Root River

Watershed Restoration and Protection Strategy Report

November 2016

Fillmore SWCD

Minnesota Pollution Control Agency

CLEAN WATER LAND & LEGACY AMENDMENT

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Note Regarding Legislative Charge

The science, analysis and strategy development described in this report began before accountability provisions were added to the Clean Water Legacy Act in 2013 (MS114D); thus, this report does not address all of those provisions. When this watershed is revisited (according to the 10-year cycle), the information will be updated according to the statutorily required elements of a Watershed Restoration and Protection Strategy Report.

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Key Terms/Acronyms:

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

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

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

BWSR: Board of Soil and Water Resources

DNR: Minnesota Department of Natural Resources

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

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

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

MDA: Minnesota Department of Agriculture

MDH: Minnesota Department of Health

MPCA: Minnesota Pollution Control Agency

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

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

RRW: Acronym used to refer to the Root River watershed

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

Introduction

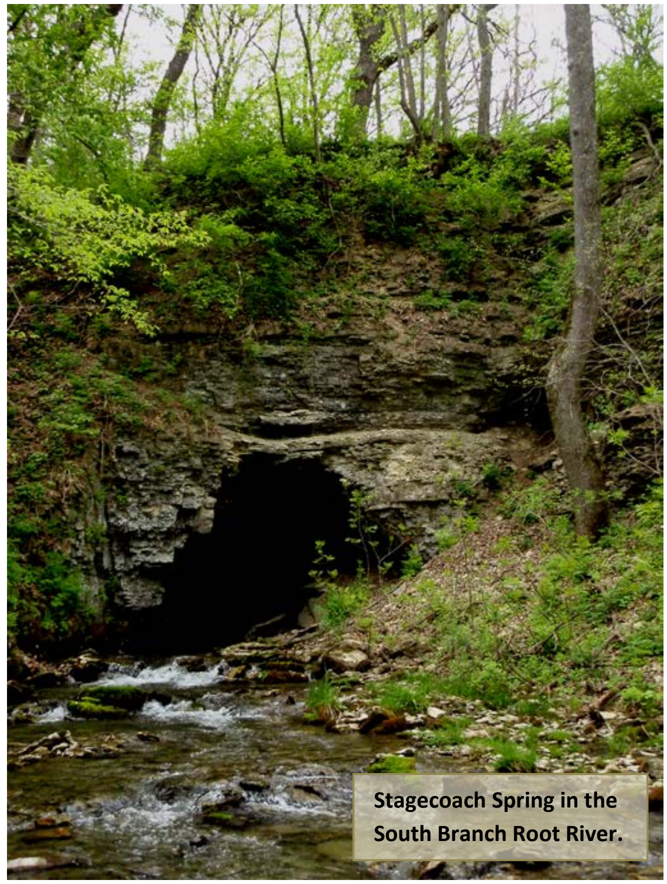
The state of Minnesota has adopted a "watershed approach" to address the state's 80 major watersheds on a 10-year cycle. This Watershed Restoration and Protection Strategy (WRAPS) report aims to summarize work done as part of this watershed approach and includes: water quality monitoring and assessment, watershed characterization, civic engagement/public participation, and restoration/protection strategy development.

Since the Root River Watershed (RRW) began watershed approach work in 2008, the work summarized in this report represents one of the first applications of the Watershed Approach in the state of Minnesota. This work by the Minnesota Pollution Control Agency (MPCA) and local partners used the best available data and emphasized citizen engagement in new ways.

This WRAPS report is intended to summarize previous work completed in the RRW within the Watershed Approach since 2008. Watershed conditions are explained as are the restoration and protection strategy recommendations describing what it will take to reach and maintain water quality standards. The reader is encouraged to access links to other relevant documents cited within to fully understand the summaries and recommendations made within this document.

Purpose	1. Develop and present scientifically and civically supported restoration and protection strategies to be used in planning that impacts water resources in the Root River watershed. 2. Summarize Watershed Approach work completed to date: • *Root River Monitoring and Assessment Report* - MPCA (2012) • *RRW Biotic Stressor Identification Report* –MPCA (2015a) • *RRW Total Maximum Daily Load Report* – MPCA (2015b draft) • *Root River Modeling and Scenarios Report* -TetraTech. (2013a,b) • Civic engagement and public participation efforts and events (included)
Scope	1. Impacts to aquatic recreation and aquatic life in all assessed streams. Impacts to drinking water in assessed coldwater streams. 2. Strategy development for restoration and protection of watershed resources.
Audience	1. Watershed stakeholders (those with an interest in technical details of their watershed and those whose actions and decisions are called upon for implementation) 2. Local working groups: local governments, SWCDs, watershed groups, etc. 3. State and Federal agencies: MPCA, DNR, BWSR, MDA, MDH, NRCS, etc.

1. Watershed Background & Description



Stagecoach Spring in the South Branch Root River.

The Root River Major (HUC-8 USGS 2014) Watershed covers 1,064,961 acres in southeast Minnesota within the Lower Mississippi River Basin. The watershed primarily lies within the Driftless Area ecoregion (EPA 2012) with a small western portion in part of the Western Corn Belt Plains ecoregion. The watershed drains west to east before joining the Mississippi River at Navigation Pool 7, approximately five miles east of the small town of Hokah, Minnesota. Fillmore County has the most area within this watershed, followed by Houston, Winona, Mower, Olmsted, and Dodge Counties (see the RRW online map). The Root River major watershed is comprised of nine HUC-10 subwatersheds (Figure 1): Root River (Lower), city of Rushford, Trout Run, Middle Branch, Money Creek, North Branch, Rush Creek, South Branch and South Fork.

The RRW has high agricultural productivity, yielding abundant corn, soybeans, beef and pork. In addition, this area provides abundant recreational opportunities including canoeing, bicycling, camping, hiking, hunting and fishing. There are two state parks (Beaver Creek Valley and Forestville-Mystery Cave) and two trout hatcheries that draw visitors and anglers from around the state and region. Coldwater streams that support trout populations make up 850 miles of the streams in the watershed.

The Root River is made up of three distinct land forms (Figure 1): 1) Uplands, till covered karst in the western part of the watershed, which tends to be flat and used for crop production 2) Driftless, near-surface karst in the central part, where the land is steep and rugged, with soluble limestone underneath. Water has carved sinkholes, caves and tunnels throughout this limestone; 3) Driftless, bluffland karst in the eastern portion, dominated by steep bluffs.

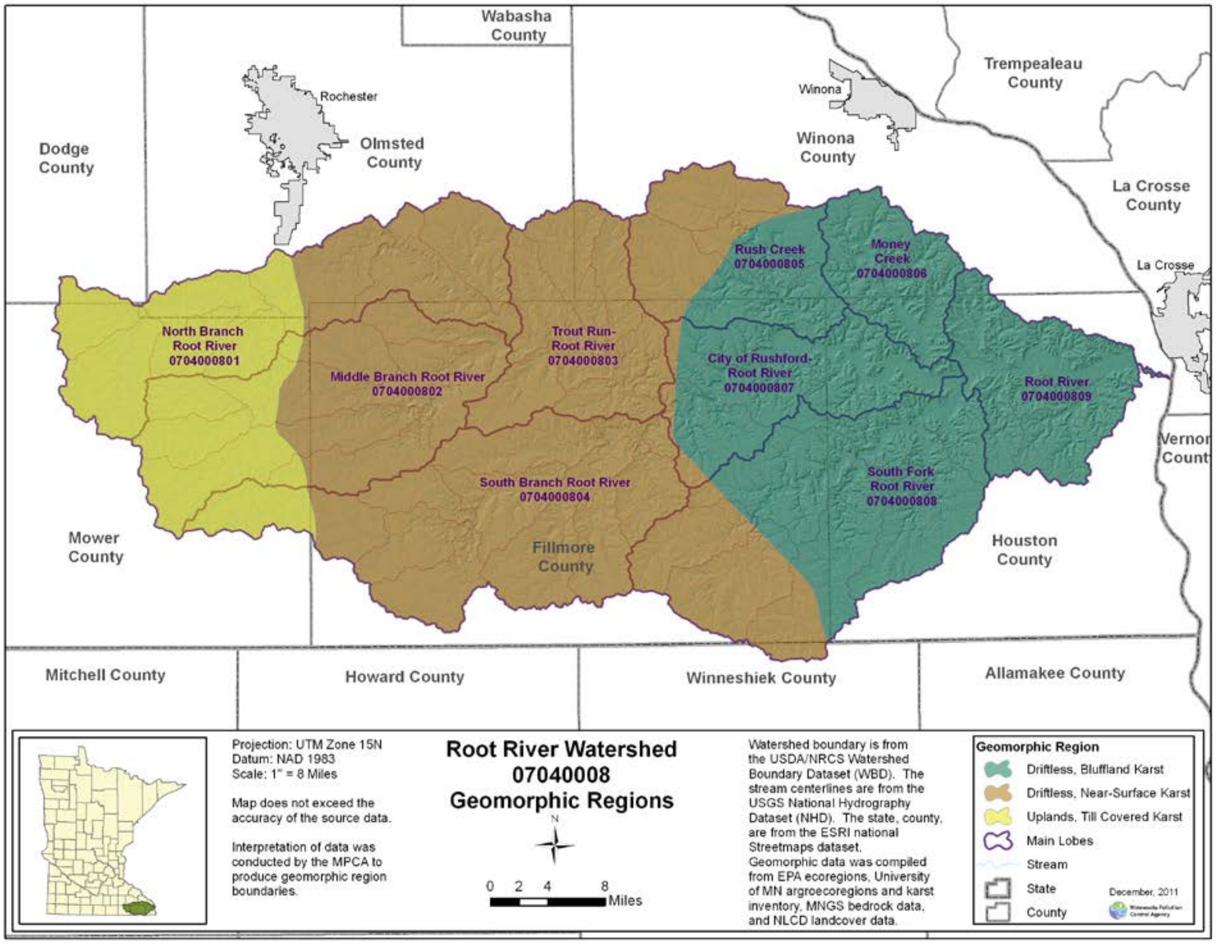


Figure 1. The RRW geomorphic regions and 10-HUC watershed delineations.

1.1 Land Use

The RRW has a diverse landscape (Figure 2). According to the 2011 National Agricultural Statistics Service (NASS), cropland was the most prevalent use (48%). Of that 48% cropland, 41% was corn/soybeans. Forest/shrub (26%) and pasture/grassland (20%) were the next most common land uses and found primarily in the rolling hills and bluff regions located in the eastern half of the watershed. Some development (5%) exists in the watershed, located around the cities and communities including Chatfield, Rushford, Stewartville, Preston, Spring Valley, Houston, Lanesboro, Grand Meadow, Harmony, Hokah, and Mabel. The population of the watershed is 43,600, primarily concentrated in the 10 communities mentioned above. Very few areas of wetlands (0.5%) and open water (0.2%) exist in the watershed; there are no lakes.

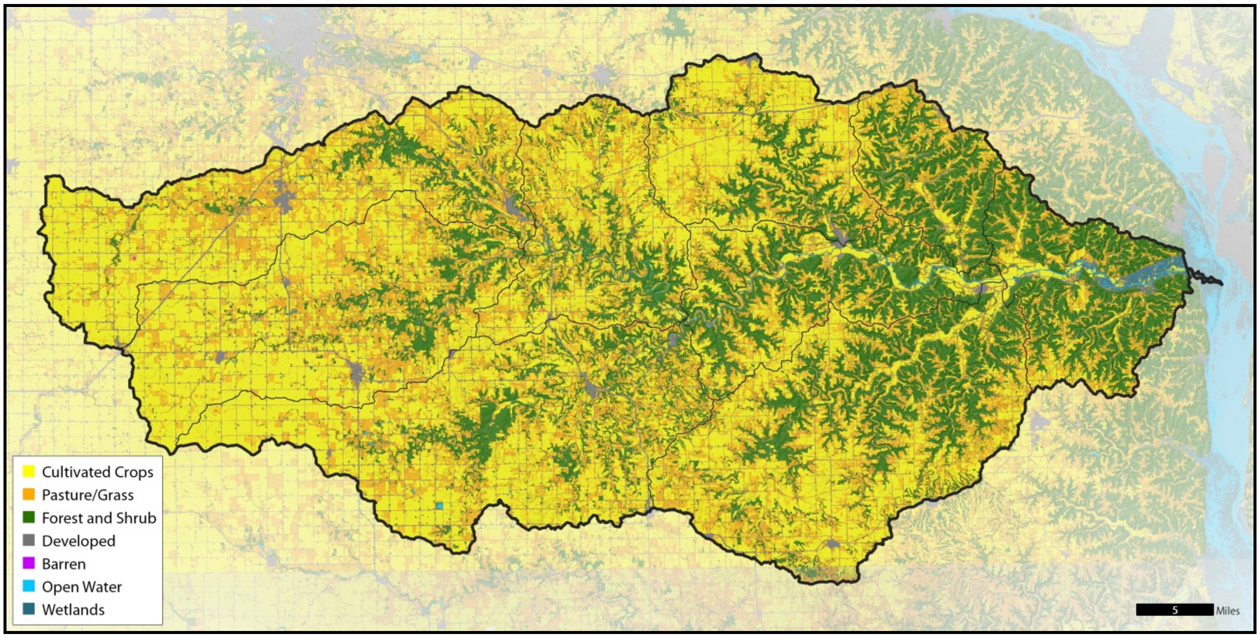


Figure 2. Land use in the RRW based on National Land Cover Dataset, 2011.

1.2 Groundwater

Southeastern Minnesota water resources are challenging to protect because limestone is slowly dissolved by infiltrating rainwater, sometimes forming hidden, rapid pathways from pollution release points to drinking water wells or surface water. These pathways can be widened, interconnected fractures or caves in the subsurface. Sometimes the process of dissolving limestone forms distinctive landforms on the ground surface, and in other places there is no distinctive landform at all. Together, the processes that dissolve limestone bedrock and the landforms that result are called karst. This geology makes the groundwater highly susceptible to pollution because contaminants on the land can easily reach groundwater, which then mixes with rivers and streams (MPCA 1989).

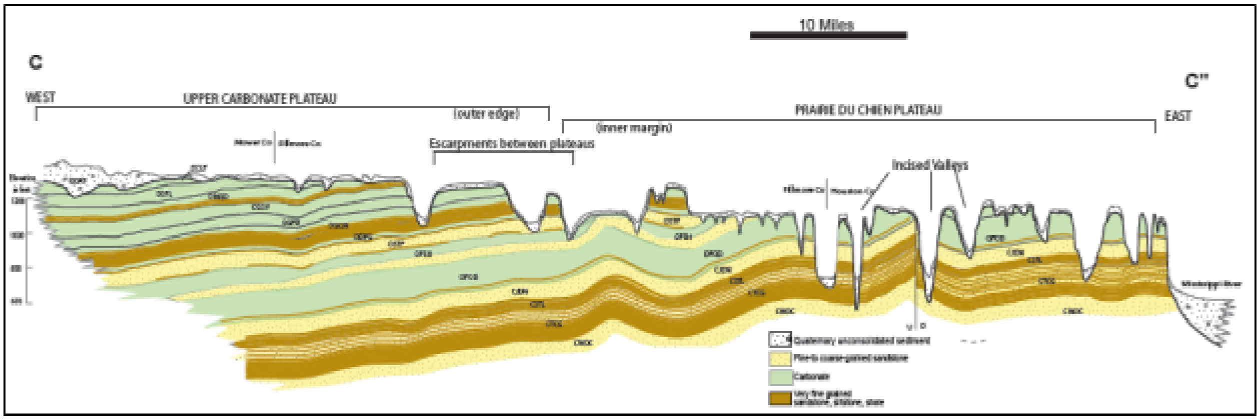
In karst landscapes, which the RRW predominately is (Figure 1), the distinction between groundwater and surface water is commonly blurry, and sometimes very tenuous. Groundwater may emerge as a spring, flow a short distance above ground, only to vanish in a disappearing stream, and perhaps re-emerge farther downstream again as surface water.

The intimate connection between groundwater and surface water gives rise to a large number of coldwater streams in southeastern Minnesota where trout and other important species thrive. Pollution traveling rapidly along a ground water path may emerge at a stream, thus posing a threat to the animals and plants living there. In the same way, pollution that has reached surface water can easily become groundwater pollution, thus posing a pollution risk to the people living in the RRW whose drinking water is groundwater.

The RRW groundwater flows through many of the Paleozoic bedrock units found throughout southeast Minnesota. The differentiation between aquifers is based on changes in geologic materials at varying depths (Figure 3). Aquifers often have a layer of low permeability material such as clay or shale separating one from another; known as aquitards or confining units. Groundwater has the potential to travel between aquifers normally separated by an aquitard when that confining layer contains fractures.

The movement of water can be on the order of days from precipitation occurring at the land surface to entering the groundwater systems and then surfacing again in springs. Water in the aquifers that are deeply confined has been shown in some areas to be many thousands of years old based on carbon-14 estimates (Fillmore County Geologic Atlas, Plate C and Mower County Geologic Atlas, Plate 8).

Figure 3. Highly generalized characterization of the materials that make up the lithostratigraphic units across the RRW, from central Mower County east to the Mississippi River. (Runkel et al. 2013)



Groundwater as the Source of Drinking Water

It can be assumed that all citizens of the RRW rely on groundwater for their source of drinking water. Of the roughly estimated 17,000 households in the watershed, approximately 60% are served by 23 community public water supply systems and 40% of the households obtain water from private wells. Of these 23 systems, 7 have primary wells that are considered vulnerable to contamination from the land surface. The vulnerability determination is made considering the geologic sensitivity, well construction, and water chemistry data and isotopic composition (tritium) of the source water (Appendix A).

Vulnerability to Contamination

The Minnesota Department of Health (MDH) has developed a method for assessing the vulnerability of water supply to contaminants from activities at the land surface. The vulnerability determination considers the geologic sensitivity, well construction, and water chemistry data and isotopic composition (tritium) of the source water.

Groundwater Use by Aquifer Group

Where it is present in the watershed, the Upper Carbonate aquifer system (Cedar Valley, Maquoketa Dubuque Formation, and Upper Galena) was once a primary source of water for domestic and farm water use in the RRW (DNR 1996). Over the last 25 years, groundwater use from this aquifer has been dramatically decreased and now the aquifer only accounts for approximately 4% of groundwater use. The aquifer exhibits significant karst features making it susceptible to contamination and was shown to commonly exceed 5-15 parts mg/l nitrate-nitrogen (Runkel et al. 2013).

The Upper Carbonate aquifer is separated from the St. Peter and Prairie du Chien Jordan aquifer by the Decorah-Platteville-Glenwood confining unit. The unit's shale and limestone material are known to have a higher level of integrity compared to aquitards below it, and can promote rapid lateral flow of water along the top of this layer leading out to streams in the form of base/spring flow. The confining layer does however have the potential of permeability in some areas and can cause some downward water transfer which mobilizes pollutants to the aquifers below.

The majority of Department of Natural Resources (DNR) appropriation permitted water withdrawls in the RRW (75%) occur from wells in the St. Peter and Prairie du Chien-Jordan aquifer group (Figure 4). This aquifer covers the majority of the watershed and is known to contribute directly to stream flows in portions of the watershed. Water use in this aquifer has declined slightly over the last 25 years, with considerable yearly variability (Figure 4). There are several communities that utilize the St Peter and Prairie du Chien Jordan aquifer group in the watershed. The vulnerability to surface contamination varies by location and the presence of confining layer and till. Community wells in Mower County and western Fillmore County utilizing this aquifer group are considered non-vulnerable because of the thickness of overlying protective tills. Whereas communities with wells in this aquifer group generally farther east, where the Decorah-Platteville-Glenwood confining units are not present, are considered vulnerable to contamination from the surface. Water quality sampling of community wells in this setting have found some with high values for nitrate concentrations greater than 5 mg/l. The cities of Chatfield, Utica and Lewiston are some examples of communities with high nitrate wells. Lewiston is in the process of sealing their high nitrate well and drilling a deeper one.

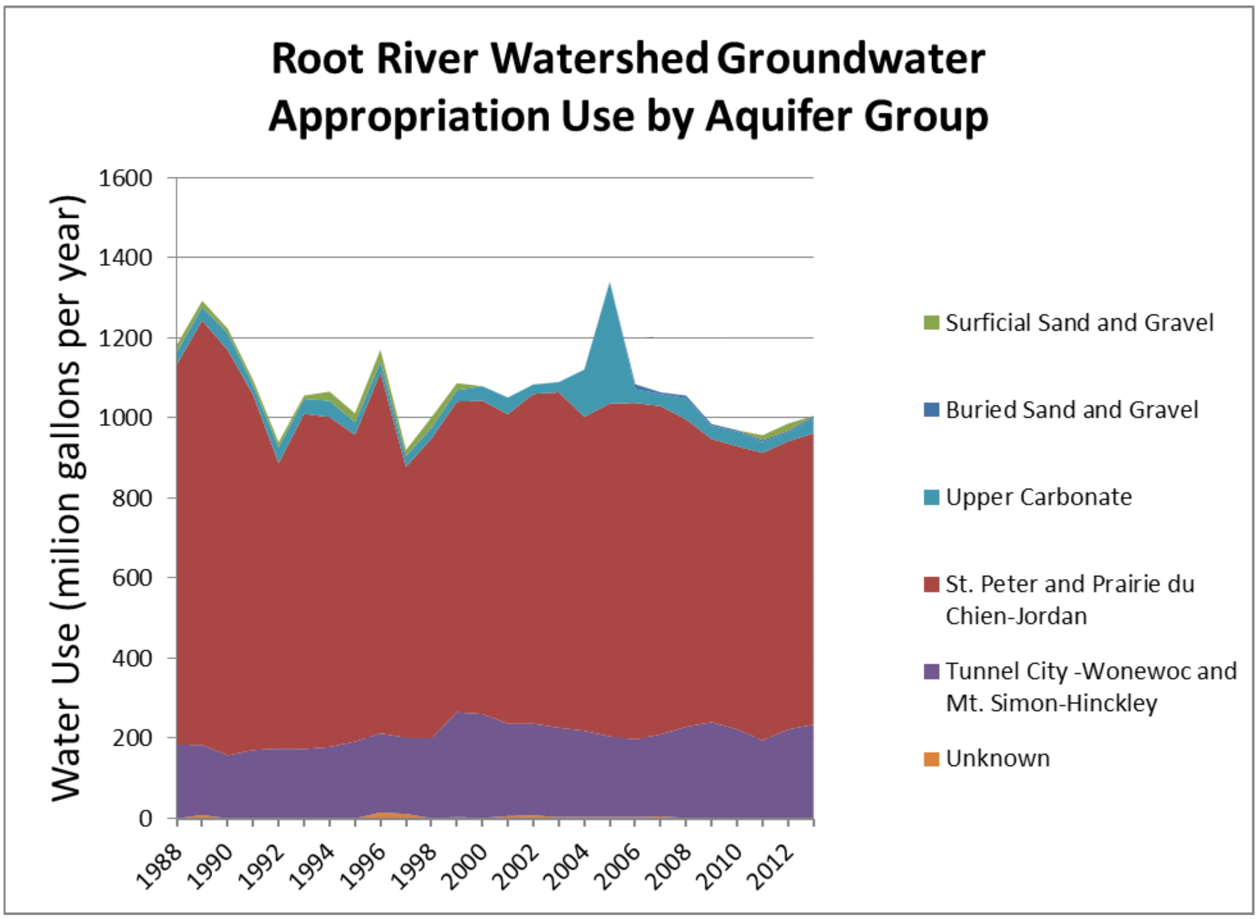


Figure 4. Minnesota DNR water appropriation reported use data by aquifer group for users of 10,000 gallons per day or one million gallons per year.

The deepest aquifers used for municipal and industrial use in the watershed are the Tunnel City-Wonewoc, formerly known as the Franconia Ironton-Galesville, and the Mount Simon-Hinckley aquifers. These two aquifer systems are both considerably deeper and much costlier to access than the shallower aquifers above. When averaged over the last 25 years, these two aquifer groups make up 20% of the total appropriations by volume in the watershed (Figure 4) and have shown a gradual increase in use over that same period (Figure 4). The Tunnel City-Wonewoc and Mount Simon aquifers in the RRW are being used by several cities particularly in the eastern part of the watershed and those located in the valley of the Root River such as Mabel, Rushford Village, and Hokah. In large part the aquifers are considered not vulnerable to contamination from human activities. Several municipal wells including Houston, Rushford Village, Lanesboro, and Lewiston that are utilizing the Mount Simon aquifer, however, have exceeded the Safe Drinking Water Act Maximum Contaminant Level of 5 Pico curies per liter for combined radium 226-228. These radionuclides are naturally occurring in the source water. There are three ways communities in this situation have found to address this issue: 1) treatment, 2) blending contaminated water with water from another source to dilute the overall contaminant level, and 3) replacing the well.

Municipal and private waterworks are the primary reported use categories in the RRW (85%) (Figure 5). The next two largest use categories are 1) industrial and construction, and 2) other, which includes major crop irrigation, aquaculture and pollution de-containment practices. Both categories each use roughly 5% of the total volume appropriated when averaged over the last 25 years. Industrial and construction uses showed gradual decline through the late 1980's and early 1990's and had a significant reduction from 1996 to 1997, where levels have remained up to the present. The remaining appropriations categories for non-major crop irrigation and livestock watering, account for the remaining 5% of the reported appropriated water volume.

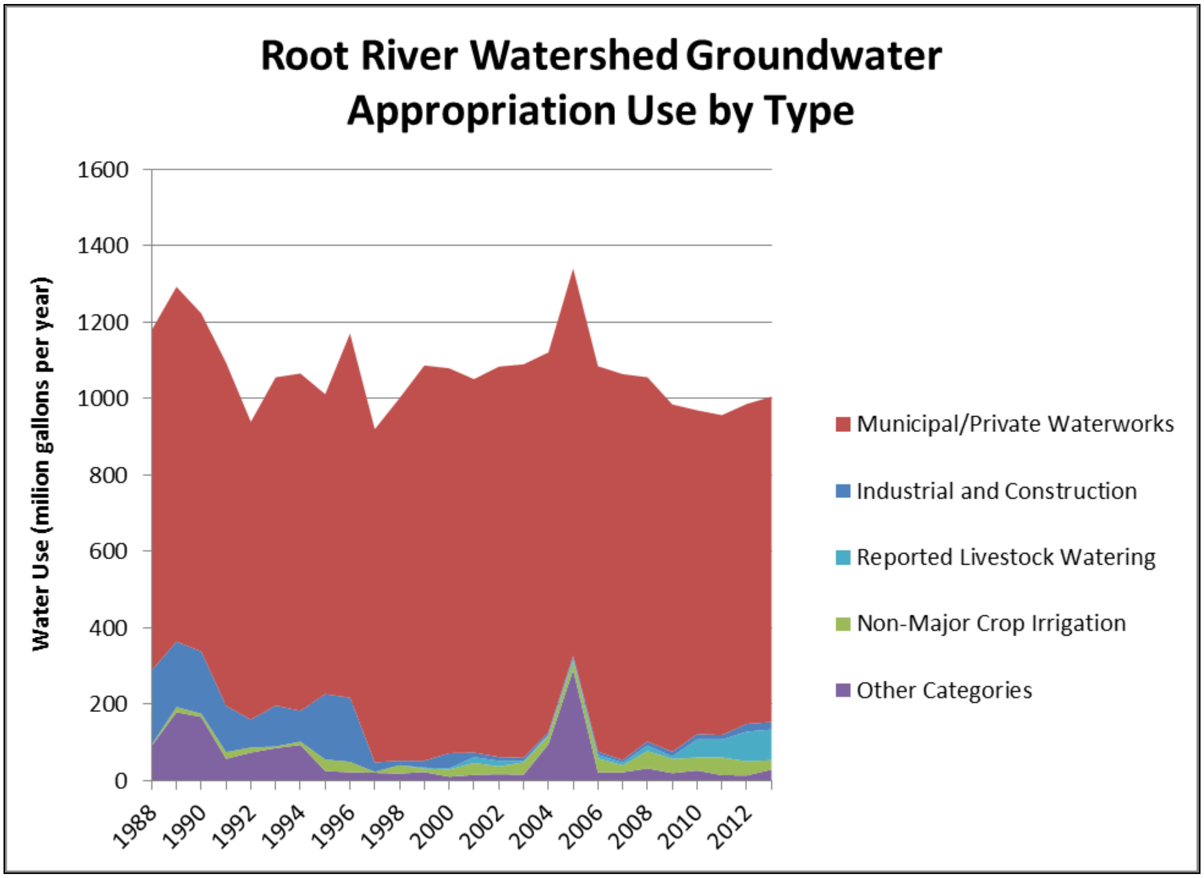


Figure 5. Minnesota DNR water appropriation reported use data, by user type, for users of >10,000gal/day or one million gal/year.

1.3 Additional Activities and Resources in the Root River Watershed

The Root River is a hub of activity focused on water quality where various research projects and partnerships exist. It also is an important area economically, based on tourism and recreational activities available. Background on these helps provide context to the WRAPS related work. A list of relevant activities and resources known at time of development of this report can be found in Appendix B.

2. Watershed Conditions

There are 1,370 stream segments referred to as Assessment Unit Identifiers (AUIDs) in the RRW, varying in length from 0.01 miles to 37.85 miles. No lakes exist in the watershed. There are also no Municipal Separate Storm Sewer Systems (MS4) communities, so the many small communities are unregulated for stormwater activities.

As part of the Watershed Approach, Intensive Watershed Monitoring (IWM) was performed in 2008, and in 2009, on 113 stream AUIDs throughout the RRW. In 2011, 110 AUIDs were analyzed using data collected through that monitoring, as well as other information collected by other agencies, groups, and individuals. Not all 110 AUIDs were able to be assessed due to insufficient (little or no) data or having limited resource waters status (ditch or heavily channelized); 84 AUIDs datasets were deemed assessable. Through the assessment process it was found that a total of 54 AUIDs were impaired in the RRW (47 for aquatic life, and/or 19 for aquatic recreation). Through a state-wide assessment effort of drinking water sources in 2010 (coldwater, class 1B/2A streams), it was found that six stream reaches in the RRW were not supporting for drinking water use based on elevated nitrate levels (Figure 6). Two of the aquatic life impairments were deferred due to an impending use class change that will occur in 2016 (they are currently incorrectly listed as class 2B warm water, that will change to class 2A coldwater).

