified through GIS terrain analyses to reduce erosion and filter pollutants (e.g., filter strips, gully stabilization)	●	●				●		Field verify all 2 high priority sites for feasibility; implement 1	Implement all feasible sites	# high priority sites and drainage areas treated		x	P			x	x			2027
High	Cedar River - Middle Fork, Westfield-Ripley Ditch to Unnamed Creek (549)	Dodge & Mower	**M-IBI Stressors:** Nitrate Phosphorus Dissolved Oxygen	M-IBI below threshold	M-IBI above threshold	Erosion Control Projects*	Implement BMPs where feasible at high priority sites identified through GIS terrain analyses to reduce erosion and filter pollutants (e.g., filter strips, gully stabilization)	●	●				●		Field verify all 2 high priority sites for feasibility; implement 1	Implement all feasible sites	# high priority sites and drainage areas treated		x	P			x	x			2027
High	Unnamed Creek, Unnamed Creek to Cedar River (529)	Dodge	**N/A**	N/A	Support Downstream WQ Goals	Erosion Control Projects*	Implement BMPs where feasible at high priority sites identified through GIS terrain analyses to reduce erosion and filter pollutants (e.g., filter strips, gully stabilization)	●	●				●		Field verify all 16 high priority sites for feasibility; implement 4	Implement all feasible sites	# high priority sites and drainage areas treated		x	P			x	x			2027
High	Unnamed Creek, Unnamed Creek Headwaters to Cedar River (532)	Mower	**N/A**	N/A	Support Downstream WQ Goals	Erosion Control Projects*	Implement BMPs where feasible at high priority sites identified through GIS terrain analyses to reduce erosion and filter pollutants (e.g., filter strips, gully stabilization)	●	●				●		Field verify all 1 high priority sites for feasibility; implement 1	Implement all feasible sites	# high priority sites and drainage areas treated		x	P			x	x			2027

Priority Ranking	Waterbody and Location		Parameter (incl. non-pollutant stressors)	Water Quality		Strategy Type	Strategies	Pollutant / Stressors Addressed							Estimated Adoption Rate			Governmental Units with Primary Responsibility P = Project lead; X =Project partner									Estimated Year to Achieve Water Quality Target
	Waterbody (ID)	**Location** and Upstream Influence Counties		Current Conditions (load or concentration)	Goals / Targets and Estimated % Reduction			Nitrate	Phosphorus	Dissolved Oxygen	Altered Hydrology	Lack of Habitat	Turbidity/TSS	*E. coli*	Interim 10-yr Milestone	Suggested Goal	Units	Turtle Creek WD	Cedar River WD	SWCD	County	MPCA	DNR	BWSR	MDA	City	
High	Unnamed Creek, Unnamed Creek to Cedar River (592)	Dodge	**N/A**	N/A	Support Downstream WQ Goals	Erosion Control Projects*	Implement BMPs where feasible at high priority sites identified through GIS terrain analyses to reduce erosion and filter pollutants (e.g., filter strips, gully stabilization)	●	●				●		Field verify all 6 high priority sites for feasibility; implement 2	Implement all feasible sites	# high priority sites and drainage areas treated		x	P			x	x			2027

Key: Red rows = impaired waters requiring restoration; White rows = unimpaired waters requiring protection.

* Erosion control projects may include the suite of BMPs available to the landowner and the involved conservation professionals, including common practices such as waterways, terraces, filter strips, contour strip farming, WASCOBs, tillage, crop rotations and soil health. A treatment train approach will be considered for each site, customized to meet the water management and agricultural elements of each site.

Roberts Creek Subwatershed

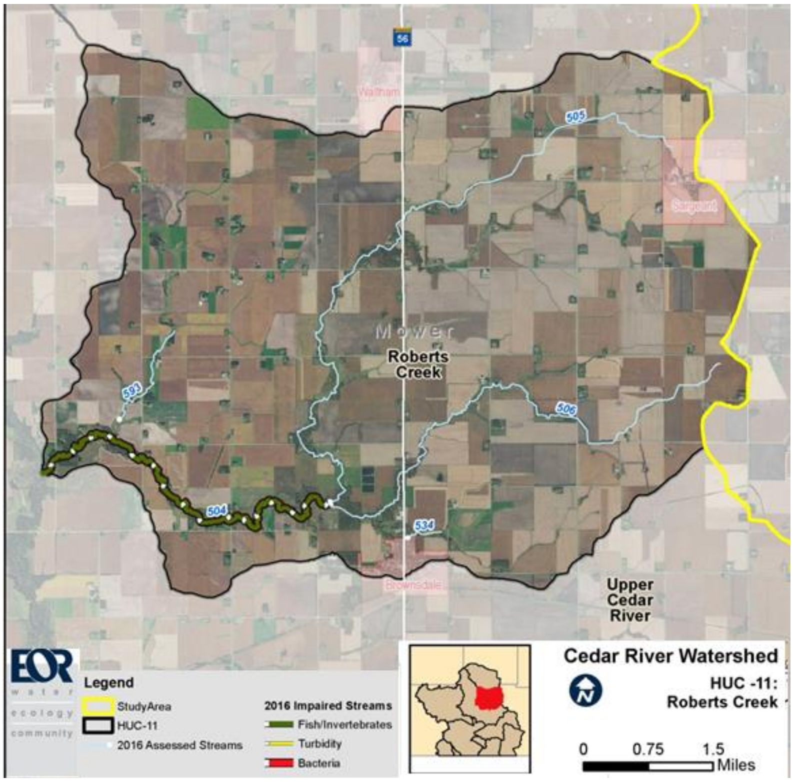


Figure 61. Roberts Creek Subwatershed

Priority Ranking - Headwaters – High; Downstream – Medium

Key Subwatershed Characteristics

- 39 square miles
- 81% row crops
- Creeks are mostly natural and unchannelized with intact forest and wetland riparian vegetation.
- One fully supporting AUID for aquatic life with sensitive fish species present, but in low numbers.

Summary of Stressors to Biologically Impaired Streams

534 – Unnamed Creek, Headwaters to Unnamed Creek

- Elevated nitrate.
- Lack of consistent baseflow.

506 - Roberts Creek, Headwaters to Unnamed Creek

- Elevated nitrates are present.
- Lack of consistent baseflow in the creek.

- Needs habitat improvement and surrounding landscape alterations to return flow regime to more consistent and less flashy system.
- Improve nutrient management within the AUID.
- Little chemical information – more monitoring needed.

593 - Unnamed Creek/Unnamed Creek to Unnamed Creek.

- Elevated nitrate – more monitoring needed.
- More than 50% channelized – very flashy flows.
- Little chemical information.
- Needs habitat improvement and nutrient management.

504 - Roberts Creek, Headwaters to Unnamed Creek

- Habitat impacted by more frequent higher flows forcing some larger scale channel changes in this reach.
- Elevated nitrate and phosphorus are present.
- More TSS and nitrate monitoring is needed.
- Needs habitat improvement and surrounding landscape alterations to return flow regime to more consistent and less flashy system.
- Improve nutrient management within the AUID.
- Two high-priority implementation areas identified through terrain analysis.

Summary of Other Impairments

504 – Roberts Creek, from an un-named creek to the Cedar River

- Bacteria

Protection Summary

505 - Unnamed creek

- The channel stability was rated as moderately unstable with excessive bank erosion and cutting being observed.
- The habitat was rated as fair but it was observed that there was severely embedded coarse substrates.
- The CRW MA Report indicates, "*in order to prevent this stream from becoming impaired in the future, attention should be given to address the geomorphic stream instability and improve habitat conditions*."

Key Strategies

- Subwatersheds with flow rate goals (as set by CRWD):

Subwatershed	Existing Flow * (cfs)	Targeted Flow (cfs)	Reduction %
Rbrts - 6	1657	1184	30%
Rbrts - 12	865	437	49%
Rbrts - 26	1383	1094	21%
Rbrts - 27	1986	728	63%
Rbrts - 33	3904	1606	59%
Rbrts - 46	1957	496	75%
Rbrts - 52	2631	856	67%
Rbrts - 57	550	347	37%

*Existing conditions and proposed conditions for a 100-year, 24-hour storm peak discharge in cubic feet per second (cfs), based on modeling results in the Upper Cedar River Surface Water Management Plan. Rates are for planning purposes and are subject to change with future study. (CRWD Watershed Mgt. Plan).

- 43 potential high priority sites for erosion control BMPs (green dots in Figure 62).

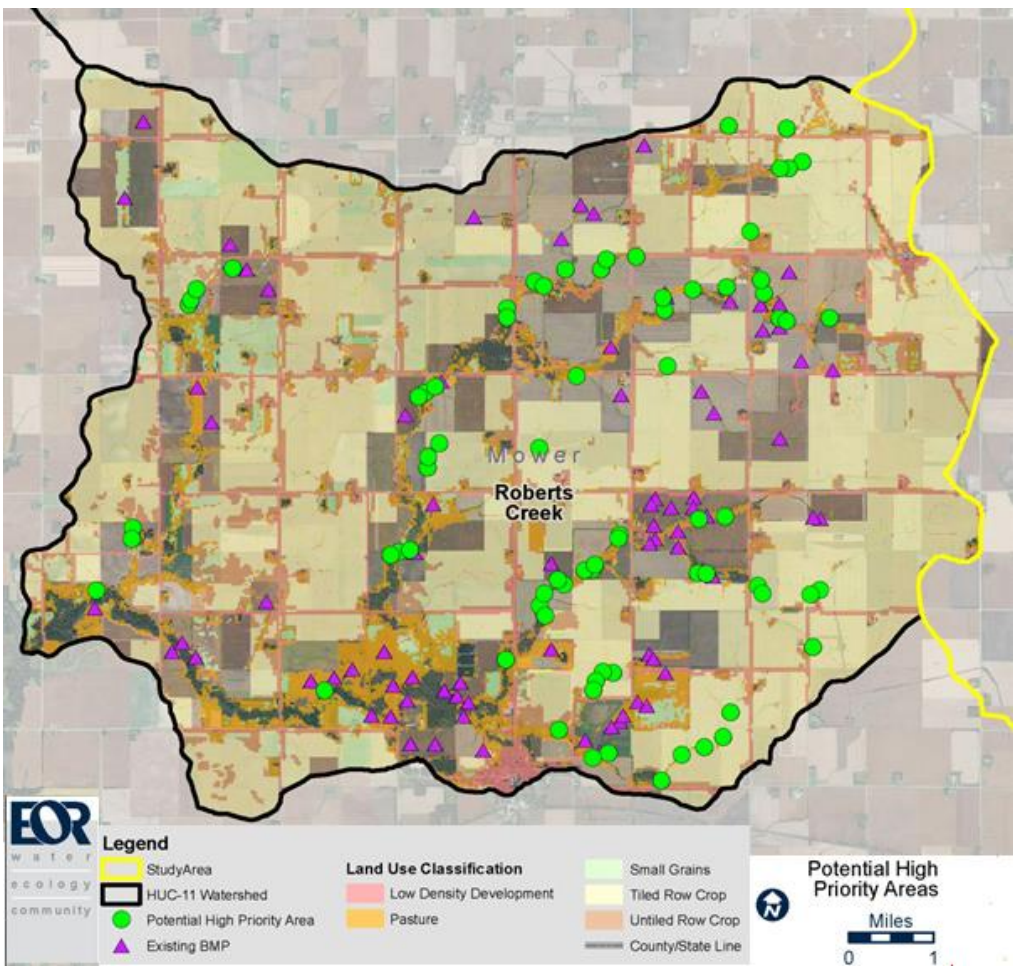


Figure 62. Roberts Creek existing BMP locations and potential high priority areas

Table 18. Strategies and actions proposed for the Roberts Creek Subwatershed

Priority Ranking	Waterbody and Location		Parameter (incl. non-pollutant stressors)	Water Quality		Strategy Type	Strategies	Pollutant / Stressors Addressed							Estimated Adoption Rate			Governmental Units with Primary Responsibility P = Project lead; X =Project partner									Estimated Year to Achieve Water Quality Target
	Waterbody (ID)	Location and Upstream Influence Counties		Current Conditions (load or concentration)	Goals / Targets and Estimated % Reduction			Nitrate	Phosphorus	Dissolved Oxygen	Altered Hydrology	Lack of Habitat	Turbidity/TSS	*E. coli*	Interim 10-yr Milestone	Suggested Goal	Units	Turtle Creek WD	Cedar River WD	SWCD	County	MPCA	DNR	BWSR	MDA	City	
Medium	Roberts Creek, Headwaters to Unnamed Creek (504)	Mower	**M-IBI & F-IBI Stressors:** Nitrate Phosphorus Dissolved Oxygen Lack of Habitat Altered Hydrology Turbidity/TSS	M-IBI & F-IBI below threshold	M-IBI & F-IBI above threshold	Erosion Control Projects*	Implement BMPs where feasible at high priority sites identified through GIS terrain analyses to reduce erosion and filter pollutants (e.g., filter strips, gully stabilization)	●	●				●		Field verify all 2 high priority sites for feasibility; implement 2	Implement all feasible sites	# high priority sites and drainage areas treated		x	P			x	x			2037
			E. coli	June-Aug geometric means 344 - 727 cfu/100ml. 2 of 17 samples > 1260 cfu/100ml.	Monthly geometric means < 126CFU/100mL	Feedlot Improvements	Reduce/eliminate uncontrolled runoff from feedlot sites	●	●					●	30%	90%	Percent of prioritized feedlot sites			x	p	x			x		
						Manured Field and Riparian Pasture Management	Reduce runoff through tillage, soil management, rotational grazing, and buffers	●	●				●	●	30%	75%	Acres of manured fields with slopes >2% and grazed riparian areas			x	P	x					
						SSTS Upgrades	County programs to convert failing septics to conforming							●	Convert 75%	Convert 100% and maintain compliance	Percent of noncompliant systems				P	x			x		
High	Roberts Creek, Headwaters to Unnamed Creek (506)	Mower	**M-IBI & F-IBI Stressors:** Nitrate Lack of Habitat Altered Hydrology Turbidity/TSS	M-IBI & F-IBI below threshold	M-IBI & F-IBI above threshold	Erosion Control Projects*	Implement BMPs where feasible at high priority sites identified through GIS terrain analyses to reduce erosion and filter pollutants (e.g., filter strips, gully stabilization)	●	●				●		Field verify all 10 high priority sites for feasibility; implement 5	Implement all feasible sites	# high priority sites and drainage areas treated		x	P			x	x			2027
Medium	Unnamed Creek, Headwaters to Unnamed Creek (534)	Mower	**M-IBI & F-IBI Stressors:** Nitrate Lack of Habitat Altered Hydrology Turbidity/TSS	M-IBI & F-IBI below threshold	M-IBI & F-IBI above threshold	Erosion Control Projects*	Implement BMPs where feasible at high priority sites identified through GIS terrain analyses to reduce erosion and filter pollutants (e.g., filter strips, gully stabilization)	●	●				●		Field verify all 6 high priority sites for feasibility; implement 3	Implement all feasible sites	# high priority sites and drainage areas treated		x	P			x	x			2037
Medium	Unnamed Creek, Unnamed Creek to Unnamed Creek (593)	Mower	**M-IBI**	M-IBI below threshold	M-IBI above threshold	Erosion Control Projects*	Implement BMPs where feasible at high priority sites identified through GIS terrain analyses to reduce erosion and filter pollutants (e.g., filter strips, gully stabilization)	●	●				●		Field verify all 3 high priority sites for feasibility; implement 1	Implement all feasible sites	# high priority sites and drainage areas treated		x	P			x	x			2037
High	Unnamed Creek, Headwaters to Roberts Cr (505)	Mower	**N/A**	N/A	Support Downstream WQ Goals	Erosion Control Projects*	Implement BMPs where feasible at high priority sites identified through GIS terrain analyses to reduce erosion and filter pollutants (e.g., filter strips, gully stabilization)	●	●				●		Field verify all 22 high priority sites for feasibility; implement 5	Implement all feasible sites	# high priority sites and drainage areas treated		x	P			x	x			2027

Key: Red rows = impaired waters requiring restoration; White rows = unimpaired

Erosion control projects may include the suite of BMPs available to the landowner and the involved conservation professionals, including common practices such as waterways, terraces, filter strips, contour strip farming, WASCOBs, tillage, crop rotations and soil health. A treatment train approach will be considered for each site, customized to meet the water management and agricultural elements of each site.

Upper Cedar River Subwatershed

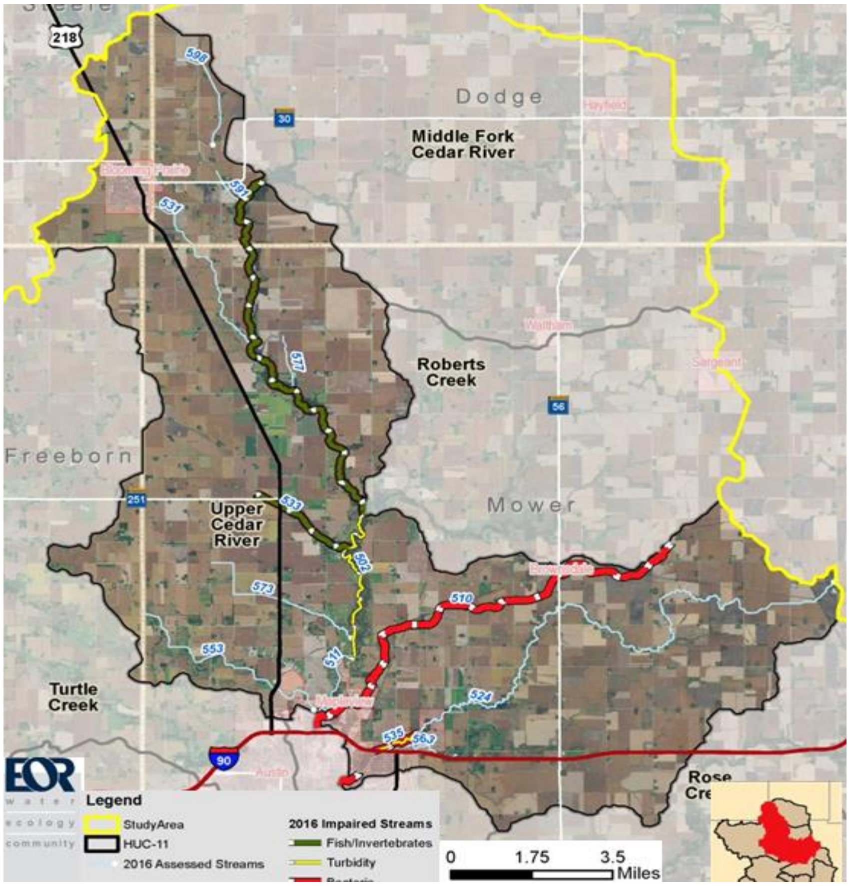


Figure 63. Upper Cedar River Subwatershed

Priority Ranking - Headwaters – High; FEMA floodplain – Medium; Downstream – Low

Subwatershed Characteristics

- 131 square miles – second largest
- 79% row crops
- Ramsey Mill Pond dam has structural integrity issues, as well as lateral connectivity and sediment build up behind the dam.
- Wolf Creek not assessed for TALU due to localized groundwater seep that co-locates with the biological monitoring station – creates atypical coldwater conditions for the otherwise warmwater stream.
- Groundwater seeps do occur along the Cedar River and tributaries, such as Wolf Creek and Dobbins Creek, with the potential to improve the thermal regime in the system, and possibly support coldwater species in localized areas.
- The Wolf Creek Subwatershed has had extensive BMP implementation, and will be considered for protection area status in the near future.

- Extensive algal growth was noted at the biological station on Wolf Creek flowing through Todd Park.

Summary of Stressors to Biologically Impaired Streams

591 - Cedar River - West Fork, Unnamed Creek to Cedar River

- Abundant channelization in the watershed leads to flashy flow and flow alteration.
- Little chemical information – more monitoring is needed.
- Habitat impacted by more frequent higher flows forcing some larger scale channel changes in this reach.

577 - Unnamed Creek, Unnamed Creek to Cedar River

- Reach dominated by sand and silt substrate with little riffle habitat.
- Habitat impacted by lack of stability in flow with more frequent higher flow events and low flow conditions forcing channel changes due to land use changes.
- Elevated nitrate.
- Better management of nutrients – little nutrient and TSS data, more monitoring needed.

503 - Cedar River, Headwaters to Roberts Creek.

- Fish performed well, macroinvertebrates poor in headwaters, fair to good in downstream reaches.
- Primary stressors: Habitat limitations and substrate embeddedness.
- Secondary stressors: Elevated TSS, low DO, elevated nitrate, elevated phosphorus and flow alteration.
- Sand dominated substrate with low gradient.
- Stream bank erosion prominent on outside banks.
- Excess bedload in upper stream reach but not as prevalent in lower reach.
- Habitat improvements needed for lack of riffles, adjacent land use, and bank erosion.
- Nutrient management needed.

533 - Unnamed Creek, Unnamed Creek to Cedar River

- Lacks good quality riffles and woody debris – only habitat was undercut banks and overhanging vegetation.
- Habitat impacted by more frequent higher flows forcing some larger scale channel changes in this reach.
- Elevated nitrate.
- Stream modifications such as straightening have caused channel instability and downstream habitat degradation.

- Better management of nutrients needed.