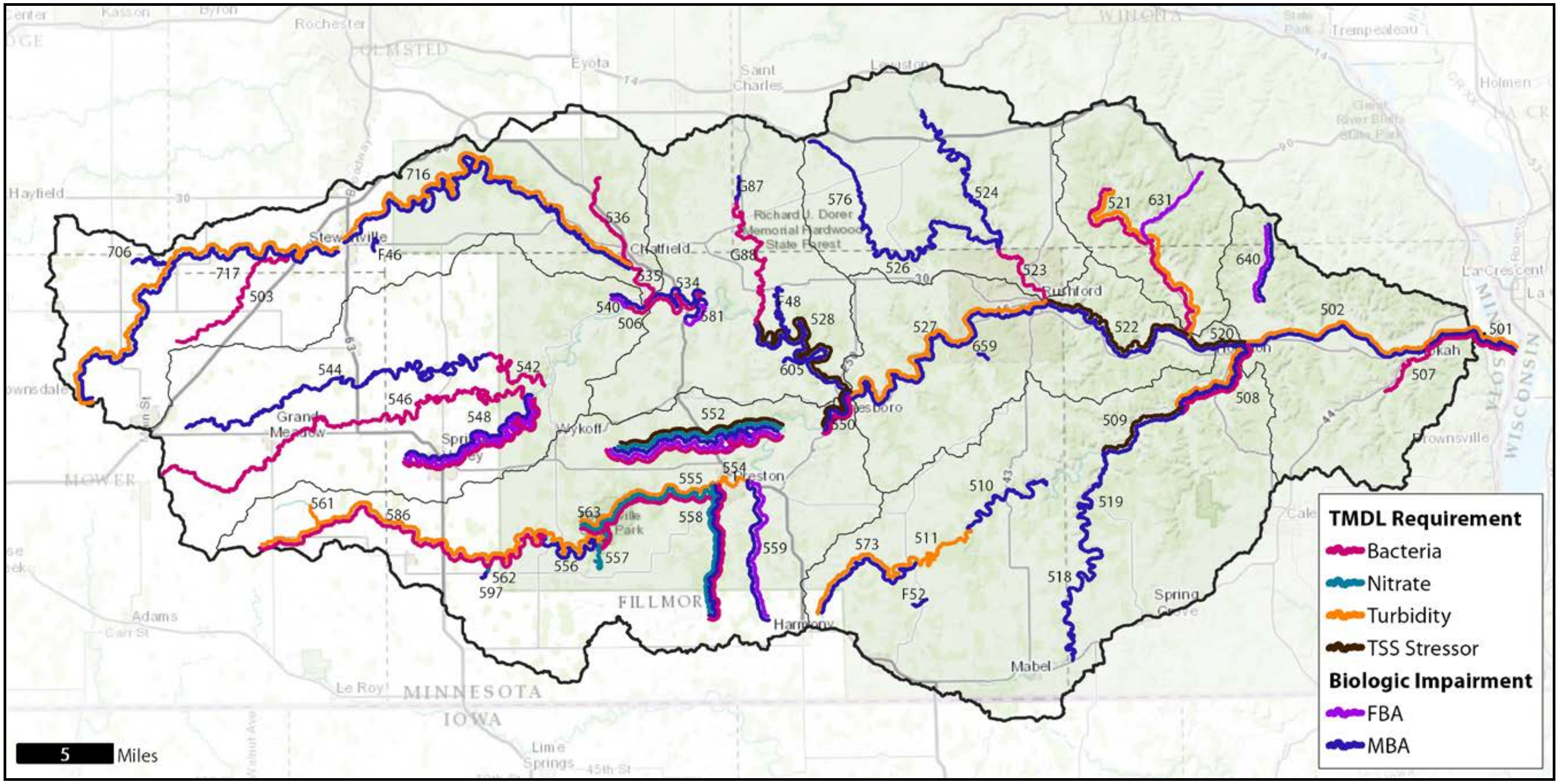


Figure 6. Impaired streams in the RRW. Colors represent type of impairment/stressor. Three-digit numbers refer to the AUID the impairments are on (07040008-XXX). Fishes bioassessment (FBA) and macroinvertebrate bioassessment (MBA) are indicated as separate biologic impairments.

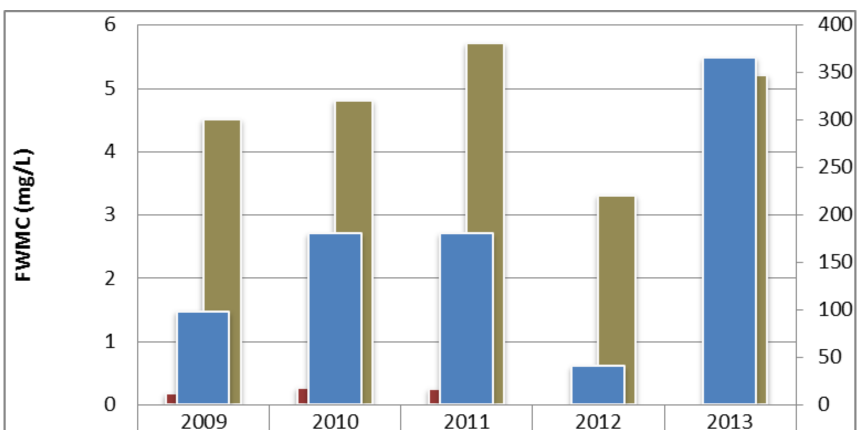
Biological criteria have only recently been developed for channelized streams and ditches in Minnesota; therefore, assessment of fish and macroinvertebrate community data for aquatic life use support was not possible for channelized streams in the RRW when information used in this report was collected and assessed. The tiered aquatic life use (TALU) framework will be used to assess such streams in the next cycle, which is anticipated to start in the RRW in 2018.

The Root River Monitoring and Assessment Report contains more detailed information on stream assessments that were completed for the watershed in 2012.

Active volunteers exist in the RRW as part of the Citizen Stream Monitoring Program (CSMP). The CSMP combines the knowledge and commitment of interested citizens with the technical expertise and resources of the MPCA. As of 2013, 23 volunteers were collecting information at various stream locations throughout the watershed. The transparency data they collect is used as supporting information during assessment of water quality conditions.

Watershed Pollutant Load Monitoring Network (WPLMN)

The MPCA's WPLMN goals are tied to the Federal Clean Water Act, with goals to measure and compare regional differences in water quality and determine long-term trends in water quality. To do this, the WPLMN collects flow and water quality data near the mouth of each major watershed in Minnesota. At the time of this report, total phosphorus, sediment (TSS), and nitrate-nitrite data was available for the Root River for the years 2009 through 2013 (other than total phosphorus which was unavailable for 2012 and 2013) (Figure 7). Displayed are flow-weighted mean concentrations, which are an expression of pollutant load divided by total flow volume. Note that the goal of the WPLMN is to track pollutant loads exported from Minnesota's watersheds; in contrast, water quality standards are applied to determine beneficial use attainment.



	2009	2010	2011	2012	2013
TP	0.171	0.258	0.241		
NO2+NO3	4.5	4.8	5.7	3.3	5.2
TSS	98	180	180	40	365

Figure 7. Watershed Pollutant Load Monitoring Network results reported in flow-weighted mean concentration (FWMC) for years 2009 through 2013. Blue bars indicate TSS; brown bars indicate NO3+NO2; red bars indicate phosphorus. Note: total phosphorus data is not available for 2012 or 2013.

Statewide information from the WPLMN can be found here.

2.1 Condition Status

The purpose of this section is to summarize the impairment status of streams assessed within the RRW. Each stream may have been assessed for one or more of the following uses: aquatic life use based on parameters that include fish and macroinvertebrate indices of biotic integrity (IBI), and turbidity (Figure 8); aquatic recreation parameters that include bacteria (fecal coliform or *E. coli*) (Figure 9); and drinking water based on nitrate concentrations (Figure 10). Some of the waterbodies in the watershed are impaired by mercury. For more information on mercury impairments see the Statewide Mercury TMDL.

There was no general geographic pattern of impairments across the RRW. Large numbers of the biological impairments were found on the larger bodies of water (main stem river reaches) within the watershed. Often times, turbidity levels were above standards in these larger river segments as well, indicating that this parameter is a potential stressor to the fish and especially macroinvertebrate communities. Aquatic recreation impairments were also prevalent (Figure 9; Appendix C).

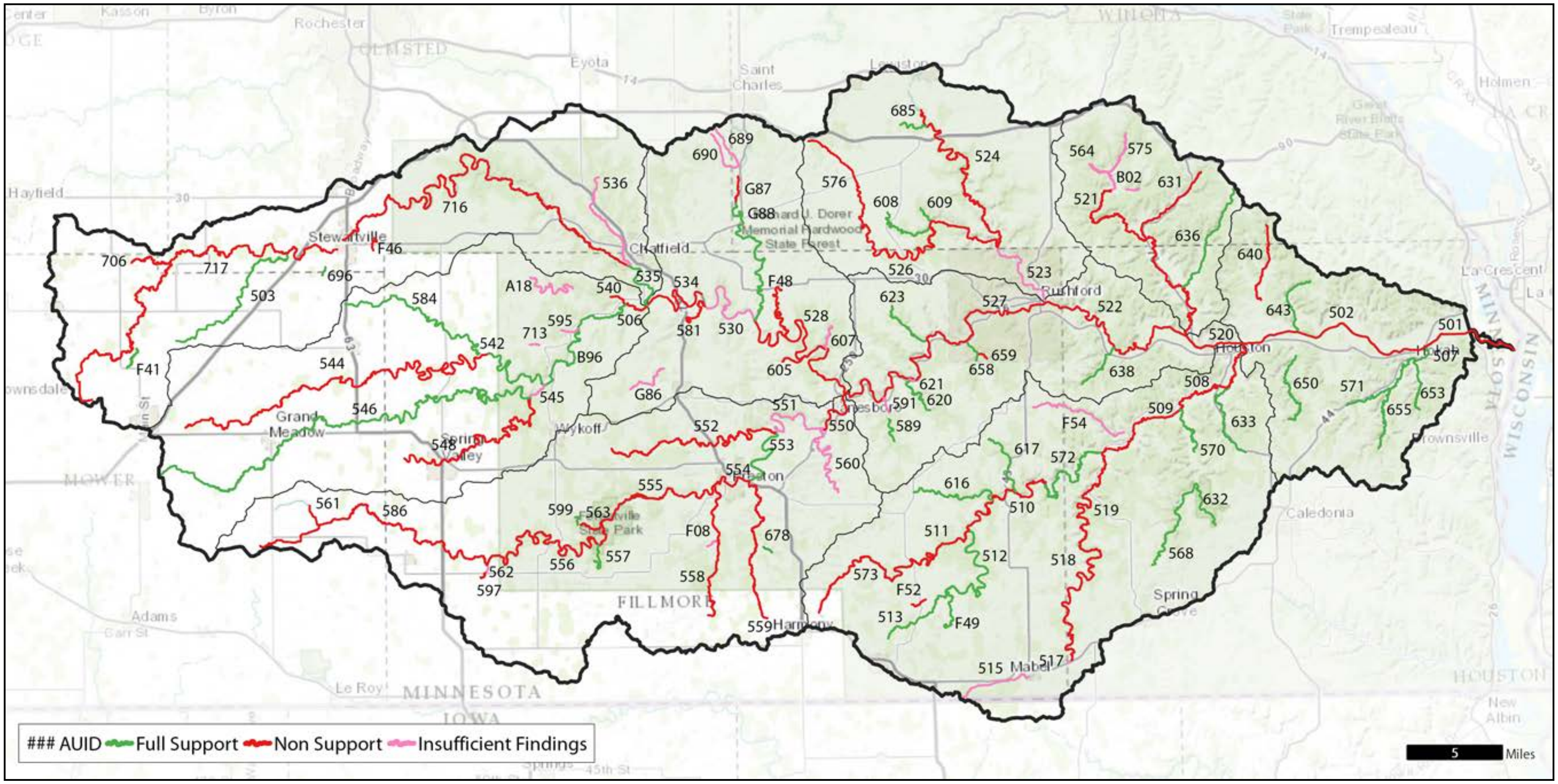


Figure 8. The RRW aquatic life use assessment results based on the 2012 303d list. Results shown are from those stream segments that had the dataset required to be assessed. (note: shaded area indicates boundary of the Richard J. Dorer Memorial Hardwood State Forest)

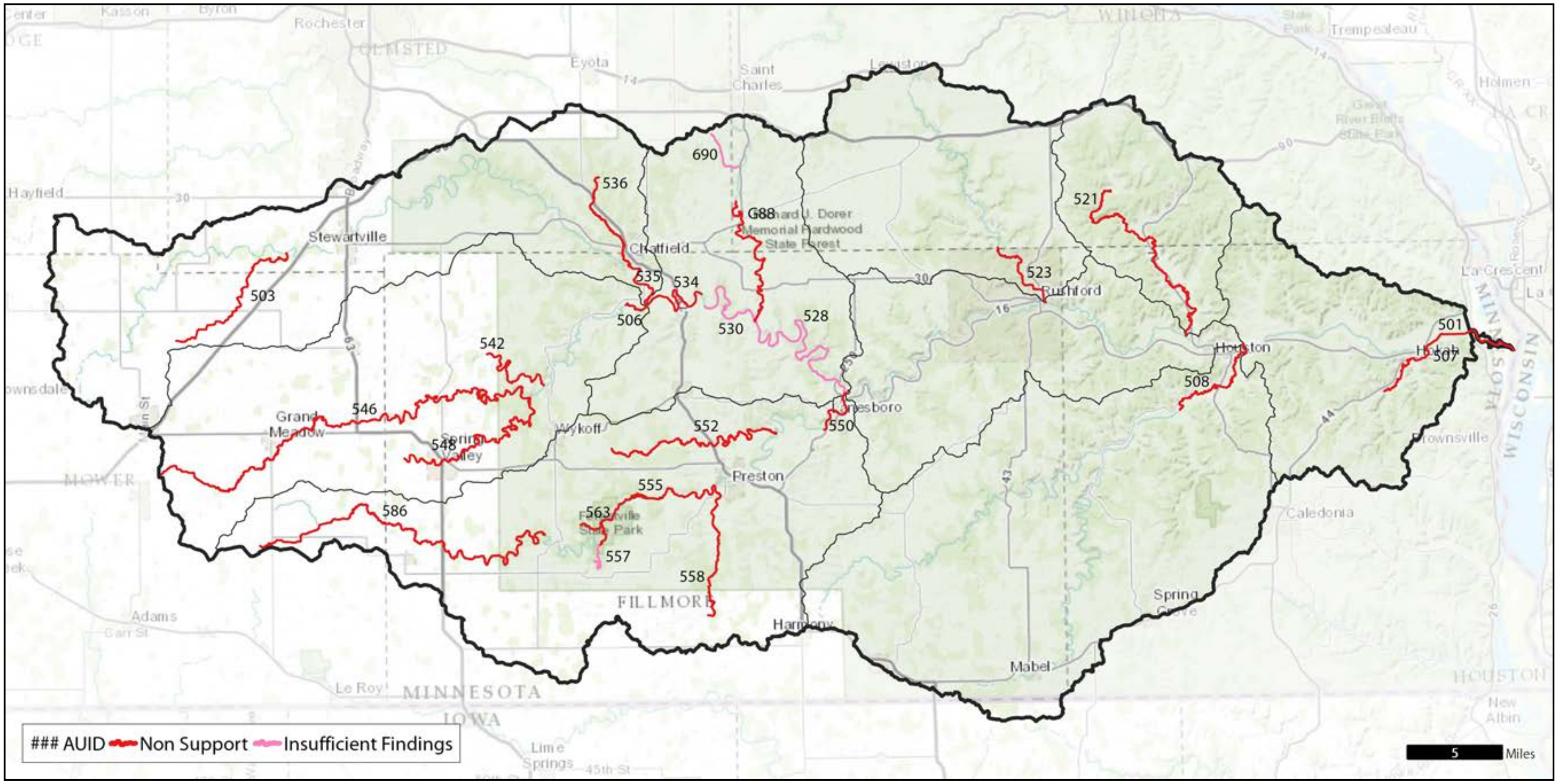


Figure 9. The RRW aquatic recreation assessment results based on the 2012 303d list. Results shown are from those stream segments that had the dataset required to be assessed. (note: shaded area indicates boundary of the Richard J. Dorer Memorial Hardwood State Forest)

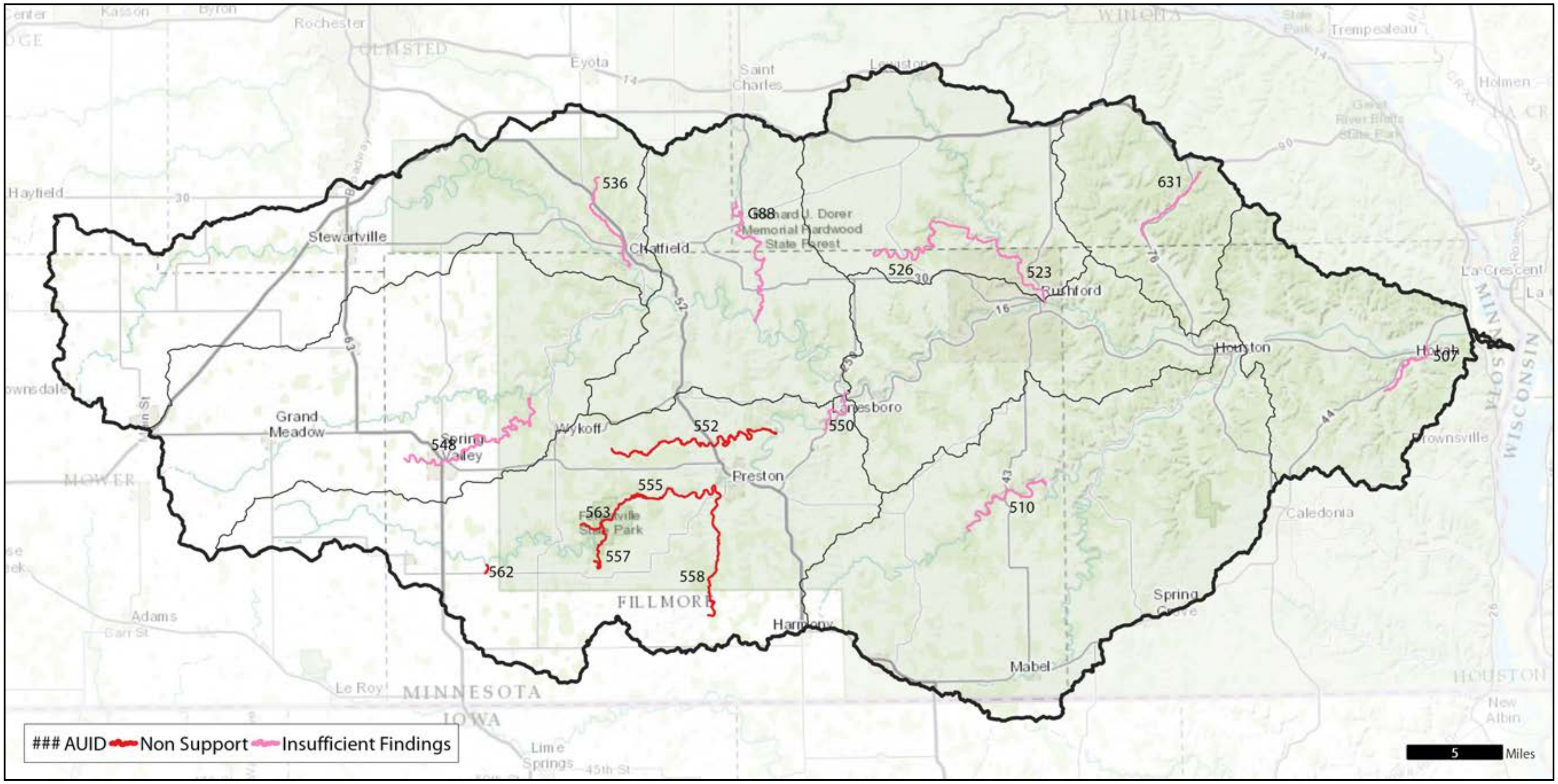


Figure 10. The RRW drinking water assessment results based on the 2012 303d list. Results shown are from those stream segments that had the dataset required to be assessed. Note: while nitrate exceedance is enough to assess as non-support, meeting nitrate standards is not enough to say full support because other parameters could cause non-support of the drinking water use. (note: shaded area indicates boundary of the Richard J. Dorer Memorial Hardwood State Forest)

2.2 Water Quality Trends

Root River Watershed Outlet Data

Long-term water quality was recorded at site S000-065, near Hokah, Minnesota from 1958 to 2008 for Total Suspended Solids (TSS), biochemical oxygen demand (BOD), total phosphorus (TP), nitrite/nitrate (N), and chloride (Cl) (Table 1). These were based on median summer (June through August) concentration values (mg/L), except for chlorides, which are median year-round values. The MPCA used this dataset to analyze the historical (1958 to 2009) and recent (1995 to 2009) water quality trends (Seasonal Kendall Trend Test) in the RRW (MPCA 2012). The TSS decreased significantly both in historical and recent trends. The BOD and TP both decreased significantly in the historical trend, but no trend was found ($p<0.01$) in recent trends. The N increased significantly in recent and historical trends. Finally, there was only sufficient data to analyze trends for historical Cl data, which showed an increase (MPCA 2012).

Table 1. Water quality trends of the Root River, 3 miles East of Hokah (just upstream from the mouth of the river), green values indicate an improving trend in water quality for that parameter, while red values indicate a degrading trend in water quality for that parameter.

Parameter	Historical Trend (1958-2009)	Recent Trend (1995-2009)
Total Suspended Solids (TSS)	**-41%**	**-61%**
Biochemical Oxygen Demand (BOD)	**-88%**	no trend
Total Phosphorus (TP)	**-70%**	no trend
Nitrite/ Nitrate (N)	**+355%**	**+39%**
Chloride (Cl)	**+76%**	little data

Nitrate

In a targeted study of southeastern Minnesota private well drinking water nitrate concentrations (Southeast Volunteer Nitrate Monitoring Network), the percent of wells exceeding 10 mg/l nitrate-N ranged between 7.6% and 14.6% during the years 2008 to 2012 (MDA 2015).

Nitrate and other parameters have been monitored in wells in southeastern Minnesota since 2006 through a partnership of volunteer well owners, MDH, MPCA, Minnesota Department of Agriculture (MDA), and the Southeast Minnesota Water Resources Board. The information gathered has been used to direct other efforts looking into groundwater contaminants in the region. Nitrate commonly occurs in groundwater and is important to understand in drinking water sources for several reasons: nitrate can be linked to activities at the ground surface; nitrate is commonly present when other contaminants are also present (serves as an indicator analyte); and nitrate is inexpensive to measure. If the occurrence of nitrate is better understood, better protection can occur.

Trend analysis

To examine changes in nitrate-N concentrations over time, trend analyses were applied to data collected at two trout hatchery springs in southeast Minnesota: Lanesboro State Hatchery and Peterson State Hatchery. Data from the Peterson State Hatchery spring is depicted in Figure 11. Statistically significant increasing trends in both nitrate-nitrogen concentration (p-values ranged from 0.01- 0.001) and load (p-values ranged from 0.05 - 0.001) were documented at each location, for periods covering the last 20 years. The potential geographic scope of this trend was described by comparing a 1990 nitrate-nitrogen data set (Muck and Newman 1992) to more recent data. Generally, at the regional scale, this comparison depicts increasing nitrate-nitrogen concentrations across southeast Minnesota. An examination of a subset of 40 coincident site locations found that a majority (33 of 40) showed increasing nitrate-nitrogen concentrations (Watkins et al. 2013). The spring at the Peterson State Hatchery discharges groundwater from a deep aquifer, which, due to very long lag times, could be reflecting historical land use activities and not necessarily current practices. There is evidence that nitrate levels are decreasing or have stabilized in several springs near the Fountain area, which are in the upper carbonate karst aquifers and respond very quickly to more recent land use activities (Runkel et al. 2013). These data are currently being analyzed through the MDA Root River Field to Stream Partnership (Appendix B) to determine if there are any land management changes that could help explain these decreasing trends. This evidence documents the complexity of nitrate trends in the RRW, and the fact that they are highly dependent on aquifer of origin.

Further trend analysis was completed by Runkel et al. 2013. Analysis of well data from the British Petroleum Spring Valley Terminal in Fillmore County was examined, and nitrate concentrations were put into hydrogeologic context to describe why trends are occurring. These detailed analyses support the trend of increasing nitrate/nitrite seen at the mouth of the Root River.

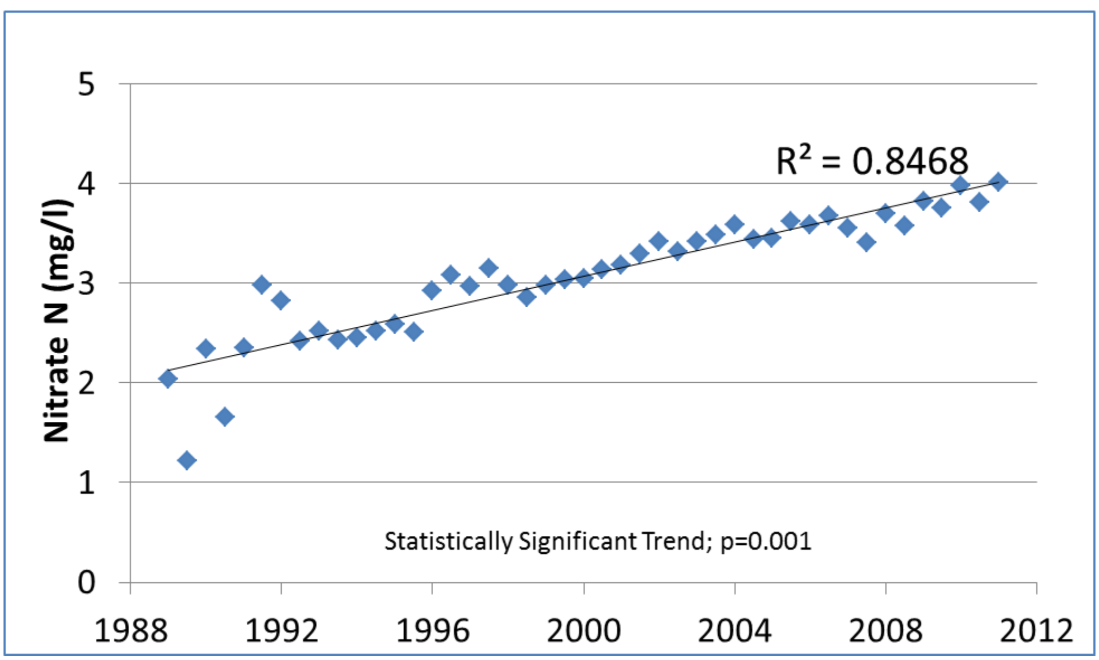
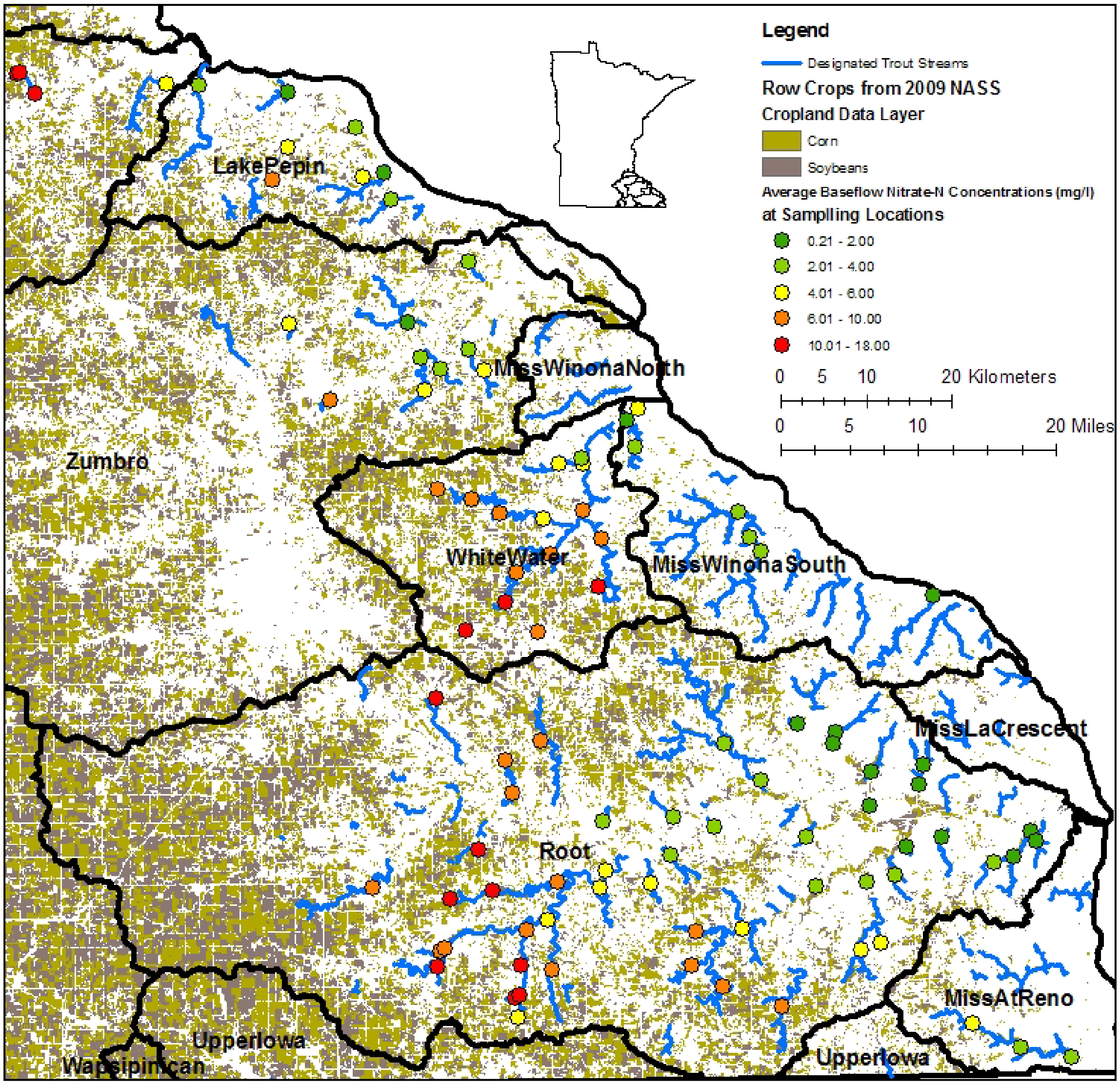


Figure 11. Peterson Hatchery Spring nitrate-N concentrations. Points represent 6-month averages.

Spatial Trends in Nitrate-N Concentrations

The Driftless, Bluffland Karst (Figure 1) region shows the lowest nitrate concentrations in the RRW (Figure 12), and also the highest concentration of fully supporting aquatic life waters in Figure 17. The Driftless, Near-Surface Karst region shows a mix of low and high nitrate-N values due to its geomorphology and other factors, and has some waters with fully supporting aquatic life. The Uplands, Till Covered Karst region does not have trout streams and therefore a comparison cannot be made.

Figure 12. Nitrate-N concentrations at various sampling locations on designated trout streams in southeast Minnesota, with green showing the lowest values, yellow showing mid values, and red showing high values above the state water quality standard of 10 mg/L (Watkins et al. 2013).



2.3 Pollutant/Stressors and Sources and Reductions

In order to develop appropriate strategies for restoring or protecting waterbodies the stressors and/or sources impacting or threatening them must be identified and evaluated. Biological stressor identification is done for streams with either fish or macroinvertebrate biota impairments and encompasses both evaluation of pollutants and non-pollutant related factors as potential stressors (e.g., altered hydrology, fish passage, habitat). Pollutant source assessments are completed where a biological stressor identification process identifies a pollutant as a stressor as well as for the typical pollutant impairment listings.

Stressors of Biologically-Impaired Stream Reaches

In the RRW, 47 stream reaches have impairments for aquatic life. Forty of those are based on fish and/or aquatic macroinvertebrate assemblages and were studied during the stressor identification process. The remaining seven are aquatic life listings due to turbidity, but fish and macroinvertebrate communities were not found to be impacted. The probable causes of aquatic life stress were determined by the MPCA to be: low dissolved oxygen levels; water temperature higher than optimal; high nitrate levels; high TSS or cloudy water; lack of physical habitat; and disrupted physical connectivity (e.g., dams or culverts blocking fish migration) (MPCA 2015a).

Pollutant sources

While both point and non-point sources contribute to impairments in the RRW, the non-point sources dominate most areas due to the low amount of developed land area (Figure 2).

Point Sources

Point sources are permitted, regulated entities that are required to adhere to the language of their permits. Compliance is ensured through state and federal programs. There are currently 50 National Pollutant Discharge Elimination System (NPDES) permitted point sources, and 1 potential future MS4, in the RRW (Appendix C).

Permitted Suspended Sediment and Bacteria sources

Municipal permit holders in the RRW have TSS and bacteria limits set in their permits and industrial permit holders in the RRW have TSS limits.

For feedlots in the RRW requiring a State Disposal System (SDS) or NPDES Permit under Minn. R. ch. 7020, the construction, operation and maintenance of the feedlot are regulated under their permit. The MPCA currently uses the federal definition of a Concentrated Animal Feeding Operation (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. A SDS Permit can be issued in lieu of a NPDES Permit if the feedlot has capacity of 1,000 or more AUs and does not discharge to the waters of the state.

Permitted N sources

According to Nitrogen in Minnesota Surface Waters (MPCA 2013), point sources are estimated to contribute 5% of the nitrogen in the Lower Mississippi River Basin (Figure 13). According to the MPCA document titled *Minnesota NPDES Wastewater Permit Nitrogen Monitoring Implementation Plan,* in order to better document the actual loading from wastewater, the frequency of nitrogen series monitoring requirements in Minnesota's industrial and municipal wastewater NPDES Permits increased, beginning with permits issued in 2014. This was done in order to develop a more complete understanding of the magnitude and dynamics of nitrogen sources and discharges from wastewater sources. On a statewide scale, it has been determined that a majority of point source nitrogen is from the 10 largest municipal facilities (MPCA 2014b). Only 1 of the 10 large facilities is in the Lower Mississippi River Basin (Rochester Wastewater Treatment Facility (WWTF)), and none are in the RRW. There are two WWTFs in the RRW that currently have a nitrate permit limit (Fountain and Ostrander), and other facilities may have them set in future permits pending further data collection and analysis.

Non-point Sources

Non-point sources are potential pollution contributors that are not required to have NPDES Permits, such as overland runoff across all acres of the watershed. They may be required in some cases to have non-federal, state, or local permits. Typically, their impact is cumulative and so they are often identified by being aggregated geographically by location or source type. Below, specific non-point sources of the three main pollutants in the RRW (sediment, nitrate and bacteria) are discussed.

Suspended Sediment

A recent study by Stout et al. (2014) determined stream sediment sources in the RRW. The goals of this study were to (1) understand the erosional and depositional history of the RRW and the implications for modern erosional processes and (2) identify potential sources and sinks distributed throughout the watershed and constrain contributions from source areas.

Authors of the study note that “the Root River is a dynamic and heterogeneous system that has experienced variable erosion rates and patterns across the landscape. Historic flow data indicate” increases in both high and low flows since the 1930s. The study examined hydrology, geomorphology and other data from the watershed to try and determine the source of sediment. Three major sources were determined: hillslopes, agricultural fields and floodplains. Data indicated that agricultural fields have contributed the dominant proportion of sediment over the past 150 years since settlement, but when looking at the river as a whole, the majority of suspended sediment in transport today has experienced storage in, and has recently been reworked from, floodplains and alluvial terraces.

These sources can vary by scale and location in the watershed. At smaller scales, in the nearly 3,800-acre Crystal Creek for example, sediment has been dominated by agricultural fields, particularly in the upper parts of the watershed. “Past land use and geomorphic setting established the template for near-channel sediment storage, and modern land use and hydrology are accelerating erosion of these near channel sources.” The study concludes with a note that multiple lines of evidence are crucial to understand a watershed’s sediment dynamics and that management and policy decisions can be based on that understanding.

Development of a RRW sediment budget was completed in 2016 as a MDA Clean Water Fund project. Researchers from Utah State University and Winona State University used sediment fingerprinting to identify sediment source contributions. Their main findings were that recent agricultural soil erosion and streambank erosion are prominent sediment sources in the RRW. They found that the Root River has very active river channels with access to easily erodible banks. And, that sediment concentrations increase with river flow at a greater rate in the RRW than almost any other river in Minnesota (Dogwiler and Belmont 2016).

Nitrate

The major source of nitrate in the RRW is leaching loss from row crop acres both to groundwater (GW) and to tile, losses from agricultural runoff, point sources and from wastewater point sources (MPCA 2014a). The MPCA and MDA monitor nitrate in surface waters. The MPCA uses these data to determine if all water quality standards are being met. In 2011, 15 coldwater streams in Minnesota were listed as impaired for not meeting the nitrate water quality standards. Six of those fifteen impairments are located in the RRW, specifically in the subwatershed of the South Branch Root River.

Minnesota recently initiated four state-level efforts related to N in surface waters.

1. The MPCA is developing water quality standards to protect aquatic life from the toxic effects of high nitrate concentrations. The standards development effort, which is required under a 2010 Legislative directive, draws upon recent scientific studies that identify the concentrations of nitrate harmful to fish and other aquatic life (MPCA 2013).

2. The Nitrogen in Minnesota Surface Waters study (MPCA 2013) was conducted to better understand the nitrogen conditions in Minnesota's surface waters, along with the sources, pathways, trends and potential ways to reduce nitrogen in waters.

   Concern about N in Minnesota's surface waters has grown in recent decades due to: 1) increasing studies showing toxic effects of nitrate on aquatic life, 2) increasing N concentrations and loads in the Mississippi River combined with nitrogen's role in causing a large oxygen-depleted zone in the Gulf of Mexico, and 3) the discovery that some Minnesota streams exceed the 10 milligrams per liter (mg/l) standard established to protect potential drinking water sources.

3. The MDA's updated Nitrogen Fertilizer Management Plan (NFMP) will be implemented in southeast Minnesota (MDA 2015). The NFMP outlines how the MDA addresses elevated nitrate levels in groundwater from nitrogen fertilizer use. The NFMP has four components: prevention, monitoring, assessment and mitigation. One program within the NFMP is the Township Testing program. The goal of MDA's Township Testing Program is to monitor nitrate levels in private drinking water wells. The program is focused on townships around the state where groundwater nitrate contamination is more likely to occur. These townships have vulnerable groundwater areas and significant row crop acres. Township testing within Fillmore County is tentatively scheduled for testing in 2017.

4. In 2014, the state of Minnesota established a state-level Nutrient Reduction Strategy (NRS), with goals to provide key strategies to protect and restore Minnesota waters and to reduce loading of nitrogen and phosphorus to the waters downstream of Minnesota. A critical part of the NRS strategies is for the HUC 8 level watershed to acknowledge their contribution to downstream nutrient concerns and to develop and apply strategies to local conditions. The RRW is part of the Mississippi River Basin where water flows to the Gulf of Mexico. Minnesota contributes the 6th highest N load to the Gulf and is 1 of 12 member states serving on the Mississippi River/Gulf of Mexico Watershed Nutrient Task Force. The cumulative N and phosphorus (P) contributions from

the Hypoxia Task Force states are largely the cause of a hypoxic (low oxygen) zone in the Gulf of Mexico. This hypoxic zone affects commercial and recreational fishing and the overall health of the Gulf, since fish and other aquatic life cannot survive with low oxygen levels. The NRS sets targets of 20% reduction of nitrogen and 12% reduction of phosphorus from current loading for the HUC 8 watershed to the Mississippi Basin by 2025 and a longer range target of 45% reduction of nitrogen by 2040 (MPCA 2014).

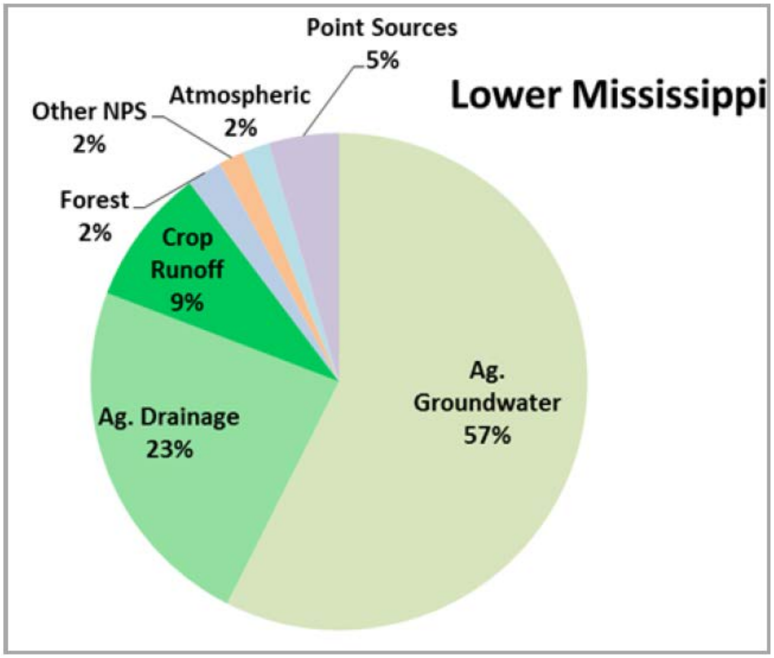


Figure 13. Estimated nitrogen sources to surface waters from the Minnesota contributing areas of the Lower Mississippi River Basin (average precipitation year) (MPCA 2013). Note: Ag. Refers to agricultural.

Nitrate analysis in Southeast Minnesota

An analysis of the relationship between base flow nitrate concentrations in southeast Minnesota trout streams and percentage of row crop land in the watersheds of these streams produced a statistically significantly regression. The one hundred trout stream sites examined included 51 sites in the RRW. Specific conclusions of this work include:

- Potential Source Linkage: Nitrate concentrations in southeast Minnesota's trout streams show a strong linear relationship to row crop land use (Figure 14). A linear regression showed a slope of 0.16, suggesting that the average base flow nitrate concentration in the trout stream watersheds of Southeast Minnesota can be approximated by multiplying a watershed's row crop percentage by 0.16. This regression analysis indicates that a watershed of approximately 60% corn and soybean acres corresponds to exceedances of Minnesota's drinking water nitrate-nitrogen standard of 10 mg/L at the point of sample in the stream (trout streams in Minnesota are protected as drinking water sources). This conclusion is supported by the findings of Nitrogen in Minnesota Surface Waters, which describe similar relationships between nitrogen in surface waters and leaching loss from agricultural lands to GW, which include areas of shallow depth to bedrock such as the trout stream region of southeast Minnesota (MPCA 2013). On a whole watershed scale, the RRW has approximately 41% land area in corn/soybean acres (Homer et al. NLCD 2011). At this scale, the 60% mark is not met. However, when focusing in on a specific 10HUC level subwatershed, this percentage changes. For example, in the South Branch Root River, 83% of acres are corn/soybean (NBMP calculator, MPCA 2013).

- Potential Natural Background: The natural background level of nitrate in streams appears to be very low given that the base flow concentrations of streams with undisturbed (very little row crop land use and little or no other human impact) watersheds were less than 1 mg/L. Statistical analysis also suggested that in the absence of human disturbance in a watershed, the base flow nitrate concentration at the point of sample in the stream could approach 0 mg/L. This is in general agreement with recent work by the U.S. Geological Survey (USGS) that concluded that human impacts are the primary reason for elevated nitrogen in United States surface waters; background concentrations of nitrate were 0.24 mg/L in watersheds dominated by non-urban and non-agricultural land uses (Dubrovsky et al. 2010) (Watkins et al. 2013).

Studies outside of southeastern Minnesota have concluded that some hydrogeological systems function in a manner whereby changes in base flow nitrate concentrations lag changes in land use practices by decades (e.g., Tesoriero et al., 2013). To analyze whether this lag occurs in southeastern Minnesota, a recent investigation was conducted by the Minnesota Geological Survey (MGS) for the MPCA. The report titled *Geologic controls on groundwater and surface water flow in southeastern Minnesota and its impact on nitrate concentrations in streams* (Runkel et al. 2013) summarized the study results, which will support watershed planning efforts in southeast Minnesota. The study provided better understanding of the geologic controls on nitrate transport in the region, including nitrate in groundwater that is the source of baseflow to streams.

The RRW was the focus of the investigation on an evaluation of nitrate (NO3 ion) transport because of the relatively advanced understanding of the karstic conditions in that area. However, the overall scope of the project included the entire bedrock-dominated landscape of southeast Minnesota. Results therefore support broader MPCA watershed planning that directly pertains to the Root River, as well as to other watersheds within the Lower Mississippi River Basin in Minnesota.

Two selected conclusions from the report:

1. *The most important factor that impacts both the magnitude and variability of nitrate concentration in spring water and stream baseflow is the proportion of regionally sourced, nitrate-poor water contributed from deep aquifers relative to more locally sourced, nitrate-enriched water from shallower aquifers.*

2. *The relative proportion of these contributions to stream baseflow can commonly be correlated with the hydrogeologic setting.*

"Results from the study have relevance for both surface and groundwater management efforts to mitigate nitrate loading. One implication is that the response time of nitrate concentrations to changes in land use practices will likely vary in different hydrogeologic settings.

The distribution of nitrate in ground and surface water depicted in the report represents the advance of nitrate from the land surface into the ground and aquifer systems over about 60 years. The accuracy of predictions of future water quality will in part be dependent on an appreciation of the dynamic nature of the transport system. Particularly important is recognition that contaminants will be transported to progressively deeper aquifers and are likely to increase in concentration with time due to a number of natural and anthropogenic factors. Assuming nitrate input from the land surface does not decrease in the future, increased levels of contamination in progressively deeper parts of the groundwater system should be expected." (pages 59-60)

The most significantly lagged response in southeastern Minnesota should be expected in the deep valleys incised into the Prairie du Chien Plateau, where significant baseflow is derived from deep, siliciclastic-dominated bedrock sources with one or more overlying aquitards.

The report also discussed additional work needed to better influence planning. One example is methods that could be used to predict the impact of changing land use practices on baseflow nitrate concentrations.

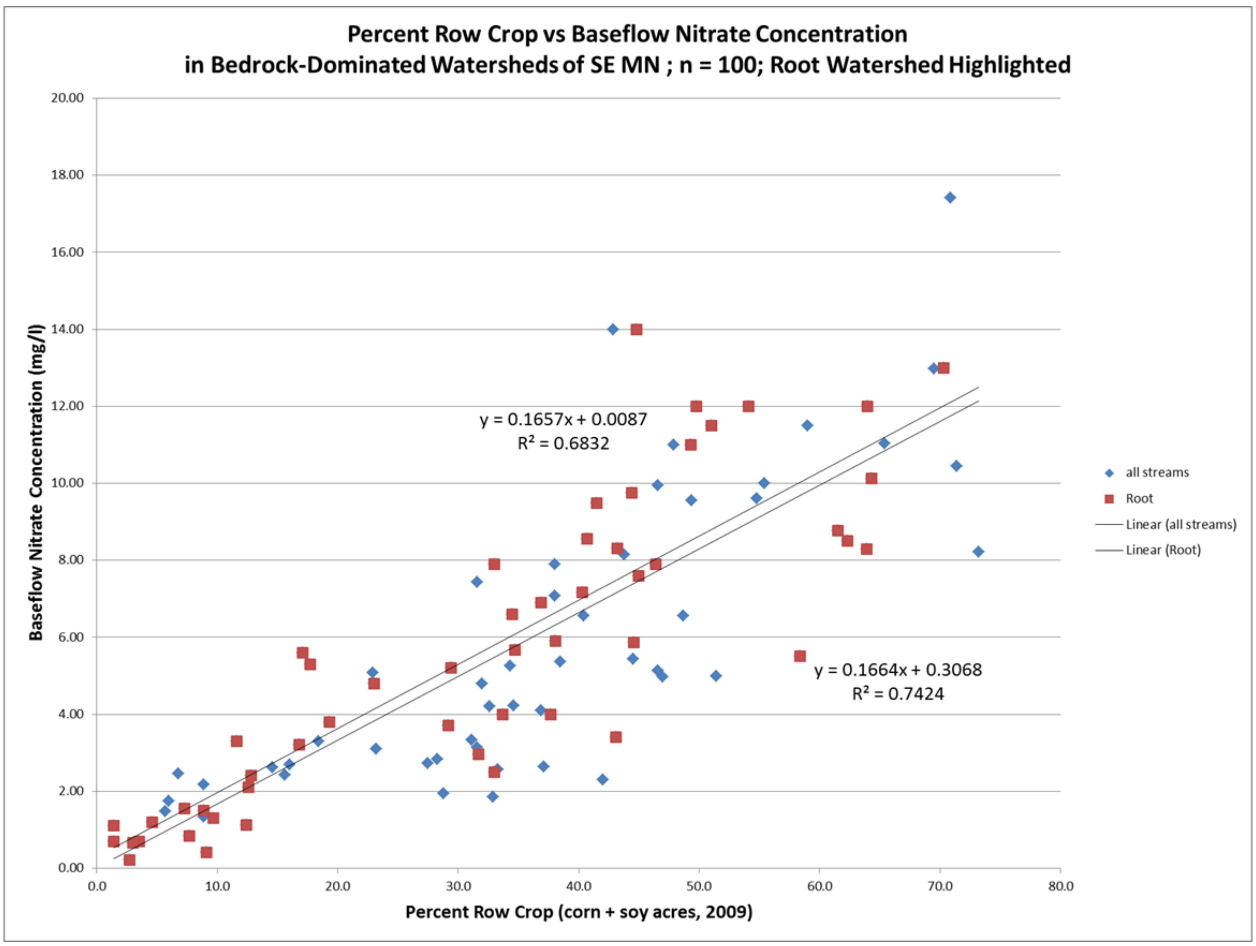


Figure 14. Baseflow nitrate and row crop acres regression (Watkins et al 2013). Root River data points are shown in red.

Fecal Bacteria (Fecal coliform and *E. coli*)

Background

Fecal bacteria are indicators of animal or human fecal matter in waters. Fecal matter impacts the safety of aquatic recreation because contact with fecal material can lead to potentially severe illnesses.

There are currently 20 stream AUIDs in the RRW that have been found to be in exceedance of the standard for fecal bacteria concentration, 15 of which were addressed in the Root River TMDL Report (MPCA draft 2015). The other five were addressed in the Regional Fecal Coliform TMDL (MPCA 2007).

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. This was discussed in detail in the *Revised Regional Total Maximum Daily Load Evaluation of Fecal Coliform Bacteria Impairments in the Lower Mississippi River Basin in Minnesota* (MPCA 2006). Fecal Bacteria source identification is difficult due to the dynamic and living attributes of bacteria. Emmons & Olivier Resources (2009) conducted a Literature Summary of Bacteria for the MPCA. The literature review summarized factors that have either a strong or weak positive relationship to fecal bacterial contamination in streams (Table 2). A study by Sadowsky et al., examined growth and survival of *E. coli* in ditch sediments and water in the Seven Mile Creek Watershed in south central Minnesota; 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 grow in the sediments and thus some sites probably contain a mixture of newly acquired and resident strains (Sadowsky et al. 2008 to 2010). Further studies on fate and ecology of *E. coli* in the environment has shown that *E. coli* may not be reliable as an indicator of water quality. Samples that were genetically analyzed in Seven Mile Creek, Minnesota, showed a mix of strains from runoff/fecal inputs and persistent strains in the soils and water which. This blend of sources complicates addressing landscape issues to see measurable improvements (Chandrasekaran et al. 2015). The EPA has an approved method (EPA Method 1602) to examine coliphages (viruses that infect E.coli and other coliform bacteria) instead of *E. coli* itself, and while this may prove to be more accurate, the current water quality standards in Minnesota are based on *E.coli.*

Hydrogeologic features in southeastern Minnesota may favor the survival of fecal coliform bacteria. Cold groundwater, shaded streams, and sinkholes may protect fecal coliform from light, heat, drying, and predation (MPCA 1999). Sampling in the South Branch of the RRW 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).

Subsurface Sewage Treatment Systems (SSTSs)

Nonconforming SSTSs are an important source of fecal coliform bacteria, particularly during periods of low precipitation and runoff when this continuous source may dominate fecal coliform loads. Some counties have an ordinance in place for point of sale (POS) compliance or other SSTS ordinances that meet state requirements and provide checks for compliance at various times (Table 3). These ordinances are important for ensuring SSTSs are not contributing to bacterial impairments in the watershed.

Unsewered and/or undersewered communities include older individual systems that are generally failing, and/or collection systems that discharge directly to surface water. This may result in locally high concentrations of wastewater contaminants in surface water, including fecal coliform bacteria, in locations close to population centers where risk of exposure is relatively high. While seven small communities have already completed work to adhere to state rules, there are 20 small communities in the RRW that have been identified by their respective counties as a group of residences that is in need of sewage work to be in compliance with state rules (Figure 15).

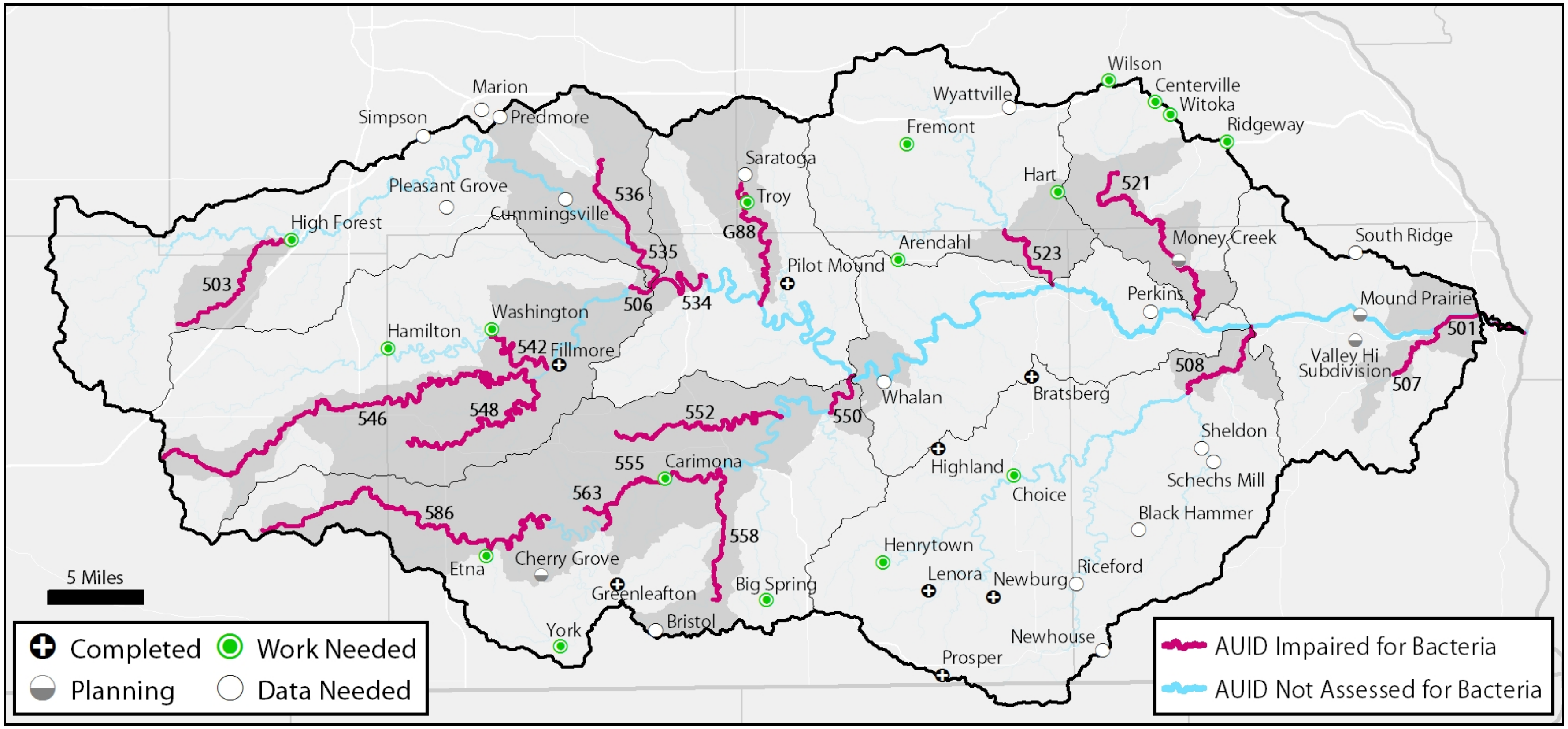


Figure 15. Status of un/undersewered small communities of the RRW. Completed = necessary work has been done to bring the community into compliance; Planning = work needed is known but community is awaiting funding, permits, etc.; Work Needed = community has been identified by their respective County and MPCA as a group of residences that is in need of sewage work to be in compliance with state rules; Data Needed = community has been identified, but it is unknown what, if any, work needs to be completed. Also shown are AUIDs that have been assessed and are impaired for bacteria.

Table 2. Strong and weak relationships of various factors to bacterial contamination of surface water determined through a literature review.

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

Table 3. Summary of SSTS ordinance status as of 2014 in the five main counties in the RRW. Conventional implies the county is meeting state rule minimums.

County	Point of Sale	Conventional
Fillmore	Yes	In Progress
Houston	No	Yes
Mower	Yes	Yes
Winona	Yes	Yes
Olmsted	No	In Progress

Livestock Facilities and Manure Application

The CAFOs with an NPDES Permit are considered point sources and are held to the limits of their permit language. However, the vast majority of livestock facilities in the Lower Mississippi River Basin in

Minnesota and the RRW are not CAFOs. Nevertheless, they are subject to state feedlot rules, which include provisions for registration, inspection, permitting, and upgrading. Much of this work is accomplished through delegation of authority from the state to county government.

There are 1,552 feedlots listed in the MPCA's database as having a current permit in the RRW. The approximate total AUs on those feedlots in the RRW watershed is slightly under 240,000 (according to the MPCA's Delta and GIS database at the time of this report). About 10% of those AUs are located on NPDES/SDS permitted CAFOs (25,106 AUs), while the remaining 90% are located on smaller feedlots, only some of which are permitted by the non-Clean Water Act based rules of Minnesota (Minn. R. ch. 7020). Many feedlots have liquid manure storage areas (LMSA), which though regulated in Minn. R. ch. 7020 to limit seepage and impacts to ground water, can still be a source of bacteria if not in proper condition or if a failure were to occur (Figure 16). A majority (99%) of the AUs across all feedlots in the RRW are: bovines (68%), pigs (27%) and poultry (4%). The other two categories are horses and sheep.