Summary of Other Impairments

535 - Dobbins Creek (Upper Reach)

- *E. coli* bacteria
- TSSs

537 – Dobbins Creek (East Side Lake to Cedar River)

- *E. coli* bacteria
- TSS

502 - Cedar River, Roberts Creek to Upper Austin Dam

- TSS

503 - Cedar River, Headwaters to Roberts Creek

- TSS

510 - Wolf Creek, Headwaters to Cedar River

- *E. coli* bacteria

Protection Summary

- Two segments of the Cedar River (AUID - 511 and – 514) and an unnamed creek (AUID – 563)
  - High nitrates and turbidity were noted in the three stream segments.
  - The CRW MA Report states, "*These streams should be monitored and included in watershed management strategies that may maintain and improve stream conditions in order to prevent future listings."*

Key Strategies

- Subwatersheds with flow rate goals (as set by CRWD). This HUC-11 includes many of the subwatersheds with flow rate goals set by the CRWD. Due to the high number of subwatersheds in Dobbins Creek (a total of 54), a graph was developed that depicts the number of subwatersheds present, with a cumulative flow reduction estimate, based on 10% increments in flow reductions. Figure 64 below illustrates these "10% groupings," with a sum for both the cumulative flow reduction and the number of subwatersheds in the grouping. It can be noted that this presentation does not take into account the land area associated with each subwatershed. Reduction percentages (i.e. existing to proposed) can be assessed with the predicted direct flow volume change, or placed on a unit-area basis, for comparison purposes.

Subwatershed	Existing Flow * (cfs)	Targeted Flow (cfs)	Reduction %
UpCdr - 13	585	225	51%
Cedr - 79	446	243	46%
Cedr - 85	1858	1311	29%
Cedr - 111	761	233	69%
Cedr - 123	1034	950	8%
Cedr - 129	11476	10381	9%
cedr- 144	2412	1865	23%
Wolf - 1	370	356	4%
Wolf - 2	86	53	38%
Wolf - 3	446	386	13%
Wolf - 5	760	414	46%
Wolf - 6	888	412	54%
Wolf - 7	1093	456	58%
Wolf - 8	183	41	78%
Wolf - 9	175	38	78%
Wolf - 10	1674	492	71%
Wolf - 11	1744	968	45%
Wolf - 12	1769	653	63%
Wolf- 13	103	30	71%
Wolf - 14	2351	931	60%

*Existing conditions and proposed conditions for a 100-year, 24-hour storm peak discharge in cubic feet per second (cfs), based on modeling results in the Upper Cedar River Surface Water Management Plan. Rates are for planning purposes and are subject to change with future study. (CRWD Watershed Mgt. Plan).

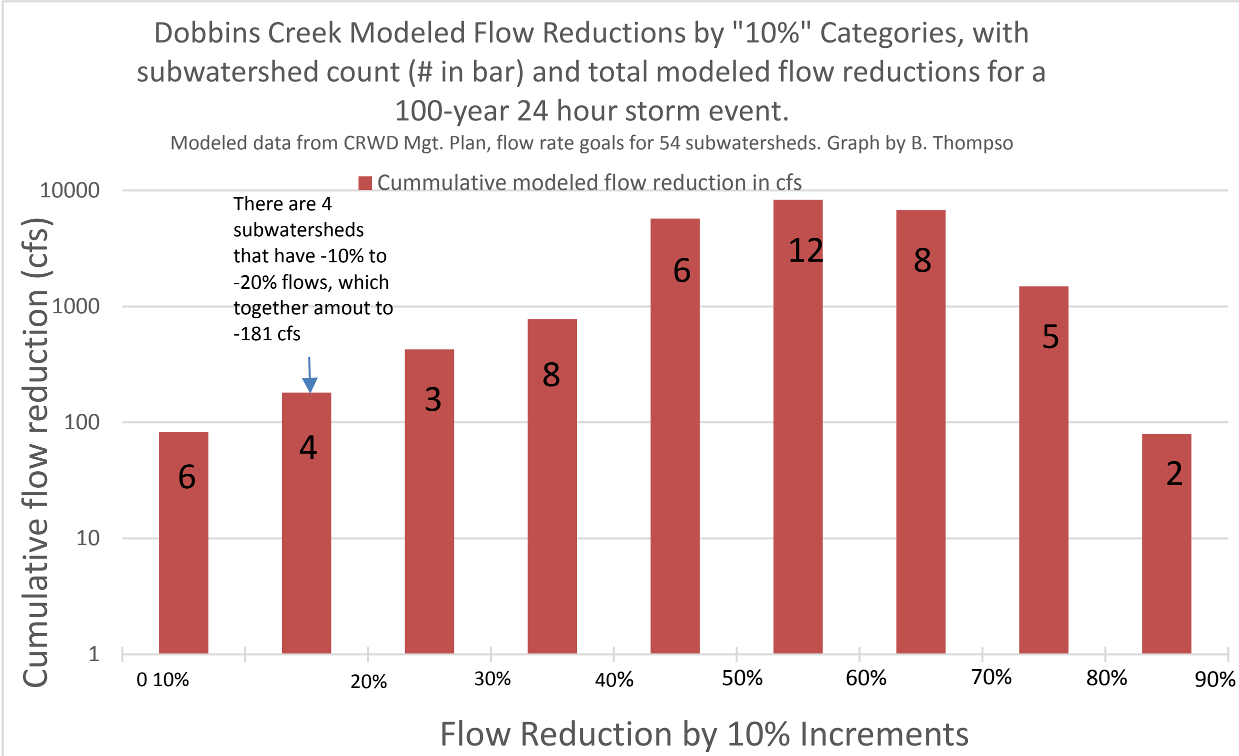


Figure 64. Dobbins Creek modeled flow reductions

The median flow reduction among the 54 subwatersheds in Dobbins Creek that have modeled flow rate goals is 50% (i.e. from existing to proposed). If all cumulative reductions were realized, this analysis suggests that a potential maximum 52% reduction in the 100-year, 24-hour storm peak discharge could be achieved. This type of analysis can also be used as a targeting method, to aid in the implementation of practices in subwatersheds that will likely produce the biggest flow reductions.

- 75 potential high priority sites for erosion control BMPs (green dots in Figure 61).
- Wetland restoration (potential area identified in Figure 66).
- Riparian protection on mainstem Cedar River and tributaries.
- Ramsey Mill Pond Wildlife Management Area (WMA)
    - Coordination with DNR on management of the WMA.
    - Improvements to in-stream habitat needed.
- Dobbins Creek and East Side Lake were the focus of an investigation by the City of Austin and Mower County in 1964. This intensive project provided monitoring data to identify pollution sources from sewage, and conditions in the streams and lake (Austin, City 1964).

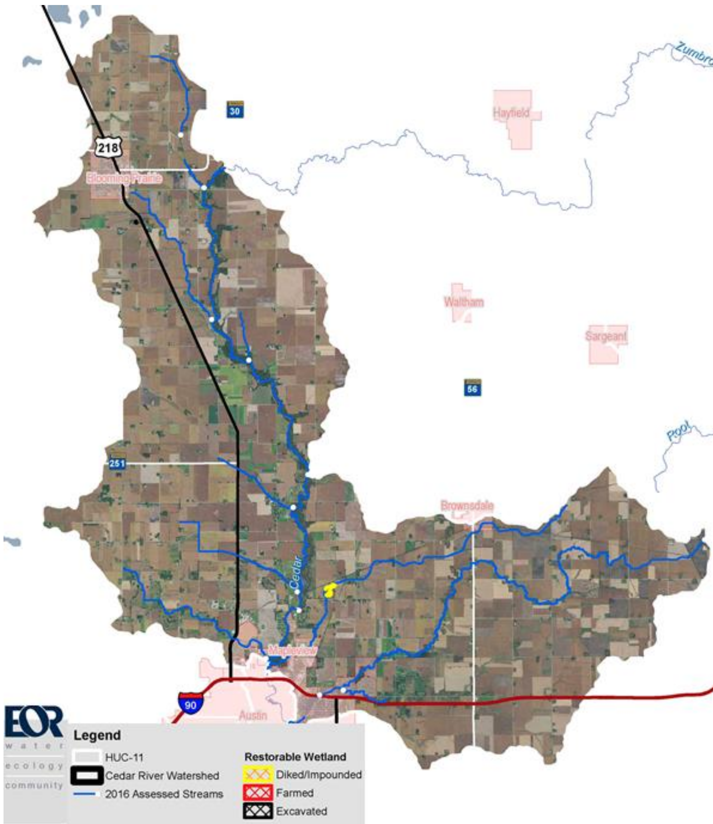


Figure 66. Upper Cedar River potential restorable wetlands

One area was identified as having the potential for wetland restoration. Further analysis is required to determine feasibility of the restoration.

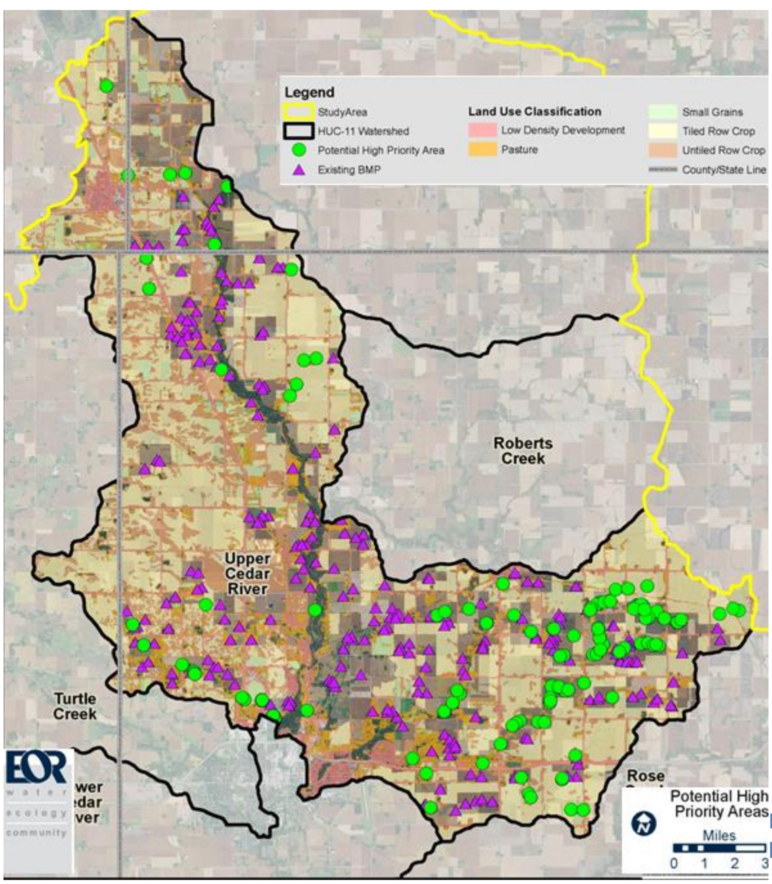


Figure 65. Upper Cedar River existing BMP locations and potential high priority areas

Table 19. Strategies and actions proposed for the Upper Cedar River Subwatershed

Priority Ranking	Waterbody and Location		Parameter (incl. non-pollutant stressors)	Water Quality		Strategy Type	Strategies	Pollutant / Stressors Addressed							Estimated Adoption Rate			Governmental Units with Primary Responsibility P = Project lead; X =Project partner									Estimated Year to Achieve Water Quality Target
	Waterbody (ID)	**Location** and Upstream Influence Counties		Current Conditions (load or concentration)	Goals / Targets and Estimated % Reduction			Nitrate	Phosphorus	Dissolved Oxygen	Altered Hydrology	Lack of Habitat	Turbidity/TSS	*E. coli*	Interim 10-yr Milestone	Suggested Goal	Units	Turtle Creek WD	Cedar River WD	SWCD	County	MPCA	DNR	BWSR	MDA	City	
Low	Cedar River, Roberts Creek to the Upper Austin Dam (502)	Mower	***E. coli***	Average = 555 cfu/100ml, 3 of 17 samples > 1260 cfu/100ml	Monthly geometric means < 126CFU/100mL	Feedlot Improvements	Reduce/eliminate uncontrolled runoff from feedlot sites	●	●					●	30%	90%	Percent of prioritized feedlot sites			x	p	x			x		2047
						Manured Field and Riparian Pasture Management	Reduce runoff through tillage, soil management, rotational grazing, and buffers	●	●				●	●	30%	75%	Acres of manured fields with slopes >2% and grazed riparian areas			x	P	x					
						SSTS Upgrades	County programs to convert failing septics to conforming							●	Convert 75%	Convert 100% and maintain compliance	Percent of noncompliant systems				P	x			x		
			Turbidity (TSS)	18% of 127 samples exceeded standard	<10% of samples exceed 65 mg/L	Erosion Control Projects*	Implement BMPs where feasible at high priority sites identified through GIS terrain analyses to reduce erosion and filter pollutants (e.g., filter strips, gully stabilization)	●	●				●		Field verify high priority site for feasibility; implement 1	Implement all feasible sites	# high priority sites and drainage areas treated		x	P			x	x			
High	Cedar River, Headwaters to Roberts Creek (503)	Dodge and Mower	**M-IBI Stressors:** Nitrate Phosphorus Lack of Habitat Altered Hydrology	M-IBI below threshold	M-IBI above threshold	Erosion Control Projects*	Implement BMPs where feasible at high priority sites identified through GIS terrain analyses to reduce erosion and filter pollutants (e.g., filter strips, gully stabilization)	●	●				●		Field verify all 3 high priority sites for feasibility; implement 1	Implement all feasible sites	# high priority sites and drainage areas treated		x	P			x	x			2027
High	Wolf Creek, Headwaters to Cedar River (510)	Mower	***E. coli***	Average = 243 cfu/100ml	Monthly geometric means < 126CFU/100mL	Erosion Control Projects*	Implement BMPs where feasible at high priority sites identified through GIS terrain analyses to reduce erosion and filter pollutants (e.g., filter strips, gully stabilization)	●	●				●		Field verify all 4 high priority sites for feasibility; implement 2	Implement all feasible sites	# high priority sites and drainage areas treated		x	P			x	x			2027
						Feedlot Improvements	Reduce/eliminate uncontrolled runoff from feedlot sites	●	●					●	30%	90%	Percent of prioritized feedlot sites			x	p	x			x		
						Manured Field and Riparian Pasture Management	Reduce runoff through tillage, soil management, rotational grazing, and buffers	●	●				●	●	30%	75%	Acres of manured fields with slopes >2% and grazed riparian areas			x	P	x					
						SSTS Upgrades	County programs to convert failing septics to conforming							●	Convert 75%	Convert 100% and maintain compliance	Percent of noncompliant systems				P	x			x		
Low	Cedar River, Dobbins to Turtle (514)	Mower	***E. coli***	June-July geometric means 153-185 cfu/100ml, 1 of 15 samples > 1260 cfu/100ml	Monthly geometric means < 126CFU/100mL	Feedlot Improvements	Reduce/eliminate uncontrolled runoff from feedlot sites	●	●					●	30%	90%	Percent of prioritized feedlot sites			x	p	x			x		2047
						Manured Field and Riparian Pasture Management	Reduce runoff through tillage, soil management, rotational grazing, and buffers	●	●				●	●	30%	75%	Acres of manured fields with slopes >2%			x	P	x					

Priority Ranking	Waterbody and Location		Parameter (incl. non-pollutant stressors)	Water Quality		Strategy Type	Strategies	Pollutant / Stressors Addressed							Estimated Adoption Rate			Governmental Units with Primary Responsibility P = Project lead; X =Project partner									Estimated Year to Achieve Water Quality Target
	Waterbody (ID)	**Location** and Upstream Influence Counties		Current Conditions (load or concentration)	Goals / Targets and Estimated % Reduction			Nitrate	Phosphorus	Dissolved Oxygen	Altered Hydrology	Lack of Habitat	Turbidity/TSS	*E. coli*	Interim 10-yr Milestone	Suggested Goal	Units	Turtle Creek WD	Cedar River WD	SWCD	County	MPCA	DNR	BWSR	MDA	City	
																	and grazed riparian areas										
						SSTS Upgrades	County programs to convert failing septics to conforming							●	Convert 75%	Convert 100% and maintain compliance	Percent of noncompliant systems				P	x			x		
						WWTP Improvements								●													
Low	Unnamed Creek, Unamed Creek to Cedar River (533)	Mower	**M-IBI & F-IBI Stressors:** Nitrate Phosphorus Dissolved Oxygen Lack of Habitat Altered Hydrology Turbidity/TSS	M-IBI & F-IBI below threshold	M-IBI & F-IBI above threshold																						2047
Low	Dobbins Creek, 103 R18 S 36 to Eastside Lake (535)	Mower	**Turbidity (TSS)**	22% of 74 samples exceeded standard	<10% of samples exceed 65 mg/L	Soil Health																					2047
			E. coli	Average = 172 cfu/100ml	Monthly geometric means < 126CFU/100mL	Feedlot Improvements	Reduce/eliminate uncontrolled runoff from feedlot sites	●	●					●	30%	90%	Percent of prioritized feedlot sites			x	p	x			x		
						Manured Field and Riparian Pasture Management	Reduce runoff through tillage, soil management, rotational grazing, and buffers	●	●				●	●	30%	75%	Acres of manured fields with slopes >2% and grazed riparian areas			x	P	x					
						SSTS Upgrades	County programs to convert failing septics to conforming							●	Convert 75%	Convert 100% and maintain compliance	Percent of noncompliant systems				P	x			x		
Low	Unnamed Creek, Unamed Creek to Cedar River (577)	Mower	**M-IBI Stressors:** Phosphorus Lack of Habitat Altered Hydrology Turbidity/TSS	M-IBI below threshold	M-IBI above threshold	Erosion Control Projects*	Implement BMPs where feasible at high priority sites identified through GIS terrain analyses to reduce erosion and filter pollutants (e.g., filter strips, gully stabilization)	●	●				●		Field verify high priority site for feasibility; implement 1	Implement all feasible sites	# high priority sites and drainage areas treated		x	P			x	x			2047
High	Cedar River - West Fork, Unamed Creek to Cedar River (591)	Steele, Dodge and Mower	**M-IBI Stressors:** Nitrate Altered Hydrology Turbidity	M-IBI below threshold	M-IBI above threshold	Erosion Control Projects*	Implement BMPs where feasible at high priority sites identified through GIS terrain analyses to reduce erosion and filter pollutants (e.g., filter strips, gully stabilization)	●	●				●		Field verify high priority site for feasibility; implement 1	Implement all feasible sites	# high priority sites and drainage areas treated		x	P			x	x			2027

Priority Ranking	Waterbody and Location		Parameter (incl. non-pollutant stressors)	Water Quality		Strategy Type	Strategies	Pollutant / Stressors Addressed							Estimated Adoption Rate			Governmental Units with Primary Responsibility P = Project lead; X =Project partner									Estimated Year to Achieve Water Quality Target
	Waterbody (ID)	**Location** and Upstream Influence Counties		Current Conditions (load or concentration)	Goals / Targets and Estimated % Reduction			Nitrate	Phosphorus	Dissolved Oxygen	Altered Hydrology	Lack of Habitat	Turbidity/TSS	*E. coli*	Interim 10-yr Milestone	Suggested Goal	Units	Turtle Creek WD	Cedar River WD	SWCD	County	MPCA	DNR	BWSR	MDA	City	
High	Dobbins Creek, Headwaters to T103 R17W S31, west line (524)	Dodge and Mower	**N/A**	N/A	Support Downstream WQ Goals	Erosion Control Projects*	Implement BMPs where feasible at high priority sites identified through GIS terrain analyses to reduce erosion and filter pollutants (e.g., filter strips, gully stabilization)	●	●				●		Field verify all 50 high priority sites for feasibility; implement 15	Implement all feasible sites	# high priority sites and drainage areas treated		x	P			x	x			2027
Low	Murphy Creek, Headwaters to Cedar River (553)	Mower	**N/A**	N/A	Support Downstream WQ Goals	Erosion Control Projects*	Implement BMPs where feasible at high priority sites identified through GIS terrain analyses to reduce erosion and filter pollutants (e.g., filter strips, gully stabilization)	●	●				●		Field verify all 12 high priority sites for feasibility; implement 3	Implement all feasible sites	# high priority sites and drainage areas treated		x	P			x	x			2047
Low	Unnamed Creek, Unnamed Creek to Dobbins Creek (563)	Mower	**N/A**	N/A	Support Downstream WQ Goals	Erosion Control Projects*	Implement BMPs where feasible at high priority sites identified through GIS terrain analyses to reduce erosion and filter pollutants (e.g., filter strips, gully stabilization)	●	●				●		Field verify high priority site for feasibility; implement 1	Implement all feasible sites	# high priority sites and drainage areas treated		x	P			x	x			2047
Low	Green Valley Ditch to Unnamed Creek (598)	Mower	**N/A**	N/A	Support Downstream WQ Goals	Erosion Control Projects*	Implement BMPs where feasible at high priority sites identified through GIS terrain analyses to reduce erosion and filter pollutants (e.g., filter strips, gully stabilization)	●	●				●		Field verify high priority site for feasibility; implement 1	Implement all feasible sites	# high priority sites and drainage areas treated		x	P			x	x			2047

Key: Red rows = impaired waters requiring restoration; White rows = unimpaired waters requiring protection.

* Erosion control projects may include the suite of BMPs available to the landowner and the involved conservation professionals, including common practices such as waterways, terraces, filter strips, contour strip farming, WASCOBs, tillage, crop rotations and soil health. A treatment train approach will be considered for each site, customized to meet the water management and agricultural elements of each site.