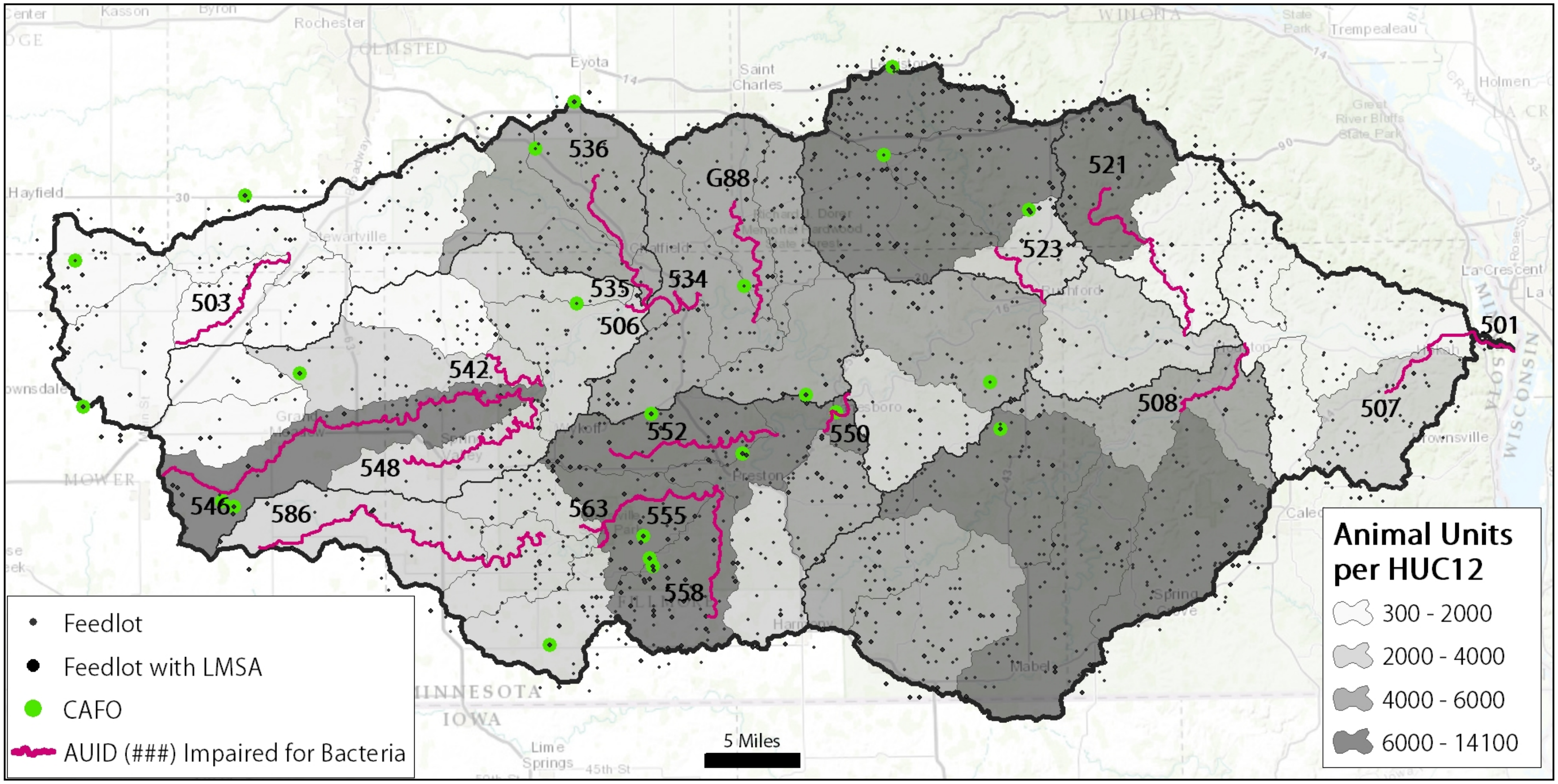


Figure 16. Locations of stream reaches impaired for bacteria, feedlots, CAFOs and animal unit density in the RRW. LMSA = Liquid Manure Storage Area.

2.4 TMDL Summary

The RRW TMDL report was drafted in 2015 and 2016 alongside this WRAPS document, and addressed 38 impairments on 30 AUIDs (Table 4). Stream allocations and reductions needed to meet standards were developed in that TMDL report. For more detail refer to the TMDL document on the RRW webpage and/or Appendix E.

Impairments not caused by pollutants, for example aquatic life use impairment for macroinvertebrate IBI caused by physical habitat, were not addressed through the TMDL process. Loading computations (TMDLs) are not required or appropriate for such impairments. The strategies in Section 3 cover areas with non-TMDL related impairments.

Table 4. Summary of AUIDs and impaired parameters addressed in the RRW TMDL report.

KEY: ● = conventional pollutant (addressing turbidity, bacteria, or nitrate impairments)

○ = Pollutant identified through the stressor identification process, partially addressing fish or macroinvertebrate bioassessment impairments

AUID	Designated Use Class	Turbidity /TSS	Bacteria	Nitrate
07040008-501	2B, 3C	●		
07040008-502	2B, 3C	●		
07040008-506	2B, 3C		●	
07040008-507	1B, 2A, 3C		●	
07040008-508	2B, 3C	●	●	
07040008-509	2B, 3C	○		
07040008-511	1B, 2A, 3C	●		
07040008-520	2B, 3C	○		
07040008-522	2B, 3C	○		
07040008-527	2B, 3C	●		
07040008-528	2B, 3C	○		
07040008-534	2B, 3C		●	

AUID	Designated Use Class	Turbidity /TSS	Bacteria	Nitrate
07040008-535	2B, 3C		●	
07040008-536	1B, 2A, 3C		●	
07040008-542	2B, 3C		●	
07040008-546	2B, 3C		●	
07040008-548	1B, 2A, 3C		●	
07040008-550	1B, 2A, 3C	○	●	
07040008-552	1B, 2A, 3C	○	●	●
07040008-554	1B, 2A, 3C	●		
07040008-555	1B, 2A, 3C	●		●
07040008-556	1B, 2A, 3C	●		
07040008-557	1B, 2A, 3C			●
07040008-558	1B, 2A, 3C		●	●
07040008-562	1B, 2A, 3C		●	●
07040008-563	1B, 2A, 3C		●	●
07040008-573	2B, 3C	●		
07040008-716	2B, 3C	●		
07040008-717	2B, 3C	●		
07040008-G88	1B, 2A, 3C		●	
TOTAL		**17**	**15**	**6**

2.5 Protection Considerations

Many areas throughout the RRW provide high quality habitat for aquatic life. Because of this, protection efforts need to be undertaken alongside restoration efforts in the watershed. Many efforts to restore areas of the watershed will also protect nearby areas and a variety of best management practices (BMPs) can be used in both instances. For purposes of this report, the MPCA's information on aquatic life assessments and IBI scores were paired with information from the DNR's Root River Landscape Stewardship Plan (DNR 2013) in an effort to prioritize areas in need of protection (Figure 17).

Protection information from the Root River Biotic Stressor Identification report

During assessment in 2011, 38 AUIDs were found to be in full support for aquatic life, 6 were found to be in full support for drinking water (note that only coldwater AUIDs with existing nitrate data were able to be assessed for drinking water), and none were found to be in full support for aquatic recreation.

Based on the MPCA's 2011 assessment of aquatic life, many areas in the RRW are doing well biologically. However, it is important to consider areas that are either in need of extra support to help sustain a high functioning aquatic environment, or help the threatened aquatic environment. In order to address protection needs across various stream types, a scale of IBI scores was made ranging from highest scores above threshold to nearest scores to threshold (Figure 17). Note that if there was more than one IBI score on an AUID, one poor score can steer the determination to non-support. This determination is made by looking at all available data and using best professional judgment by a group of water resource professionals familiar with the area and information.

Root River Landscape Stewardship Plan and Conservation Opportunity Areas (COAs):

The goals of the DNR's Root River Landscape Stewardship Plan were 1) to conserve areas of high biodiversity and distinctive geology while 2) managing areas that protect watershed health and water quality. Three layers were incorporated: the areas of biodiversity and geologic concentration, hydrology, and topography. By combining these layers of interest, the physical and functional context of the COA was created in a realistic three-dimensional model. An ideal outline was identified that followed natural boundaries suggested by the watershed units and topographic elevation lines, and incorporated the areas of greatest concentration of natural resource features.

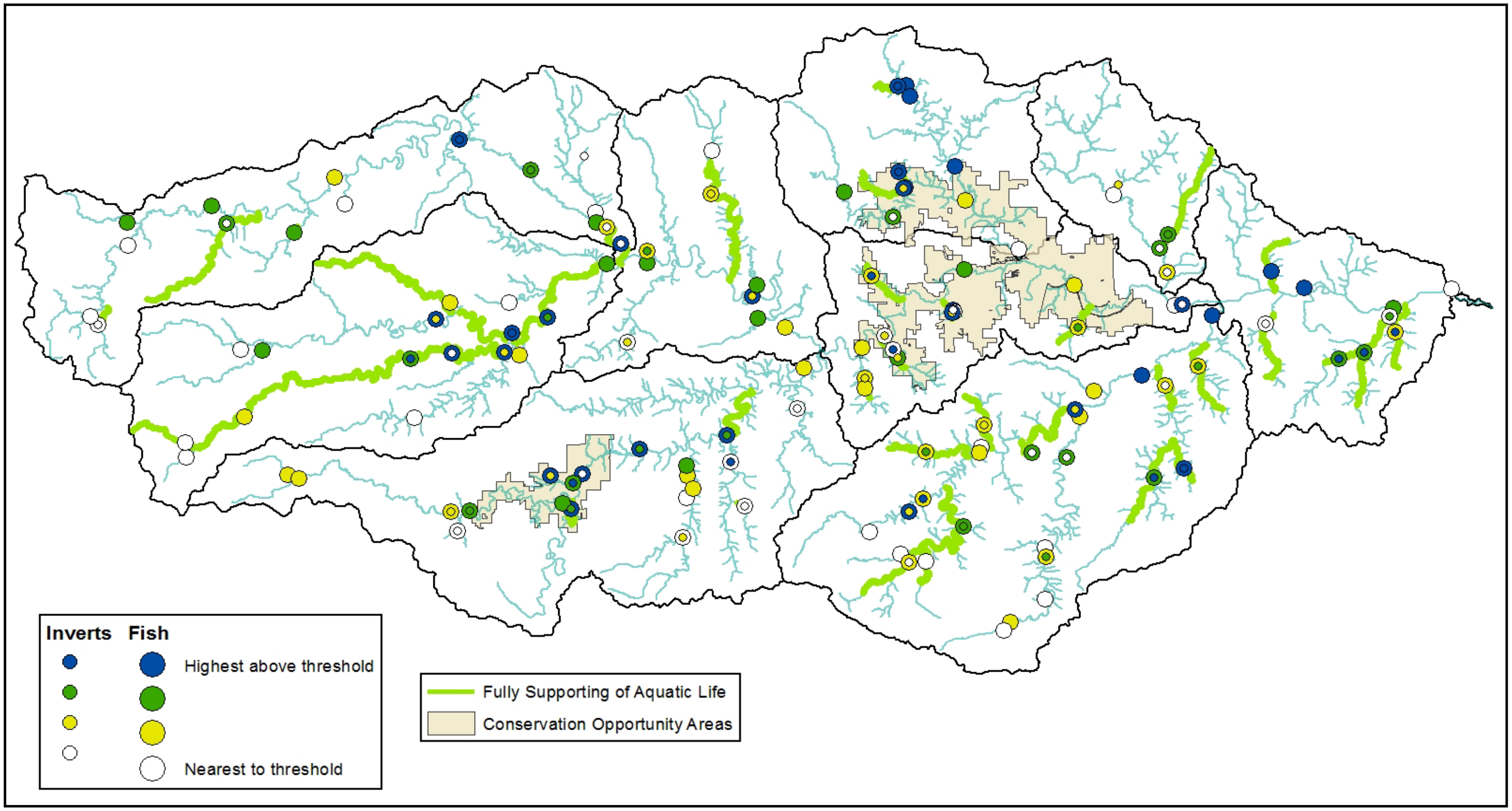


Figure 17. **Areas in need of protection consideration in the RRW. River reaches in green are those assessed as fully supporting of aquatic life. Macroinvertebrate and fishes IBI scores shown as distance from community impairment threshold, where blue (highest above threshold) indicates areas where IBI scores were the highest. Conservation Opportunity Areas included to show any overlap, and therefor priority, for areas with both high aquatic life health and high biological diversity from the Root River Landscape Stewardship Plan.**

3. Prioritizing and Implementing Restoration and Protection

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

This section of the report provides the results of such prioritization and strategy development. Because many of the nonpoint source strategies outlined in this section rely on voluntary implementation by landowners, land users and residents of the watershed it is imperative to create social readiness or capacity of land management decision makers (measured in terms of a good understanding of problems and solutions, and motivation to adopt good management practices) and sufficient support and resources to enable the BMP implementation. Some of the social strategies seek to instill trust, networks and positive relationships with those who will be needed to voluntarily implement BMPs. Thus, effective ongoing civic engagement with key decision makers, stakeholders and community and programs is fully a part of the overall plan moving forward.

The implementation strategies, including associated scales of adoption and timelines, are based on what is likely needed to meet the water quality goals for restoration and protection. Those strategies provided in this section are the result of previous watershed reports completed in the Watershed Approach context, watershed modeling efforts and professional judgment based on what is known at this time and, thus, should be considered approximate. Furthermore, many strategies are predicated on building social readiness and sufficient resource support including needed funding being secured. As such, the proposed actions outlined are subject to adaptive management—an iterative approach of implementation, evaluation and course correction.

The RRW was approved for state funding for the purpose of creating a single watershed plan through Board of Water and Soil Resource's (BWSR's) *One Watershed, One Plan* (1W1P) granting process. The 1W1P effort requires participation by many organization/agency stakeholders in the watershed that include: six counties, six soil and water conservation districts (SWCDs), and one watershed district. A Memorandum of Understanding (MOU) was established to complete 1W1P planning efforts. Targeting and prioritizing accomplished during the WRAPS process was utilized to the extent possible. The RRW 1W1P is set to be completed in 2016.

3.1 Targeting of Geographic Areas

The primary purpose of this section, and the statutory language on which it is based, is to identify priority or critical areas for implementation. This section describes the selected tools, illustrates overall results/output and explains how the tools can be used over time.

HSPF/SWAT Model Efforts

HSPF

Hydrologic models were used to support decision-making for potential sediment and nutrient reduction strategies in the RRW. A Hydrological Simulation Program – FORTRAN (HSPF) for the entire RRW was developed and supported by a Soil and Water Assessment Tool (SWAT) data from three subwatersheds (North Branch and Money Creek, as well as the upper portion of the South Fork) within the RRW.

Three USGS and five DNR field stations generated data used for hydrologic calibration. Data collection years varied at different stations, but occurred between 1994 and 2010. Increased time series water quality data would be preferred when refreshing future models.

The Root HSPF model has been deemed well calibrated and validated, except for simulation of specific individual run-off events. This may be attributed partly to problems with the precipitation (NEXRAD) data and because of challenges in modeling karst topography – even with adjustments made for karst parameters. Therefore, the model for the RRW is best suited for informing long periods of time as opposed to impacts of specific precipitation events.

For both sediment and nutrient simulation, the model was effective in general trends and seasonal changes. Not all extreme values were accurately simulated, however. Based on Tetra Tech metrics for model success, "a majority of the constituents and [calibration] stations achieved a good or very good fit" (TetraTech 2013a). Situations in which constituents were poorly modeled occurred because of influence by specific high flow events.

<u>Karst Simulation</u>

Karst features, significant subsurface water flow paths over large areas of the Root Watershed, were also accounted for in the model as a separate set of stream reaches that ran parallel to surface reaches. Remote sensing images and GIS were used to identify karst locations. However, it is likely many karst features with no surface expression were not identified and further, their subsurface pathways are not well characterized.

Because of these unknown karst pathways, the secondary parallel karst network "significantly increases potential for [model] uncertainty," according to Tetra Tech staff. The necessarily imperfect location of karst features and corresponding pathways made simulation of karst hydrology challenging (personal communication, Tetra Tech). Additionally, small order upstream reaches in the model were often simulated as having zero base-flow when there were field observations to the contrary.

SWAT

The SWAT models are similar to HSPF, but are considered to be better at simulating specific farming practices but not in-stream hydrological processes. For example, the SWAT is better at approximating sediment erosion rates than pollutant transport. The SWAT models only simulate on a daily time-step as well, while the HSPF can simulate continuous data.

Three subwatersheds were selected – North Branch Root River, Money Creek, and the South Fork Root River. The South Fork Basin contained the most karst features. Water quality loading data from these models were used to guide the calibration processes of the HSPF model. Also, a SWAT model for a portion of the South Branch was developed in 2009 and was reviewed during map development, but not used in the HSPF calibration.

Load averages for nutrients, sediment and flow were all predicted very well by the model. However, as expected with the daily temporal resolution of the SWAT, specific, often high-flow events were poorly modeled.

A primary issue with many karst simulations in the SWAT is that surface flow is not allowed a direct interaction with groundwater flow. Instead, water is simulated as percolation into aquifers. Therefore, land management changes in the SWAT scenarios are not linked with physical and chemical changes in groundwater.

Model Scenarios

The HSPF and SWAT models were used to simulate seven scenarios designed to determine the effect of land use change and varying nutrient application strategies on watershed water quality. Staff from the Fillmore County SWCD, MDA, MPCA (feedlot and watershed programs), and Winona County (feedlot officer) met in 2012 to discuss and prioritize these scenarios:

1. Cover crop (rye) in corn-soybean and continuous corn fields, planted on October 23, harvested on April 30.
2. Increased nitrogen fertilizer application to 160 lbs-N/ac on corn-soybean rotations and 200 lbs-N/ac on continuous corn. (The standard model had 125 lbs-N/ac on corn-soybean and 170 lbs-N/ac on continuous corn.)
3. Apply buffer strips on stream corridors with slopes less than 3%.
4. Decreased nitrogen fertilizer application to 110 lbs-N/ac on corn-soybean rotations and 150 lbs-N/ac on continuous corn.
5. For corn-soybean rotation fields, change N fertilizer application from May 4 to October 28.
6. For corn-soybean rotation fields, 50% of N fertilizer is applied on May 4 and the rest is applied in on June
7. Addition of perennial vegetative strips to agricultural toe slopes in order to protect shallow groundwater flow.

Side-by-side comparisons of HSPF scenarios with the base modeled simulation can be used to help determine appropriate land management decisions. Changes in stream output (HUC-8 scale) for nitrate and sediment in each HSPF scenario compared to the observed, base model varied across scenarios (Table 5). Changes in stream outputs at each HUC-10 outlet were also examined and can be found in more detail in Appendix F.

In the next round of watershed examination, set to begin in 2018, the RRW models are hoped to be improved by increased ability to model karst (if possible) and increased area that subwatersheds are modeled with SWAT.

Table 5. Total nitrate (NO3) and sediment at the stream outlet of the RRW from October 1, 1995 to October 1, 2010, for the baseline HSPF model conditions and seven scenarios.

Scenario	NO3 (lbs)	% Change from Baseline (NO3)	Sediment (tons)	% Change from Baseline (Sed.)
Baseline	194,770,600	-	4,523,723	-
S1	186,944,800	-4.02%	4,315,129	-4.61%
S2	203,282,500	4.37%	4,521,885	-0.04%
S3	191,904,200	-1.47%	4,221,325	-6.68%
S4	192,470,100	-1.18%	4,526,157	0.05%
S5	190,754,800	-2.06%	4,544,203	0.45%
S6	189,393,000	-2.76%	4,519,215	-0.10%
S7	190,115,200	-2.39%	4,450,150	-1.63%

Completed Watershed Approach related reports

1. The RRW Monitoring and Assessment Report (MPCA 2013) was referenced for the IBI scores.
2. The RRW Biotic Stressor Identification Report (MPCA 2014) conclusions were used to identify nitrate, physical habitat, physical connectivity, temperature, and DO stressed biological communities.
3. The RRW TMDL Report (MPCA draft 2016) calculated load reductions needed at various flow regimes. Suspended sediment, bacteria, and nitrate impairments were addressed in the report. These areas of impairments were considered when targeting and prioritizing.
4. *Geologic controls on groundwater and surface water flow in southeastern Minnesota and its impact on nitrate concentrations in streams* (Runkel et al. 2013). This report identified areas where groundwater is susceptible to nitrate contamination from surface activities based on an analysis of the geologic setting of southeast Minnesota. Specific areas such as the upland area in the Willow Creek subwatershed in the South Branch of the RRW were identified as areas in need of nitrate reduction.

Professional Judgment

Professional judgment is crucial when considering social aspects as well as landscape details valuable for targeting and prioritizing critical areas. Professionals working in the watershed have connections to private landowners, and know the landscape on a personal basis. They are able to look at results from other tools and determine what actions will produce results. Various formats were used to collect professional opinion and use that to formulate judgment.

a. Citizen conversations (discussed in further detail in Section 3.2) gave the opportunity to collect input from over 100 landowners within the RRW.

b. A Root River Technical Advisory Group meeting on November 25, 2013, included an introduction of the WRAPS Implementation table (Section 3.3). A plan was developed that would be used to incorporate comments from the main five counties and SWCDs in the RRW to complete the table.

c. Following the developed plan, the five SWCDs and/or counties in the watershed were met with individually to consult about restoration practices to include in the table in the impaired reaches of their respective counties

Local water resource professionals and stakeholder groups can use the information included in this section in a variety of ways while planning for future development, future projects and related funding, and other natural resource planning.

Prioritization and Critical Areas

The tools described above (model, completed reports, and professional judgment) were used to the extent possible to prioritize areas within each parameter. Criteria were used to determine priority level for each parameter, with high priority areas considered synonymous with critical areas. The process for prioritization per parameter was as follows:

Restoration

Aquatic Recreation Use Impairments – Bacteria (E. coli)

To reduce bacteria levels, pasture management, manure management (feedlots and fields) and repair of malfunctioning septic systems are needed. Bacteria impairments affecting aquatic recreation use are prevalent across the watershed. As mentioned before, any AUID that had enough data to be assessed for aquatic recreation was found to be impaired in the RRW. Large scale efforts to address these impairments can be found in the *Lower Mississippi River Basin Fecal Coliform Implementation Plan* (MPCA 2007). Many of these efforts have already been funded and are ongoing in the RRW and the greater southeast region of Minnesota and should continue to receive support.

Three criteria were chosen to identify levels of priority for AUIDs with high bacteria levels:

1. Bacteria impairment is present.
2. Identified unsewered community within the impaired drainage area (Figure 15). These communities have been identified by the MPCA's Municipal Division to help prioritize and direct funding for community fixes.
3. High density of AUs within the impaired drainage area (Figure 16). In the absence of manure spreading information, number of AUs indicates livestock activity in the direct drainage area for impairment.

If all are met, it is high priority (critical area). If #1 and #2, or #1 and #3 are met, it is medium priority. And if only #1 is met it is a low priority. It should be noted that the state of Minnesota has rules regulating un/undersewered communities (Minn. R. ch. 7082) and feedlots (Minn. R. ch. 7020) and compliance to those rules will be sought beyond what is listed here.

Drinking Water Use Impairments - Nitrate

Increased perennial cover, cover crops, and nutrient management would help address areas in the RRW with elevated nitrate levels.

Two criteria were examined to identify levels of priority (Figure 18):

1. Drinking water impairment is present (water quality standard for nitrate is not being met).
2. Biota impairment is present on a coldwater AUID and nitrate was identified as a conclusive stressor to the biological community.

If both criteria are met, it is high priority (critical area). If only #2 is met, it is a medium priority. Because high nitrate levels can potentially impact public health, no low priority was assigned.

It should be noted that other state agencies have focus areas in the RRW. The MDH has wellhead protection areas and other public water supply data, and MDA has priority areas for nitrate reduction. These should both be considered in comprehensive watershed planning efforts.

Aquatic Life Use Impairments – Suspended sediment (TSS/turbidity)

For areas with high suspended sediment, an applicable BMP should be determined and implemented.

Suspended sediment prioritization was based on three criteria, and one consideration (Figure 19):

1. The TSS/turbidity impairment is present.
2. Biota impairment is present and has TSS as conclusive stressor.
3. The AUID is in an upstream area of the RRW (not on the main stem).

If all criteria are met, it is high priority (critical area). If #1 or #2 are met, and #3 is met it is medium priority. If #1 and/or #2 is met, it is low priority.

Subwatershed areas identified as high sediment loaders using HSPF were also taken into consideration when prioritizing (Figure 20). Because of the uncertainty with portions of the model, it was not used to identify areas of focus (Section above on HSPF/SWAT Model Efforts).

Aquatic Life Use Impairments – Biota (Aquatic macroinvertebrate and fish communities)

Aquatic macroinvertebrate and fish communities in the RRW are impacted by various stressors including: low DO levels, temperature, physical habitat, physical connectivity, high nitrate, and high suspended sediment levels (MPCA 2014). In many instances, these aquatic life use impairments can be addressed indirectly through the BMPs aimed at addressing sediment, nitrates, and bacteria.

Prioritization of biotic impairments is based on the following criteria (Figure 21):

1. Biota impairment is present (fishes and/or macroinvertebrates).
2. Either a nitrate or sediment impairment is present on the same AUID, and that impaired parameter is a conclusive stressor.
3. AUID is in an upstream area of the RRW (not on the mainstem).

If all three criteria are met, it is high priority (critical area). If #1 and #3 are met it is medium priority. If #1 and #2 is met, it is low priority.

Protection

As discussed previously (Section 2.5), areas in the RRW labeled as fully supporting aquatic life were identified as those critical areas in need of protection in the RRW (Figure 17). The goal is to avoid degradation of high quality waters. Since they are found throughout the RRW, watershed-wide goals were used to address them (Table 7).These critical areas were based on:

1. AUIDs assessed and deemed fully supporting for aquatic life use.
2. Areas contributing to sites where IBI scores were the highest above assessment thresholds.
3. Root River Landscape Stewardship Plan Conservation Opportunity Areas, which are areas of high quality biodiversity and native plant communities.

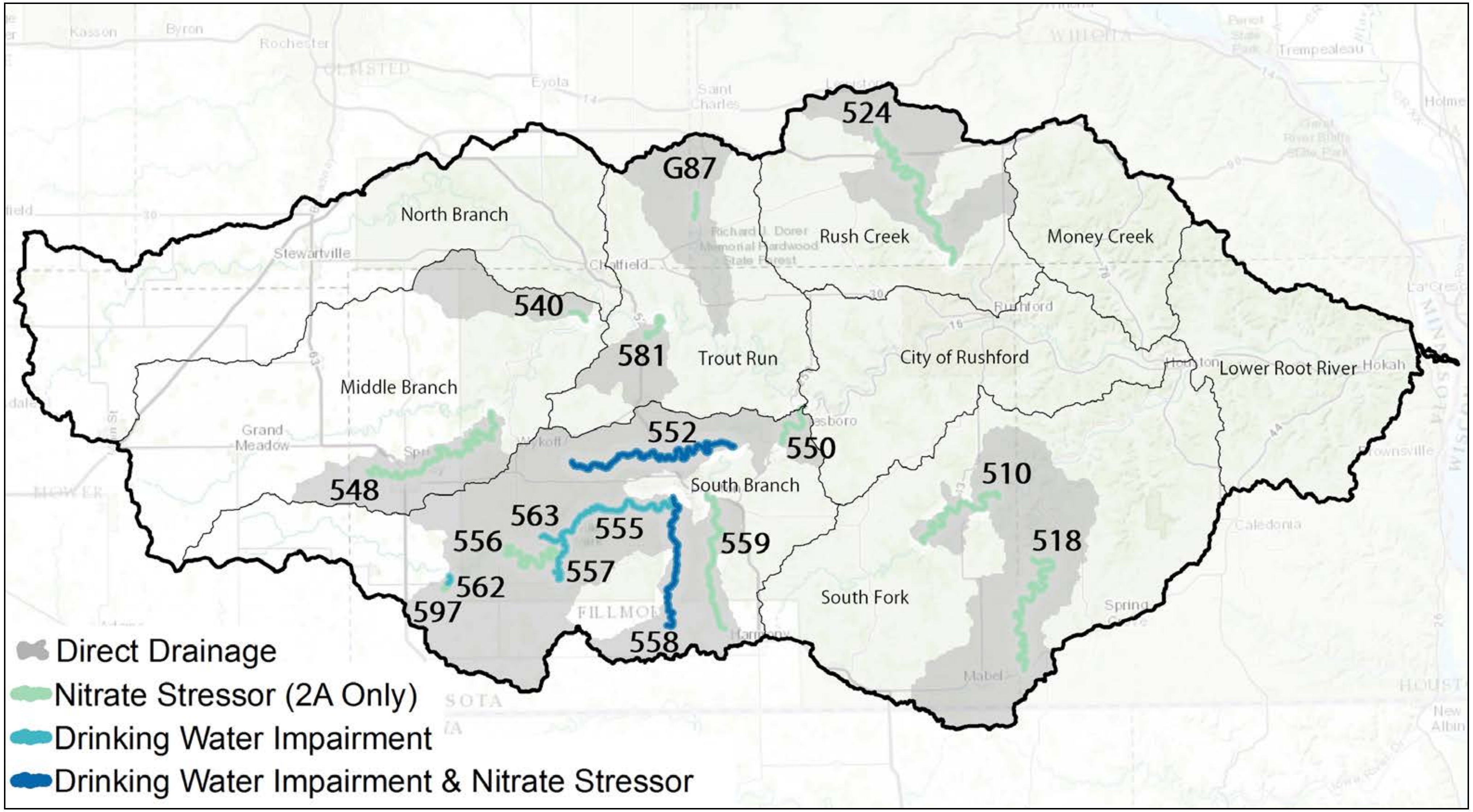


Figure 18. Nitrate prioritization based on where conclusive stressors and drinking water use impairments occur in the RRW.

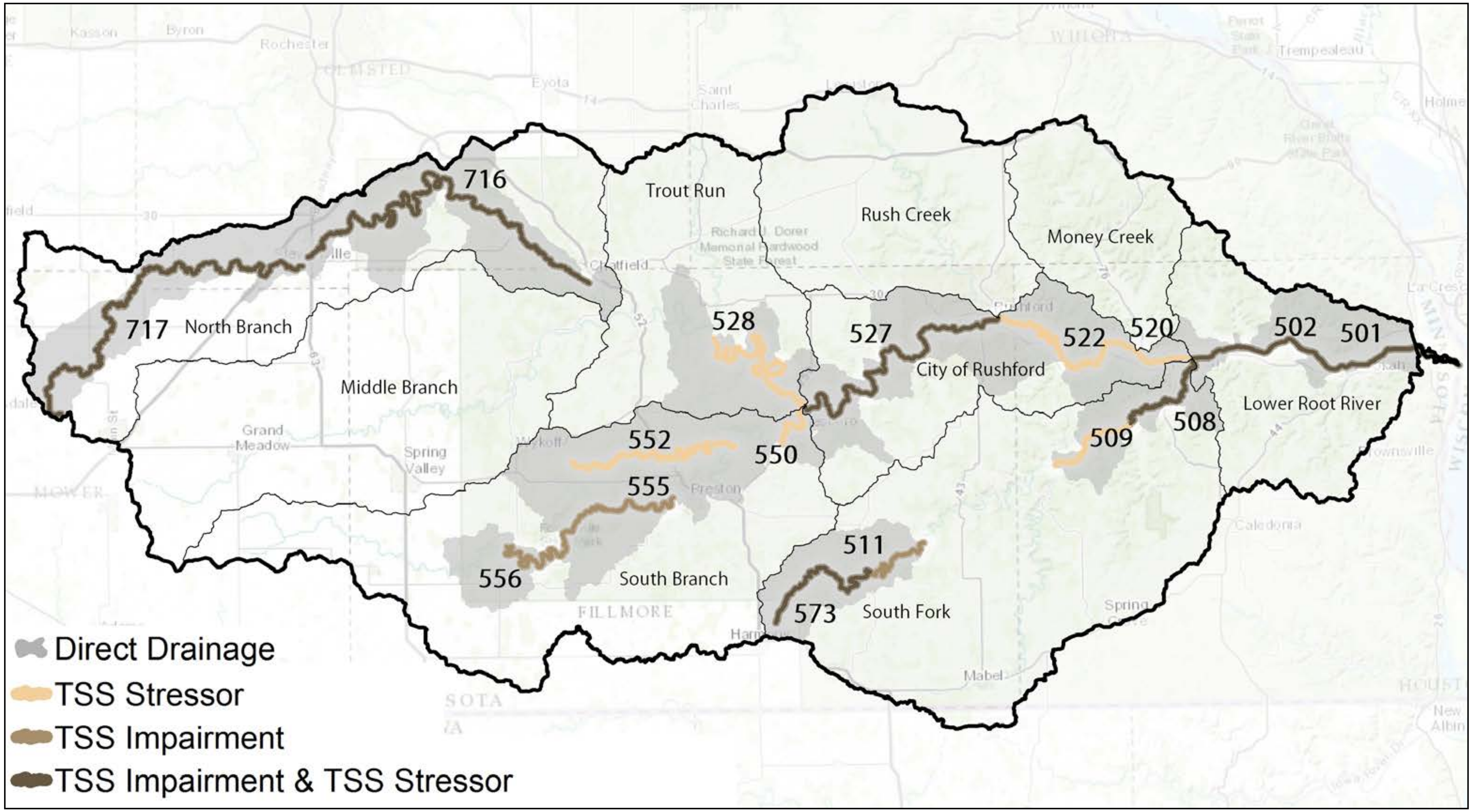


Figure 19. Sediment prioritization based on where suspended sediment (TSS) and aquatic life use impairments based on TSS occur in the RRW.

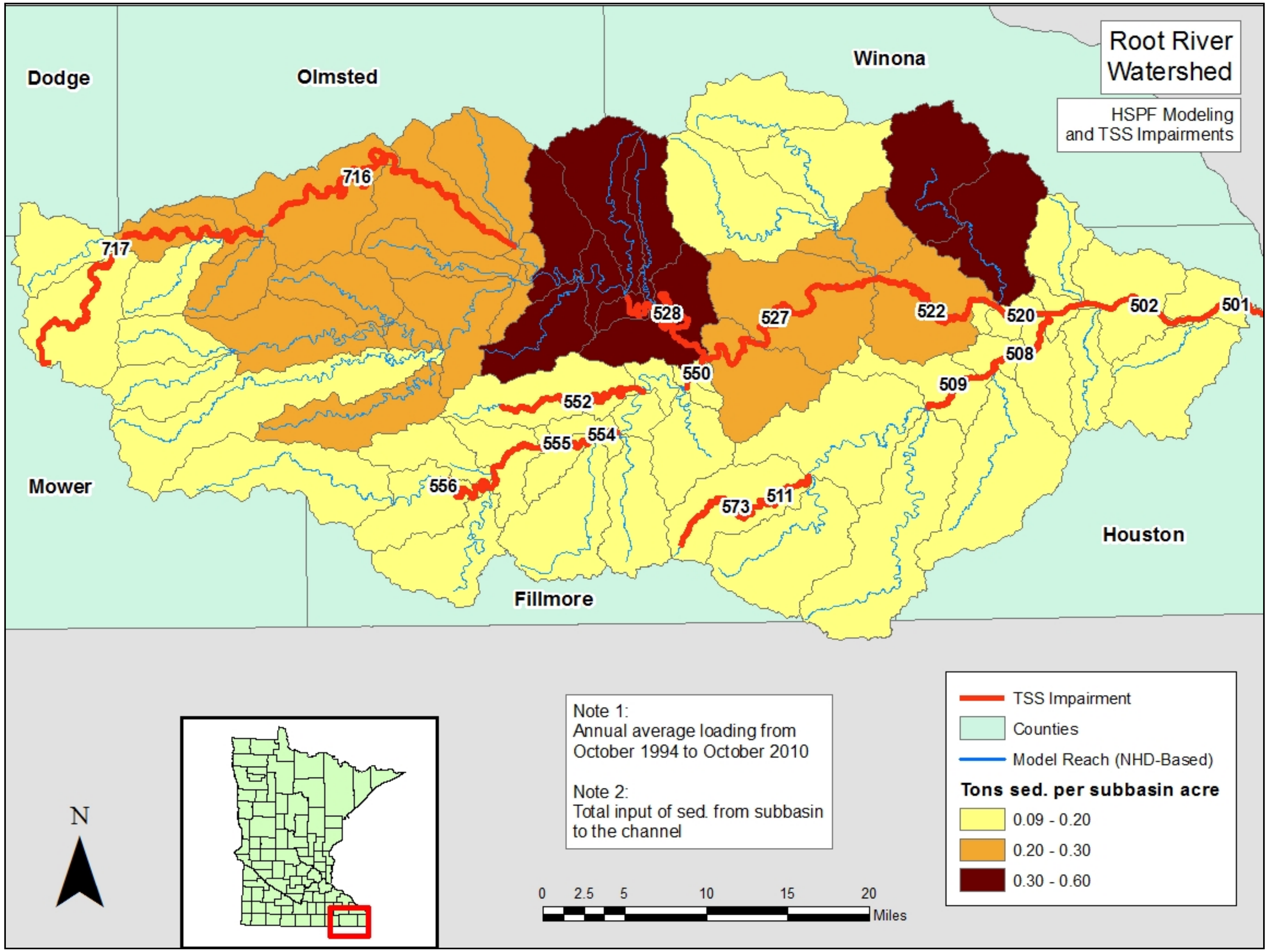


Figure 20. HSPF modeling results for sediment loading and TSS impairments in the RRW.

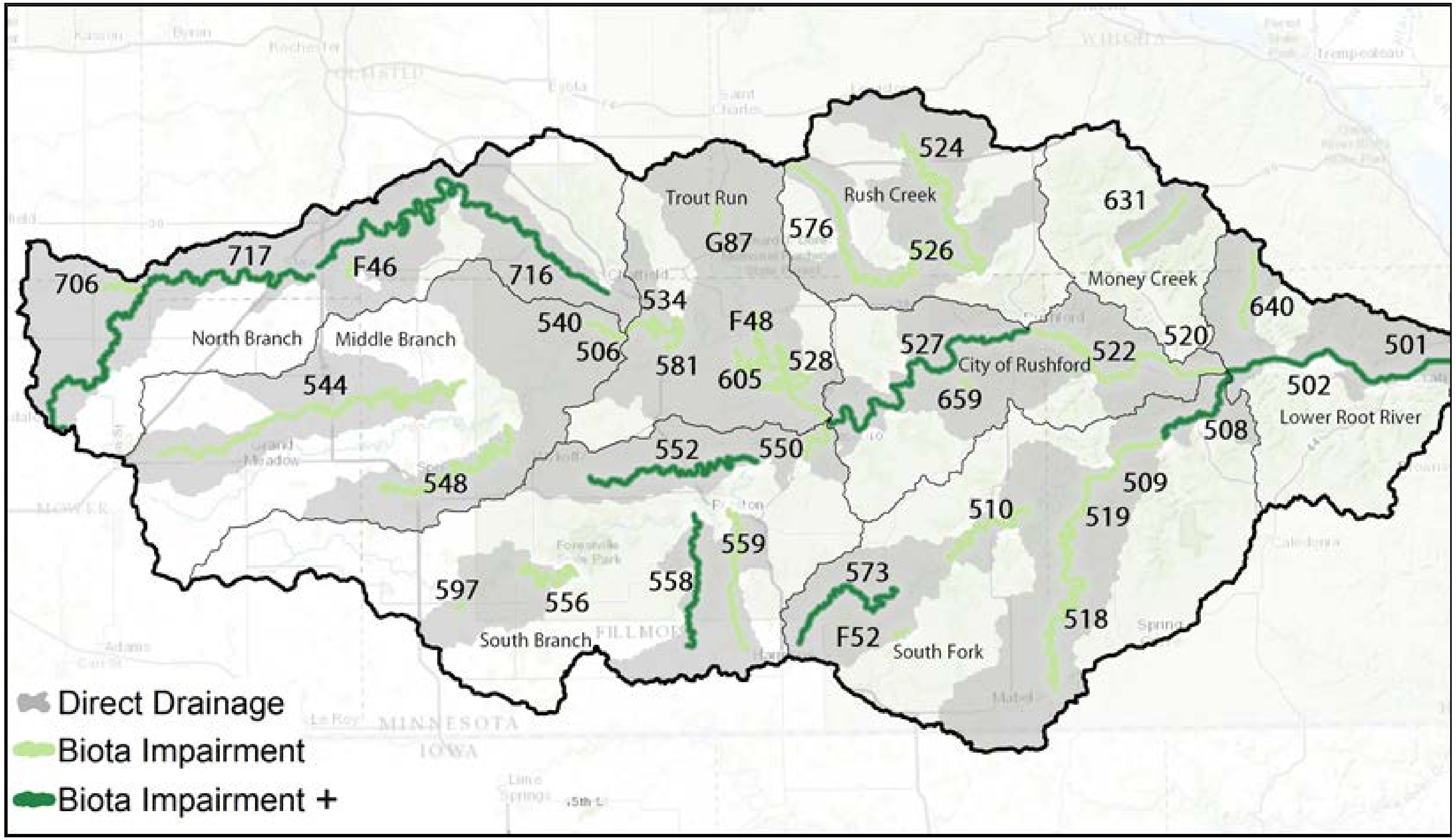


Figure 21. Biota prioritization based on where aquatic life use impairments based on IBIs (fish and/or aquatic macroinvertebrates) occur in the RRW. It is also based on either a sediment driver of aquatic life use impairment and drinking water use impairment and associated conclusive stressors, which is denoted with the + on the map.

3.2 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. 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." A resourceFULL decision is 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 this University of Minnesota Extension website.

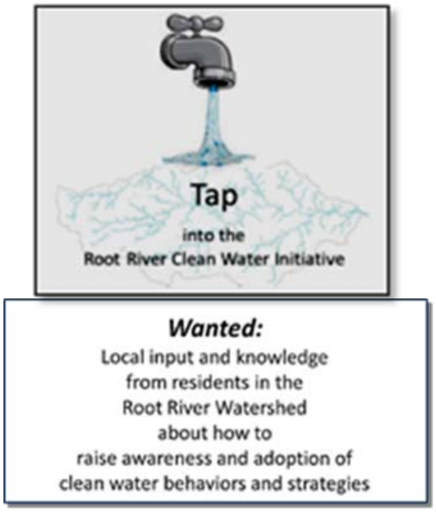
Development of Citizen Advisory Group (CAG) in Root River:

Local citizen input is needed for developing strategies to encourage adoption of BMPs that will fit the landscape and land uses in different parts of the RRW. In order to make informed recommendations, local citizens must also understand the issues and the tools that can be used. Natural resource professionals cannot do this alone. It takes a network of informed citizens throughout the watershed to keep this conversation going.

Barb Radke, a University of Minnesota-Extension (UM-E) Educator, from the Leadership and Civic Engagement Program, developed a program that included training in civic engagement, leadership and facilitation techniques.

CAG Recruitment Process

The recruitment phase began with Fillmore SWCD (FSWCD) and UM-E attending community service group meetings (such as Lions and Rotary Clubs) from April 2011 to April 2012. The purpose was to recruit volunteers for a watershed group to: 1) provide input into strategies to raise public awareness of water resource issues in the watershed and 2) to encourage adoption of BMPs for water quality restoration and protection. Presentations were given at meetings of civic organizations in 12 cities in the watershed. An attempt was made to present to 10 agricultural and conservation groups, but no response was received. The FSWCD and UM-E staff met several times to develop the presentation format and theme, which was *Tap into the Root River: Clean Water Initiative (Tap into the Root)*. The presentation was usually done in pairs. Articles about *Tap into the Root* were published by Historic Bluff Country in the newsletter that goes to all their members and in the December 2011 edition of the FSWCD Conservation Chronicles online newsletter.



CAG Meetings

The *Tap into the Root* Citizens' Advisory Group (CAG) began meeting in May 2012, with a dozen members. The group met six times in 2012. At the initial meetings, members were:

- oriented to their roles and responsibilities and the game plan for the next meetings;
- provided with water quality information for the Root River;
- asked to respond to the question "What has to happen to keep you involved?"

The later meetings included training in civic engagement skills and processes/methods for doing effective civic engagement, identifying stakeholders, and dealing with difficult people. These meetings were to prepare them to lead citizen conversations in their respective communities within the watershed.

Citizen Conversations

How people were invited

Advertisements for the citizen conversations were placed in local papers and on the radio. Poster invitations were hung around local communities also inviting anyone from the public to attend. Personal invitations were made from the CAG to fellow citizens in their respective communities.

Agenda creation

Agendas for the citizen conversations were set through discussions at the CAG meetings prior to the conversations. The CAG, Fillmore SWCD, UM-E and the MPCA all had input on the conversations and how they would be carried out. The goal was to get input from local citizenry on what was important to them regarding their water resources, and opinions on how those important items should be addressed.

Content of the Citizen Conversations

Round 1: From March 25 to May 8, 2013, seven Citizen Conversations were held across the RRW. The purpose of these Conversations was to gather citizen input for developing implementation strategies for the RRW that will reduce concentrations of sediment, bacteria and nitrates. The members of the Root CAG led the conversations. A Meadowlark Foundation grant was used to pay for food for the participants, a welcoming meeting space, door prizes from local businesses, advertising, and other meeting needs. A total of 148 people attended the seven events. Food (either a meal or dessert, depending on time of event) was served. Local groups (such as 4-H or a church) or caterers provided the food. People who pre-registered for the events received a bonus gift. Door prizes were also raffled off to the participants from local businesses (e.g., Norseland Lefse, Red Barn Ice Cream, SWCD trees and plat books, National Trout Center items, Houston Nature Center books). A placemat was created which had the watershed printed on it plus facts about the watershed. Some brief background was provided before the civic engagement activity about the purpose of the meeting, the funding sources, and information about the watershed. The general tone of all the meetings was respectful and focused. The events lasted 2.5 hours; however, many stayed later to discuss issues further.

Directed paired conversations along with other activities were provided at the Citizen Conversations. A large, poster-sized watershed map was placed on a wall at each meeting and participants were asked to mark where they lived with a colored dot sticker. The same map was brought to each conversation, so in the end, there was a visual representation of where participants came from in the watershed.

A timeline of watershed events was also placed on a wall at each Conversation. Participants were asked to think about events that had happened either on their property or in the watershed in general and write them along the timeline.

Round 2: In June of 2014, five follow-up Root River Citizen Conversations were convened and attended by 39 citizens. These Conversations were held after the WRAPS table was drafted to inform people of the land use practices proposed to address water quality impairments and to identify local resources and assets that can help to implement the practices. These events were again led by the CAG members using training provided by UM-E staff. Before each of the four questions was posed to the group for discussion, a short presentation was given including: background on the WRAPS, and a summary of the BMPs that were chosen for the WRAPS table.

Survey results

After each citizen conversation, a survey was given to participants to gauge their satisfaction with the event. Results indicated that a majority of the participants valued the conversations.

Lessons Learned/Challenges

For recruitment of the CAG, organizers had to rely on other group's agendas. Organizers also found that extending the civic engagement process to groups that serve more rural landowners is a challenge. Typically, the existing civic organizations are comprised heavily of people who live and work in town versus farmers and rural landowners.

The Citizens' Group assisted with preparing applications submitted to the Bush Foundation in July 2013 and in March 2014 (with Eagle Bluff Environmental Learning Center as a partner) for a Community Innovations Grant to embed civic engagement into a watershed plan using the Citizens' Group as the core entity for developing this process for the watershed. The grants were not funded. However, the Citizens' Group continues to meet to plan future activities building on what was learned from the Citizen Conversations (now called FORR-see Future Plans section for more). Maintaining interest in the Citizens' Group is a challenge especially on a watershed-wide scale. Groups formed on the subwatershed scale may be more effective and foster more connection with a local stream.

Development of a Farmer-led Council in the Rush-Pine subwatershed

Two planning meetings were held in late 2011 with Winona County staff about formulating a farmer-led council in Rush-Pine Watershed. A federal grant application submitted by Winona County to the Fishers and Farmers Program was partially funded for a facilitator in the Rush-Pine watershed to establish a farmer-led watershed council. Funding from The Nature Conservancy also helped fund the facilitator.

The facilitator contacted about 30 farmers and landowners in the watershed to generate support for the farmer-led council which began meeting in April 2012. The Rush-Pine Farmer Led Council hosted a dinner meeting at the Rick Ruberg farm on September 11, 2012, that was attended by about 25 people. SWCD staff presented information about the Mississippi River Basin Initiative (MRBI) funding that was available through fiscal year 2013, for the watershed. One of the council members talked about his no till operation and had some of his equipment on hand for people to see. The Council met in January and February 2013, to discuss outreach activities for the coming year. Council officers were elected at the February meeting. Priorities were placed on encouraging cover crops. A cover crop field day was sponsored at the Bruihler farm in April 2013. The Council met again in July to develop a cover crop program with $10,000 from The Nature Conservancy. Local co-ops purchased winter rye seed and distributed it to farmers who in turn seeded slightly less than 400 acres. Those planting cover crops for the first time were given priority. The SWCD administered the funds for the project. The cooperatives were active partners in signing up acres and tracking seed use. The Rush-Pine council continues to meet today and host field days to engage and educate surrounding farmers.

Future Plans

Friends of the Root River (FORR)

Members of the *Tap into the Root* CAG took the initiative to continue their efforts after monetary support for the group had ended. New members have joined the group since the initial effort and a board of approximately 10 members has been established. A mission statement and action areas have been agreed upon by the board, and board positions have been voted upon. The FORR is now officially a 501c3 non-profit entity. They have established a website to help connect with citizens of the watershed.

The FORR will be a key in moving forward with citizen driven actions in the watershed to protect and restore its water quality.

Mission statement: "The Friends of the Root River engages citizens to protect, restore and value the water resources in the Root River watershed."

Action Areas:

1. Advocate for positive conservation actions that mitigate land and water impairments, enhance and restore wetlands, and reduce effects of natural disasters to the watershed.
2. Connect with groups, agencies, farmers, land owners, local businesses and individuals who value the health of the natural resources in the watershed.
3. Educate residents, visitors and other stakeholders about the vast dimensions of the watershed's natural resources through educational programs and conservation actions.
4. Engage residents and stakeholders to participate in conservation, educational programs and adopt appropriate BMPs.

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 April 18, 2016 to May 17, 2016.

3.3 Restoration & Protection Strategies

As referenced throughout this document, the RRW is the focus of various research projects and planning efforts. Strong partnerships exist between state agencies, local government units, non-profit groups and federal agencies. Therefore, it is important to take into account this other activity and rely on professional judgment to determine what restoration and protection efforts are viable and supported in the RRW. This was done to the extent possible for the strategies in this report.

The HSPF model scenarios that were developed in discussion with state agency and local government partners focused on nitrogen reduction (see Section 3.1 Targeting of Geographic Areas) including increases in cover crop implementation, changes in nitrogen fertilizer application rates and timing, and perennial vegetation put in place on toe slopes.

Strategies from the NRS were examined to determine how stakeholders of the RRW could do their part to reduce downstream impacts. The Nitrogen Reduction Planning tool (NBMP tool) used to estimate types and magnitude of the BMPs needed to get to the NRS recommended reductions was run with various scenarios in a meeting of local partners. One scenario is shown below (Table 6).

The main issues that need to be addressed in the RRW for restoration are:

1. Nitrate reduction via reduction of input to and loss from corn/soy agricultural acres,
2. Reduction of sediment loss from upland areas and stabilization of flood plains and terraces,
3. Determination of why bacteria concentrations remain high in many streams despite numerous efforts at reduction, and
4. Addressing physical habitat issues that are affecting aquatic life communities of the streams.

Strategies to address these issues are laid out in the implementation tables later in this section.

For protection concerns, overlap of areas identified by various planning efforts should be considered. This includes the high fish and macroinvertebrate IBI scores and Conservation Opportunity Areas from the Root River Landscape Stewardship Plan included in Section 2.5 Protection Considerations. Others include various DNR identified areas (Outstanding Resource Value Waters, Minnesota's State Wildlife Action Plan, State Parks and Trails, etc.), MDH identified areas (Drinking Water Supply Management Areas, Water supplies vulnerable to surface contaminants, etc.), and others.

It is assumed that Local Water Plans/1W1P documents will utilize the technical information provided in this document describing what needs to be done to reach water quality goals and make decisions on what geographic areas and/or parameters they have time, resources and willingness to focus on.

NBMP Tool

According to the NRS (MPCA 2014) the main nutrient sources to the Mississippi River are phosphorus from agricultural cropland runoff, wastewater, and streambank erosion, and nitrogen from water leaving cropland via groundwater and agricultural tile. The associated phase I milestones for the Mississippi River Basin N and P are 20% reduction in N loads and an additional 12% reduction in P loads from current conditions. These reductions represent a target reduction from the Root River, which when combined with similar proportional loads from other Mississippi River Basin HUC 8 watersheds will meet Minnesota's combined reduction goals for the Mississippi River leaving Minnesota.

The purpose of the Nitrogen in Minnesota Surface Waters (MPCA 2013) study was to characterize N loading to Minnesota's surface waters, and assess conditions, trends, sources, pathways, and potential BMPs to achieve nitrogen reductions in our waters. Part of this study's effort was to develop a spreadsheet tool called the NBMP tool (the tool is described in more detail in the nitrogen study report chapter F1). Using the nitrogen reduction planning tool involves three steps. Since the NBMP tool and the later developed PBMP tool only evaluate agricultural practices, which will be less than the total watershed acreage, the first step is to acknowledge the total number of cropland acres being considered, along with the total number of suitable acres that are applicable for each BMP being considered, enter proposed target adoption rates for each selected BMP, and compare the effectiveness and cost of the individual BMPs. The second step is to compare suites of the BMPs that would attain any given reduction in the N load noting the associated estimated cost. The third step is to "drill down" to the details and assumptions behind the models of effectiveness and costs of any particular BMP and make any adjustments to reflect your particular situation. The tool was used to view a scenario in the RRW that would approximate acres of BMP adoption necessary to achieve roughly a 20% N reduction. This aligns with the NRS phase 1 reduction goal for N. While the tool was recently updated and now has the capability to be applied to HUC-10 level watersheds, at the time of developing this report and working with local partners, the HUC-8 scale was what was available and therefore what was used as reference. The net BMP treatment cost in this scenario, including N fertilizer cost savings and corn yield impacts, was $20.7 million per year (Table 6).

For more information on a pilot project conducted for the NRS in the Root River subwatershed of Watson Creek using the NBMP and PBMP tool, see this Minnesota University at Mankato website.

Table 6. An example of the Nitrogen Reduction Planning tool output for a hypothetical scenario based on 568,000 total suitable acres in the RRW. An average weather pattern where all preplant N is available was assumed. The four columns represent from left to right, the BMP Type, the total fraction of acres in the RRW where the BMP is considered suitable, the level of adoption of the suitable acres, and finally the resulting number of acres that will be treated if that BMP is implemented at that level of adoption.

BMP Type	% agricultural acres suitable	% of suitable acres targeted for adoption	Acres treated
Corn acres receiving target N rate, no inhibitor or timing shift	55%	55%	159,000
Fall N applications switched to spring, % of fall-app. acres	4%	80%	1,750
Restored wetlands	3%	80%	1,570
Saturated buffers	2%	80%	10,610
Riparian buffers 100' wide	5%	90%	26,470
Corn grain and soybean acres w/cereal rye cover crop	10%	90%	50,400
Short season crops planted to a rye cover crop	5%	80%	19,650
Perennial crop % of corn & soy area (marginal land only)	6%	40%	12,910

Implementation Tables

Due to the high number of impairments in the RRW, the implementation table was split out by HUC-10 subwatershed in an effort to make it easier to read and reference. Therefore, one table contains strategies that address overarching watershed needs, and nine subsequent tables, one for each HUC-10 subwatershed within the RRW, contain strategies that address needs specific to the respective subwatershed. Subwatershed maps appear before each subwatershed table in order to orient the reader to the impairments that exist in the subwatershed, as well as the critical areas that were identified. An overarching HUC-8 map of the RRW critical areas can be found at the end of the subwatershed tables (Figure 31).

As noted in the disclaimer in the beginning of this document, the RRW is a 2008 start watershed that followed the original process for WRAPS first set out by MPCA, and was initiated prior to the Clean Water Accountability Act (CWAA). Therefore, the same tools were not used as those WRAPS than began after the CWAA, resulting in less rigor than is preferred with more recently begun watersheds. Within the table, the “Timeline to reach WQ goal” column is based on goals from the NRS document (MPCA 2014a). Suspended sediment goals are tied to the phosphorus goal of 12% reduction by 2025. Nitrate and other parameters follow the nitrate goal of 45% reduction by 2045. These goals were chosen as the best estimate at the time of this report since analysis to determine more detailed timelines was not done. Also, the columns “Estimated Scale of Adoption Needed” and “Interim 10-year Milestones” are narrative benchmarks are the best information available at the time of this report. It is hoped that in cycle two, the RRW will go through more vigorous analysis to improve these columns.

Watershed Wide

Across the entire RRW, restoration and protection strategies to address sediment, nitrate, bacteria, and aquatic communities would improve the landscape. Steps should be taken beyond those needed in specific sections of the watershed to reduce the amounts of sediment, phosphorus, and nitrates leaving the mouth and entering the Mississippi River to assist with reduction of nutrients and the resulting hypoxic zone in the Gulf of Mexico (Table 7).

Table 7. Implementation table showing an example of strategies and actions proposed across the entire RRW that could achieve water quality targets, both for the RRW and for downstream goals.