Turtle Creek Subwatershed

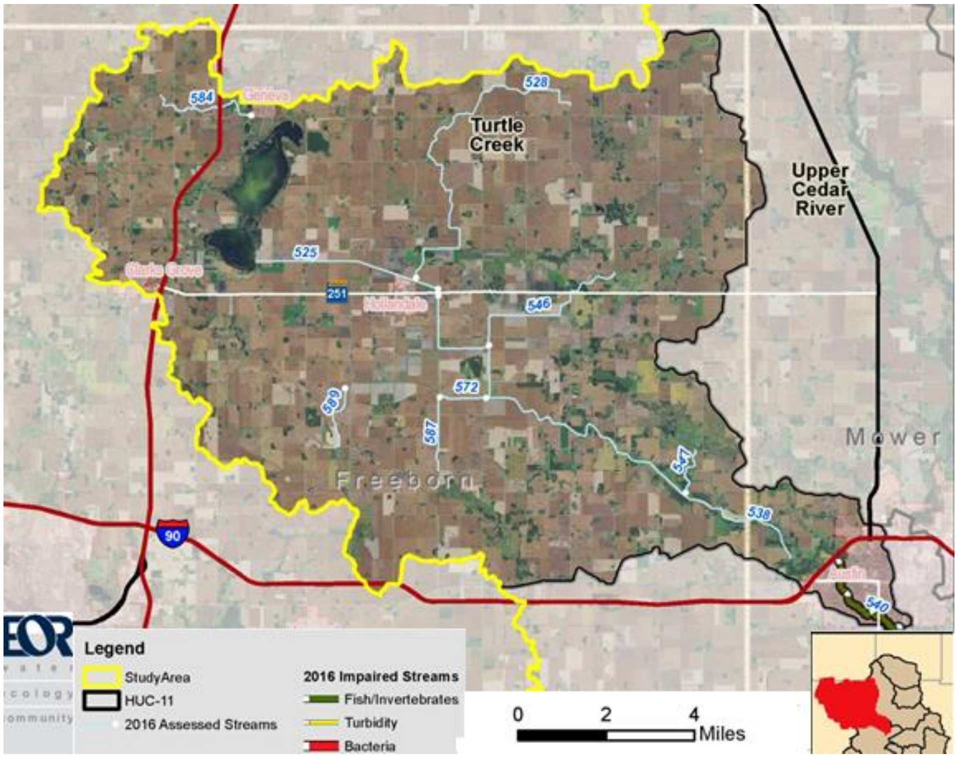


Figure 67. Turtle Creek Subwatershed

Priority Ranking Headwaters – High; FEMA floodplain – Medium; Downstream – Low

Subwatershed Characteristics

- 154 square miles – largest
- Historically a large wetland complex covered over 15,000 acres near Hollandale – drainage ditches constructed and wetlands drained (1905 through 1925) for agricultural production and transportation (many entities and people were involved, including Albert Lea Farms Company, Payne Investment Company and government).
- 77% row crops
- Geneva Lake reclamation project in 2010 (DNR)– water control structure and fish barrier installed to draw down lake levels, and has increased water clarity, re-establishment of near shore native plants.
- Many pollution-sensitive fish species collected along Turtle Creek, including Rainbow Darter, Fantail Darter, and Ozark Minnow (listed as a special concerns species in Minnesota, which had not previously been found in Turtle Creek), and sizable game fish such as Walleye and Northern Pike (move upstream from Cedar River).
- Nine subwatersheds in the Turtle Creek HUC-11 were modeled in 2007, and preliminary flow rate goals were calculated. This includes a total watershed area of about 13,460 acres, or 14% of the entire Turtle Creek drainage area. Total inundated acres for eight of these sub watersheds is

about 1266 acres, and excludes Turtle-22, which is the outlet to Geneva Lake. In addition to the nine-modeled subwatersheds, there are another 10 subwatersheds that have potential water storage sites from the 1970 Turtle Creek plan, and about 80 subwatersheds that need to develop flow rate goals (CRWD 2009).

- Good groundwater support.
- 350 acre Riceland Wetland Restoration near Geneva Lake – intended as a flood reduction project but has provided additional benefits such as improved water quality and wildlife habitat.
- Sedimentation into Geneva Lake, resulting in sediment deltas.

Summary of Stressors to Biologically Impaired Streams

547 - Unnamed Creek, Unnamed Creek to Turtle Creek

- Habitat good with good riffles with cobble substrate.
- Extensive cover within AUID.
- Flow alteration (including climate change, channelization and tile drainage) is one potential area of concern.
- Channelized upstream reaches.
- Elevated nitrate.
- Additional TSS and nutrient data needed.

540 - Turtle Creek, Austin Township Section 4, to the Cedar River Confluence

- Flow alteration and habitat primary stressors.
- Elevated TSS, low DO, elevated nitrate and elevated phosphorus.
- Significant indicators of stream hydrology change due to land use and precipitation.
- Channel straightening has caused channel instability and downstream habitat degradation.
- Hydrology drives elevated TSS within AUID.
- High daily fluctuations of DO are connected to increased nutrients.

Summary of other impairments

540 - Turtle Creek

- Fecal coliform bacteria (2006 listed)
- Turbidity/sediment (2006 listed)

538 - Upper Turtle Creek

- Turbidity – a potential exceedance for turbidity was assessed in 2012 for this reach of Turtle Creek, but insufficient data was determined. This is a Class 2C reach.

525 - Turtle Creek

    - This reach has been determined to be a modified use, under TALU. It is channelized with limiting habitat. It is currently supporting the modified use thresholds for M-IBI and F-IBI.

Geneva Lake

    - Nutrient impairment

Key Strategies

- 79 potential high priority sites for erosion control BMPs (green dots in Figure 68).
- Wetland restorations (potential locations identified in Figure 69).
- County Ditch 8 sediment retention.
- Improve soil health and moraine wetland restoration upstream of Geneva Lake.
- Geneva Lake Management
    - In-lake habitat management
    - Bio-manipulations
    - Restore aquatic habitat in wetland restorations
- Opportunity for RIM or CRP around Hollandale and Maple Island.
- Cover crops on vegetative land around Hollandale.
- Minimize/mitigate impacts of irrigation.
- Wetland restoration and improve in-stream habitat on tributary to -547 Unnamed Creek,

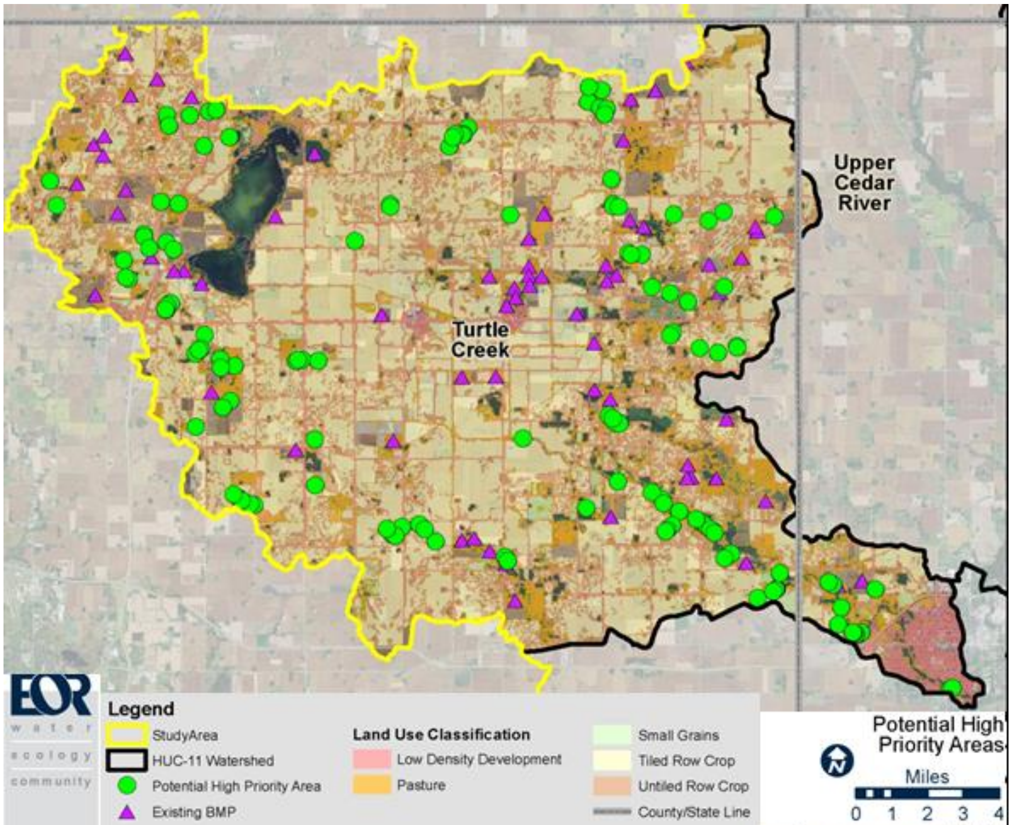


Figure 68. Turtle Creek existing BMP locations and potential high priority areas

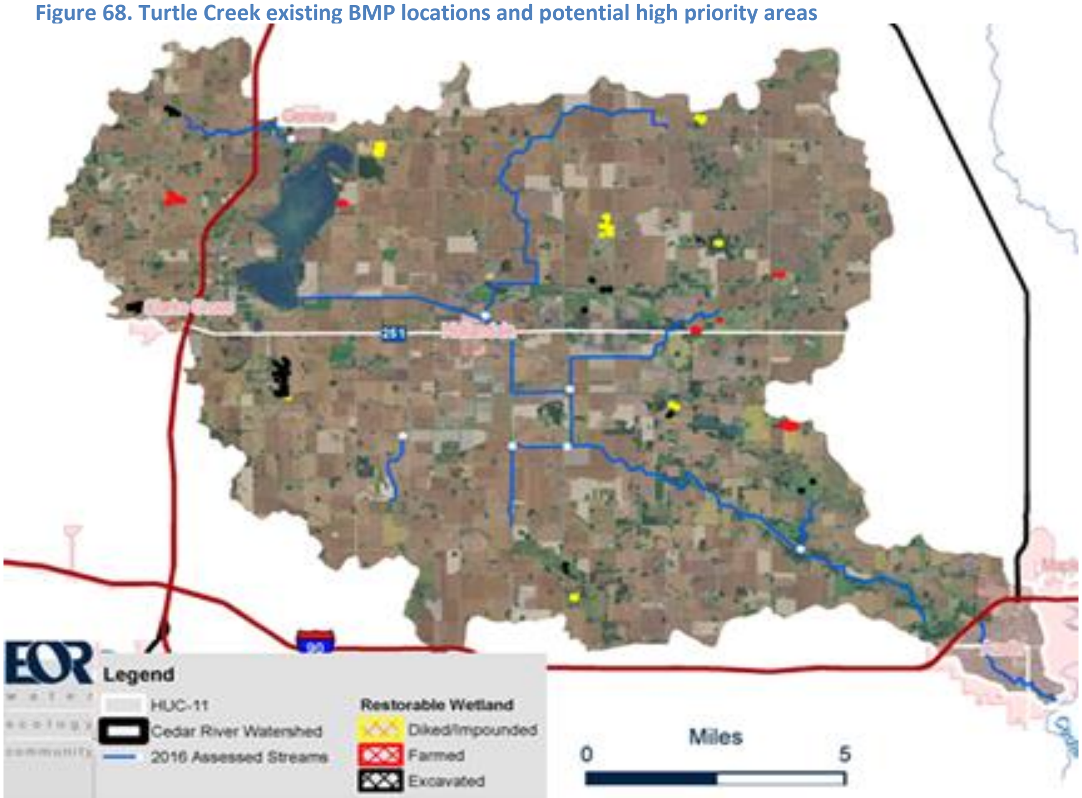


Figure 69. Turtle Creek Subwatershed potential restorable wetlands

Thirteen general areas were identified as having the potential for restored wetlands. In several of the general areas, multiple wetland basin locations were identified. Further analysis is required to determine feasibility of the restorations.

Table 20. Strategies and actions proposed for the Turtle Creek Subwatershed

Priority Ranking	Waterbody and Location		Parameter (incl. non-pollutant stressors)	Water Quality		Strategy Type	Strategies	Pollutant / Stressors Addressed							Estimated Adoption Rate			Governmental Units with Primary Responsibility P = Project lead; X =Project partner									Estimated Year to Achieve Water Quality Target
	Waterbody (ID)	**Location** and Upstream Influence Counties		Current Conditions (load or concentration)	Goals / Targets and Estimated % Reduction			Nitrate	Phosphorus	Dissolved Oxygen	Altered Hydrology	Lack of Habitat	Turbidity/TSS	*E. coli*	Interim 10-yr Milestone	Suggested Goal	Units	Turtle Creek WD	Cedar River WD	SWCD	County	MPCA	DNR	BWSR	MDA	City	
Low	Turtle Creek, Austin Township Section 4, to the Cedar River Confluence (540)	Mower + Freeborn	**Turbidity (TSS)**	Average of 12 samples exceeded standard	<10% of samples exceed 65 mg/L	Erosion Control Projects*	Implement BMPs where feasible at high priority sites identified through GIS terrain analyses to reduce erosion and filter pollutants (e.g., filter strips, gully stabilization)	●	●				●		Field verify high priority site for feasibility; implement 1	Implement all feasible sites	# high priority sites and drainage areas treated	x		P			x	x			2047
			M-IBI & F-IBI Stressors: Nitrate Turbidity/TSS Phosphorus Altered Hydrology Dissolved Oxygen Lack of Habitat	M-IBI & F-IBI below threshold	M-IBI & F-IBI above threshold	Erosion Control Projects*	Implement BMPs where feasible at high priority sites identified through GIS terrain analyses to reduce erosion and filter pollutants (e.g., filter strips, gully stabilization)	●	●				●		Field verify high priority site for feasibility; implement 1	Implement all feasible sites	# high priority sites and drainage areas treated		x	P			x	x			
						Stream Restoration	Implement stream habitat improvement/restoration projects								Seven Springs area and Nursing Heart (2)		projects			x							
						Stormwater Management	Coordination with City on stormwater improvements		●				●		Quarterly	Annually	meetings									P	
			E. coli	Average = 419 CFU/100mL. June-Aug geometric means 141 - 316 CFU/100mL	Monthly geometric means < 126CFU/100mL	Feedlot Improvements	Reduce/eliminate uncontrolled runoff from feedlot sites	●	●					●	30%	90%	Percent of prioritized feedlot sites			x	p	x			x		
						Manured Field and Riparian Pasture Management	Reduce runoff through tillage, soil management, rotational grazing, and buffers	●	●				●	●	30%	75%	Acres of manured fields with slopes >2% and grazed riparian areas			x	P	x					
						SSTS Upgrades	County programs to convert failing septics to conforming							●	Convert 75%	Convert 100% and maintain compliance	Percent of noncompliant systems				P	x			x		
Low	Unnamed Creek, Unnamed Creek to Turtle Creek (547)	Freeborn	**M-IBI**	M-IBI below threshold	M-IBI above threshold	Wetland Restorations	Restore wetlands			●	●									P							2047
						Stream Restoration	Improve in-stream habitat					●															
High	Geneva Lake (24-0015-00)	Freeborn	**Nutrients**	Summer average in-lake TP = 222 ug/L	Summer average in-lake TP < 90 ug/L	Erosion Control Projects*	Reduce sediment runoff in upstream drainage area						●		Reduce sediment loading by 10%	Meet TP reduction goals, with partition of P between attached and dissolved		x		P							2050
						In-lake management	Biomanipulations		●									x		P			x				
							Carp removal/management		●																		
							Vegetation management		●						Reference DNR lake mgmt plans			x		P			x				

Priority Ranking	Waterbody and Location: Waterbody (ID)	Waterbody and Location: Location and Upstream Influence Counties	Parameter (incl. non-pollutant stressors)	Water Quality: Current Conditions (load or concentration)	Water Quality: Goals / Targets and Estimated % Reduction	Strategy Type	Strategies	Pollutant / Stressors Addressed: Nitrate	Phosphorus	Dissolved Oxygen	Altered Hydrology	Lack of Habitat	Turbidity/TSS	*E. coli*	Estimated Adoption Rate: Interim 10-yr Milestone	Suggested Goal	Units	Governmental Units with Primary Responsibility (P = Project lead; X =Project partner): Turtle Creek WD	Cedar River WD	SWCD	County	MPCA	DNR	BWSR	MDA	City	Estimated Year to Achieve Water Quality Target
						Nutrient Management	Reduce nutrient runoff in upstream drainage area		●						Reduce average TP of inflow from 566 ug/L to 250 ug/L	Reduce average TP of inflow to 150 ug/L		x		P							
High	Turtle Creek, Headwaters (Geneva Lk 24-0015-00) to T104 R20W S35, south line (525)	Freeborn	**N/A**	N/A	Support Downstream WQ Goals	Erosion Control Projects*	Implement BMPs where feasible at high priority sites identified through GIS terrain analyses to reduce erosion and filter pollutants (e.g., filter strips, gully stabilization)	●	●				●		Field verify all 18 high priority sites for feasibility; implement 4	Implement all feasible sites	# high priority sites and drainage areas treated	x		P			x	x			2027
						Land Use	Cover crops, RIM or CRP on vegetative land around Hollandale and Maple Island	●	●				●							P							
High	Mud Creek, Headwaters to Turtle Cr (JD 24) (528)	Freeborn	**N/A**	N/A	Support Downstream WQ Goals	Erosion Control Projects*	Implement BMPs where feasible at high priority sites identified through GIS terrain analyses to reduce erosion and filter pollutants (e.g., filter strips, gully stabilization)	●	●				●		Field verify all 9 high priority sites for feasibility; implement 3	Implement all feasible sites	# high priority sites and drainage areas treated	x		P			x	x			2027
Low	Turtle Creek, T103 R20W S2, north line to T103 R18W S31, south line (538)	Freeborn	**N/A**	N/A	Support Downstream WQ Goals	Erosion Control Projects*	Implement BMPs where feasible at high priority sites identified through GIS terrain analyses to reduce erosion and filter pollutants (e.g., filter strips, gully stabilization)	●	●				●		Field verify all 16 high priority sites for feasibility; implement 4	Implement all feasible sites	# high priority sites and drainage areas treated	x		P			x	x			2047
High	Deer Creek, Ditch to Cedar R (546)	Freeborn	**N/A**	N/A	Support Downstream WQ Goals	Erosion Control Projects*	Implement BMPs where feasible at high priority sites identified through GIS terrain analyses to reduce erosion and filter pollutants (e.g., filter strips, gully stabilization)	●	●				●		Field verify all 12 high priority sites for feasibility; implement 3	Implement all feasible sites	# high priority sites and drainage areas treated	x		P			x	x			2027
High	County Ditch 8, Unnamed cr to Unnamed ditch (584)	Freeborn	**N/A**	N/A	Support Downstream WQ Goals	Erosion Control Projects*	Implement BMPs where feasible at high priority sites identified through GIS terrain analyses to reduce erosion and filter pollutants (e.g., filter strips, gully stabilization)	●	●				●		Field verify all 12 high priority sites for feasibility; implement 3	Implement all feasible sites	# high priority sites and drainage areas treated	x		P			x	x			2027
High	County Ditch 8, Unnamed cr to Unnamed ditch (587)	Freeborn	**N/A**	N/A	Support Downstream WQ Goals	Erosion Control Projects*	Implement BMPs where feasible at high priority sites identified through GIS terrain analyses to reduce erosion and filter pollutants (e.g., filter strips, gully stabilization)	●	●				●		Field verify all 7 high priority sites for feasibility; implement 3	Implement all feasible sites	# high priority sites and drainage areas treated	x		P			x	x			2027

Priority Ranking	Waterbody and Location		Parameter (incl. non-pollutant stressors)	Water Quality		Strategy Type	Strategies	Pollutant / Stressors Addressed							Estimated Adoption Rate			Governmental Units with Primary Responsibility P = Project lead; X =Project partner									Estimated Year to Achieve Water Quality Target
	Waterbody (ID)	**Location** and Upstream Influence Counties		Current Conditions (load or concentration)	Goals / Targets and Estimated % Reduction			Nitrate	Phosphorus	Dissolved Oxygen	Altered Hydrology	Lack of Habitat	Turbidity/TSS	*E. coli*	Interim 10-yr Milestone	Suggested Goal	Units	Turtle Creek WD	Cedar River WD	SWCD	County	MPCA	DNR	BWSR	MDA	City	
High	Judicial Ditch 18, Unnamed ditch to JD 24 (589)	Freeborn	**N/A**	N/A	Support Downstream WQ Goals	Erosion Control Projects*	Implement BMPs where feasible at high priority sites identified through GIS terrain analyses to reduce erosion and filter pollutants (e.g., filter strips, gully stabilization)	●	●				●		Field verify all 4 high priority sites for feasibility; implement 2	Implement all feasible sites	# high priority sites and drainage areas treated	x		P			x	x			2027

Key: Red rows = impaired waters requiring restoration; White rows = unimpaired waters requiring protection.

* Erosion control projects may include the suite of BMPs available to the landowner and the involved conservation professionals, including common practices such as waterways, terraces, filter strips, contour strip farming, WASCOBs, tillage, crop rotations and soil health. A treatment train approach will be considered for each site, customized to meet the water management and agricultural elements of each site.

Rose Creek Subwatershed

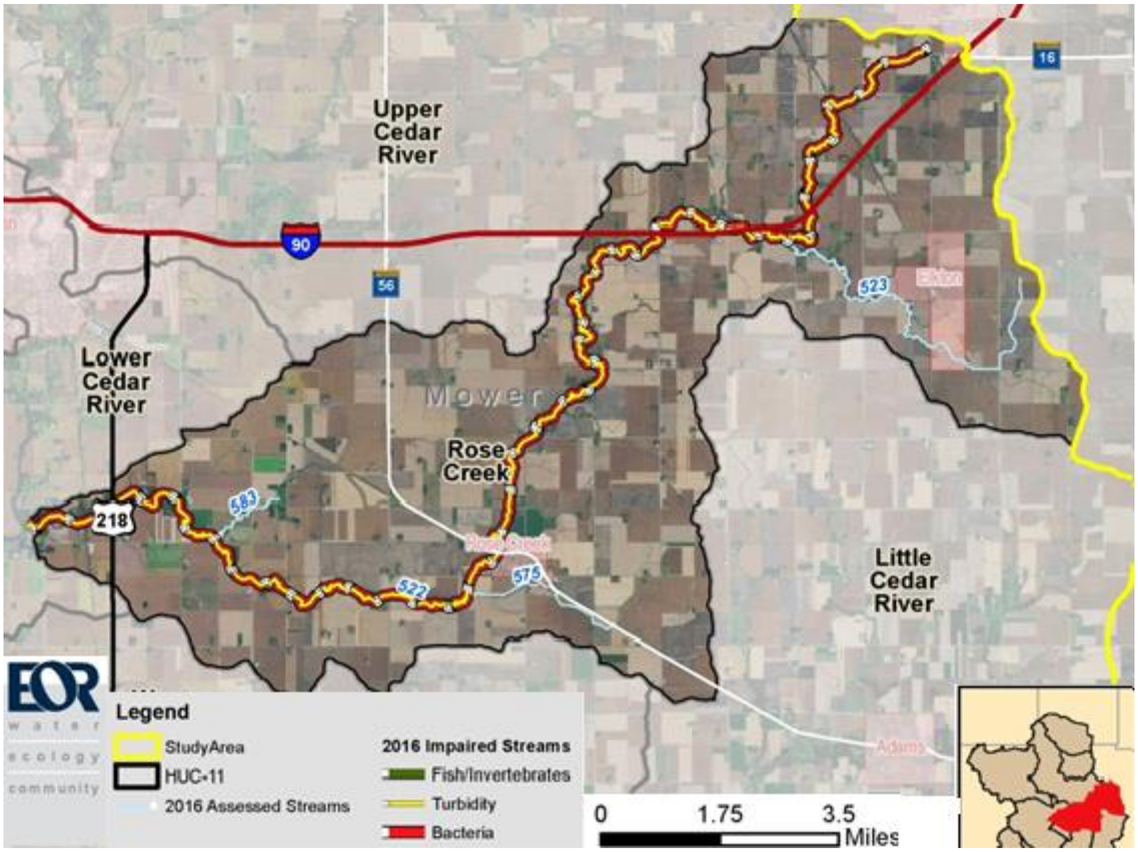


Figure 70. Rose Creek Subwatershed

Priority Ranking - Headwaters – High; FEMA floodplain – Medium; Downstream – Low

Subwatershed Characteristics

- 66 square miles.
- 83% row crops.
- Some riparian area with forest and wetland areas.
- Sensitive mussel beds located in subwatershed.
- Rose Creek is a subwatershed without flow rate goals, and no modeling has been completed.

Summary of Stressors to Biologically Impaired Streams

583 - Unnamed Creek, Unnamed Creek to Rose Creek

- Unstable reach with excess cutting, bank erosion, and unstable substrates.
- Altered hydrology from changes in land use and precipitation driving sedimentation issues.
- Elevated nitrate and phosphorus.
- Nutrient management is needed.

- Needs diurnal DO monitoring.

523 - Schwerin Creek, Headwaters to Rose Creek

- Unstable reach with excess sedimentation.
- Increasing number of filter strips and grassed waterways will help with sediment reduction and habitat loss.
- Upstream reaches are channelized.
- Additional monitoring for TSS and phosphorus needed.
- Elevated nitrate.
- Needs more forested riparian cover.

Summary of other impairments

522 – Rose Creek, Headwaters to Cedar River

- *E. coli* bacteria impairment (2006 listing - addressed in CRW TMDL).
- TSSs impairment (2012 listing – addressed in CRW TMDL).

Key Strategies

- 97 potential high priority sites for erosion control BMPs (green dots in Figure 71).
- Near-channel sediment sources in the middle section of this reach are important to address by implementing numerous hydrology and land management practices.
- Monitor the scale of irrigation water usage, and minimize/mitigate impacts of irrigation linked to stream habitat and water quantity/water quality.

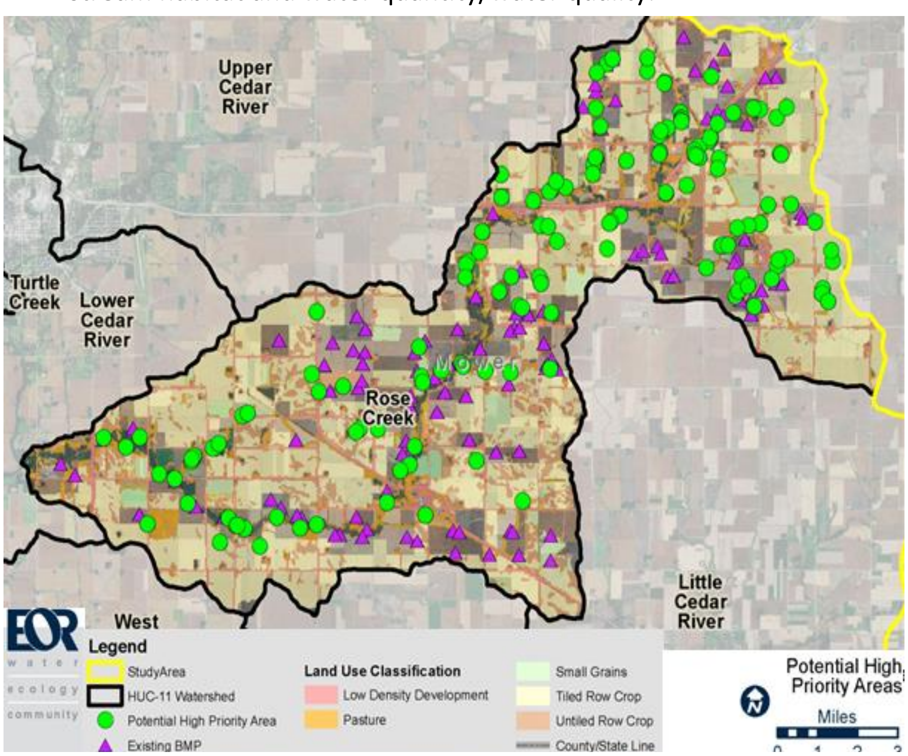


Figure 71. Rose Creek existing BMP locations and potential high priority areas

- AUID – 575 is a tributary creek to Rose Creek that enters into Rose Creek at about mile nine. This tributary is currently not listed for any impairments, and any protection measures should be implemented in this small subwatershed.

Table 21. Strategies and actions proposed for the Rose Creek Subwatershed

Priority Ranking	Waterbody and Location: Waterbody (ID)	Waterbody and Location: Location and Upstream Influence Counties	Parameter (incl. non-pollutant stressors)	Water Quality: Current Conditions (load or concentration)	Water Quality: Goals / Targets and Estimated % Reduction	Strategy Type	Strategies	Pollutant / Stressors Addressed: Nitrate	Phosphorus	Dissolved Oxygen	Altered Hydrology	Lack of Habitat	Turbidity/TSS	*E. coli*	Estimated Adoption Rate: Interim 10-yr Milestone	Suggested Goal	Units	Governmental Units with Primary Responsibility (P = Project lead; X =Project partner): Turtle Creek WD	Cedar River WD	SWCD	County	MPCA	DNR	BWSR	MDA	City	Estimated Year to Achieve Water Quality Target
High	Rose Creek, Headwaters to Cedar River (522)	Mower	**M-IBI Stressor:** Turbidity/TSS	M-IBI below threshold	M-IBI above threshold	Erosion Control Projects*	Implement BMPs where feasible at high priority sites identified through GIS terrain analyses to reduce erosion and filter pollutants (e.g., filter strips, gully stabilization)	●	●				●		Field verify all 69 high priority sites for feasibility; implement 23	Implement all feasible sites	# high priority sites and drainage areas treated		x	P			x	x			2027
			Turbidity (TSS)	Average of 84 samples exceeded standard	<10% of samples exceed 65 mg/L	Feedlot Improvements	Reduce/eliminate uncontrolled runoff from feedlot sites	●	●					●	30%	90%	Percent of prioritized feedlot sites			x	p	x			x		
						Manured Field and Riparian Pasture Management	Reduce runoff through tillage, soil management, rotational grazing, and buffers	●	●				●	●	30%	75%	Acres of manured fields with slopes >2% and grazed riparian areas			x	P	x					
						SSTS Upgrades	County programs to convert failing septics to conforming							●	Convert 75%	Convert 100% and maintain compliance	Percent of noncompliant systems				P	x			x		
High	Schwerin Creek, Headwaters to Rose Creek (523)	Mower	**M-IBI Stressors:** Nitrate Lack of Habitat Altered Hydrology	M-IBI below threshold	M-IBI above threshold	Erosion Control Projects*	Implement BMPs where feasible at high priority sites identified through GIS terrain analyses to reduce erosion and filter pollutants (e.g., filter strips, gully stabilization)	●	●				●		Field verify all 17 high priority sites for feasibility; implement 6	Implement all feasible sites	# high priority sites and drainage areas treated		x	P			x	x			2027
Low	Unnamed Creek, Unnamed Creek to Rose Creek (583)	Mower	**M-IBI Stressors:** Nitrate Turbidity/TSS Phosphorus Lack of Habitat	M-IBI below threshold	M-IBI above threshold	Erosion Control Projects*	Implement BMPs where feasible at high priority sites identified through GIS terrain analyses to reduce erosion and filter pollutants (e.g., filter strips, gully stabilization)	●	●				●		Field verify all 8 high priority sites for feasibility; implement 4	Implement all feasible sites	# high priority sites and drainage areas treated		x	P			x	x			2047
Low	Unnamed Creek to Rose Creek (575)	Mower	**N/A**	N/A	Support Downstream WQ Goals	Erosion Control Projects*	Implement BMPs where feasible at high priority sites identified through GIS terrain analyses to reduce erosion and filter pollutants (e.g., filter strips, gully stabilization)	●	●				●		Field verify all 3 high priority sites for feasibility; implement 1	Implement all feasible sites	# high priority sites and drainage areas treated		x	P			x	x			2047

Key: Red rows = impaired waters requiring restoration; White rows = unimpaired waters requiring protection.

* Erosion control projects may include the suite of BMPs available to the landowner and the involved conservation professionals, including common practices such as waterways, terraces, filter strips, contour strip farming, WASCOBs, tillage, crop rotations and soil health. A treatment train approach will be considered for each site, customized to meet the water management and agricultural elements of each site.

West Beaver Creek Subwatershed

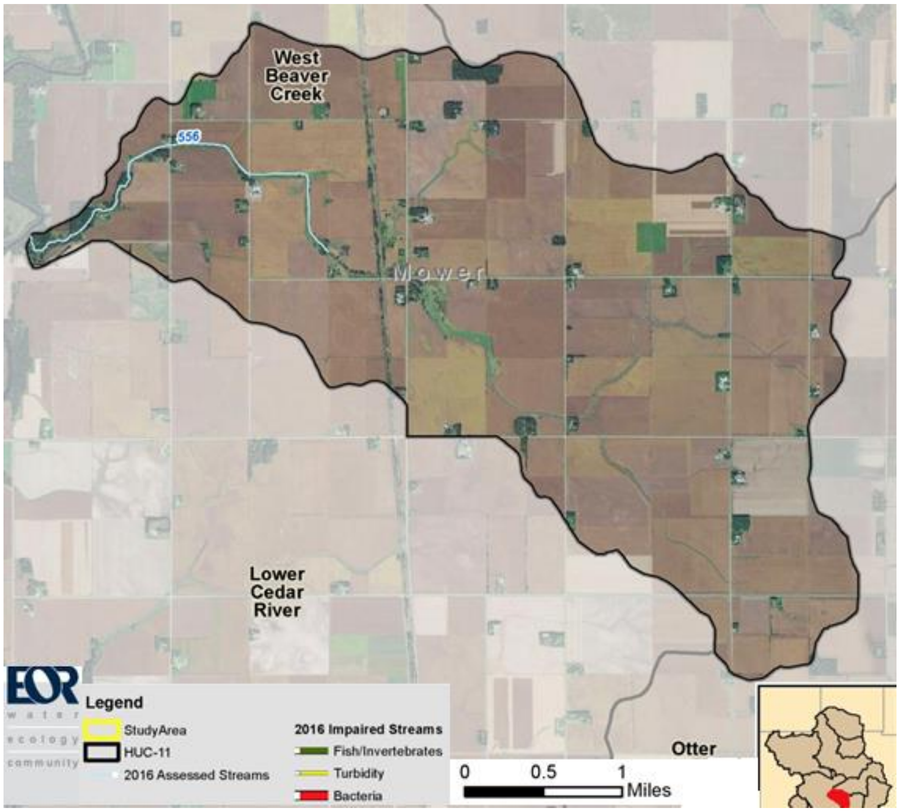


Figure 72. West Beaver Creek Subwatershed

Priority Ranking - Low

Subwatershed Characteristics

- 11 square miles – smallest.
- 88% row crops.
- Lack of variable water depth and amount of fish cover.
- Very narrow riparian zone of trees but lack of woody debris and overhanging vegetation in contact with the water.
- Incised and over widened due to channelization and flashy hydrology.
- Elevated nitrate.
- Fish community good with some pollution sensitive species.
- West Beaver Creek is a subwatershed without flow rate goals, and no modeling has been completed for it.

Protection Summary

Unnamed creek (AUID – 556)

- Several types of pollution sensitive fish (Pearl Dace, Rainbow Darter and Fantail Darter) were collected in the AUID.

- The habitat had sufficient riparian shading, instream fish cover and depth variability resulting in rating of good.
- However, there was moderately poor channel stability and embeddedness of the substrate. Elevated nitrite- N was also noted.
- Failure to address channel stability and the elevated N may lead to future impairment listing.

Key Strategies

- Five potential high priority sites for erosion control BMPs (green dots in Figure73). Out of the 10 BMPs currently in place from the survey, most of these are in the eastern one-half of the catchment, while many of the higher priority erosion sites are located in the western one-half. Some further in-field assessments by conservation staff could help confirm any issues that need to be addressed.

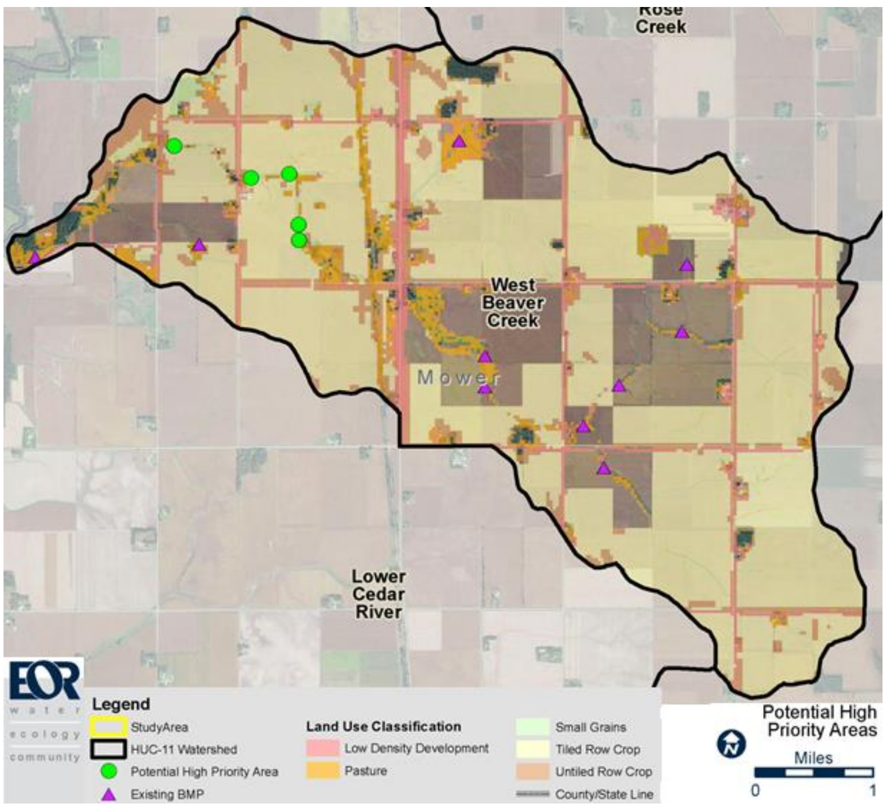


Figure 73. West Beaver Creek existing BMP locations and potential high priority areas.

Table 22. Strategies and actions proposed for the West Beaver Creek Subwatershed

Priority Ranking	Waterbody and Location		Parameter (incl. non-pollutant stressors)	Water Quality		Strategy Type	Strategies	Pollutant / Stressors Addressed							Estimated Adoption Rate			Governmental Units with Primary Responsibility P = Project lead; X =Project partner									Estimated Year to Achieve Water Quality Target
	Waterbody (ID)	**Location** and Upstream Influence Counties		Current Conditions (load or concentration)	Goals / Targets and Estimated % Reduction			Nitrate	Phosphorus	Dissolved Oxygen	Altered Hydrology	Lack of Habitat	Turbidity/TSS	*E. coli*	Interim 10-yr Milestone	Suggested Goal	Units	Turtle Creek WD	Cedar River WD	SWCD	County	MPCA	DNR	BWSR	MDA	City	
Low	All	All	All	All	Maintain or improve	Erosion Control							X		Assess priority sites	Implement high priority sites	5		x	P				x			2047
Low	All	All	NO3-N	Loads	50% reduction in NO3-N loads	Saturated buffers		X							Assess priority sites	Implement highest priority sites	10		x	P				x			2035

Key: Red rows = impaired waters requiring restoration; White rows = unimpaired waters requiring protection.

* Erosion control projects may include the suite of BMPs available to the landowner and the involved conservation professionals, including common practices such as waterways, terraces, filter strips, contour strip farming, WASCOBs, tillage, crop rotations and soil health. A treatment train approach will be considered for each site, customized to meet the water management and agricultural elements of each site.

Lower Cedar River Subwatershed

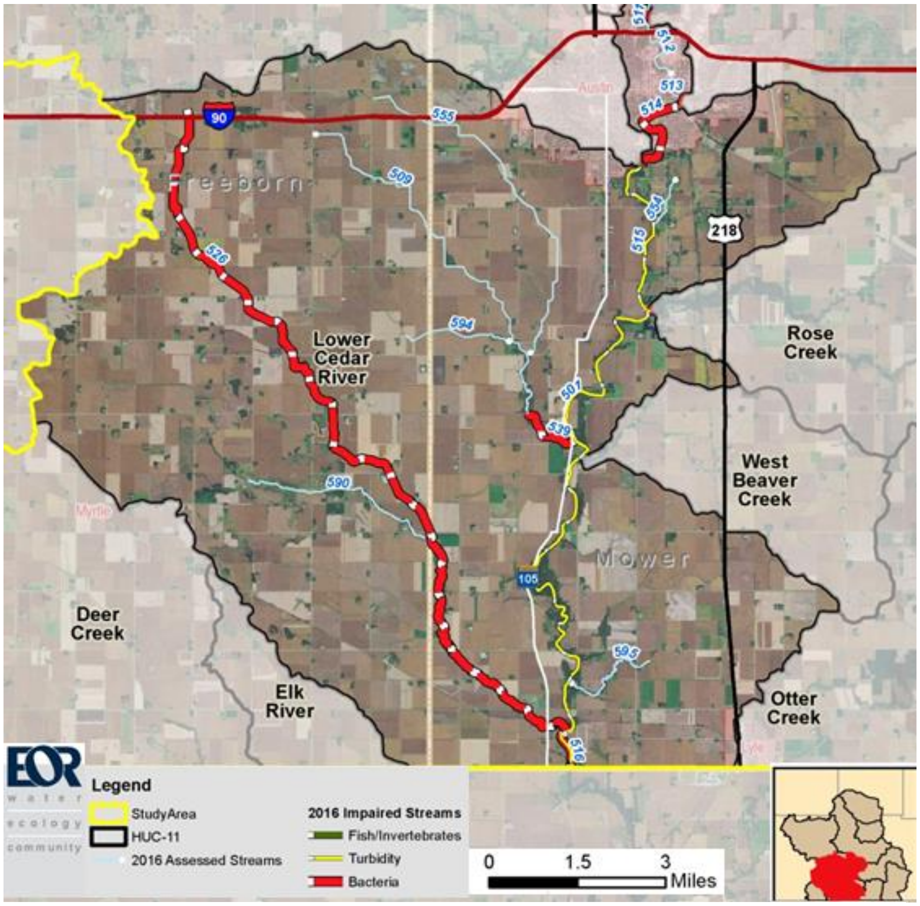


Figure 74. Lower Cedar River Subwatershed.

Priority Ranking - FEMA floodplain – Medium; Uplands – Low

Subwatershed Characteristics

- 117 square miles – third largest.
- 83% row crops.
- The Ramsey Mill Pond, located in the most northern segment of this subwatershed, is only reservoir/lake in this catchment.
- Woodson Creek is one mile in length, and is the only DNR-designated cold water stream in the CRW.
- Brook Trout were once abundant in Woodbury Creek – but have not been recorded since 1984.
- Cedar River is incised and over widened. Portions are down cut to bedrock and river is adjusting to changes in watershed hydrology. Over widened cross section with shallow depth and minimal flow velocity variation, limiting certain fish species.

Summary of Stressors to Biologically Impaired Streams

554 - Woodson Creek, Austin Township Section 14, to Cedar River Confluence

- Woodson Creek only DNR designated cold water stream in the Cedar Watershed.
- Brook trout once were present but were not present in the 2009 MPCA survey.
- Lack of suitable and diverse habitat.
- Altered hydrology from changes in land use and precipitation.
- Well-intentioned landowners built a rock dam to increase pool volume in Woodson Creek – interrupting natural flow and migration route of Brook trout.
- Restoration efforts to bring back cold water community include habitat restoration and reintroduction of Brook Trout.
- More TSS and nutrient monitoring needed.
- Woodson Creek is contained within Cedr-154 and Cedr-156 modeling subwatersheds, and no flow rate goals have been set, and modeling has been completed.

515 - Cedar River, Turtle Creek to Rose Creek

- Elevated nitrate, phosphorus, and fluctuating DO primary stressors.
- Discharge from Austin WWTP is a major source of nutrients, especially during lower river flows.
- Nutrient management throughout the upper contributing watersheds is needed.
- TSSs impairment for this reach addressed in the CRW TMDL.