HUC-10 Subwatershed	Waterbody and Location		Parameter (incl. non-pollutant stressors)	Water Quality		Strategies	Estimated Scale of Adoption Needed	Governmental Units with Primary Responsibility										Other Partners				Timeline to reach WQ goal	Interim 10-yr Milestones
	Waterbody (ID)	**Location** and Upstream Influence Counties		Current Conditions	Goals / Targets			MDA	BWSR/SWCD	MPCA	County	DNR	MDH	SE Tach JPB	SE WRB	Cities	Townships	NRCS	TNC	TU	LSP		
Restoration Strategies for all Subwatersheds	All Impaired Streams	**All**	Suspended Sediment, E. coli, Nitrate, Fish and Macroinvertebrates	Varies	Varies	NPDES point source compliance	Watershed wide, MPCA permitted facilities			•												NA	NA
						Cover Crops (340)	Corn silage and soybean acres		•					•				•			•		
						Shoreland ordinance buffer compliance (390, 391, 393)	Watershed wide, DNR protected waters		•		•		•					•					
						Grassed waterways (412)	Watershed wide, row crop acres; SPI/LiDAR analysis		•				•					•					
						Contour farming (330)	Watershed wide, row crop acres >6% slope		•									•					
						Water and sediment storage practices (410, 600,638)	Target using tools such as LiDAR		•		•			•				•					
						Residue management (329, 345)	Watershed wide		•									•					
						Civic Engagement	Watershed wide	•	•	•	•	•	•			•	•				•		
Protection Strategies for all Subwatersheds	All Unimpaired Streams	All	Suspended Sediment, E. coli, Nitrate, Fish and Macroinvertebrates	Varies	Maintain and enhance	Same as Restoration Strategies	Watershed Wide	•	•	•	•	•	•			•	•				•	NA	NA

HUC-10 Subwatershed	Waterbody and Location		Parameter (incl. non-pollutant stressors)	Water Quality		Strategies	Estimated Scale of Adoption Needed	Governmental Units with Primary Responsibility										Other Partners				Timeline to reach WQ goal	Interim 10-yr Milestones
	Waterbody (ID)	**Location** and Upstream Influence Counties		Current Conditions	Goals / Targets			MDA	BWSR/SWCD	MPCA	County	DNR	MDH	SE Tach JPB	SE WRB	Cities	Townships	NRCS	TNC	TU	LSP		
	All	Fillmore, Houston, Winona	Landscape Protection	High quality native vegetation and high biodiversity in watershed	Maintain and enhance	Root River Landscape Stewardship Plan (2013) See Key to Strategies Table[4]	Landscape Stewardship Plan Pine Creek-Rushford Conservation Opportunity Area parcel identification		•			•						•	•				Increase number of private lands completing and implementing Comprehensive Stewardship Plans
Strategies to Address Downstream Goals	All	All	Phosphorus and Sediment	No local phosphorus impairments; separate from local sediment-driven impairments.Downstream impairments: Mississippi River, Gulf of Mexico 2009: 164,870 kg TP 94,165,485 kg TSS 2010: 342,900 kg TP 238,992,310 kg TSS 2011: 359,760 kg TP 268,670,900 kg TSS Measured at Root River outlet (near Hokah)	45% phosphorus load reduction per NRS (which would meet Pepin goal too); some progress already documented20% TSS load reduction per South Metro Mississippi TMDL	Nutrient Reduction Strategy (NRS)	Saturation effort in upland segments of each subwatershed with focus provided by local partners.		•									•				2025	Phosphorus and sediment loads continue to decrease; examine in 2025 (first NRS milestone)Subwatersheds with the lowest treatment percentage, increased to >20% treated (end goal of 40%)
						Stream and Streambank Restoration	Focus on DNR priority areas		•			•											
						Land Retirement/Acquisition			•			•							•				
						Local Land Use Ordinance Administration	100% compliance as it applies to shoreland, blufflands, feedlots, wetlands, mining		•							•	•	•					

HUC-10 Subwatershed	Waterbody and Location		Parameter (incl. non-pollutant stressors)	Water Quality		Strategies	Estimated Scale of Adoption Needed	Governmental Units with Primary Responsibility										Other Partners				Timeline to reach WQ goal	Interim 10-yr Milestones
	Waterbody (ID)	**Location** and Upstream Influence Counties		Current Conditions	Goals / Targets			MDA	BWSR/SWCD	MPCA	County	DNR	MDH	SE Tach JPB	SE WRB	Cities	Townships	NRCS	TNC	TU	LSP		
	All	All	Nitrogen	Separate from local nitrogen-driven impairments; Downstream impairments: Gulf of Mexico 2009: 4,320,674 kg NOx 2010: 6,351,388 kg NOx 2011: 8,567,361 kg NOx Measured at Root River outlet (near Hokah)	45% load reduction per NRS	Nutrient Reduction Strategy (NRS)	Saturation effort in upland segments of each subwatershed with focus provided by local partners.		•									•				2045	Decreased nitrate loads by 2025 (first NRS milestone); observed change in nitrate trend at wells/springs (per MGS lag time analysis)
						Local Land Use Ordinance Administration	100% compliance as it applies to shoreland, blufflands, feedlots, wetlands, mining		•							•	•	•					

Root River (Lower)

In the Root River (Lower) subwatershed, suspended sediment concentrations (turbidity) as well as poor macroinvertebrate communities are the main issues (Figure 22). Strategies to address these issues and others can be found in Table 8. Addressing the concerns on the AUIDs of the mainstem is dependent on upstream activities. There are not any critical areas identified in this subwatershed.

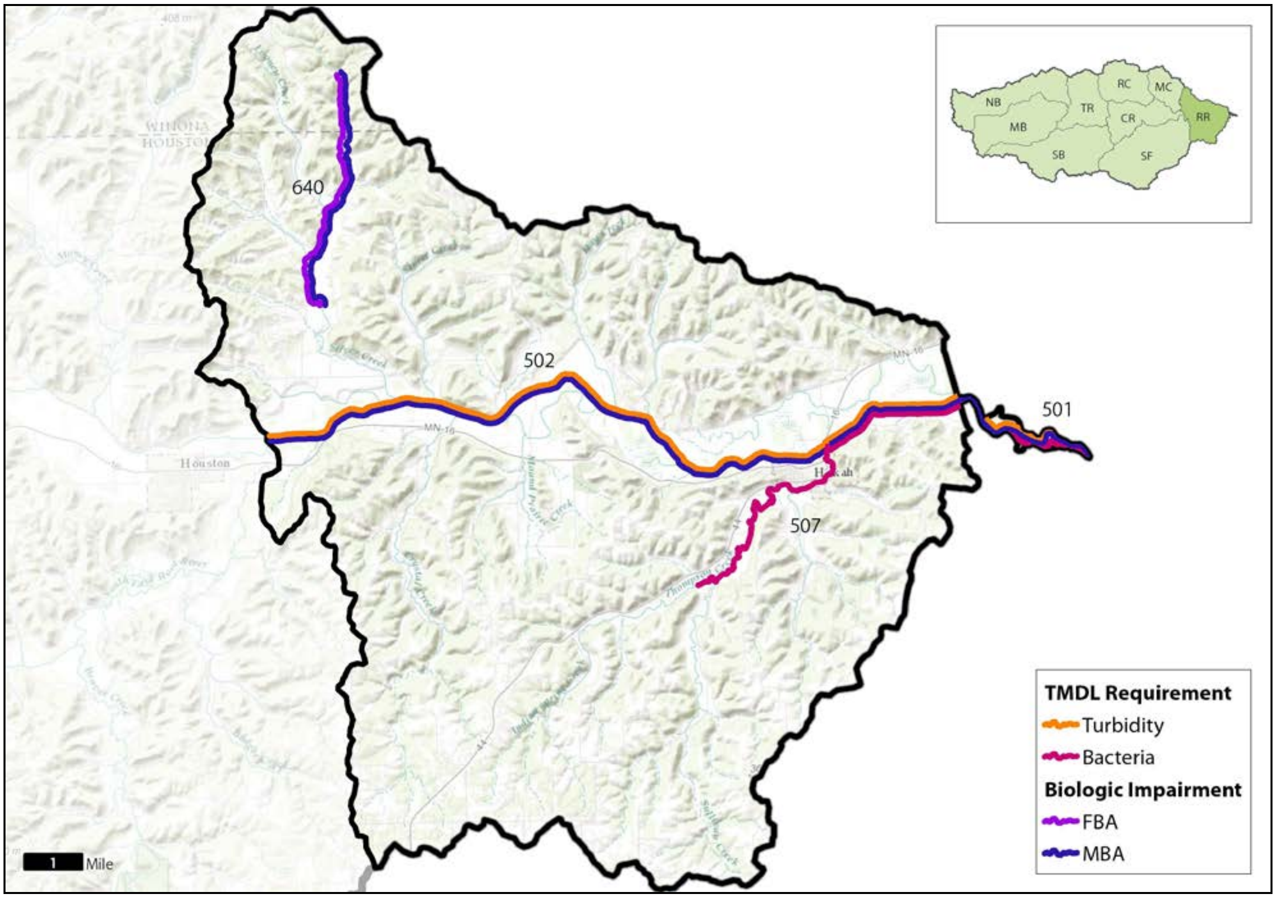


Figure 22. Impairments for bacteria, fishes bioassessment (FBA), aquatic MBA and turbidity in the Root River (Lower) Subwatershed. Last three-digits of impaired AUID appear next to stream reaches.

Table 8. Implementation table showing an example of strategies and actions proposed for the Root River (Lower) subwatershed that could achieve water quality targets.

HUC-10 Subwatershed	Waterbody and Location		Parameter (incl. non-pollutant stressors)	Water Quality		Strategies	Estimated Scale of Adoption Needed	Governmental Units with Primary Responsibility										Other Partners				Priority Level	Timeline to reach WQ goal	Interim 10-yr Milestones
	Waterbody (ID)	**Location** and Upstream Influence Counties		Current Conditions	Goals / Targets			MDA	BWSR/SWCD	MPCA	County	DNR	MDH	SE Tech JPB	SE WRB	Cities	Townships	NRCS	TNC	TU	LSP			
Root River (Lower)	Root River (501), Thompson Cr to Mississippi R	**Houston,** Dodge, Fillmore, Olmsted, Mower, Winona	Macroinvertebrates (Physical Habitat)	MIBI: 19; Threshold 30.7	Increase quality of habitat	See Key to Strategies Table[5]	Upstream subwatersheds		•	•		•		•	•			•	•	•	•	L	2045	Improved IBI.
			Macroinvertebrates (Nitrate)	Nitrate tolerant species comprise 80.5% to 87% of total community	Reduce nitrate tolerant species	See Key to Strategies Table[1]	Upstream subwatersheds	•	•	•	•	•		•	•	•		•	•		•	M	2045	Improved MIBI.
			Suspended Solids	Very High: 521 tons/day High: 257 tons/day Mid: 192 tons/day Low: 155 tons/day Very Low: 121 tons/day	65 mg/L TSS met 90% of time Apr-Sep	See Key to Strategies Table[2]	Upstream subwatersheds	•	•		•	•		•	•			•	•	•	•	L	2025	Decreasing TSS trend. Improved IBI.
	Root River (502), S Fk Root R to Thompson Cr	**Houston**, Dodge, Fillmore, Mower, Olmsted, Winona	Macroinvertebrates (Physical Habitat)	MIBI: 20; Threshold 30.7	Increase quality of habitat	See Key to Strategies Table[5]	Upstream subwatersheds		•	•		•		•	•			•	•	•	•	L	2045	Decreasing trends. Improved MIBI.
			Macroinvertebrates (Nitrate)	84% average for nitrate tolerant species	Reduce nitrate tolerant species	See Key to Strategies Table[1]	Upstream subwatersheds	•	•	•	•	•		•	•	•		•	•		•	M	2045	Decreasing trends. Improved IBI.
			Suspended Solids	Very High: 474 tons/day High: 241 tons/day Mid: 168 tons/day	65 TSS mg/L met 90% of time Apr-Sep	See Key to Strategies Table[2]	Upstream subwatersheds	•	•		•	•		•	•			•	•	•	•	L	2025	Decreasing TSS trend. Improved IBI.

HUC-10 Subwatershed	Waterbody and Location		Parameter (incl. non-pollutant stressors)	Water Quality		Strategies	Estimated Scale of Adoption Needed	Governmental Units with Primary Responsibility										Other Partners				Priority Level	Timeline to reach WQ goal	Interim 10-yr Milestones
	Waterbody (ID)	**Location** and Upstream Influence Counties		Current Conditions	Goals / Targets			MDA	BWSR/SWCD	MPCA	County	DNR	MDH	SE Tech JPB	SE WRB	Cities	Townships	NRCS	TNC	TU	LSP			
				Low: 126 tons/day																				
				Very Low: 77 tons/day																				
	Thompson Cr (507), T103N R5W S12, south line to Root R	**Houston**	*E. coli*	Very High: 19 billions orgs/day	Geometric mean:126/100ml Individual: 1,260/100 ml	SEMN Bacteria Implementation Plan (2007) See Key to Strategies Table[3]	Upstream subwatersheds		•	•	•			•				•				L	2045	Decreasing E.coli trend.
				High: 2 billion orgs/day																				
				Mid: 0.7 billion orgs/day																				
				Low: 0.4 billion orgs/day																				
				Very Low: 0.2 billion orgs/day																				
	Silver Creek (640), T105 R6W S35, north line to T104 R6W S14, south line	**Winona, Houston**	Fish and Macroinvertebrates (Physical Habitat)	FIBI: 34; Threshold 45 MIBI: 18; Threshold 46	Reduce peak flows to improve channel stability	Pasture Management/Prescribed Grazing (528)	Riparian Pastures		•					•				•			•	L	2045	Improved IBI.
						Cover crops (340)	Corn silage and soybean acres		•					•				•	•		•			
						Streambank Protection and Stream Habitat Improvement (580, 395)	Localized stream reaches; DNR Fisheries priorities		•			•		•				•	•	•				

City of Rushford-Root River

In the city of Rushford Subwatershed, high suspended sediment concentrations (turbidity) as well as poor macroinvertebrate communities are the main issues (Figure 23). Strategies to address these issues and others can be found in Table 9. Addressing the concerns on the AUIDs of the mainstem will be dependent on upstream activities. There are not any critical areas identified in this subwatershed.

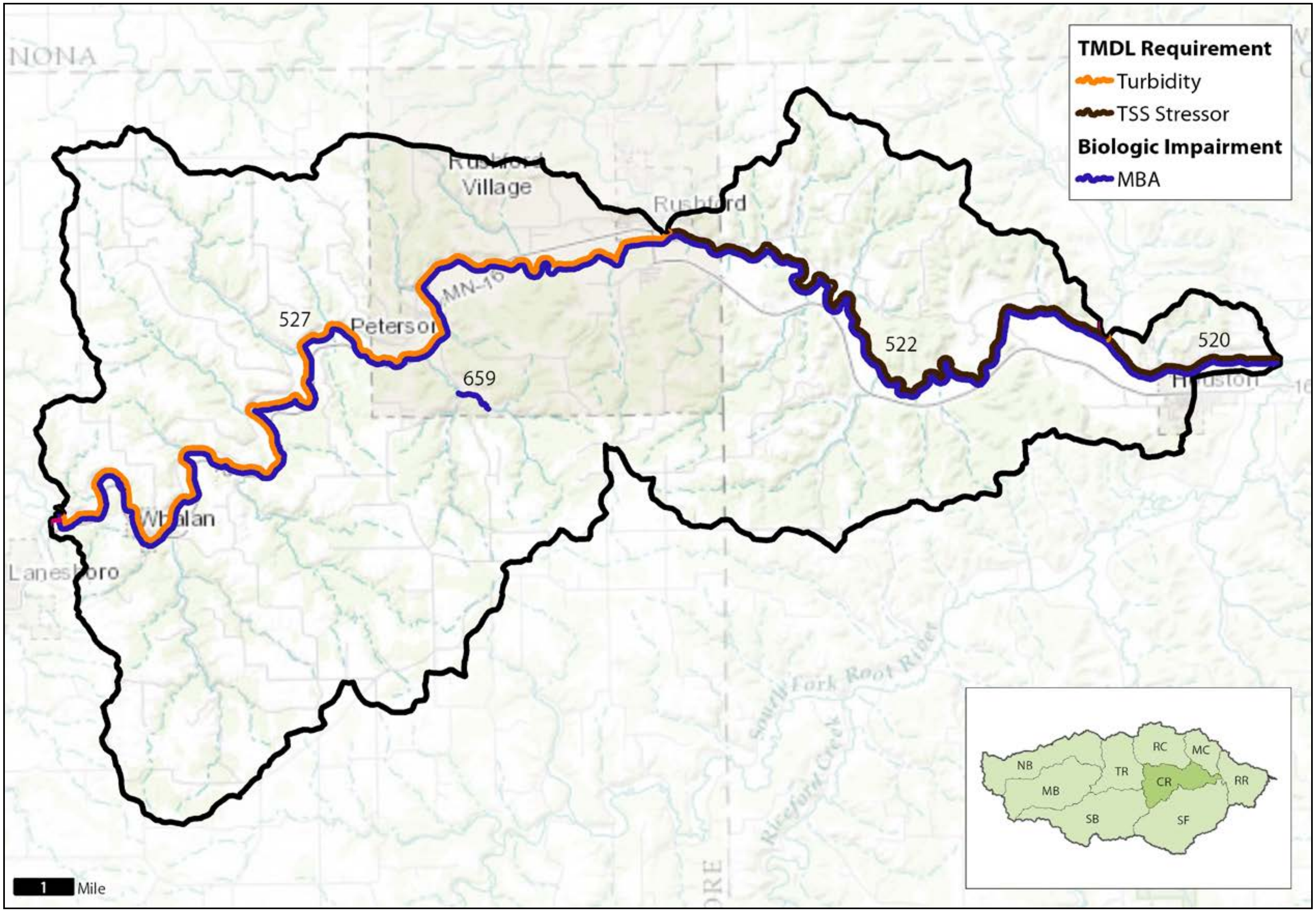


Figure 23. Impairments for aquatic MBA, TSS and turbidity in the City of Rushford-Root River Subwatershed. Last three-digits of impaired AUID appear next to stream reaches.

Table 9. Implementation table showing an example of strategies and actions proposed for the city of Rushford-Root River subwatershed that could achieve water quality targets.

HUC-10 Subwatershed	Waterbody and Location		Parameter (incl. non-pollutant stressors)	Water Quality		Strategies	Estimated Scale of Adoption Needed	Governmental Units with Primary Responsibility										Other Partners				Priority Level	Timeline to reach WQ goal	Interim 10-yr Milestones
	Waterbody (ID)	**Location** and Upstream Influence Counties		Current Conditions	Goals / Targets			MDA	BWSR/SWCD	MPCA	County	DNR	MDH	SE Tech JPB	SE WRB	Cities	Townships	NRCS	TNC	TU	LSP			
City of Rushford - Root River	Root R (520), Money Cr to S Fk Root R	**Houston**, Dodge, Fillmore, Mower, Olmsted, Winona	Macroinvertebrates (Physical Habitat)	MIBI: 17.6, 37.5; Threshold 30.7	Increase quality of habitat	See Key to Strategies Table[5]	Upstream subwatersheds		•	•		•		•	•			•	•	•	•	L	2045	Improved habitat rating and MIBI.
			Macroinvertebrates (Suspended Sediment)	Very High: 418 tons/day High: 200 tons/day Moderate: 130 tons/day Low: 92 tons/day Very Low: 57 tons/day	Improve to 35% TSS intolerant (avg of RR warm water stations)	See Key to Strategies Table[2]	Upstream subwatersheds	•	•		•	•		•	•			•	•	•	•	L	2025	Decreasing trend in sediment levels. Increased TSS intolerant species
	Root R (522), Rush Cr to Money Cr	**Fillmore, Houston,**Dodge, Olmsted, Mower, Winona	Macroinvertebrates (Physical Habitat)	MIBI 21.36; Threshold 30.7	Increase quality of habitat	See Key to Strategies Table[5]	Upstream subwatersheds		•	•		•		•	•			•	•	•	•	L	2045	Improved habitat rating and MIBI.
			Macroinvertebrates (Suspended Sediment)	Very High: 409 tons/day High: 191 tons/day Moderate: 123 tons/day Low: 85 tons/day Very Low: 52 tons/day	Improve to 35% TSS intolerant (avg of RR warm water stations)	See Key to Strategies Table[2]	Upstream subwatersheds	•	•		•	•		•	•			•	•	•	•	L	2025	Decreasing TSS trends. Increased TSS intolerant species.
	Root River (527), M Br Root R to Rush Cr	**Fillmore,**Mower, Dodge, Winona	Macroinvertebrates (Physical Habitat)	MIBI: 38.3, 24.03, 17.81; Threshold 30.7	Increase quality of habitat	See Key to Strategies Table[5]	Upstream subwatersheds		•	•		•		•	•			•	•	•	•	L	2045	Improved habitat rating and MIBI.

HUC-10 Subwatershed	Waterbody and Location		Parameter (incl. non-pollutant stressors)	Water Quality		Strategies	Estimated Scale of Adoption Needed	Governmental Units with Primary Responsibility										Other Partners				Priority Level	Timeline to reach WQ goal	Interim 10-yr Milestones
	Waterbody (ID)	**Location** and Upstream Influence Counties		Current Conditions	Goals / Targets			MDA	BWSR/SWCD	MPCA	County	DNR	MDH	SE Tech JPB	SE WRB	Cities	Townships	NRCS	TNC	TU	LSP			
			Suspended Sediment	Very High: 367 tons/day High: 157 tons/day Moderate: 96 tons/day Low: 60 tons/day Very Low: 32 tons/day	65 mg/L met 90% of time Apr-Sep	See Key to Strategies Table[2]	Upstream subwatersheds	•	•		•	•		•	•			•	•	•	•	L	2025	Decreasing trend in sediment levels. Increased TSS intolerant species
	Unnamed creek (659), T104 R8W S32, east line to Unnamed cr	**Fillmore**	Macroinvertebrates (Physical Habitat)	MIBI 17.8, 16.4, 38.3; Threshold 30.7	Increase quality of habitat	Pasture Management/ Prescribed grazing (528)	Riparian pastures		•					•				•				L	2045	Improved habitat rating and MIBI.
						Cover crops (340)	Corn silage and soybean acres		•					•				•	•		•			
						Streambank Protection and Stream Habitat Improvement (580, 395)	Localized stream reaches; DNR Fisheries priorities		•			•		•				•		•				

Trout Run

In the Trout Run Subwatershed, poor macroinvertebrate communities are the main issue, especially along the main stem (Figure 24). Addressing the issues on the AUIDs of the mainstem will be dependent on activities on upstream stream reaches. Also, high bacteria concentrations are an issue on upstream reaches. Strategies to address these issues and others can be found in Table 10. No critical areas were identified.

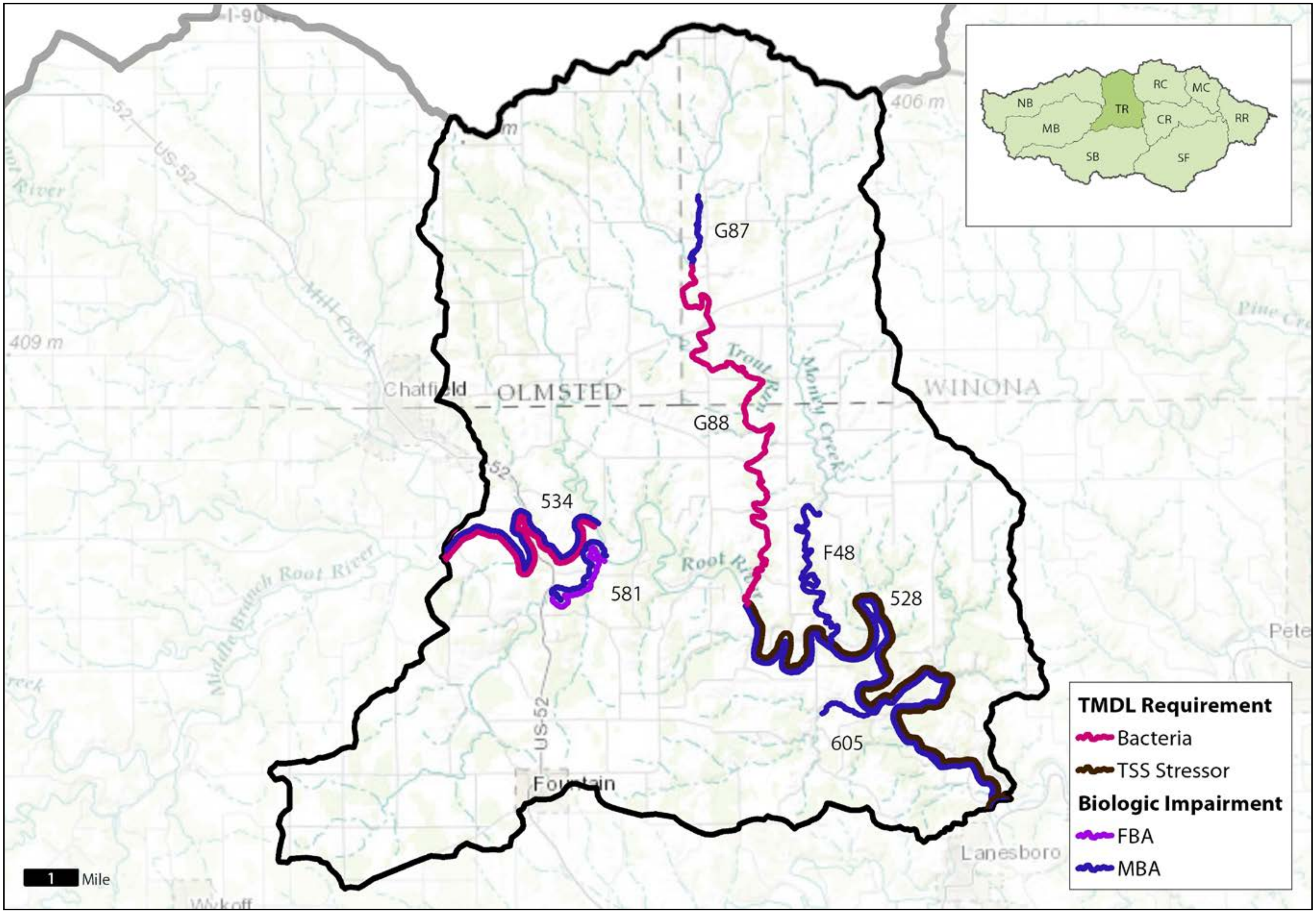


Figure 24. Impairments for bacteria, FBA, aquatic MBA and TSS in the Trout Run Subwatershed of the Root River. Last three-digits of impaired AUID appear next to stream reaches.

Table 10. Implementation table showing an example of strategies and actions proposed for the Trout Run subwatershed that could achieve water quality targets.

HUC-10 Subwatershed	Waterbody and Location		Parameter (incl. non-pollutant stressors)	Water Quality		Strategies	Estimated Scale of Adoption Needed	Governmental Units with Primary Responsibility										Other Partners				Priority Level	Timeline to reach WQ goal	Interim 10-yr Milestones
	Waterbody (ID)	**Location** and Upstream Influence Counties		Current Conditions	Goals / Targets			MDA	BWSR/SWCD	MPCA	County	DNR	MDH	SE Tech JPB	SE WRB	Cities	Townships	NRCS	TNC	TU	LSP			
Trout Run – Root River	Root River, North Branch (528), Trout Run Cr to S Br Root R	**Fillmore**, Winona, Olmsted, Mower, Dodge	Macroinvertebrates (Physical Habitat)	MIBI: 43.5, 15.3; Threshold 30.7	Increase in quality habitat	See Key to Strategies Table[5]	Upstream watersheds		•	•		•		•	•			•	•	•	•	L	2045	Improved habitat rating and MIBI.
			Macroinvertebrates (Suspended Sediment)	Very High: 242 tons/day High: 98 tons/day Moderate: 59 tons/day Low: 34 tons/day Very Low: 17 tons/day	65 mg/L TSS met 90% of time Apr-Sep	See Key to Strategies Table[5]	Upstream watersheds																2045	Decreasing trend in sediment levels.
	Root River, North Branch (534), Middle Br Root R to Lynch Cr	**Fillmore**, Olmsted, Mower, Dodge	Macroinvertebrates (Physical Habitat)	MIBI: 32.7; Threshold 35.9/ 65; Threshold 46.8	Increase in quality habitat	See Key to Strategies Table[5]	Upstream watersheds															L	2045	Improved habitat rating and MIBI.
			E. coli	Very High: 3,406 billion orgs/day High: 1,350 billion orgs/day Mid: 798 billion orgs/day Low: 457 billion orgs/day	Geometric mean: 126/100 ml Individual: 1,260/100 ml	SEMN Bacteria Implementation Plan (2007) See Key to Strategies Table[3]	Targeted to upstream sub watersheds where specific strategies apply		•	•	•			•				•				L	2045	Decreasing trend in bacteria levels.

HUC-10 Subwatershed	Waterbody and Location		Parameter (incl. non-pollutant stressors)	Water Quality		Strategies	Estimated Scale of Adoption Needed	Governmental Units with Primary Responsibility										Other Partners				Priority Level	Timeline to reach WQ goal	Interim 10-yr Milestones
	Waterbody (ID)	**Location** and Upstream Influence Counties		Current Conditions	Goals / Targets			MDA	BWSR/SWCD	MPCA	County	DNR	MDH	SE Tech JPB	SE WRB	Cities	Townships	NRCS	TNC	TU	LSP			
				Very Low: 221 billion orgs/day																				
	Rice Creek (581), T104 R11W S23, west line to M Br Root R	**Fillmore**	Fish and Macroinvertebrates (Physical Habitat)	FIBI: 36; Threshold 45 MIBI: 29.6, 30.5; Threshold 46.1	Increase in quality habitat	Streambank Protection and Stream Habitat Improvement (580, 395)	Localized stream reaches		•			•		•				•		•		M	2045	Improved habitat and MIBI and FIBI.
						Cover crops (340)	Corn silage and soybean acres		•					•				•	•		•			
			Fish and Macroinvertebrates (Nitrates)	75% average nitrate tolerant macroinvertebrate taxa	Reduce nitrate tolerant species	Increased Perennial Cover (645, 342, 643) CRP, RIM	Watershed wide, marginal lands		•			•											2045	Improved MIBI. Decreasing trend in nitrate levels.
						Nutrient (N) Management	Watershed wide	•	•	•								•			•			
						Cover crops (340)	Corn silage, soybean acres		•									•	•		•			
	Trout Run Creek (G87), T105 R10W S18, north line to Unnamed cr	**Winona,** Olmsted	Macroinvertebrates (Physical Habitat)	MIBI: 14; Threshold 46.1	Increase in quality habitat	Cover crops (340)	Canning crop, corn silage, soybean acres		•									•	•		•	M	2045	Improved habitat and MIBI.
			Macroinvertebrates (Nitrates)	88% average nitrate tolerant taxa	Reduce nitrate tolerant species	Nutrient (N) Management (590)	Watershed wide	•	•	•								•			•		2045	Improved MIBI. Decreasing trend in nitrate levels.
						Cover crops (340)	Canning crop, corn silage, soybean acres		•									•	•		•			
						Increased Perennial Cover (645, 342, 643) CRP, RIM	RIM Decorah Shale edge		•															
	Trout Run Creek (G88), Unnamed cr to M Br Root R	**Fillmore**, Olmsted, Winona	*E. coli*	Very High: 159 billion orgs/day		SEMN Bacteria Implementation Plan (2007) See Key to	Targeted to upstream sub watersheds where specific		•	•	•			•				•					2045	Decreasing trend in bacteria

HUC-10 Subwatershed	Waterbody and Location		Parameter (incl. non-pollutant stressors)	Water Quality		Strategies	Estimated Scale of Adoption Needed	Governmental Units with Primary Responsibility										Other Partners				Priority Level	Timeline to reach WQ goal	Interim 10-yr Milestones
	Waterbody (ID)	**Location** and Upstream Influence Counties		Current Conditions	Goals / Targets			MDA	BWSR/SWCD	MPCA	County	DNR	MDH	SE Tech JPB	SE WRB	Cities	Townships	NRCS	TNC	TU	LSP			
				High: 122 billion orgs/day	Geometric mean: 126/100 ml	Strategies Table[3]	strategies apply															M		level.
				Mid: 106 billion orgs/day																				
				Low: 95 billion orgs/day	Individual: 1,260/100 ml	Septic System Compliance	Community of Troy			•	•				•									
				Very Low: 53 billion orgs/day																				

Middle Branch Root River

In the Middle Branch Subwatershed, poor fish and macroinvertebrate communities and high bacteria concentrations are the main issues (Figure 25). Strategies to address these concerns can be found in Table 11. There are no critical areas identified in this subwatershed.