501 - Cedar River, Rose Creek to Woodbury Creek

- Flow alteration is a stressor and a driver for sediment and habitat issues in this mainstem reach.
- Altered hydrology from changes in land use and precipitation.
- Stream modifications such as straightening have caused channel instability and downstream habitat degradation.
- Watershed wide changes are needed over localized projects to sustainably restore the mainstem.
- TSSs impairment for this reach addressed in the CRW TMDL.
- Fecal coliform bacteria impairment for this reach addressed in Lower Mississippi Basin Regional Bacteria TMDL (MPCA 2006).

Summary of other impairments

- 515 – Cedar River, Turtle Creek to Rose Creek. TSSs impairment, which is addressed in the CRW TMDL.
- 516 – Cedar River Woodbury Creek to MN/IA border. TSSs and bacteria impairments. Both impairments are covered in the CRW TMDL.
- 539 – Orchard Creek. Bacteria-impaired reach, covered in CRW TMDL. The upper portion of Orchard Creek (AUID -509), is not currently impaired by bacteria, due to the split in AUIDs.
- 526 – Woodbury Creek, Headwaters to Cedar River Bacteria-impaired reach, covered in CRW TMDL.

Protection Summary

Orchard Creek (AUID – 539) and Woodbury Creek (AUID – 526)

- Good quality habitat with clean, coarse substrates of cobble and gravel was noted in both creeks. Channel stability was rated as fairly stable.
- Sensitive fish species were collected in creeks including the Ozark Minnow, which is considered a special concern species by the DNR. Other sensitive fish collected included Rainbow Darter, Fantail Darter, Stonecat, Hornyhead Chub and Northern Hogsucker
- High nitrite- N levels was noted in both creeks, which may indicate a potential nutrient issue that should be addressed.
- The CRW MA report notes "*Due to the presence of special concern species and the high diversity of aquatic communities collected within the Orchard Creek watershed, this watershed could be considered a target for additional monitoring and land use protections in order to better preserve these valuable resource areas".*

Key Strategies

- 45 potential high priority sites for erosion control BMPs, many of these potential sites are in the north and west regions (Orchard and Woodbury Creek drainages), where it appears that fewer BMPs have been installed (green dots in Figure 75).
- Urban storm water BMPs in City of Austin.

- Conservation practices to improve soil health, improve water infiltration and water storage in the soil profile, and reduce runoff volume.

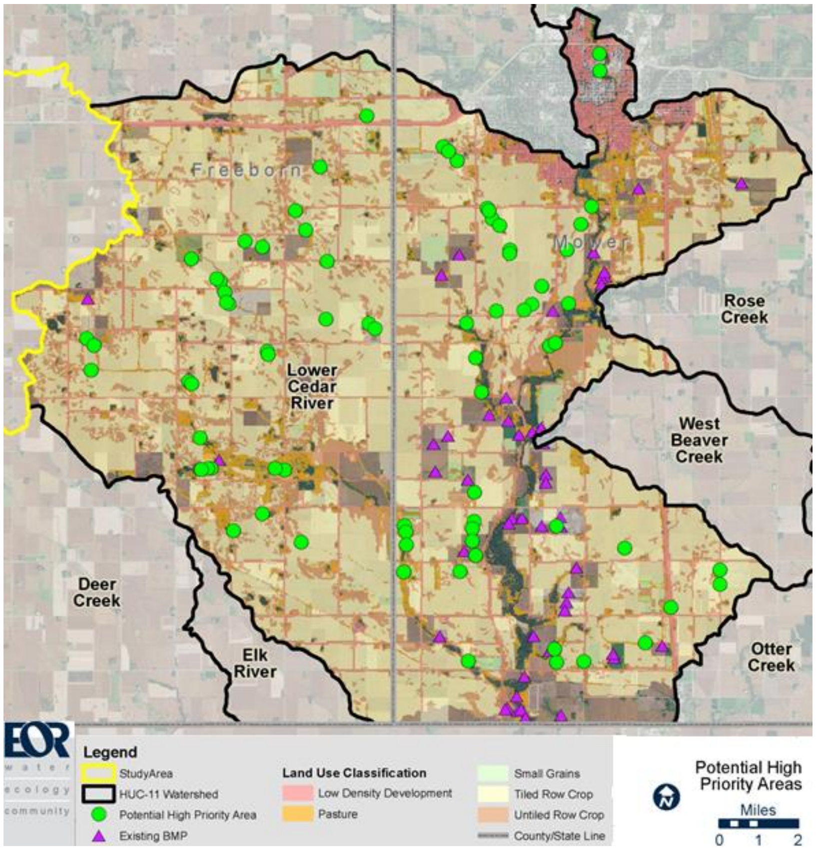


Figure 75. Lower Cedar River subwatershed existing BMP locations and potential high priority areas

Table 23. Strategies and actions proposed for the Lower Cedar River Subwatershed

Priority Ranking	Waterbody and Location		Parameter (incl. non-pollutant stressors)	Water Quality		Strategy Type	Strategies	Pollutant / Stressors Addressed							Estimated Adoption Rate			Governmental Units with Primary Responsibility P = Project lead; X =Project partner									Estimated Year to Achieve Water Quality Target
	Waterbody (ID)	**Location** and Upstream Influence Counties		Current Conditions (load or concentration)	Goals / Targets and Estimated % Reduction			Nitrate	Phosphorus	Dissolved Oxygen	Altered Hydrology	Lack of Habitat	Turbidity/TSS	*E. coli*	Interim 10-yr Milestone	Suggested Goal	Units	Turtle Creek WD	Cedar River WD	SWCD	County	MPCA	DNR	BWSR	MDA	City	
Low	Cedar River, Rose Creek to Woodbury Creek (501)	Mower	**Turbidity (TSS)**	38.4% of 39 samples exceeded standard	<10% of samples exceed 65 mg/L	Erosion Control Projects*	Implement BMPs where feasible at high priority sites identified through GIS terrain analyses to reduce erosion and filter pollutants (e.g., filter strips, gully stabilization)	●	●				●		Field verify all 7 high priority sites for feasibility; implement 2	Implement all feasible sites	# high priority sites and drainage areas treated		x	P			x	x			2047
			M-IBI & F-IBI Stressors: Nitrate Phosphorus Lack of Habitat Altered Hydrology Dissolved Oxygen Turbidity/TSS	M-IBI & F-IBI below threshold	M-IBI & F-IBI above threshold	Erosion Control Projects*	Implement BMPs where feasible at high priority sites identified through GIS terrain analyses to reduce erosion and filter pollutants (e.g., filter strips, gully stabilization)	●	●				●		Field verify all 7 high priority sites for feasibility; implement 2	Implement all feasible sites	# high priority sites and drainage areas treated		x	P			x	x			
Low	Cedar River, Turtle Creek To Rose Creek (515)	Mower	**Turbidity (TSS)**	21% of 434 samples exceeded standard	<10% of samples exceed 65 mg/L	Erosion Control Projects*	Implement BMPs where feasible at high priority sites identified through GIS terrain analyses to reduce erosion and filter pollutants (e.g., filter strips, gully stabilization)	●	●				●		Field verify all 3 high priority sites for feasibility; implement 1	Implement all feasible sites	# high priority sites and drainage areas treated		x	P			x	x			2047
						Stormwater Management	MS4 stormwater BMP implementation		●				●		Achieve WLAs	Achieve WLAs	TMDL WLAs									P	
			M-IBI Stressors: Nitrate Phosphorus Dissolved Oxygen Lack of Habitat Altered Hydrology Turbidity/TSS	M-IBI below threshold	M-IBI above threshold	Erosion Control Projects*	Implement BMPs where feasible at high priority sites identified through GIS terrain analyses to reduce erosion and filter pollutants (e.g., filter strips, gully stabilization)	●	●				●		Field verify all 3 high priority sites for feasibility; implement 1	Implement all feasible sites	# high priority sites and drainage areas treated		x	P			x	x			
Low	Cedar River, Woodbury Cr to Iowa Border (516)	Mower	***E. coli***	June-July geometric means > 126 MPN/100mL	Monthly geometric means < 126CFU/100mL	Feedlot Improvements	Reduce/eliminate uncontrolled runoff from feedlot sites	●	●					●	30%	90%	Percent of prioritized feedlot sites			x	p	x			x		2047
						Manured Field and Riparian Pasture Management	Reduce runoff through tillage, soil management, rotational grazing, and buffers	●	●				●	●	30%	75%	Acres of manured fields with slopes >2% and grazed riparian areas			x	P	x					
						SSTS Upgrades	County programs to convert failing septics to conforming							●	Convert 75%	Convert 100% and maintain compliance	Percent of noncompliant systems				P	x			x		

Priority Ranking	Waterbody and Location		Parameter (incl. non-pollutant stressors)	Water Quality		Strategy Type	Strategies	Pollutant / Stressors Addressed							Estimated Adoption Rate			Governmental Units with Primary Responsibility P = Project lead; X =Project partner									Estimated Year to Achieve Water Quality Target
	Waterbody (ID)	**Location** and Upstream Influence Counties		Current Conditions (load or concentration)	Goals / Targets and Estimated % Reduction			Nitrate	Phosphorus	Dissolved Oxygen	Altered Hydrology	Lack of Habitat	Turbidity/TSS	*E. coli*	Interim 10-yr Milestone	Suggested Goal	Units	Turtle Creek WD	Cedar River WD	SWCD	County	MPCA	DNR	BWSR	MDA	City	
			Turbidity (TSS)	17% of samples exceeded standard	<10% of samples exceed 65 mg/L	Soil Health																					
Low	Woodbury Creek, Headwaters to Cedar River (526)	Mower + Freeborn	***E. coli***	Average = 746 CFU/100ml	Monthly geometric means < 126CFU/100mL	Feedlot Improvements	Reduce/eliminate uncontrolled runoff from feedlot sites	●	●					●	30%	90%	Percent of prioritized feedlot sites			x	p	x			x		2047
						Manured Field and Riparian Pasture Management	Reduce runoff through tillage, soil management, rotational grazing, and buffers	●	●				●	●	30%	75%	Acres of manured fields with slopes >2% and grazed riparian areas			x	P	x					
						SSTS Upgrades	County programs to convert failing septics to conforming							●	Convert 75%	Convert 100% and maintain compliance	Percent of noncompliant systems				P	x			x		
						Erosion Control Projects*	Implement BMPs where feasible at high priority sites identified through GIS terrain analyses to reduce erosion and filter pollutants (e.g., filter strips, gully stabilization)	●	●				●		Field verify all 11 high priority sites for feasibility; implement 4	Implement all feasible sites	# high priority sites and drainage areas treated		x	P			x	x			
Low	Orchard Creek, 101 18 W North Line to Cedar River (539)	Mower + Freeborn	***E. coli***	Average = 579 CFU/100mL, 2 of 6 samples > 1260 cfu/100ml	Monthly geometric means < 126CFU/100mL	Feedlot Improvements	Reduce/eliminate uncontrolled runoff from feedlot sites	●	●					●	30%	90%	Percent of prioritized feedlot sites			x	p	x			x		2047
						Manured Field and Riparian Pasture Management	Reduce runoff through tillage, soil management, rotational grazing, and buffers	●	●				●	●	30%	75%	Acres of manured fields with slopes >2% and grazed riparian areas			x	P	x					
						SSTS Upgrades	County programs to convert failing septics to conforming							●	Convert 75%	Convert 100% and maintain compliance	Percent of noncompliant systems				P	x			x		
Low	Woodson Creek, Austin Township Section 14, to Cedar River Confluence (554)	Mower	**M-IBI & F-IBI Stressors:** Lack of Habitat Altered Hydrology	M-IBI & F-IBI below threshold	M-IBI & F-IBI above threshold																						2047
Low	Orchard Creek, Headwaters to T102 R18W S32, south line (509)	Freeborn	**N/A**	N/A	Support Downstream WQ Goals	Erosion Control Projects*	Implement BMPs where feasible at high priority sites identified through GIS terrain analyses to reduce erosion and filter pollutants (e.g., filter strips, gully stabilization)	●	●				●		Field verify all 3 high priority sites for feasibility; implement 1	Implement all feasible sites	# high priority sites and drainage areas treated		x	P			x	x			2047

Priority Ranking	Waterbody and Location		Parameter (incl. non-pollutant stressors)	Water Quality		Strategy Type	Strategies	Pollutant / Stressors Addressed							Estimated Adoption Rate			Governmental Units with Primary Responsibility P = Project lead; X =Project partner									Estimated Year to Achieve Water Quality Target
	Waterbody (ID)	**Location** and Upstream Influence Counties		Current Conditions (load or concentration)	Goals / Targets and Estimated % Reduction			Nitrate	Phosphorus	Dissolved Oxygen	Altered Hydrology	Lack of Habitat	Turbidity/TSS	*E. coli*	Interim 10-yr Milestone	Suggested Goal	Units	Turtle Creek WD	Cedar River WD	SWCD	County	MPCA	DNR	BWSR	MDA	City	
Low	Cedar Creek, Wolf Cr to Lower Austin Dam (512)	Mower	**N/A**	N/A	Support Downstream WQ Goals	Erosion Control Projects*	Implement BMPs where feasible at high priority sites identified through GIS terrain analyses to reduce erosion and filter pollutants (e.g., filter strips, gully stabilization)	●	●				●		Field verify all 2 high priority sites for feasibility; implement 1	Implement all feasible sites	# high priority sites and drainage areas treated		x	P			x	x			2047
Low	Unnamed creek, Headwaters to Orchard Cr (555)	Freeborn	**N/A**	N/A	Support Downstream WQ Goals	Erosion Control Projects*	Implement BMPs where feasible at high priority sites identified through GIS terrain analyses to reduce erosion and filter pollutants (e.g., filter strips, gully stabilization)	●	●				●		Field verify all 10 high priority sites for feasibility; implement 2	Implement all feasible sites	# high priority sites and drainage areas treated		x	P			x	x			2047
Low	Mud Lake Creek/County Ditch 75 (590)	Freeborn	**N/A**	N/A	Support Downstream WQ Goals	Erosion Control Projects*	Implement BMPs where feasible at high priority sites identified through GIS terrain analyses to reduce erosion and filter pollutants (e.g., filter strips, gully stabilization)	●	●				●		Field verify all 5 high priority sites for feasibility; implement 1	Implement all feasible sites	# high priority sites and drainage areas treated		x	P			x	x			2047
Low	Unnamed Creek, Unnamed creek to Orchard Cr (594)	Mower	**N/A**	N/A	Support Downstream WQ Goals	Erosion Control Projects*	Implement BMPs where feasible at high priority sites identified through GIS terrain analyses to reduce erosion and filter pollutants (e.g., filter strips, gully stabilization)	●	●				●		Field verify all 3 high priority sites for feasibility; implement 1	Implement all feasible sites	# high priority sites and drainage areas treated		x	P			x	x			2047
Low	Unnamed Creek to Cedar River (595)	Mower	**N/A**	N/A	Support Downstream WQ Goals	Erosion Control Projects*	Implement BMPs where feasible at high priority sites identified through GIS terrain analyses to reduce erosion and filter pollutants (e.g., filter strips, gully stabilization)	●	●				●		Field high priority site for feasibility; implement 1	Implement all feasible sites	# high priority sites and drainage areas treated		x	P			x	x			2047

Key: Red rows = impaired waters requiring restoration; White rows = unimpaired waters requiring protection.

* Erosion control projects may include the suite of BMPs available to the landowner and the involved conservation professionals, including common practices such as waterways, terraces, filter strips, contour strip farming, WASCOBs, tillage, crop rotations and soil health. A treatment train approach will be considered for each site, customized to meet the water management and agricultural elements of each site.

Otter Creek Subwatershed

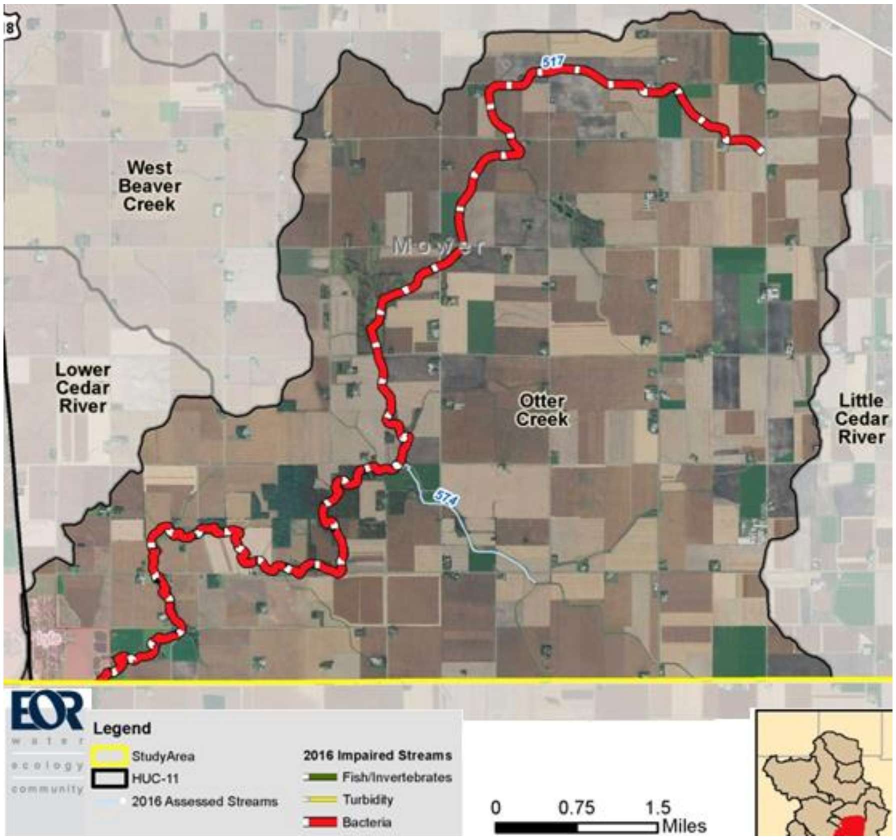


Figure 76. Otter Creek Subwatershed

Priority Ranking - High

Subwatershed Characteristics

- 33 square miles.
- 83% row crop.
- The survey of BMPs did not take place in the Otter Creek catchment.
- Rose and Larson WMAs located in subwatershed.
- The Otter Creek Subwatershed is a designated protection demonstration area within the CRW.
- No TSSs (or turbidity) impairments.
- Two special concern species present: Least Darter in headwaters of Otter Creek near Larson State WMA, and Ozark Minnow on Otter Creek near boarder with Iowa.
- Natural springs provide good groundwater support to maintain baseflow and regulate water temperature.

- An artificial rock dam on Otter Creek may be limiting to fish migration during critical spawning times.
- Nitrate levels are high and algae observed on shallow sections indicating a potential nutrient issue.
- Channel stability rated moderately unstable to very unstable.
- Historic channelization coupled with incision and over widening is creating a shallow aggraded bed with poor pool development.
- Additional protections and BMPs are recommended in order to maintain and improve habitat conditions and water quality to protect sensitive and special concern species.

Summary of other impairments

- 517 Otter Creek Bacteria-impaired (*E. coli*) and covered by the CRW TMDL.

Key Strategies

- Conservation practices to improve soil health, improve water infiltration and water storage in the soil profile, and reduce runoff volume.
- Maintain intact riparian zone to protect stream channel stability.
- Encourage and promote diversity in land use and land management in the subwatershed.

Table 24. Strategies and actions proposed for the Otter Creek Subwatershed

Priority Ranking	Waterbody and Location		Parameter (incl. non-pollutant stressors)	Water Quality		Strategy Type	Strategies	Pollutant / Stressors Addressed							Estimated Adoption Rate			Governmental Units with Primary Responsibility P = Project lead; X =Project partner									Estimated Year to Achieve Water Quality Target
	Waterbody (ID)	**Location** and Upstream Influence Counties		Current Conditions (load or concentration)	Goals / Targets and Estimated % Reduction			Nitrate	Phosphorus	Dissolved Oxygen	Altered Hydrology	Lack of Habitat	Turbidity/TSS	*E. coli*	Interim 10-yr Milestone	Suggested Goal	Units	Turtle Creek WD	Cedar River WD	SWCD	County	MPCA	DNR	BWSR	MDA	City	
High	Otter Creek, Headwaters to MN Border (517)	Mower	***E. coli***	Average = 977 cfu/100ml	Monthly geometric means < 126CFU/100mL	Feedlot Improvements	Reduce/eliminate uncontrolled runoff from feedlot sites	●	●					●	30%	90%	Percent of prioritized feedlot sites			x	p	x			x		2027
						Manured Field and Riparian Pasture Management	Reduce runoff through tillage, soil management, rotational grazing, and buffers	●	●				●	●	30%	75%	Acres of manured fields with slopes >2% and grazed riparian areas			x	P	x					
						SSTS Upgrades	County programs to convert failing septics to conforming							●	Convert 75%	Convert 100% and maintain compliance	Percent of noncompliant systems				P	x			x		
			Nutrients & Biota	n/a	Maintain or improve	Land Use/Mgt.	Maintain existing high quality land uses; Increase protected natural areas	●	●		●	●	●							P	x			x	x		

Key: Red rows = impaired waters requiring restoration; White rows = unimpaired waters requiring protection.

* Erosion control projects may include the suite of BMPs available to the landowner and the involved conservation professionals, including common practices such as waterways, terraces, filter strips, contour strip farming, WASCOBs, tillage, crop rotations and soil health. A treatment train approach will be considered for each site, customized to meet the water management and agricultural elements of each site.

Deer Creek Subwatershed

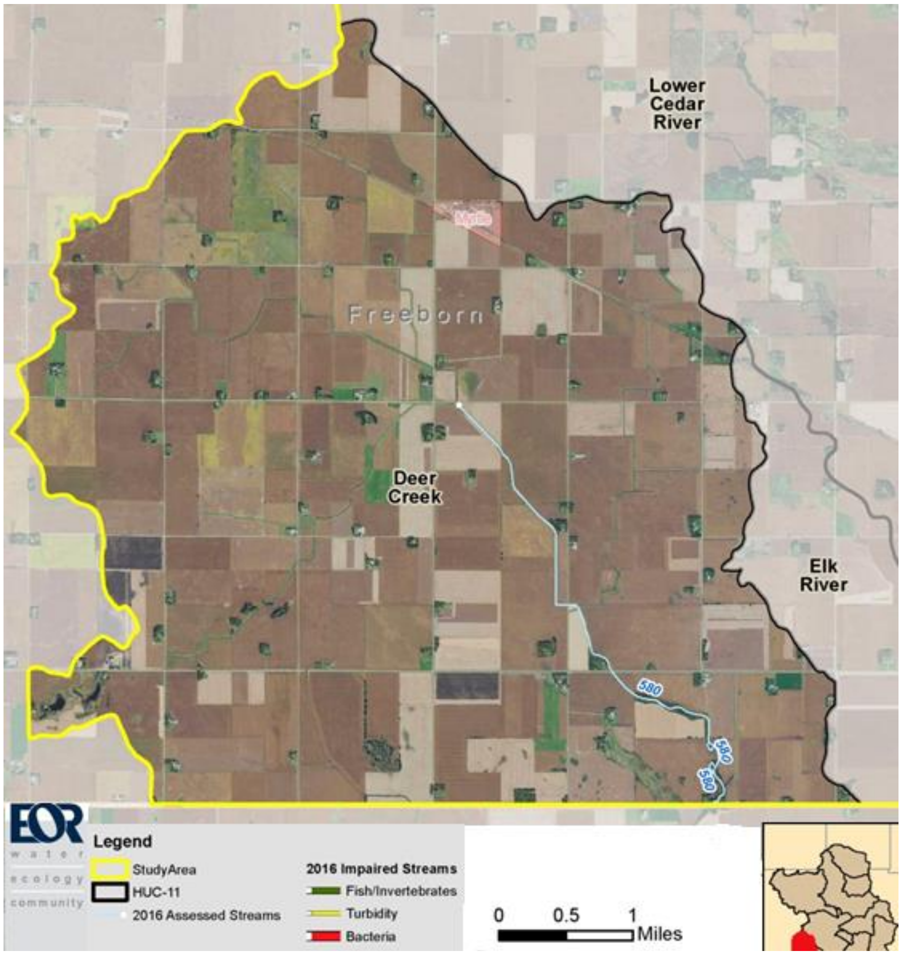


Figure 77. Deer Creek Subwatershed.

Priority Ranking - FEMA floodplain – Medium; Uplands – Low

Subwatershed Characteristics

- 25 square miles.
- Smallest percent of uncultivated land.
- 92% row crop
- The survey of BMPs did not take place in the Deer Creek catchment.
- Majority of stream miles are channelized with narrow riparian corridors surrounded by row crops.
- Cycle 1 assessments deferred, pending the development of TALU.
- Deer Creek -546 has been determined to be a modified use channel, under TALU. It is currently meeting the modified use thresholds, for both M-IBI and F-IBI.

- Deer Creek -580 (CD-71) has existing F-IBI impairment that will be removed, and this reach will be reassessed by the MPCA.
- Biological community fair for fish and good for invertebrates using lower threshold for channelized reaches.
- Fish community dominated by two taxa.
- Reach has unstable, cut banks and appears to be over widened, contributing to lack of overhanging vegetation and pool depth.

Key Strategies

- Conservation practices to improve soil health, improve water infiltration and water storage in the soil profile, and reduce runoff volume.
- Maintenance of the ditch buffers per Minnesota drainage law and buffer law.
- Implementation of multi-purpose drainage water management practices, as noted in Minn. Stat. 103E.015 (Minnesota Drainage Code, Consideration before drainage work is done).

Table 25. Strategies and actions proposed for the Deer Creek Subwatershed

Priority Ranking	Waterbody and Location		Parameter (incl. non-pollutant stressors)	Water Quality		Strategy Type	Strategies	Pollutant / Stressors Addressed							Estimated Adoption Rate			Governmental Units with Primary Responsibility P = Project lead; X =Project partner									Estimated Year to Achieve Water Quality Target
	Waterbody (ID)	**Location** and Upstream Influence Counties		Current Conditions (load or concentration)	Goals / Targets and Estimated % Reduction			Nitrate	Phosphorus	Dissolved Oxygen	Altered Hydrology	Lack of Habitat	Turbidity/TSS	*E. coli*	Interim 10-yr Milestone	Suggested Goal	Units	Turtle Creek WD	Cedar River WD	SWCD	County	MPCA	DNR	BWSR	MDA	City	
Low	All	All	All	All	Maintain or improve	Assess conservation practice status	Implement highest priority projects	x			x				25% of projects identified	85 % of projects identified				X	X						2047

Key: Red rows = impaired waters requiring restoration; White rows = unimpaired waters requiring protection.

* Erosion control projects may include the suite of BMPs available to the landowner and the involved conservation professionals, including common practices such as waterways, terraces, filter strips, contour strip farming, WASCOBs, tillage, crop rotations and soil health. A treatment train approach will be considered for each site, customized to meet the water management and agricultural elements of each site.

Little Cedar River Subwatershed

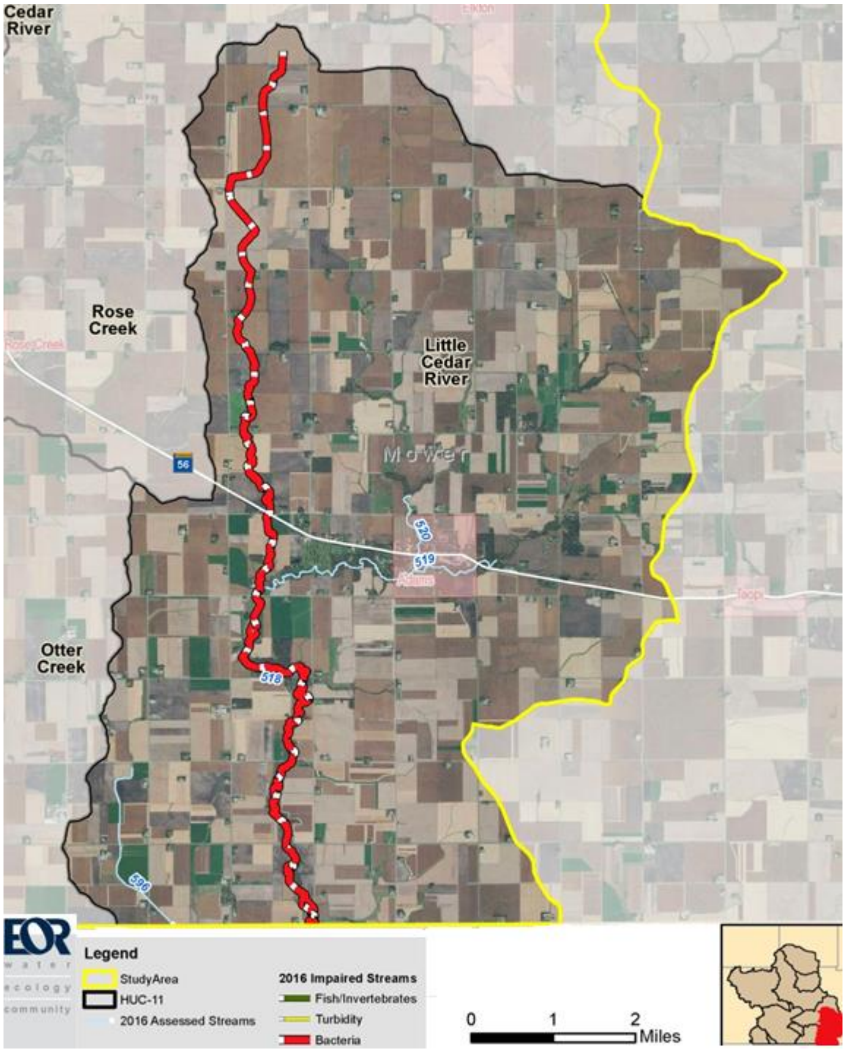


Figure 78. Little Cedar River Subwatershed

Priority Ranking - FEMA floodplain – Medium; Uplands – Low

Subwatershed Characteristics

- 59 square miles.
- 90% agricultural production.
- The survey of BMPs did not take place in the Little Cedar River catchment.
- 2.7% undeveloped.
- A private ditch located south of Adams was redesigned into a two-stage self-sustaining ditch that can reduce maintenance costs and improve water quality (Krider etal. 2014).
- High nitrate levels.

Summary of Stressors to Biologically Impaired Streams

519 - Unnamed Creek

- Adams WWTP discharges to -519.
- Elevated nitrate levels.
- Flow alteration and lack of habitat, in particular poor substrate and lack of features, stressing invertebrates.
- DO, TP, and TSS inconclusive – more monitoring needed.
- Better management of nutrients is needed within AUID.
- Additional TSS and chemical monitoring needed.

520 - Unnamed Creek

- Flow alteration is a source of habitat alteration and stressor to the biology.
- Macroinvertebrate habitat limited.
- Reach dominated by sand substrate with little riffle habitat.
- Little TSS data but macroinvertebrates present show sensitivity to TSS.
- Better management of nutrients is needed.
- Additional TSS and chemical monitoring needed.

Summary of other impairments

518 – Little Cedar River, headwaters to Minnesota/Iowa border. Bacteria (*E. coli*) impairment, addressed in the CRW TMDL.

Protection Summary

Little Cedar River mainstem (AUID – 518)

- Habitat quality was rated as fair and the channel stability was rated as fairly stable.
- High nitrite-nitrate values between 9 and 17 mg/L was observed and will need to be addressed to ensure the Little Cedar River does not become impaired.

Key Strategies

- Conservation practices to improve soil health, improve water infiltration and water storage in the soil profile, and reduce runoff volume.

Table 26. Strategies and actions proposed for the Little Cedar River Subwatershed

Priority Ranking	Waterbody and Location		Parameter (incl. non-pollutant stressors)	Water Quality		Strategy Type	Strategies	Pollutant / Stressors Addressed							Estimated Adoption Rate			Governmental Units with Primary Responsibility P = Project lead; X =Project partner									Estimated Year to Achieve Water Quality Target
	Waterbody (ID)	**Location** and Upstream Influence Counties		Current Conditions (load or concentration)	Goals / Targets and Estimated % Reduction			Nitrate	Phosphorus	Dissolved Oxygen	Altered Hydrology	Lack of Habitat	Turbidity/TSS	*E. coli*	Interim 10-yr Milestone	Suggested Goal	Units	Turtle Creek WD	Cedar River WD	SWCD	County	MPCA	DNR	BWSR	MDA	City	
Low	Little Cedar River, Headwaters to MN Border (518)	Mower	***E. coli***	June-Aug geometric means 463 - 863 CFU/100mL	Monthly geometric means < 126CFU/100mL	Feedlot Improvements	Reduce/eliminate uncontrolled runoff from feedlot sites	●	●					●	30%	90%	Percent of prioritized feedlot sites			x	p	x			x		2047
						Manured Field and Riparian Pasture Management	Reduce runoff through tillage, soil management, rotational grazing, and buffers	●	●				●	●	30%	75%	Acres of manured fields with slopes >2% and grazed riparian areas			x	P	x					
						SSTS Upgrades	County programs to convert failing septics to conforming							●	Convert 75%	Convert 100% and maintain compliance	Percent of noncompliant systems				P	x			x		
Low	Unnamed Creek, Unnamed Creek to Little Cedar (519)	Mower	**M-IBI Stressors:** Nitrate Lack of Habitat Altered Hydrology Turbidity/TSS	M-IBI below threshold	M-IBI above threshold	Soil Health	Cover crops, tillage management, and nutrient management.	☒	x		☒		x		10% adoption	30% adoption	Row cropped acres			P	x			x	x		2047
Low	Unnamed Creek, Unnamed Creek to Unnamed Creek (520)	Mower	**M-IBI Stressors:** Nitrate Turbidity/TSS Phosphorus Altered Hydrology Dissolved Oxygen Lack of Habitat	M-IBI below threshold	M-IBI above threshold	Soil Health	Cover crops, tillage management, and nutrient management.	☒	x		☒		x		10% adoption	30% adoption	Row cropped acres			P	x			x	x		2047

Key: Red rows = impaired waters requiring restoration; White rows = unimpaired waters requiring protection.

* Erosion control projects may include the suite of BMPs available to the landowner and the involved conservation professionals, including common practices such as waterways, terraces, filter strips, contour strip farming, WASCOBs, tillage, crop rotations and soil health. A treatment train approach will be considered for each site, customized to meet the water management and agricultural elements of each site.

Elk River Subwatershed

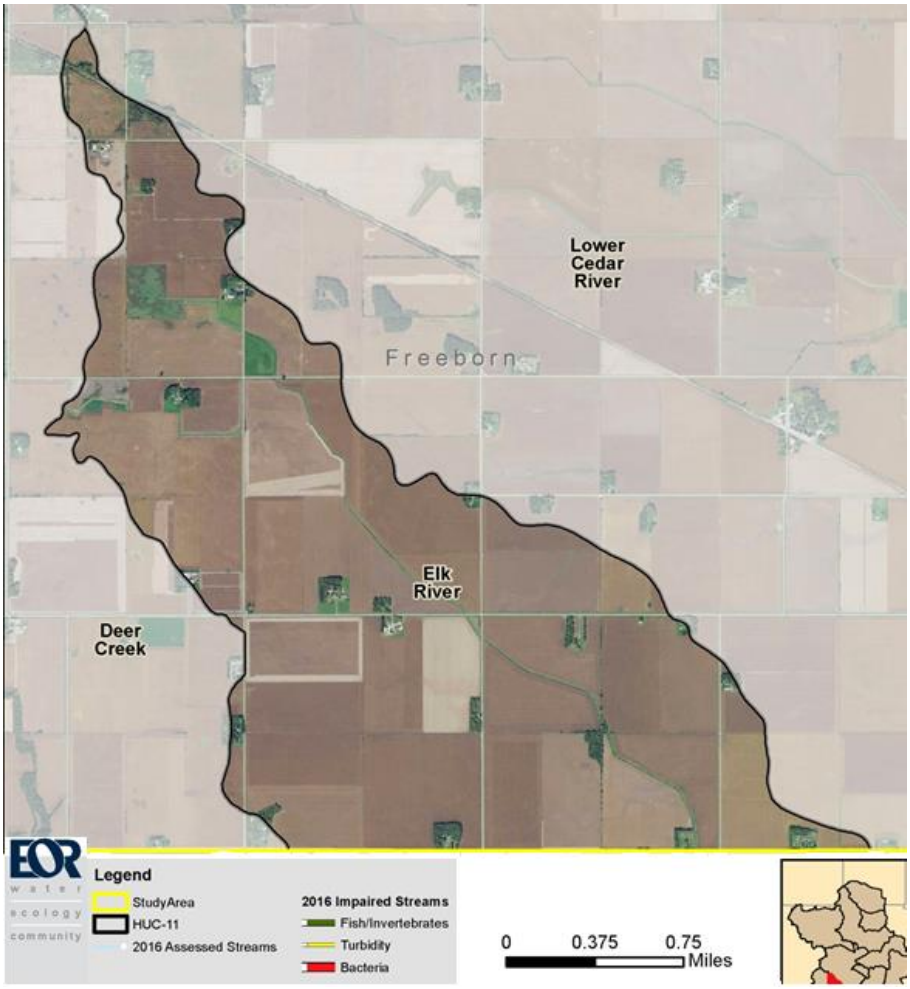


Figure 79. Elk River Subwatershed.

Priority Ranking - Low

Subwatershed Characteristics

- Four square miles (in Minnesota).
- There is one stream AUID in this subwatershed, and insufficient water quality data to complete an assessment.

Table 27. Strategies and actions proposed for the Elk River Subwatershed

Priority Ranking	Waterbody and Location		Parameter (incl. non-pollutant stressors)	Water Quality		Strategy Type	Strategies	Pollutant / Stressors Addressed							Estimated Adoption Rate			Governmental Units with Primary Responsibility P = Project lead; X =Project partner									Estimated Year to Achieve Water Quality Target
	Waterbody (ID)	**Location** and Upstream Influence Counties		Current Conditions (load or concentration)	Goals / Targets and Estimated % Reduction			Nitrate	Phosphorus	Dissolved Oxygen	Altered Hydrology	Lack of Habitat	Turbidity/TSS	*E. coli*	Interim 10-yr Milestone	Suggested Goal	Units	Turtle Creek WD	Cedar River WD	SWCD	County	MPCA	DNR	BWSR	MDA	City	
Low	All	All	All	All	Maintain or improve	Assess conservation practice needs	Implement priority projects	x			x	x			25% of identified projects	85% of identified projects	# BMP projects			P	x						2047

Key: Red rows = impaired waters requiring restoration; White rows = unimpaired waters requiring protection.

* Erosion control projects may include the suite of BMPs available to the landowner and the involved conservation professionals, including common practices such as waterways, terraces, filter strips, contour strip farming, WASCOBs, tillage, crop rotations and soil health. A treatment train approach will be considered for each site, customized to meet the water management and agricultural elements of each site.

Table 28. Key for Strategies Column

Parameter (incl. non-pollutant stressors)	Strategy Key: Description	Strategy Key: Example BMPs/actions
TSS	Improve upland/field surface runoff controls: Soil and water conservation practices that reduce soil erosion and field runoff, or otherwise minimize sediment from leaving farmland	Cover crops
		Water and sediment basins, terraces
		Rotations including perennials
		Conservation cover easements
		Grassed waterways
		Strategies to reduce flow- some of flow reduction strategies should be targeted to ravine subwatersheds
		Residue management - conservation tillage
		Forage and biomass planting
		Open tile inlet controls - riser pipes, french drains
		Contour farming
		Wetland restoration
		Stripcropping
	Protect/stabilize banks/bluffs: Reduce collapse of bluffs and erosion of streambank by reducing peak river flows and using vegetation to stabilize these areas.	Strategies for altered hydrology (reducing peak flow)
		Streambank stabilization
		Establish or re-establish riparian forest buffer
		Livestock exclusion - controlled stream crossings
	Stabilize ravines: Reducing erosion of ravines by dispersing and infiltrating field runoff and increasing vegetative cover near ravines. Also, may include earthwork/regrading and revegetation of ravine.	Field edge buffers, borders, windbreaks and/or filter strips
		Contour farming and contour buffer strips
		Diversions
		Water and sediment control basin
		Terrace
		Conservation crop rotation
		Cover crop
		Residue management - conservation tillage
	Improve forestry management	Proper water crossings and road construction
		Forest roads - cross-drainage
		Maintaining and aligning active forest roads
		Closure of inactive roads & post Harvest
		Location & sizing of landings
		Establish or re-establish riparian management zone widths and/or filter strips
	Improve urban stormwater management [to reduce sediment and flow]	See MPCA Stormwater Manual: http://stormwater.pca.state.mn.us/index.php/Information_on_pollutant_removal_by_BMPs
Phosphorus (TP)	Improve upland/field surface runoff controls: Soil and water conservation practices that reduce soil erosion and field runoff, or otherwise minimize sediment from leaving farmland	Strategies to reduce sediment from fields (see above - upland field surface runoff)
		Constructed or restored wetlands
		Pasture management
		Restored wetlands
	Reduce bank/bluff/ravine erosion	Strategies to reduce TSS from banks/bluffs/ravines (see above for sediment)
	Increase vegetative cover/root duration: Planting crops and vegetation that maximize vegetative cover and minimize erosion and soil losses to waters, especially during the spring and fall.	Conservation cover (easements/buffers of native grass & trees, pollinator habitat)
		Perennials grown on marginal lands and riparian lands
		Cover crops
		Rotations that include perennials
	Preventing feedlot runoff: Using manure storage, water diversions, reduced lot sizes and vegetative filter strips to reduce open lot phosphorus losses	Open lot runoff management to meet 7020 rules
		Manure storage in ways that prevent runoff
	Improve fertilizer and manure application management: Applying phosphorus fertilizer and manure onto soils where it is most needed using techniques, which limit exposure of phosphorus to rainfall and runoff.	Soil P testing and applying nutrients on fields needing phosphorus
		Incorporating/injecting nutrients below the soil
		Manure application meeting all 7020 rule setback requirements
		Sewering around lakes