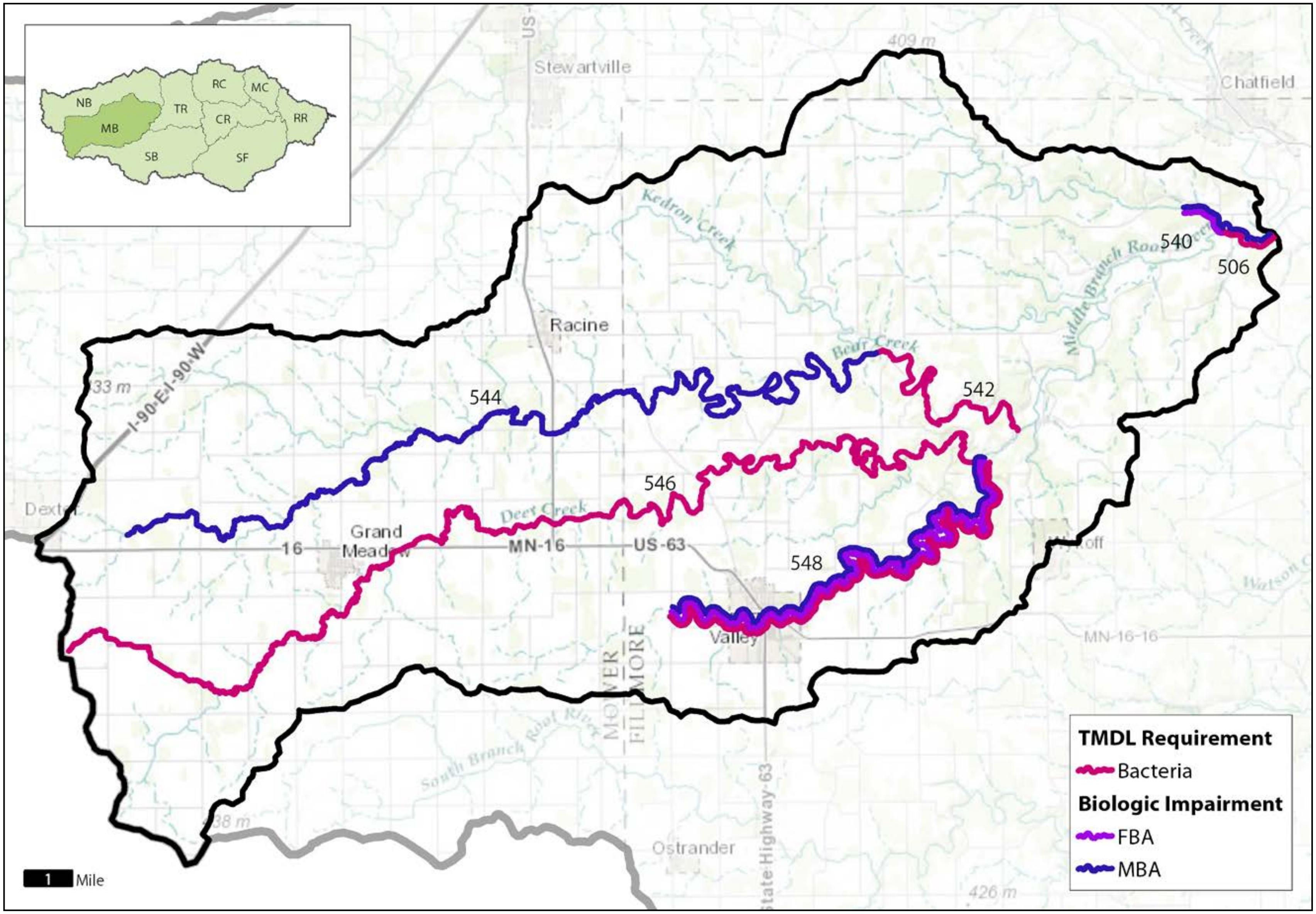


Figure 25. Impairments for bacteria, FBA and aquatic MBA in the Middle Branch subwatershed of the Root River. Last three-digits of impaired AUID appear next to stream reaches.

Table 11. Implementation table showing an example of strategies and actions proposed for the Middle Branch Root River subwatershed that could achieve water quality targets.

HUC-10 Subwatershed	Waterbody and Location		Parameter (incl. non-pollutant stressors)	Water Quality		Strategies	Estimated Scale of Adoption Needed	Governmental Units with Primary Responsibility										Other Partners				Priority Level	Timeline to reach WQ goal	Interim 10-yr Milestones
	Waterbody (ID)	**Location** and Upstream Influence Counties		Current Conditions	Goals / Targets			MDA	BWSR/SWCD	MPCA	County	DNR	MDH	SE Tach JPB	SE WRB	Cities	Townships	NRCS	TNC	TU	LSP			
Middle Branch Root River	Root River, Middle Branch (506), Upper Bear Cr to N Br Root R	**Fillmore,** Olmsted, Mower	*E. coli*	Very High: 1708 billion orgs/day High: 712 billion orgs/day Mid: 440 billion orgs/day Low: 264 billion orgs/day Very Low: 140 billion orgs/day	Geometric mean: 126/100 ml Individual: 1,260/100 ml	SEMN Bacteria Implementation Plan (2007) See Key to Strategies Table[3]	Targeted to upstream sub watersheds where specific strategies apply		•	•	•			•				•				L	2045	Decreasing trend in bacteria levels.
						Karst sinkhole treatment (527)	Sinkholes		•									•						
			Macroinvertebrates (Physical Habitat)	MIBI: 26, Threshold 34.9	Increase quality of habitat	Streambank Protection and Stream Habitat Improvement (580, 395)	Localized stream reaches		•			•		•				•		•		M	2045	Improved habitat rating and MIBI.
						Cover crops (340)	Corn silage and soybean acres		•					•				•	•		•			
			Macroinvertebrates (Nitrates)	80% nitrate tolerant taxa	Reduce nitrate tolerant species	Increased Perennial Cover (645, 342, 643) CRP, RIM	Watershed wide, focus on marginal lands		•			•							•			M	2045	Improved MIBI. Decreasing trend in nitrate levels.
						Nutrient (N) Management (590)	Watershed wide	•	•									•			•			
						Cover crops (340)	Corn silage, soybean acres		•					•				•	•		•			
	Upper Bear Creek (540), T104 R11W S18, west line to M Br Root R	**Fillmore,** Olmsted, Mower	Fish and Macroinvertebrates (Physical Habitat)	FIBI: 37; Threshold 45 MIBI: 29.6, 35; Threshold 46.1	Increase quality of habitat	Streambank Protection and Stream Habitat Improvement (580, 395)	Localized stream reaches		•			•		•				•		•		M	2045	Improved habitat rating and MIBI and FIBI.
						Pasture Management and Prescribed grazing (528)	Riparian pastures		•					•				•		•				
			Fish and Macroinvertebrates (Nitrates)	71% average nitrate tolerant taxa	Reduce nitrate tolerant species	Increased Perennial Cover (645, 342, 643) CRP, RIM	Watershed wide, focus on marginal lands		•			•							•			M	2045	Improved habitat rating and MIBI and FIBI.
						Nutrient (N) Management (590)	Watershed wide	•	•									•			•			

HUC-10 Subwatershed	Waterbody and Location		Parameter (incl. non-pollutant stressors)	Water Quality		Strategies	Estimated Scale of Adoption Needed	Governmental Units with Primary Responsibility										Other Partners				Priority Level	Timeline to reach WQ goal	Interim 10-yr Milestones
	Waterbody (ID)	**Location** and Upstream Influence Counties		Current Conditions	Goals / Targets			MDA	BWSR/SWCD	MPCA	County	DNR	MDH	SE Tach JPB	SE WRB	Cities	Townships	NRCS	TNC	TU	LSP			
						Cover crops (340)	Corn silage, soybean acres		•					•				•	•		•			
	Bear Creek (542), Kedron Cr to M Br Root R	**Fillmore**, Mower	*E. coli*	Very High: 735 billion orgs/day		SEMN Bacteria Implementation Plan (2007)	Targeted to upstream sub watersheds where specific strategies apply		•	•	•			•								M	2045	Decreasing trend in bacteria levels.
				High: 303 billion orgs/day	Geometric mean: 126/100 ml																			
				Mid: 187 billion orgs/day		See Key to Strategies Table[3]			•	•	•			•				•						
				Low: 111 billion orgs/day	Individual: 1,260/100 ml	Karst sinkhole treatment (527)	Sinkholes		•									•						
				Very Low: 59 billion orgs/day		Septic System Compliance	Communities of Hamilton and Washington			•	•				•									
	Bear Creek (544), Headwaters to Kedron Cr	**Mower, Fillmore**	Macroinvertebrates (Physical Habitat)	MIBI: 47.7, 29.1; Threshold 35.9	Increase quality of habitat	Streambank Protection and Stream Habitat Improvement (580, 395)	Localized stream reaches		•			•		•				•		•		M	2045	Improved habitat rating and MIBI.
						Flow reduction practices (410)	<80 acre drainage areas		•					•				•						
						Side inlet buffers	Target using tools such as LiDAR, etc.		•									•	•					
	Deer Creek (546), Headwaters to M Br Root R	**Mower, Fillmore**	*E. coli*	Very High: 429 billion orgs/day		SEMN Bacteria Implementation Plan (2007) See Key to Strategies Table[3]	Targeted to upstream sub watersheds where specific strategies apply		•	•	•			•								M	2045	Decreasing trend in bacteria levels.
				High: 180 billion orgs/day	Geometric mean: 126/100 ml																			

HUC-10 Subwatershed	Waterbody and Location: Waterbody (ID)	Waterbody and Location: **Location** and Upstream Influence Counties	Parameter (incl. non-pollutant stressors)	Water Quality: Current Conditions	Water Quality: Goals / Targets	Strategies	Estimated Scale of Adoption Needed	MDA	BWSR/SWCD	MPCA	County	DNR	MDH	SE Tach JPB	SE WRB	Cities	Townships	NRCS	TNC	TU	LSP	Priority Level	Timeline to reach WQ goal	Interim 10-yr Milestones
				Mid: 112 billion orgs/day Low: 67 billion orgs/day Very Low: 36 billion orgs/day	Individual: 1,260/100 ml	Karst sinkhole treatment (527)	Sinkholes		•									•						
	Spring Valley Creek (548), T103 R13W S29, west line to Deer Cr	**Fillmore**, Mower	Fish and Macroinvertebrates (Physical Habitat)	FIBI: 32, 26, 48; Threshold 45	Increase quality of habitat	Streambank Protection and Stream Habitat Improvement (580, 395)	Localized stream reaches		•			•		•				•		•		M	2045	Improved habitat rating and MIBI and FIBI.
				MIBI: 30.9, 6.5, 37.2; Threshold 46.1		Pasture Management and Prescribed grazing (528)	Riparian pastures		•					•				•		•				
			Fish and Macroinvertebrates (Nitrates)	83% average nitrate tolerant taxa	Reduce nitrate tolerant species	Increased Perennial Cover (645, 342, 643) CRP, RIM	Watershed wide, with focus on marginal lands		•			•							•			M	2045	Improved MIBI and FIBI. Decreasing trend in nitrate levels.
						Nutrient (N) Management (590)	Watershed wide, focus on row crop acres	•	•									•			•			
						Cover crops (340)	Corn silage, soybean acres		•					•				•	•		•			
			E. coli	Very High: 224 billion orgs/day High: 94 billion orgs/day	Geometric mean: 126/100 ml	SEMN Bacteria Implementation Plan (2007) See Key to Strategies Table[3]	Targeted to upstream sub watersheds where specific strategies apply		•	•	•			•								L	2045	Decreasing trend in bacteria levels.
				Mid: 58 billion orgs/day Low: 35 billion orgs/day Very Low: 19 billion orgs/day	Individual: 1,260/100 ml	Karst sinkhole treatment (527)	Sinkholes		•									•						

HUC-10 Subwatershed	Waterbody and Location		Parameter (incl. non-pollutant stressors)	Water Quality		Strategies	Estimated Scale of Adoption Needed	Governmental Units with Primary Responsibility										Other Partners				Priority Level	Timeline to reach WQ goal	Interim 10-yr Milestones
	Waterbody (ID)	**Location** and Upstream Influence Counties		Current Conditions	Goals / Targets			MDA	BWSR/SWCD	MPCA	County	DNR	MDH	SE Tach JPB	SE WRB	Cities	Townships	NRCS	TNC	TU	LSP			
			Fish and Macroinvertebrates (Temperature)	Temperature >19º C 30-60% in July (DNR-2006)	Reduce avg in July, Aug <19ºC	Urban Storm Water Practices	City of Spring Valley		•							•						M	2045	Improved MIBI. Stabilizing temperature levels.
						Trout pond modifications/spring restoration	Spring Valley Trout Ponds		•			•								•				
						Riparian Forest Buffer	Localized stream reaches		•			•						•	•	•				
						Streambank Protection and Stream Habitat Improvement (580, 395)	Localized stream reaches		•			•		•				•		•				

Money Creek

In the Money Creek Subwatershed, poor fish communities and high bacteria concentrations are the main issues (Figure 26). Strategies to address these concerns can be found in Table 12. There is one critical area in this subwatershed based on high bacteria concentrations.

The turbidity impairment on AUID -521 will undergo a 303d list correction, meaning it will be removed from the impaired waters list (turbidity only) based on new information showing turbidity is not exceeding the standard.

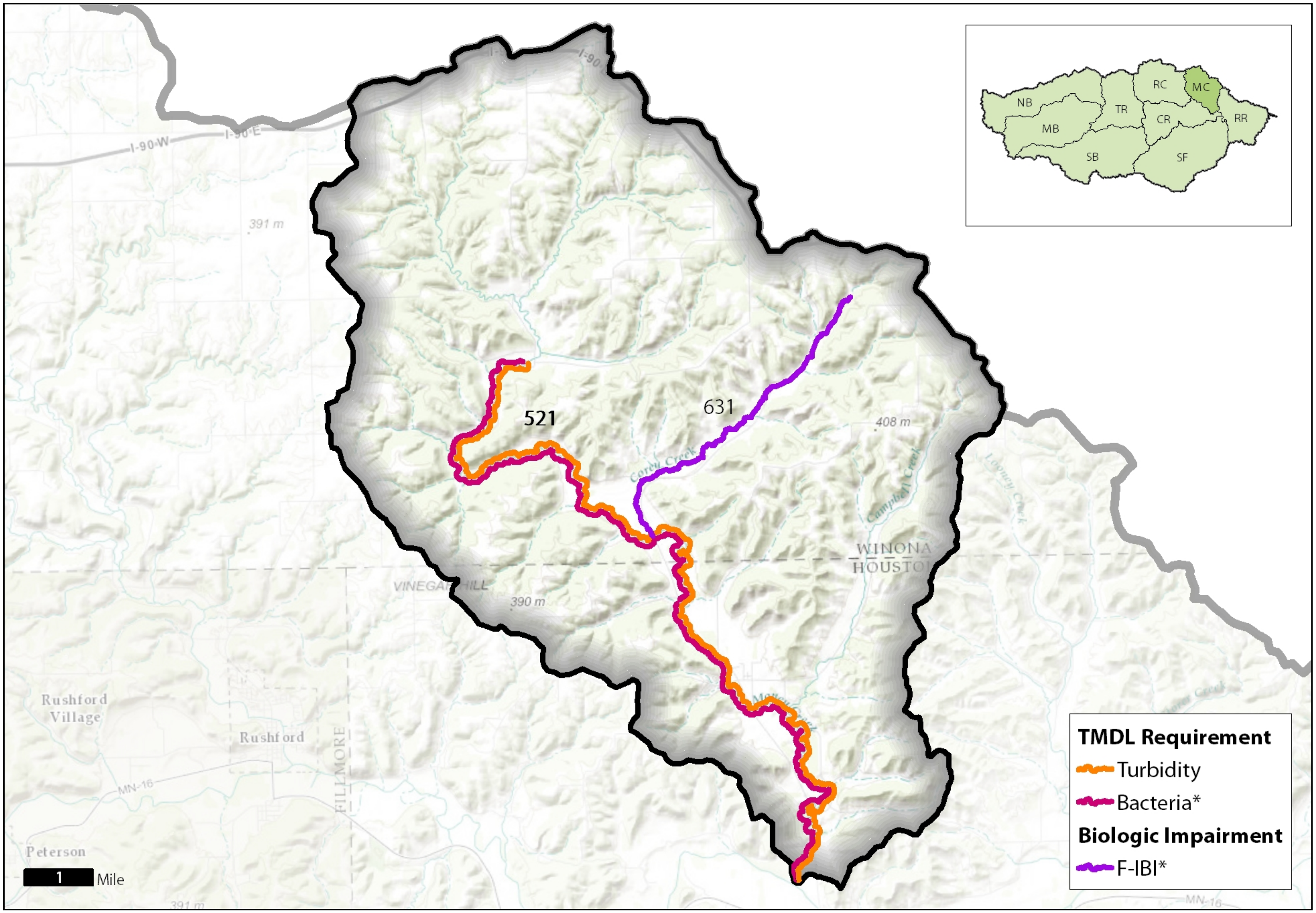


Figure 26. Impairments for bacteria, FBA, and turbidity in the Money Creek subwatershed of the Root River. Last three-digits of impaired AUID appear next to stream reaches. Note that the turbidity impairment shown on the map will be list corrected based on new information. Shaded area denotes catchment of AUID identified as a critical area while the (*) in the legend denotes the parameter that critical area is based on.

Table 12. Implementation table showing an example of strategies and actions proposed for the Money Creek subwatershed that could achieve water quality targets.

HUC-10 Subwatershed	Waterbody and Location		Parameter (incl. non-pollutant stressors)	Water Quality		Strategies	Estimated Scale of Adoption Needed	Governmental Units with Primary Responsibility										Other Partners				Priority Level	Timeline to reach WQ goal	Interim 10-yr Milestones
	Waterbody (ID)	**Location** and Upstream Influence Counties		Current Conditions	Goals / Targets			MDA	BWSR/SWCD	MPCA	County	DNR	MDH	SE Tech JPB	SF WRB	Cities	Townships	NRCS	TNC	TU	LSP			
Money Creek	Corey Creek (631), T105 R6W S18, east line to Money Cr	**Winona**	Fish (Physical Habitat and Connectivity)	FIBI 34, 36; Threshold 45	Reduce percentage of pioneer fish species; Remove fish migration barriers	Pasture Management/Prescribed Grazing (528)	Riparian pastures		•					•							•	M	2045	Improved habitat rating and FIBI.
						Cover crops (340)	Corn silage and soybean acres		•					•				•	•		•			
						Streambank Protection and Stream Habitat Improvement (580, 395)	Localized stream reaches; DNR Fisheries priorities		•			•		•				•		•				
						Replace CR17 culvert	Replace CR17 culvert				•	•												
						Work with DNR to identify beaver dams that act as barriers	Selected stream reaches affected by beaver dams		•			•												
			Fish (Temperature)	Avg 30% of time in June, July, Aug >19°C	Reduce avg in June, July, Aug <19°C	See Physical Habitat strategies	See Physical Habitat strategies		•		•			•				•	•	•	•	M	2045	Decreasing trend in temperature and improved FIBI
	Money Creek (521), T105 R7W S21, north line to Root R	**Winona, Houston**	*E. coli*	Very High: 934 billion orgs/day High: 658 billion orgs/day Mid: 547 billion orgs/day	Geometric mean:126/100ml	SEMN Bacteria Implementation Plan (2007) See Key to Strategies Table3	Targeted to upstream sub watersheds where specific strategies apply		•	•	•			•				•				**H**	2045	Decreasing trend in bacteria levels.
				Low: 447 billion orgs/day	Individual: 1,260/100 ml	Karst Sinkhole Treatment (527)	Sinkholes		•									•						
				Very Low: 262 billion orgs/day		Septic System Compliance	Communities of Centerbille, Money Creek, Ridgeway, Wilson, Wioka			•	•				•									

North Branch Root River

In the North Branch Root River, high suspended sediment concentrations (turbidity) and high bacteria concentrations are the main issues and have correlating critical areas based on prioritization criteria. Other concerns in this subwatershed are macroinvertebrate communities affected by poor physical habitat (Figure 27). Strategies to address these issues can be found in Table 13.

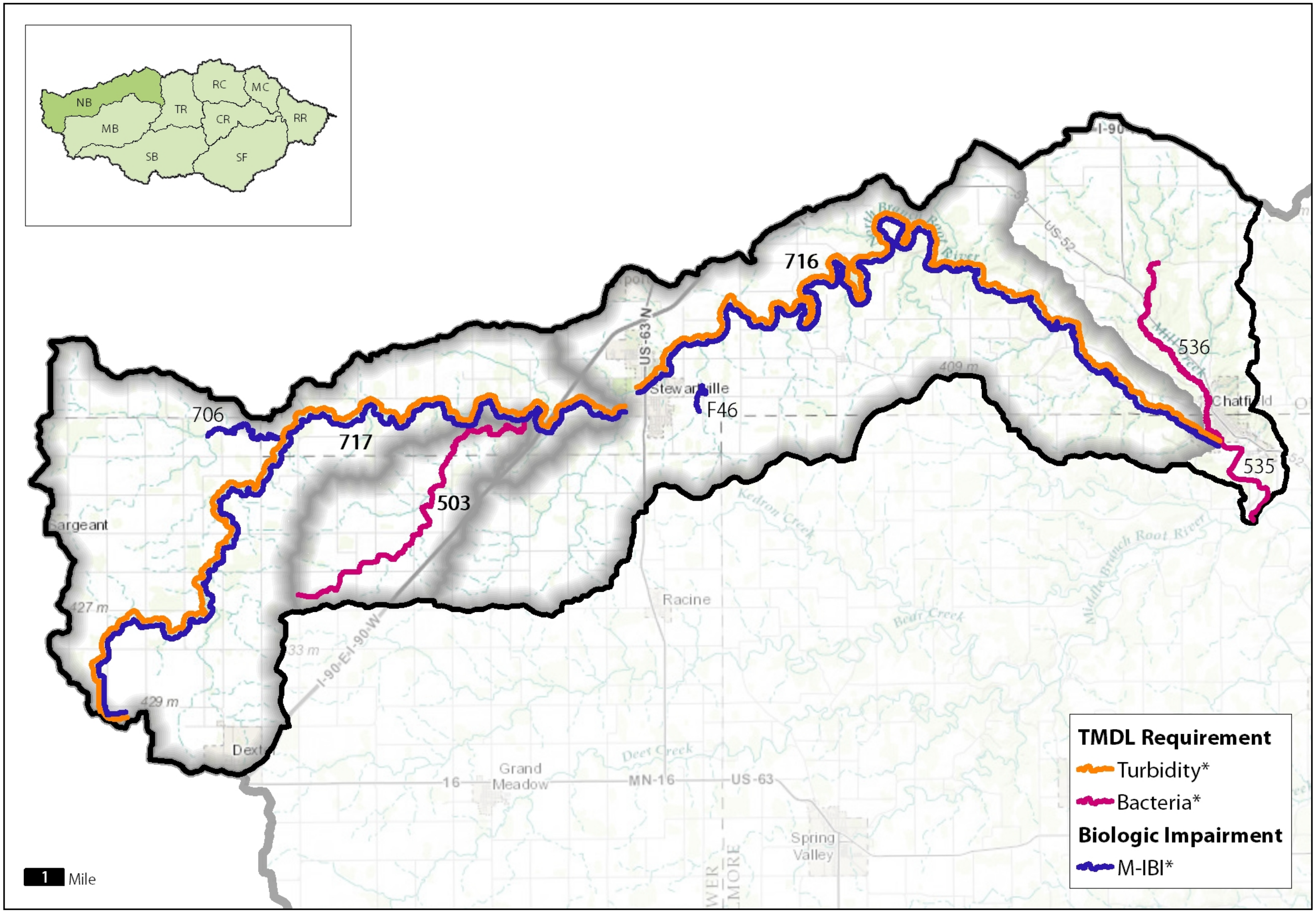


Figure 27. Impairments for bacteria, aquatic MBA, and turbidity in the North Branch of the Root River. Last three-digits of impaired AUID appear next to stream reaches. Shaded area denotes catchment of AUIDs identified critical areas while the (*) in the legend denotes the parameters that critical area is based on.

Table 13. Implementation table showing an example of strategies and actions proposed for the North Branch Root River subwatershed that could achieve water quality targets.

HUC-10 Subwatershed	Waterbody and Location: Waterbody (ID)	Waterbody and Location: **Location** and Upstream Influence Counties	Parameter (incl. non-pollutant stressors)	Water Quality: Current Conditions	Water Quality: Goals / Targets	Strategies	Estimated Scale of Adoption Needed	MDA	BWSR/SWCD	MPCA	County	DNR	MDH	SE Tech JPB	SE WRB	Cities	Townships	NRCS	TNC	TU	LSP	Priority Level	Timeline to reach WQ goal	Interim 10-yr Milestones
North Branch Root River	Root River, North Branch (535), Mill Cr to M Br Root R	**Fillmore**, Mower, Olmsted, Dodge	*E. coli*	Very High: 1,873 billion orgs/day High: 676 billion orgs/day Mid: 346 billion orgs/day Low: 177 billion orgs/day Very Low: 75 billion orgs/day	Geometric mean: 126/100 ml Individual: 1,260/100 ml	SEMN Bacteria Implementation Plan (2007) See Key to Strategies Table[3]	Watershed wide		•	•	•			•				•				L	2045	Decreasing trend in bacteria levels.
						Karst sinkhole treatment (527)	Sinkholes		•									•						
	Mill Creek (536), T105 R12W S14, north line to N Br Root R	**Olmsted, Fillmore**	*E. coli*	Very High: 58 billion orgs/day High: 5 billion orgs/day Mid: 1.4 billion orgs/day Low: 1.1 billion orgs/day Very Low: 0.8 billion orgs/day	Geometric mean: 126/100 ml Individual: 1,260/100 ml	SEMN Bacteria Implementation Plan (2007) See Key to Strategies Table[3]	Watershed wide		•	•	•			•				•				L	2045	Decreasing trend in bacteria levels.
						Karst sinkhole treatment (527)	Sinkholes		•									•						
	Unnamed creek (706), Unnamed cr to N Br Root R	**Mower, Olmsted,** Dodge	Macroinvertebrates (Physical Habitat)	MIBI: 41.7; Threshold 46.8	Increase quality of habitat	Flow reduction practices (410)*	Watershed wide		•													M	2045	Improved habitat and MIBI.
						Wetland restoration (657)	Hydric soils, marginal cropland		•			•		•				•	•					
						Cover crops (340)	Canning crops, soybeans		•					•				•	•		•			
						Streambank Protection and Stream Habitat Improvement (580, 395)	Localized stream reaches		•			•		•				•		•				

HUC-10 Subwatershed	Waterbody and Location		Parameter (incl. non-pollutant stressors)	Water Quality		Strategies	Estimated Scale of Adoption Needed	Governmental Units with Primary Responsibility										Other Partners				Priority Level	Timeline to reach WQ goal	Interim 10-yr Milestones
	Waterbody (ID)	**Location** and Upstream Influence Counties		Current Conditions	Goals / Targets			MDA	BWSR/SWCD	MPCA	County	DNR	MDH	SE Tech JPB	SE WRB	Cities	Townships	NRCS	TNC	TU	LSP			
	Root River, North Branch (716), Unnamed cr to Mill Cr	**Olmsted, Fillmore,** Mower, Dodge	Macroinvertebrates (Physical Habitat)	MIBI: 38.5; Threshold 46.8/ 35.6, 61.5, 67.5, 61.3, 53.1; Threshold 35.9	Increased quality of habitat	See Key to Strategies Table[1]	Upstream subwatersheds	•	•	•	•	•		•	•	•		•	•		•	H	2045	Improved MIBI.
			Suspended Sediment	Very High: 126 tons/day	65 mg/L TSS met 90% of time Apr-Sep	See Key to Strategies Table[2]	Upstream subwatersheds	•	•		•	•		•	·			•	•	•	•	H	2025	Decreasing trend in sediment levels.
				High: 38 tons/day Moderate: 22 tons/day		Wetland restoration (657)	Hydric soils, marginal cropland		•			•		•				•	•					
				Low: 13 tons/day Very Low: 7 tons/day		RIM, CRP	Watershed wide		•															
	Root River, North Branch (717), Headwaters to Carey Cr	**Mower, Olmsted,** Dodge	Macroinvertebrates (Physical Habitat)	MIBI: 33.7; Threshold 46.8/ 25, 30.4; Threshold 35.9	Increase quality of habitat	Flow reduction practices (410)*	Watershed wide		•					•				•				H	2045	Improved MIBI.
						Cover crops (340)	Canning crops, soybeans		•															
						Streambank Protection and Stream Habitat Improvement (580, 395)	Localized stream reaches		•			•		•				•		•				
			Macroinvertebrates (Dissolved Oxygen)	DO tolerant species percentage increased from upstream to downstream	Reduce DO tolerant species	Nutrient/Manure Management (590)	Hogs and cattle operations	•	•					•				•				H	2045	Improved MIBI. Stablized DO levels.
						See Turbidity/TSS strategies and Physica Habitat strategies for this reach	See Turbidity/TSS and Physical Habitat strategies for this reach																	
			Suspended Sediment	Very High: 53 tons/day	65 mg/L TSS met 90% of time Apr-Sep	Side inlet buffers*	Target using GIS tools such as LiDAR, etc.		•			•						•				H	2025	Decreasing trend in sediment levels.
				High: 16 tons/day		Flow reduction practices (410)*	Target using LiDAR		•					•				•						
				Moderate: 9 tons/day		Cover crops (340)	Canning crops, soybeans		•					•				•	•		•			

HUC-10 Subwatershed	Waterbody and Location		Parameter (incl. non-pollutant stressors)	Water Quality		Strategies	Estimated Scale of Adoption Needed	Governmental Units with Primary Responsibility										Other Partners				Priority Level	Timeline to reach WQ goal	Interim 10-yr Milestones
	Waterbody (ID)	**Location** and Upstream Influence Counties		Current Conditions	Goals / Targets			MDA	BWSR/SWCD	MPCA	County	DNR	MDH	SE Tech JPB	SE WRB	Cities	Townships	NRCS	TNC	TU	LSP			
				Low: 5.5 tons/day Very Low: 3 tons/day		Streambank Protection and Stream Habitat Improvement (580, 395)	Localized stream reaches		•			•		•				•		•				
	Unnamed creek (F46), Unnamed cr to Unnamed cr	**Olmsted**	Macroinvertebrates (Physical Habitat)	MIBI: 31.7; Threshold 46.8	Increase quality of habitat	Cover crops (340)	Canning crops, soybeans		•					•				•	•		•	M	2045	Improved MIBI.
						Streambank Protection and Stream Habitat Improvement (580, 395)	Localized stream reaches		•			•		•				•		•				
						Side inlet buffers	Target using GIS tools such as LiDAR, etc.		•			•						•						
	Robinson Creek (503); Headwaters to N Br Root R	**Mower**	*E.coli*	Very High: 15 billion orgs/day High: 8.0 billion orgs/day	Geometric mean:126/100 ml	SEMN Bacteria Implementation Plan (2007)	Targeted to upstream sub watersheds where specific strategies apply		•	•	•				•			•				H	2045	Decreasing trend in bacteria levels.
				Mid: 6.0 billion orgs/day		Septic system compliance	Community of High Forest			•	•				•									
				Low: 4.5 billion orgs/day Very Low: 3.5 billion orgs/day	Individual: 1,260/100 ml	See Key to Strategies Table[3]	Upstream subwatersheds		•	•	•				•			•						

Rush Creek

In the Rush Creek Subwatershed, poor macroinvertebrate communities, high bacteria concentrations and high nitrate concentrations are the main issues (Figure 28). Strategies to address these issues can be found in Table 14. There are no critical areas in this subwatershed.