Parameter (incl. non-pollutant stressors)	Strategy Key: Description	Strategy Key: Example BMPs/actions
	Address failing septic systems: Fixing septic systems so that on-site sewage is not released to surface waters. Includes straight pipes.	Eliminating straight pipes, surface seepages
	Reduce in-water loading: Minimizing the internal release of phosphorus within lakes	Rough fish management
		Curly-leaf pondweed management
		Alum treatment
		Lake drawdown
		Hypolimnetic withdrawal
	Improve forestry management	See forest strategies for sediment control
	Reduce Industrial/Municipal wastewater TP	Municipal and industrial treatment of wastewater P
		Upgrades/expansion. Address inflow/infiltration.
	Treat tile drainage waters: Treating tile drainage waters to reduce phosphorus entering water by running water through a medium which captures phosphorus	Bioreactor
	Improve urban stormwater management	See MPCA Stormwater Manual: http://stormwater.pca.state.mn.us/index.php/Information_on_pollutant_removal_by_BMPs
E. coli	Reducing livestock bacteria in surface runoff: Preventing manure from entering streams by keeping it in storage or below the soil surface and by limiting access of animals to waters.	Strategies to reduce field TSS (applied to manured fields, see above)
		Improved field manure (nutrient) management
		Adhere/increase application setbacks
		Improve feedlot runoff control
		Animal mortality facility
		Manure spreading setbacks and incorporation near wells and sinkholes
		Rotational grazing and livestock exclusion (pasture management)
	Reduce urban bacteria: Limiting exposure of pet or waterfowl waste to rainfall	Pet waste management
		Filter strips and buffers
		See MPCA Stormwater Manual: http://stormwater.pca.state.mn.us/index.php/Information_on_pollutant_removal_by_BMPs
	Address failing septic systems: Fixing septic systems so that on-site sewage is not released to surface waters. Includes straight pipes.	Replace failing septic (SSTS) systems
		Maintain septic (SSTS) systems
	Reduce Industrial/Municipal wastewater bacteria	Reduce straight pipe (untreated) residential discharges
		Reduce WWTP untreated (emergency) releases
Dissolved Oxygen	Reduce phosphorus	See strategies above for reducing phosphorus
	Increase river flow during low flow years	See strategies above for altered hydrology
	In-channel restoration: Actions to address altered portions of streams.	
Altered hydrology; peak flow and/or low base flow (Fish/Macroinvertebrate IBI)	Increase living cover: Planting crops and vegetation that maximize vegetative cover and evapotranspiration especially during the high flow spring months.	Grassed waterways
		Cover crops
		Conservation cover (easements & buffers of native grass & trees, pollinator habitat)
		Rotations including perennials
	Improve drainage management: Managing drainage waters to store tile drainage waters in fields or at constructed collection points and releasing stored waters after peak flow periods.	Treatment wetlands
		Restored wetlands
	Reduce rural runoff by increasing infiltration: Decrease surface runoff contributions to peak flow through soil and water conservation practices.	Conservation tillage (no-till or strip till w/ high residue)
		Water and sediment basins, terraces
	Improve urban stormwater management	See MPCA Stormwater Manual: http://stormwater.pca.state.mn.us/index.php/Information_on_pollutant_removal_by_BMPs
	Improve irrigation water management: Increase groundwater contributions to surface waters by withdrawing less water for irrigation or other purposes.	Groundwater pumping reductions and irrigation management
Poor Habitat (Fish/Macroinvertebrate IBI)	Improve riparian vegetation: Planting and improving perennial vegetation in riparian areas to stabilize soil, filter pollutants and increase biodiversity	50' vegetated buffer on protected of waterways
		One rod ditch buffers
		Lake shoreland buffers
		Increase conservation cover: in/near water bodies, to create corridors

Parameter (incl. non-pollutant stressors)	Strategy Key	
	Description	Example BMPs/actions
		Improve/increase natural habitat in riparian, control invasive species
		Tree planting to increase shading
		Streambank and shoreline protection/stabilization
		Wetland restoration
		Accurately size bridges and culverts to improve stream stability
	Restore/enhance channel: Various restoration efforts largely aimed at providing substrate and natural stream morphology.	Retrofit dams with multi-level intakes
		Restore riffle substrate
		Two-stage ditch
		Dam operation to mimic natural conditions
		Restore natural meander and complexity
Connectivity (Fish IBI)	Removal fish passage barriers: Identify and address barriers.	Dam removal
		Properly size and place culverts for flow and fish passage
		Construct nature-like fish passage

4. Monitoring Plan

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 CRW, there needs to be reliable data that can be used to generate information. The basic needs include an understanding of variability, scale, confidence, and associated risk levels. For example, the scale of the Cedar River at Austin, and the requirement of reliable stream hydrology data is different than the need for data on land uses, bacteria and habitat for the Otter Creek Subwatershed. Monitoring of both land and water components is needed and data is then used to inform and calibrate watershed models. Section 5 of the CRW TMDL includes more information on monitoring.

Land information includes the following, and is critical for interpreting any water monitoring data:

- Land use and land cover
- Conservation practices
  - Agricultural (erosion control, nutrient management, tillage, and cover cropping as examples)
  - Urban (storm water management, erosion control, rate control practices as examples)
- Crop residue levels (including new satellite imagery methods being developed by BWSR)
- Culvert and bridge projects
- Ditch channels and drainage system projects (rural and urban)

Water information includes current data and actionable reports about:

- Water quality (chemical, biological, sediment)
- Precipitation
- Stream geomorphology
- Stream hydrology (continuous flow at selected sites at a variety of scales)
- Point source pollutant monitoring
- Pollutant source assessment for nonpoint sources
- Stormwater management activities

It is the intent of the implementing organizations in this watershed to make steady progress in terms of pollutant reduction. Accordingly, as a very general guideline, progress benchmarks are established for this watershed that implement activities and practices which will result in a water quality pollutant load decline, as a mid-term to longer-term trend (15 to 30 years). For example, sediment load reductions in the high flow zone will be a function of many factors, including rainfall, runoff, land use, cropping patterns, and numerous management actions across the watershed. Having an alignment of positive trends for all of these, on a yearly basis, would not be practical. However, over a 15 to 20 year timeframe at the HUC-11 scale, a significant level of BMP adoption and sustained implementation can occur, which can result in a decreasing trend (improvement) in pollutant loads. It is acknowledged that larger rainfall-runoff events, as monitored at the larger scales (i.e. Lower Cedar River reaches), will remain a challenge for decades to come. However, sustained soil and water management improvements at all of the lower/smaller scales, will over time accrue, and promote, improving trends for both hydrology and pollutant loading.

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

Data from numerous monitoring programs will continue to be collected and analyzed for the CRW. Monitoring is conducted by local, state and federal departments, and also special projects that include some type of monitoring can be especially helpful.

Local

- **SWCDs and private citizens** – rain gauge networks
- **WWTPs** – City discharges of treatment wastewater
- **MS4 Cities** – Stormwater management
- **Counties** – Feedlots, SSTS, planning and zoning, and public drainage system administration
- **Watershed Districts** – River and stream monitoring. Bridge and culvert replacements

State

- ***Intensive Watershed Monitoring*** collects water quality and biological data throughout each major watershed, once every 10 years. This work is scheduled for its second iteration in the CRW to begin in 2020. This data provides a periodic but intensive “snapshot” of water quality throughout the watershed.

http://www.pca.state.mn.us/index.php/water/water-monitoring-and-reporting/water-quality-and-pollutants/water-quality-condition-monitoring/watershed-sampling-design-intensive-watershed-monitoring.html

- The ***Watershed Pollutant Load Monitoring Network*** intensively collects pollutant samples and flow data to calculate daily sediment and nutrient loads on an annual or seasonal (no-ice) basis. In the CRW, there are two seasonal subwatershed pollutant load monitoring sites.

http://www.pca.state.mn.us/index.php/water/water-types-and-programs/surface-water/streams-and-rivers/watershed-pollutant-load-monitoring-network.html

- The ***Citizen Surface Water Monitoring Program*** is a network of volunteers who make monthly lake and river transparency readings. Several dozen data collection locations exist in the CRW. This data provides a continuous record of water transparency measurements throughout much of the watershed.

http://www.pca.state.mn.us/index.php/water/water-monitoring-and-reporting/volunteer-water-monitoring/volunteer-surface-water-monitoring.html

- **DNR/MPCA Cooperative Stream Gaging** – Turtle Creek, Cedar River at Lansing, Dobbins Creek at J.C. Hormel Nature Center.

Federal

- **USGS Sites -** (Cedar River at Austin)
- **National Weather Service** (flood warning gages at Lansing, Turtle Creek and Dobbins Creek)

In addition to the monitoring conducted in association with the WRAPS process, each local unit of government associated with water management may have their own monitoring plan. All data collected locally should be submitted regularly to the MPCA for entry into the EQuIS database system. http://www.pca.state.mn.us/index.php/data/surface-water.html

5. References and Further Information

Additional Information on the CRW including the Monitoring and Assessment Report and the Stressor Identification Report can be found on the MPCA CRW website: https://www.pca.state.mn.us/water/watersheds/cedar-river

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6. Appendix A: Stream Assessment Status

Table 29. Assessment status of stream reaches in the Cedar River Watershed

HUC-11	AUID (Last 3 digits)	Stream	Reach Description	Aquatic Life Indicators: Fish – IBI	M – IBI	Dissolved Oxygen	Turbidity/ TSS	Chloride	pH	Ammonia	AQUATIC LIFE	RECREATION (Bacteria)
Middle Fork Cedar River	**503**	**Cedar River**	Headwaters to Roberts Creek	MTS	EXP	IF	EXP	MTS	MTS	MTS	NS	EX
	529	Unnamed creek	Unnamed creek to Cedar River	MTS	MTS	--	--	--	--	--	FS	--
	592	Unnamed creek	Unnamed creek to Cedar River	EXP	NA	--	--	--	--	--	FS	--
	532	Unnamed creek	Headwaters to Cedar River	EXP	EXS	--	--	--	--	--	IF*	--
	549	**Cedar River, Middle Fork**	Westfield-Ripley Ditch to Unnamed creek	MTS	EXP	--	--	--	--	--	NS	--
	530	**Cedar River, Middle Fork**	Unnamed creek to Cedar River	MTS	EXP	IF	EXP	--	MTS	--	NS	--
Roberts Creek	505	Unnamed creek	Headwaters to Roberts Creek	MTS	MTS	--	--	--	--	--	FS	--
	534	**Unnamed creek**	Unnamed creek to T103 R17W S10, west line	EXP	EXS	--	--	--	--	--	NS	--
	593	**Unnamed creek**	Unnamed creek to Unnamed creek	MTS	EXP	--	--	--	--	--	NS	--
	506	**Roberts Creek**	Headwaters to Unnamed creek	EXS	EXS	--	--	--	--	--	NS	--
	504	**Roberts Creek**	Unnamed creek to Cedar River	MTS	EXP	IF	EXP	MT	MTS	MT	NS	EX
Upper Cedar River	**591**	**Cedar River, West Fork**	Unnamed Cr to Cedar River	MTS	EXP	--	--	--	--	--	NS	--
	577	**Unnamed creek**	Unnamed creek to Cedar River	MTS	EXS	--	--	--	--	--	NS	--
	553	Murphy Creek	Headwaters to Cedar River	NA	NA	IF	EXP	--	MTS	MTS	NA*	IF
	503	Cedar River	Headwaters to Roberts Creek	MTS	EXP	IF	EXP	MTS	MTS	MTS	NS	EX
	533	**Unnamed creek**	Unnamed creek to Cedar River	MTS	EXP	IF	EXP	MTS	MTS	MTS	NS	IF
	573	Judicial Ditch 5	Headwaters to Cedar River	MTS	EXP	IF	EXP	MTS	MTS	MTS	IF*	IF
	502	**Cedar River**	Roberts Creek to Upper Austin Dam	MTS	MTS	IF	EXP	MTS	MTS	MTS	NS	EX
	511	Cedar River	Upper Austin Dam to Wolf Creek	MTS	EXP	--	--	--	--	--	FS	--

HUC-11	AUID (Last 3 digits)	Stream	Reach Description	Aquatic Life Indicators							AQUATIC LIFE	RECREATION (Bacteria)
				Fish – IBI	M – IBI	Dissolved Oxygen	Turbidity/ TSS	Chloride	pH	Ammonia		
	563	Unnamed creek	Unnamed creek to Dobbins Creek	EXP	EXP	--	--	--	--	--	FS	--
	535	**Dobbins Creek**	T103 R18W S36, east line to East Side Lake	EXP	MTS	IF	EXP	--	MTS	--	NS	--
	537	Dobbins Creek	East Side Lake to Cedar River	--	--	--	--	--	--	--	NA	--
	510	**Wolf Creek**	Headwaters to Cedar River	--	--	--	--	--	--	--	NA	--
	514	**Cedar River**	Dobbins Creek to Turtle Creek	MTS	MTS	--	EXP	MTS		MTS	FS	EX
Turtle Creek	**547**	**Unnamed creek**	Unnamed creek to Turtle Creek	MTS	EXP	--	--	--	--	--	NS	--
	538	Turtle Creek	T103 R20W S2, north line to T103 R18W S32, south line	NA	NA	--	EXP	--	MTS	--	IF*	--
	540	**Turtle Creek**	T102 R18W S4, north line to Cedar River	EXP	EXP	IF	EXS	MTS	MTS	MTS	NS	EX
Rose Creek	**523**	**Schwerin Creek**	Headwaters to Rose Creek	EXP	EXP	--	--	--	--	--	NS	--
	583	**Unnamed creek**	Unnamed creek to Rose Creek	EXP	EXS	IF	EXP	--	MTS	--	NS	--
Rose Creek	**522**	**Rose Creek**	Headwaters to Cedar River	MTS	MTS	IF	EXP	MTS	MTS	MTS	NS	EX
West Beaver Creek	556	Unnamed creek	Unnamed creek to Cedar River	MTS	MTS	--	--	--	--	--	FS	--
Lower Cedar River	512	Cedar River	Wolf Creek to Lower Austin Dam	--	--	--	EXP	--	--	--	IF	--
	554	**Woodson Creek**	T102 R18W S14, north line to Cedar River	EXS	EXP	--	--	--	--	--	NS	--
	515	**Cedar River**	Turtle Cr to Rose Creek	MTS	EXP	IF	EXS	MT	MTS	MTS	NS	--
	594	Unnamed creek	Unnamed creek to Orchard Creek	EXP	EXS	--	--	--	--	--	IF*	--
	555	Unnamed creek	Headwaters to Orchard Creek	MTS/NA	EXS/NA	--	--	--	--	--	IF*	--
	509	Orchard Creek	Headwaters to T102 R18W S32, south line	EXP	EXS	--	--	--	--	--	IF*	--
	539	**Orchard Creek**	T101 R18W S5 north line to Cedar River	MTS	MTS	IF	EXP	MT	MTS	MTS	FS	IF

HUC-11	AUID (Last 3 digits)	Stream	Reach Description	Aquatic Life Indicators							AQUATIC LIFE	RECREATION (Bacteria)
				Fish – IBI	M – IBI	Dissolved Oxygen	Turbidity/ TSS	Chloride	pH	Ammonia		
	501	**Cedar River**	Rose Cr to Woodbury Creek	EXS	EXP	IF	EXS	MT	MTS	MTS	NS	EX
	526	**Woodbury Creek**	Headwaters to Cedar River	MTS	MTS	IF	EXP	MT	MTS	MTS	FS	IF
	590	Mud Lake Creek/ County Ditch 25	Unnamed creek to Woodbury Creek	EXP	EXP	--	--	--	--	--	IF*	--
	516	**Cedar River**	Woodbury Creek to MN/IA border	EXP	EXP	--	EXP	MT	--	MTS	NS	EX
Otter Creek	**517**	**Otter Creek**	Headwaters to MN/IA border	MTS	MTS	--	MTS	--	--	--	FS	--
Deer Creek	580	Deer Creek/ County Ditch 71	T101 R19W S19, north line to MN/IA border	EXP	MTS	--	--	--	--	--	IF*	--
Little Cedar River	**520**	**Unnamed creek**	Unnamed creek to Unnamed creek	EXP	EXP	--	--	--	--	--	NS	--
	519	**Unnamed creek**	Unnamed creek to Little Cedar River	MTS	EXP	--	--	--	--	--	NS	--
	518	**Little Cedar River**	Headwaters to MN/IA border	MTS	MTS	IF	IF	MT	MTS	MTS	FS	EX

Abbreviations:
-- = No Data;
MTS = Meets criteria; EXP = Exceeds criteria, potential impairment; EXS = Exceeds criteria, potential severe impairment; EX = Exceeds criteria (Bacteria); IF* = assessment has been deferred until the adoption of Tiered Aquatic Life Uses due to the AUID having biological data limited to a station occurring on a channelized portion of the stream

Key for Impairment Shading:

Existing impairment, listed prior to 2012 reporting cycle;
New impairment;
No impairment

Key for Stream Shading:
Included in 2014 Strategy Table
Included in Stressor Identification Study

7. Appendix B: BMP Targeting Tools

Restorable Wetland Identification

A general approach to modifying stream hydrology by reducing runoff, increasing infiltration, and improving water storage in wetlands and floodplains has been pursued in the CRW for decades. Due to the extent of historical wetland drainage, continuing to refine a restorable wetland strategy is a critical element in the CRW.

An initial, GIS based weight of evidence approach was used to create a pool of potentially viable wetland mitigation areas by stacking GIS layers (Figure 80). The high resolution nature of the LiDAR dataset in combination with the Soil Survey Geographic Database (SSURGO) soils data and the National Wetlands Inventory (NWI) modified wetland attribute provided a means to quickly screen the watershed and identify sites that contain three key metrics which are critical to most successful wetland restoration projects including 1) hydric soils 2) topographic depression and 3) NWI- modified (farmed, ditched, excavated) wetlands. This analysis resulted in the creation of 84 unique polygons. These 84 polygons formed the basis for establishing a pool of potential wetland mitigation sites.

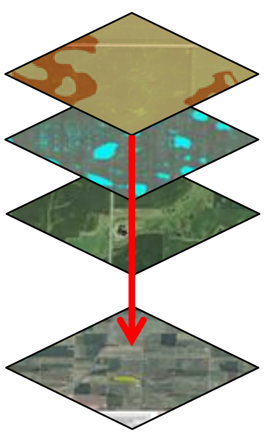


Figure 80. GIS based weight of evidence approach to identifying potential wetland mitigation sites

To further prioritize potential wetland mitigation sites, a secondary set of value-based metrics can be used. Value-based metrics including parcel land value (https://www.acrevalue.com/map/) and agricultural field performance (e.g., crop yields = bushels/acre) (https://agsolver.com/products/) can be used to further prioritize sites for conservation practices. These tools display the following output metrics for a given parcel on which a wetland restoration practice (or other BMP) could be applied:

1. Average acre-value of property in comparison with county average
2. Crop Productivity Index (CPI) based on mapped soils
3. Land value history
4. Crop history
5. Cash flow rent value

6. Index based rent value

These value based metrics are most useful when implementation of an identified wetland restoration practice can be demonstrated as financially beneficial to prospective landowners when evaluating potential implementation options.

Modeling Tools: SWAT and GSSHA

This section has highlighted some modeling results at the small scale, with results from the SWAT model and the GSSHA model. The targeted SWAT model was only used at the small watershed scale (Roberts Creek and Otter Creek), as presented above. The GSSHA model was used at the small tributary subwatershed scale (Dobbins Creek outlet), and for only a portion of the Upper North Branch Dobbins Creek. The timeframes for these modeling tools were also different; SWAT – 10 years and GSSHA – 4 years with storm event and shorter duration modeling completed. The results of these models should be assessed carefully, as they provide predictions, based on the input data and the modeling routines for each tool. Both of these models make use of water monitoring data for calibration. Due to the high cost of water monitoring, the careful use of such models are needed to help in goal setting and decision-making.

SWAT BMP Scenarios: Roberts Creek and Otter Creek Subwatersheds

In the Cedar River Basin, a SWAT model (see description in previous section) was developed in 2012 that simulated conditions from 2000 to 2010. This model was then refined in 2014 to more accurately account for current BMPs, tiling, and soils. The exact refinements are given in a technical memorandum (Barr 2014), and are summarized below in Table 30, to stress the importance of these factors in goal setting and strategy development.

The refined SWAT Model was then combined with results from the digital terrain analysis (see description in previous section) to further identify and prioritize critical source areas throughout the CRW. The final application of the SWAT model in the CRW was applied to two selected subwatersheds – Roberts Creek and Otter Creek – to assess pollutant reductions from various land use/land management scenarios. Roberts Creek, a tributary to the Upper Cedar River, was selected as a subwatershed with a restoration focus; and Otter Creek, a tributary to the Lower Cedar River, was selected as a subwatershed with a protection focus. Results from this analysis, as summarized in Table 31 and Table 32, were used to compare the reductions in cumulative loads for sediment, nitrate-nitrogen, and TP for four implementation scenarios. In both watersheds, conservation tillage provided a 4% to 6% reduction in total sediment load, from the existing conditions. Nitrate-N loads were reduced in both pilot subwatersheds by about a fourth, by using the UMN's fertilizer recommendations. The scenario (#4) that simulated drainage water management (controlled drainage) also produced decent nitrate load reductions in both watersheds (12% to 21% reductions). Conservation tillage was effective at reducing TP loads by nearly one-half, in both subwatersheds. When assessed as a whole, these modeling data can help land managers, conservation staff, and water managers better understand practical changes in pollutant loads that could occur, over the midterm (5 to 15 years), for these types of systems.

Table 30. Cedar River Watershed Revised SWAT Watershed Modeling Components and relevance to the WRAPS

Revised SWAT Component	What was done?	Why is this important?
Hydrologic soils classes C and D	Used updated soils classifications from NRCS	Improved estimates of croplands that are likely poorly drained, and could be considered for agricultural drainage tile installations of some sort
Agricultural Drainage Tile	Intersected hydrologic soil classes C and D with cropland LULC	Estimate of tiled lands changed from 51% to 84% of cultivated croplands. This improved estimate was consistent with information provided by local conservation professionals
Agricultural land conservation practices – inventory of BMPs	SWCDs inventoried installed BMPs, which were likely to affect erosion and sediment transport. 927 practices identified – by type and location	The tributary areas receiving some level of BMP treatment was 58,418 acres, or 21% of the row crop area. These BMPs removed 25% of the overall watershed sediment load.

Table 31. Roberts Creek Watershed Scenario results from the Cedar River Revised SWAT Model (BARR 2014)

Roberts Creek					
		Simulated Cumulative Loads (2000 to 2010)			
Scenario	**Description**	**Flow (m^3)**	**Sediment (tons,% from baseline)**	**NO3 (tons,% from baseline)**	**Total P (tons,% from baseline)**
Baseline	Existing Conditions	1.3E+07	281	109	4.6
1	Continuous corn with moldboard tillage.	1.4E+07	301, 7%	96, -12%	4.7, 2%
2	Conservation tillage of corn	1.2E+07	264, -6%	110, 1%	2.4, -48%
3	U of M agronomic fertilization rates	1.2E+07	275, -2%	81, -26%	4.4, -4%
4	Increase the tile drainage time	1.3E+07	262, -7%	86, -21%	4.7, 2%
5	Strategic application of grassed waterways/filter strips	1.3E+07	242, -14%	107, -2%	4.5, -2%

Table 32. Otter Creek Watershed Scenario results from the Cedar River Revised SWAT Model (BARR 2014)

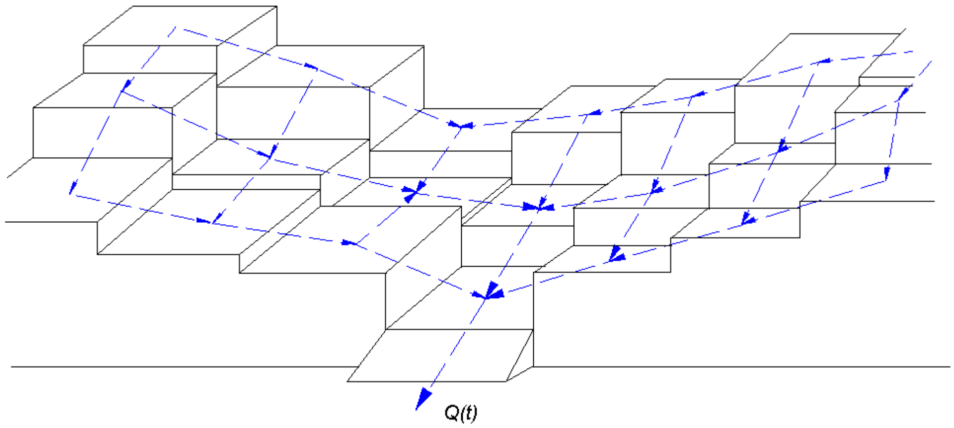
Otter Creek						
		Simulated Cumulative Loads (2000 to 2010)				
Scenario	Description	Flow (m3)	Sediment (tons,% from baseline)	NO3 (tons,% from baseline)	Total P (tons,% from baseline)
Baseline	Existing Conditions	2.5E+07	355	266	5.3
1	Continuous corn with moldboard tillage.	2.7E+07	371, 5%	228, -14%	5.5, 4%
2	Conservation tillage of corn	2.5E+07	341, -4%	300, 13%	2.8, -47%
3	U of M agronomic fertilization rates	2.5E+07	343, -3%	184, -31%	5.2, -2%
4	Increase the tile drainage time	2.5E+07	322, -9%	235, -12%	5.5, 4%
5	Strategic application of wetland restoration	2.5E+07	186, -48%	231, -13%	4.6, -13%

Gridded Surface Subsurface Hydrologic Analysis (GSSHA): Dobbins Creek

GSSHA is a continuous, distributed-parameter, two-dimensional, hydrologic watershed model developed by the Hydrologic Systems Branch of the U.S. COE Coastal and Hydraulics Laboratory (U.S. COE 2014). The watershed is divided into homogeneous square grid cells. Surface and subsurface hydrology within each grid are routed through the flow network and integrated to produce the watershed output. GSSHA offers the capability of determining the value of any hydrologic variable at any grid point in the watershed at the expense of requiring significantly more input than traditional approaches.

- Rigorous 2 dimensional overland flow and groundwater routing algorithms and dynamic 1–D channel routing.
- Simulates vadose zone and groundwater flow and interactions with surface flow.
- Simulates sediment, nutrients, and biochemical oxygen demand.
- Wetland simulation capabilities added due to USACOE delegated wetland regulation.
- Requires use of the proprietary Watershed Modeling System.

This conceptual diagram illustrates how the GSSHA model uses a uniform spatial grid. A “headwaters” cell is connected to an adjacent cell, with connections down the grid, to an outlet cell.



DNR staff have developed a GSSHA model for several scales in the Dobbins Creek Subwatershed, as part of their overall hydrology assistance work. Figure 81 shows that stream flow peaks are higher when no tiles are present in the watershed, there is increased flow in the receding limbs of several of the storm hydrographs, and from a cumulative streamflow basis, and total annual flow is about one inch higher, when tiles are included in the model (Figure 82).

While the Dobbins Creek Subwatershed has been a priority for local conservation staff and leaders for several decades, the emphasis was increased in 2015, with the Targeted Implementation Project. This project combined a targeted BMP grant from BWSR; with an enhanced effort to plan, measure, monitor and model the subwatershed, with a second grant from the EPA's 319 Program. This resulted in a smaller portion of the Upper North Branch of Dobbins Creek being a focus area for conservation practice implementation and smaller-scaled GSSHA modeling (Figure 83).

Two modeled hydrographs from the Upper North Branch Dobbins Creek (September 2010 and May 2013, Figure 84 and Figure 85, respectively) serve to illustrate that reductions in both peak flow and overall volumes can be achieved, at this scale, with a combination of management (soil health) and structural management practices. Results of the following scenarios are shown; 1) without any BMPs, 2) with BMPs, 3) a prairie conversion scenario, 4) a scenario with BMPs, 5) conservation tillage and soil health at 25%, and 6) a scenario with soil health at 100%.

In addition to meaningful changes to the hydrology of the small-scaled Upper North Branch Dobbins Creek, the GSHHA model was used to simulate sediment loads to the channel for a two-week period in June, 2009. Predicted reductions in sediment loading are shown in Figure 86. The installation of water and sediment control basin (WASCOB) can reduce sediment loading by about 25%. A modeled reduction around 50% is predicted when both WASCOB and soil health practices are combined, for this time period. The "Prairie" scenario is used to check model results, and is not intended to be a management objective or goal.

When the stream channel and riparian corridor conditions in the upper North Branch Dobbins Creek are the focus of a GSSHA-model scenario, we can predict the value of a 20-meter buffer, or an intact riparian corridor, when compared to a "no-buffer" condition. At this scale, reductions of sediment in the range of 40-50% are observed, for this time period.

The upshot of the Dobbins Creek BMP implementation and modeling efforts, thus far, suggest that a robust combination of structural and agricultural management practice implementation can reduce peak flows, total discharge, and sediment delivery to the channels. A key aspect of this will be the broad scale adoption of practices that improve water infiltration at the field scale, which includes tillage, vegetative covers, and generally an array of practices to boost soil organic matter.

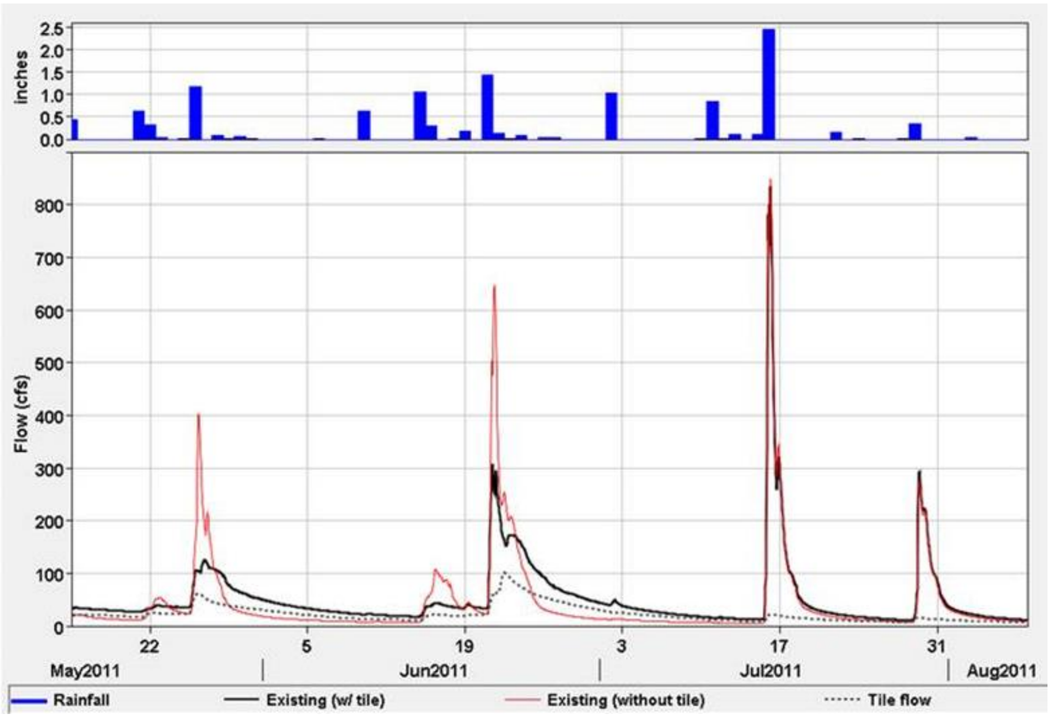


Figure 81. Dobbins Creek Outlet, measured precipitation, and modeled stream flow for May – August, 2011, showing tile flows, and outlet stream flows with and without tiles (Jim Solstad, DNR)

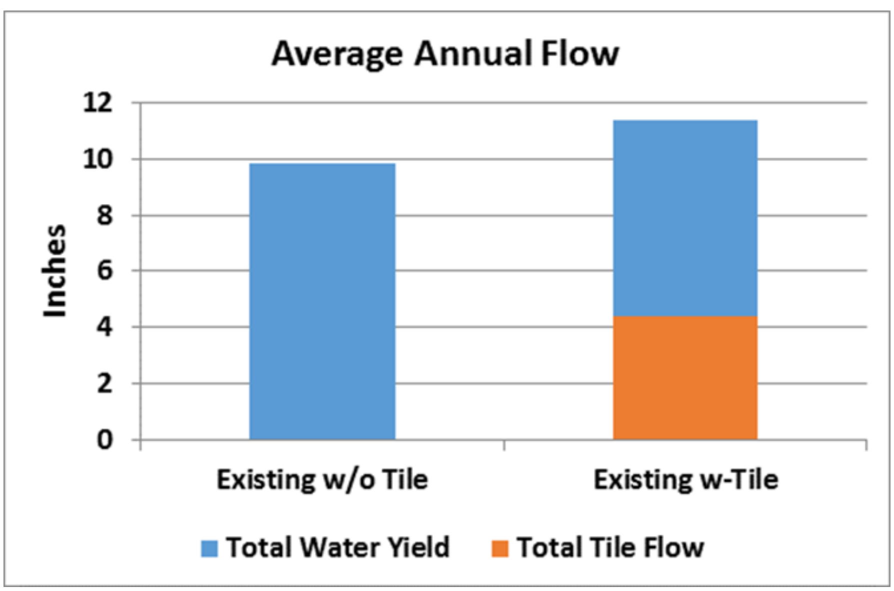


Figure 82. Modeled average annual flow from the outlet of Dobbins Creek, for existing conditions with and without tile (Jim Solstad, DNR)

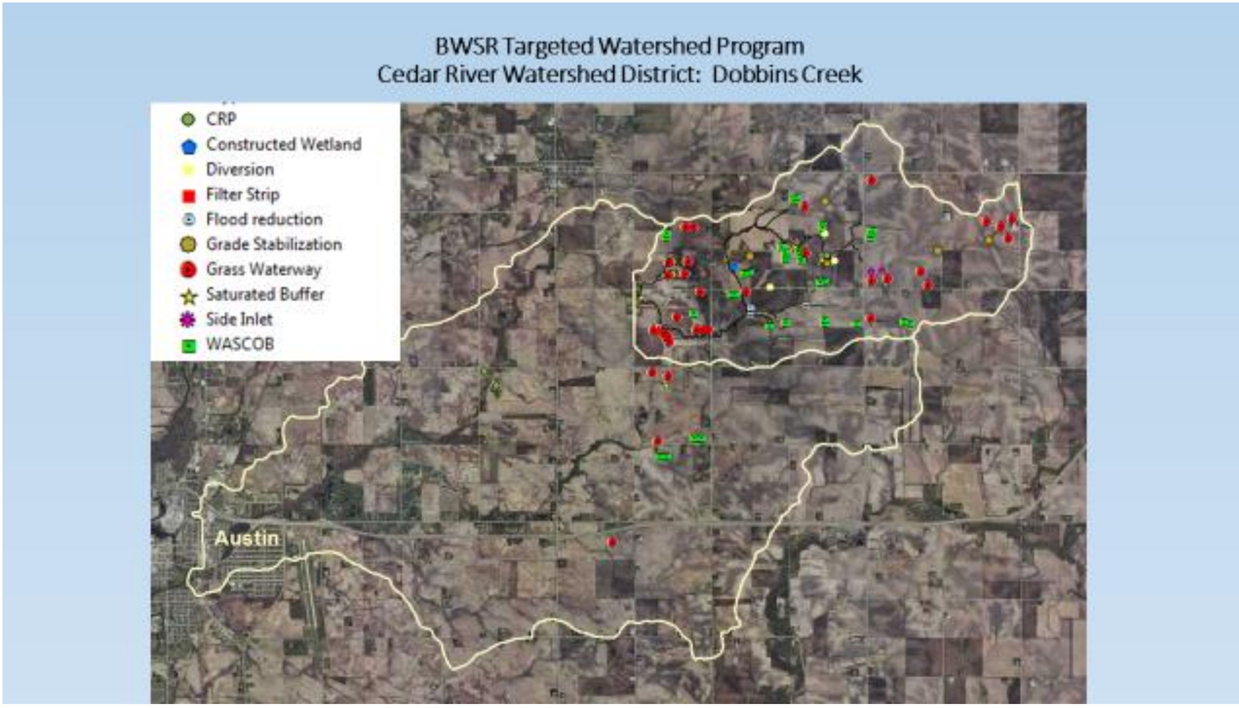


Figure 83. Upper North Branch Dobbins Creek illustrating BMP implementation planning with BWSR's Targeted Watershed Project

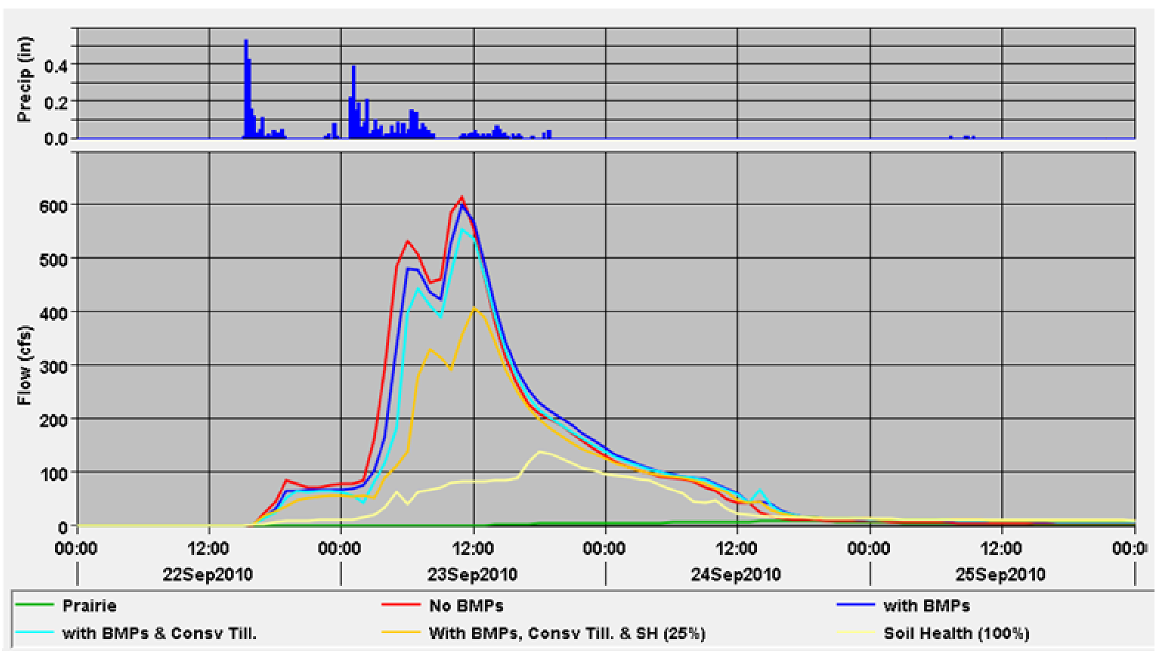


Figure 84. Upper North Branch Dobbins Creek (10 sq. miles drainage area), measured precipitation and modeled stream flows for six scenarios, for September 22-25, 2010 (Jim Solstad, DNR)

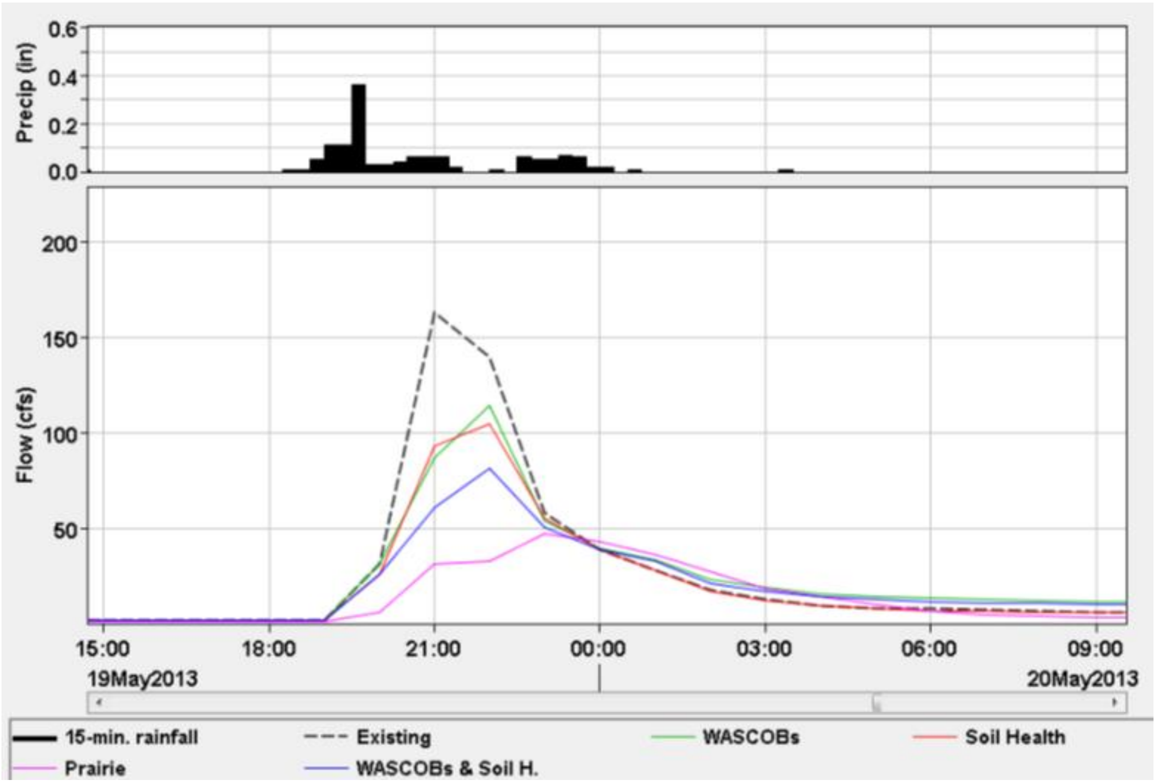
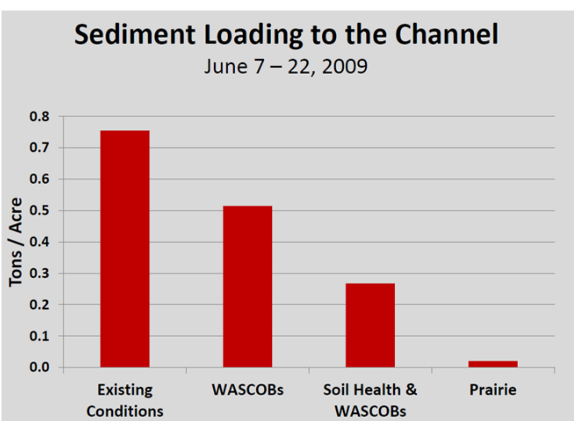


Figure 85. Upper North Branch Dobbins Creek (10 sq. miles drainage area), measured precipitation and modeled stream flows for four scenarios, for May 19-20, 2013 (Jim Solstad, DNR)



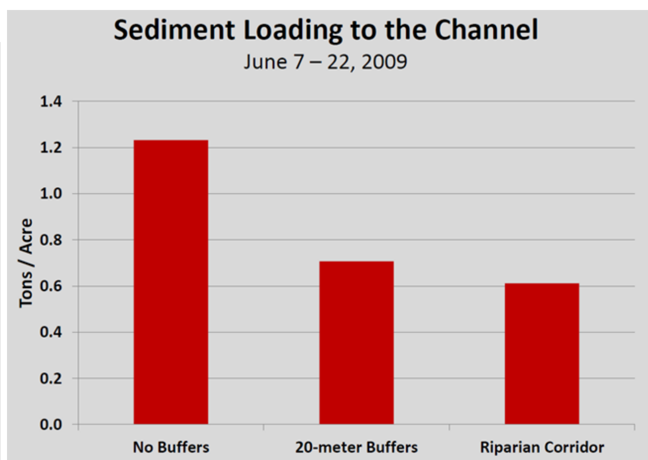


Figure 86. Upper North Branch Dobbins Creek (10 sq. miles drainage area) modeled sediment for June 2009 with (Left) Various BMP Scenarios, and (Right) a 20-meter buffer and for riparian corridor (Jim Solstad, DNR)

8. Appendix C: ET Rate Data & Calculation

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

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

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

Using the highest crop ET rates for comparison was desired for multiple reasons: 1) pan coefficients were developed using older data sets and it is likely that corn, with higher crop densities and larger plant sizes, uses more water today than it did when the coefficients were determined, 2) using lower crop ET rates may appear to exaggerate the difference between crop and non-crop ET rates, and 3) error associated with pan ET rates could result in exaggerated differences between estimated wetland/lake ET and crop ET. More information on calculating ET rates is available here: http://deepcreekanswers.com/info/evaporation/ET_water_surf.pdf.

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