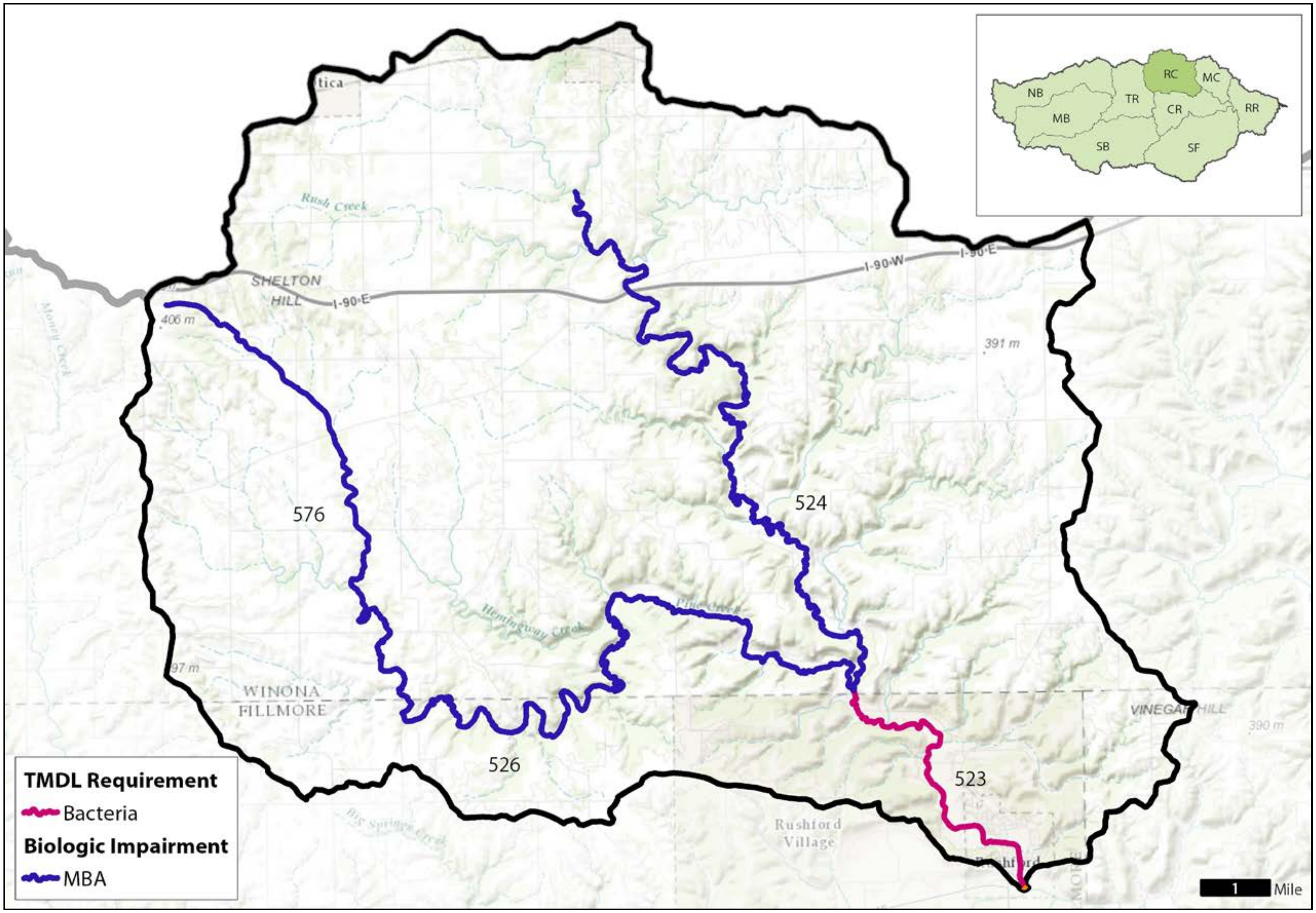


Figure 28. Impairments for bacteria and, aquatic MBA in the Rush Creek subwatershed of the Root River. Last three-digits of impaired AUID appear next to stream reaches.

Table 14. Implementation table showing an example of strategies and actions proposed for the Rush Creek subwatershed that could achieve water quality targets.

HUC-10 Subwatershed	Waterbody and Location		Parameter (incl. non-pollutant stressors)	Water Quality		Strategies	Estimated Scale of Adoption Needed	Governmental Units with Primary Responsibility										Other partners				Priority Level	Timeline to reach WQ goal	Interim 10-yr Milestones
	Waterbody (ID)	**Location** and Upstream Influence Counties		Current Conditions	Goals / Targets			MDA	BWSR/SWCD	MPCA	County	DNR	MDH	SE Tech JPB	SE WRB	Cities	Townships	NRCS	TNC	TU	LSP			
Rush Creek	Rush Creek (523), Pine Cr to Root R	Fillmore, Winona, Houston	*E. coli*	Very High: 399 billion orgs/day High: 288 billion orgs/day Mid: 238 billion orgs/day	Geometric mean: 126/100 ml	SEMN Bacteria Implementation Plan (2007)	Watershed wide		•	•	•			•				•				M	2045	Decreasing trend
				Low: 201 billion orgs/day Very Low: 155 billion orgs/day	Individual: 1,260/100 ml	Septic System Compliance	Communities of Fremont, Arendahl, Hart			•								•						
	Rush Creek (524), Unnamed cr to Pine Cr	**Winona**	Macroinvertebrates (Physical Habitat)	MIBI: 23.1, 23.5, 37.7; Threshold 46.1	Increase in quality habitat	Streambank Protection and Stream Habitat Improvement (580, 395)	Localized Stream Reaches		•			•		•				•		•		L	2045	Improved habitat rating and MIBI.
						Pasture Management/Prescribed Grazing (528)	Riparian Pastures		•					•				•						
			Macroinvertebrates (Nitrates)	83% average nitrate tolerant taxa	Reduce nitrate tolerant species	Nutrient (N) Management	Watershed wide	•	•	•			•					•			•	L	2045	Improved MIBI. Decreasing trend in nitrate levels.
						Cover crops (340)	Canning crop, corn silage and soybean acres		•					•				•	•		•			
						Increased Perennial Cover (645, 342, 643) CRP, RIM	Watershed wide, marginal lands		•			•	•											
	Pine Creek (526), T104 R9W S4, north line to Rush Cr	**Fillmore, Winona**	Macroinvertebrates (Physical Habitat)	MIBI: 45.4, 45.8, 24.2, 51.2; Threshold 46.1	Increase in quality habitat	Streambank Protection and Stream Habitat Improvement (580, 395)	Localized Stream Reaches		•			•		•				•		•		L	2045	Improved habitat and MIBI.
						Pasture Management/Prescribed Grazing (528)	Riparian Pastures		•					•				•			•			

HUC-10 Subwatershed	Waterbody and Location		Parameter (incl. non-pollutant stressors)	Water Quality		Strategies	Estimated Scale of Adoption Needed	Governmental Units with Primary Responsibility										Other partners				Priority Level	Timeline to reach WQ goal	Interim 10-yr Milestones
	Waterbody (ID)	**Location** and Upstream Influence Counties		Current Conditions	Goals / Targets			MDA	BWSR/SWCD	MPCA	County	DNR	MDH	SE Tech JPB	SE WRB	Cities	Townships	NRCS	TNC	TU	LSP			
	Pine Creek (576), Headwaters to T105 R9W S32, south line	**Fillmore, Winona**	Macroinvertebrates (Physical Habitat)	MIBI: 23.1; Threshold 35.9	Increase in quality habitat	Streambank Protection and Stream Habitat Improvement (580, 395)	Localized Stream Reaches		•			•		•				•		•		L	2045	Improved habitat and MIBI.
						Pasture Management/Prescribed Grazing (528)	Riparian Pastures		•					•				•						
						Cover crops (340)	Canning crop, corn silage and soybean acres		•					•				•	•		•			

South Branch Root River

In the South Branch Root River Subwatershed, there are many stream impairments based on various parameters (Figure 29). High nitrate concentrations are of specific concern as this is the subwatershed where all six drinking water impairments based on nitrate concentrations are located in the RRW. Correlated to the impairments based on nitrate levels in this subwatershed are three critical areas. Other critical areas are based on bacteria, TSS, and biota based aquatic life impairments. Strategies to address the issues in this subwatershed can be found in Table 15.

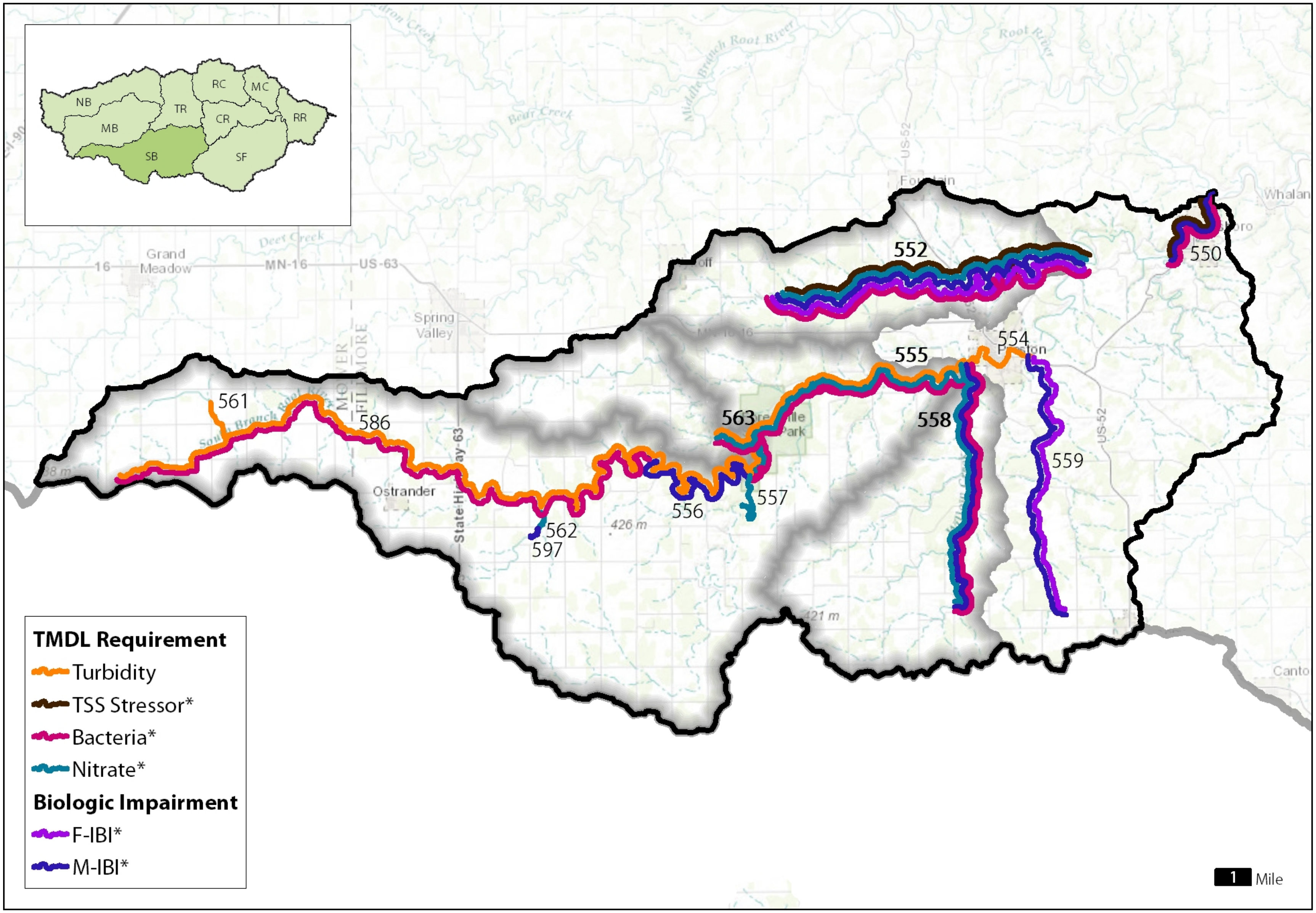


Figure 29. Impairments for bacteria, FBA, aquatic MBA, nitrate, TSS and turbidity in the South Branch of the Root River. Last three-digits of impaired AUID appear next to stream reaches. Shaded areas denote drainage areas of the four AUIDs identified as critical areas while the (*) in the legend denotes the parameters the critical areas are based on.

Table 15. Implementation table showing an example of strategies and actions proposed for the South Branch Root River subwatershed that could achieve water quality targets.

HUC-10 Subwatershed	Waterbody and Location		Parameter (incl. non-pollutant stressors)	Water Quality		Strategies	Estimated Scale of Adoption Needed	Governmental Units with Primary Responsibility										Other Partners				Priority Level	Timeline to reach WQ goal	Interim 10-yr Milestones
	Waterbody (ID)	**Location** and Upstream Influence Counties		Current Conditions	Goals / Targets			MDA	BWSR/SWCD	MPCA	County	DNR	MDH	SE Tech JPB	SE WRB	Cities	Townships	NRCS	TNC	TU	LSP			
South Branch Root	Willow Creek (558), T101 R11W S12, west line to S Br Root R	**Fillmore**	*E. coli*	Very High: 265 billion orgs/day High: 118 billion orgs/day Low: 44 billion orgs/day Very Low: 23 billion orgs/day	Geometric mean:126/100 ml Individual: 1,260/100 ml	SEMN Bacteria Implementation Plan (2007) See Key to Strategies Table[3]	Targeted to upstream sub watersheds where specific strategies apply		•	•	•				•			•				M	2045	Decreasing trend in bacteria levels.
						Karst Sinkhole Treatment (527)	Sinkholes		•	•	•				•			•						
			Nitrate	Very High: 4646 lbs/day High: 2073 lbs/day Moderate: 1289 lbs/day Low:775 lbs/day Very Low: 399 lbs day	<10 mg/L	Increased Perennial Cover (645, 342, 643, CRP)	Watershed wide, with focus on marginal lands		•			•						•				**H**	2045	Decreasing trend in nitrate levels.
						Nutrient (N) Management (590)	Watershed wide	•	•	•								•			•			
						Cover crops (340)	Corn silage, soybean acres		•									•	•		•			
			Macroinvertebrates (Physical Habitat)	MIBI: 27.3, 41.7, 63.7, 60.3, 28.4; Threshold 46.1	Increase quality of habitat	Streambank Protection/Stream Habitat Improvement (580, 395)	Localized Stream Reaches		•			•		•				•		•		**H**	2045	Improved habitat rating
						Pasture Management/Prescribed Grazing (528)	Riparian pastures		•					•				•			•			

HUC-10 Subwatershed	Waterbody and Location		Parameter (incl. non-pollutant stressors)	Water Quality		Strategies	Estimated Scale of Adoption Needed	Governmental Units with Primary Responsibility										Other Partners				Priority Level	Timeline to reach WQ goal	Interim 10-yr Milestones
	Waterbody (ID)	**Location** and Upstream Influence Counties		Current Conditions	Goals / Targets			MDA	BWSR/SWCD	MPCA	County	DNR	MDH	SE Tech JPB	SE WRB	Cities	Townships	NRCS	TNC	TU	LSP			
	Root River, South Branch (550) Duschee Cr to M Br Root R	**Fillmore**, Mower	Macroinvertebrates (Suspended Sediment)	Very High: 16 tons/day High: 7 tons/day Moderate: 5 tons/day Low: 3 tons/day Very Low: 1.5 tons/day	10 mg/L TSS met 90% of time Apr-Sep	See Key to Strategies Table[2]	Upstream subwatersheds															M	2025	Decreasing trend in sediment levels. Increased TSS intolerant species
			Macroinvertebrates (Nitrate)	64% nitrate tolerant taxa	Reduce nitrate tolerant species	See Key to Strategies Table[1]	Upstream subwatersheds															M	2045	Decreasing trends. Improved MIBI.
			E. coli	Very High: 1839 billion orgs/day High: 830 billion orgs/day Mid: 513 billion orgs/day Low: 324 billion orgs/day Very Low: 176 billion orgs/day	Geometric mean:126/100 ml Individual: 1,260/100 ml	SEMN Bacteria Implementation Plan (2007) See Key to Strategies Table3	Targeted to upstream subwatersheds where specific strategies apply															M	2045	Decreasing trends.
	Watson Creek (552), T103 R11W S30, west line to S Br Root R	**Fillmore**	Fish and Macroinvertebrates (Physical Habitat)	FIBI: 41 (08LM004), 29 (04LM057); Threshold 45	Increase quality of habitat	Streambank Protection and Stream Habitat Improvement (580,385)	Localized stream reaches		•			•		•				•		•		**H**	2045	Improved habitat and improved MIBI and FIBI.

HUC-10 Subwatershed	Waterbody and Location		Parameter (incl. non-pollutant stressors)	Water Quality		Strategies	Estimated Scale of Adoption Needed	Governmental Units with Primary Responsibility										Other Partners				Priority Level	Timeline to reach WQ goal	Interim 10-yr Milestones
	Waterbody (ID)	**Location** and Upstream Influence Counties		Current Conditions	Goals / Targets			MDA	BWSR/SWCD	MPCA	County	DNR	MDH	SE Tech JPB	SE WRB	Cities	Townships	NRCS	TNC	TU	LSP			
				MIBI: 30.5 (08LM004), 33.2 (04LM057); Threshold 46.1		See Suspended Sediment strategies for this reach	See Suspended Sediment strategies for this reach																	
			E. coli	Very High: 199 billion orgs/day	Geometric mean: 126/100 ml Individual: 1,260/100 ml	SEMN Bacteria Implementation Plan (2007) See Key to Strategies Table[3]	Targeted to upstream sub watersheds where specific strategies apply		•	•	•				•			•				M	2045	Decreasing trend in bacteria levels.
				High: 90 billion orgs/day																				
				Mid: 55 billion orgs/day																				
				Low: 33 billion orgs/day																				
				Very Low: 17 billion orgs/day		Karst Sinkhole Treatment (527)	Sinkholes		•									•						
			Fish and Macroinvertebrates (Suspended Sediment)	Very High: 1.7 tons/day	10 mg/L TSS met 90% of time Apr-Sep	Pasture Management/Prescribed grazing (528)	Riparian pastures		•					•				•			•	H	2025	Decreasing trend in sediment levels. Increased TSS intolerant species
				High: 0.8 tons/day																				
				Moderate: 0.5 tons/day		Karst sinkhole treatment (527)	Sinkholes (including entire springshed)		•									•						
				Low: 0.3 tons/day																				
				Very Low: 0.15 tons/day																				
			Nitrate	Very High: 3480 lbs/day	<10 mg/L	Increased Perennial Cover (645, 342, 643, CRP)	Watershed wide, with focus on marginal lands		•			•						•	•			H	2045	Decreasing trend in nitrate levels. 20% reduction by 2025.
				High: 1585 lbs/day		Nutrient (N) Management (590)	Watershed wide	•	•					•				•						

HUC-10 Subwatershed	Waterbody and Location		Parameter (incl. non-pollutant stressors)	Water Quality		Strategies	Estimated Scale of Adoption Needed	Governmental Units with Primary Responsibility										Other Partners				Priority Level	Timeline to reach WQ goal	Interim 10-yr Milestones
	Waterbody (ID)	**Location** and Upstream Influence Counties		Current Conditions	Goals / Targets			MDA	BWSR/SWCD	MPCA	County	DNR	MDH	SE Tech JPB	SE WRB	Cities	Townships	NRCS	TNC	TU	LSP			
				Moderate: 696 lbs/day		Cover crops (340)	Corn silage, soybean acres		•					•				•	•		•			
				Low: 582 lbs/day Very Low: 299 lbs/day		Fountain drainfield reclamation and monitoring	Drainfield site and discharge			•						•								
			Fish and Macroinvertebrates (Temperature)	Average temp in July, Aug was >19ºC	Reduce avg in July, Aug <19ºC	Streambank Protection and Stream Habitat Improvement (580, 395)	Localized stream reaches		•			•		•				•		•		**H**	2045	Improved FIBI and MIBI. Stabilizing temperature levels.
						See Suspended Sediment strategies for this reach	See Suspended Sediment strategies for this reach																	
						Urban stormwater practices	Fountain, Wykoff, Preston, POET Ethanol Plant		•	•		•				•	•							
						springshed protection*	Stagecoach Spring and Thunderhead Spring and catchments		•	•		•		•						•				
	Root River, South Branch (554), Willow Cr to Camp Cr	**Fillmore**, Mower	Suspended Sediment	Very High: 16 tons/day High: 6 tons/day Moderate: 4 tons/day	10 mg/L TSS met 90% of time Apr-Sep	See Key to Strategies Table[2]	Upstream subwatersheds	•	•		•	•		•	•			•	•	•	•	M	2025	Decreasing trend in sediment levels.
				Low: 2.5 tons/day Very Low: 1.4 tons/day		Urban stormwater practices	City of Preston		•	•		•				•				•				
	Root River, South Branch (555), Canfield Cr to Willow Cr	**Fillmore**, Mower	Nitrate	Very High: 14,823 lbs/day High: 6,456 lbs/day	<10 mg/L	See Key to Strategies Table[1]	Upstream subwatersheds															M	2045	Decreasing trend in nitrate levels. 20% reduction by 2025.

HUC-10 Subwatershed	Waterbody and Location		Parameter (incl. non-pollutant stressors)	Water Quality		Strategies	Estimated Scale of Adoption Needed	Governmental Units with Primary Responsibility										Other Partners				Priority Level	Timeline to reach WQ goal	Interim 10-yr Milestones
	Waterbody (ID)	**Location** and Upstream Influence Counties		Current Conditions	Goals / Targets			MDA	BWSR/SWCD	MPCA	County	DNR	MDH	SE Tech JPB	SE WRB	Cities	Townships	NRCS	TNC	TU	LSP			
				Mid: 3,803 lbs/day Low: 2,275 lbs/day Very Low: 1,196 lbs/day				•	•	•	•	•		•	•	•		•	•		•			
			Suspended Sediment	Very High: 7.4 tons/day High: 3 tons/day Moderate: 2 tons/day Low: 1 ton/day Very Low: 0.6 tons/day	10 mg/L TSS met 90% of time Apr-Sep	See Key to Strategies Table[2]	Upstream subwatersheds	•	•		•	•		•	•			•	•	•	•	M	2025	Decreasing trend in sediment levels.
			E.coli	Very High: 15 billion orgs/day High: 8.0 billion orgs/day	Geometric mean:126/100 ml	SEMN Bacteria Implementation Plan (2007)	Targeted to upstream sub watersheds where specific strategies apply		•	•	•				•			•				**H**	2045	Decreasing trend in bacteria levels.
				Mid: 6.0 billion orgs/day		Septic system compliance	Carimona			•	•				•									
				Low: 4.5 billion orgs/day	Individual: 1,260/100 ml	Karst Sinkhole Treatment (527)	Sinkholes			•								•						
				Very Low: 3.5 billion orgs/day		See Key to Strategies Table[3]	Upstream subwatersheds		•	•	•				•			•						
	Root River, South Branch (556), T102 R12W S21, north line to	**Fillmore**, Mower	Macroinvertebrates (Nitrate)	73% nitrate tolerant taxa	Reduce nitrate tolerant species	See Key to Strategies Table[1]	Upstream subwatersheds															M	2045	Improved MIBI and FIBI. Decreasing trend in nitrate levels.

HUC-10 Subwatershed	Waterbody and Location		Parameter (incl. non-pollutant stressors)	Water Quality		Strategies	Estimated Scale of Adoption Needed	Governmental Units with Primary Responsibility										Other Partners				Priority Level	Timeline to reach WQ goal	Interim 10-yr Milestones
	Waterbody (ID)	**Location** and Upstream Influence Counties		Current Conditions	Goals / Targets			MDA	BWSR/SWCD	MPCA	County	DNR	MDH	SE Tech JPB	SE WRB	Cities	Townships	NRCS	TNC	TU	LSP			
	Canfield Cr		Suspended Sediment	Very High: 4 tons/day High: 2 tons/day Moderate: 1 ton/day Low:0.6 tons/day Very Low: 0.3 tons/day	10 mg/L TSS met 90% of time Apr-Sep	See Key to Strategies Table[2]	Upstream subwatersheds	•	•		•	•		•	•			•	•	•	•	M	2025	Decreasing trend in sediment levels.
	Canfield Creek (557), T102 R12W S25, west line to S Br Root R	**Fillmore**, Mower	Nitrates	Very High: 3629 lbs/day High: 1605 lbs/day Moderate: 984 lbs/day Low: 594 lbs/day Very Low: 311 lbs/day	<10 mg/L	Cover crops (340)	Corn silage and soybean acres		•					•				•	•		•	M	2045	Decreasing trend in nitrate levels. 20% reduction by 2025.
						Nutrient Management (590)	Watershed wide	•	•					•				•						
						Increased Perennial Cover (645, 342, 643) CRP, RIM	Watershed wide, focus on marginal lands		•			•						•	•					
						Septic system compliance	Greenleafton			•	•				•									
						Feedlot runoff control (635, 367)/ag waste storage (313)	Registered feedlots with open lots not in compliance with 7020		•	•	•				•			•						
	Camp Creek (559), Headwaters to S Br Root R	**Fillmore**	Fish and Macroinvertebrates (Physical Habitat)	Fish IBI: 45, 10; Threshold 45 MIBIs: 66, 60, 30; Threshold 46.1	Increase quality of habitat	Streambank Protection and Stream Habitat Improvement (580, 395)	Localized stream reaches		•			•		•				•		•		M	2045	Improved habitat rating and MIBI/FIBI.
						Pasture Management and Prescribed grazing (528)	Riparian pastures		•					•				•		•				
			Fish and Macroinvertebrates (Nitrate)	69% average nitrate tolerant taxa	Reduce nitrate tolerant species	Cover crops (340)	Watershed wide, corn silage and soybean acres		•					•				•	•		•	M	2045	Improved MIBI and FIBI. Decreasing trend in nitrate levels.
						Nutrient Management (590)	Watershed wide	•	•					•				•						

HUC-10 Subwatershed	Waterbody and Location		Parameter (incl. non-pollutant stressors)	Water Quality		Strategies	Estimated Scale of Adoption Needed	Governmental Units with Primary Responsibility										Other Partners				Priority Level	Timeline to reach WQ goal	Interim 10-yr Milestones
	Waterbody (ID)	**Location and Upstream Influence Counties**		Current Conditions	Goals / Targets			MDA	BWSR/SWCD	MPCA	County	DNR	MDH	SE Tech JPB	SE WRB	Cities	Townships	NRCS	TNC	TU	LSP			
						Increased Perennial Cover (645, 342, 643) CRP, RIM	Watershed wide, with focus on marginal lands and Shoreland		•			•						•	•					
						Feedlot runoff control (635, 367)/ag waste storage (313)	Registered feedlots with open lots not in compliance with 7020		•	•	•			•				•						
			Fish and Macroinvertebrates (Temperature)	Average temp in July, Aug was >19ºC	Reduce avg in July, Aug <19ºC	Streambank Protection (580) and Stream Habitat Improvement (580, 395)	Localized stream reaches		•			•		•				•		•		M	2045	Improved MIBI and FIBI. Stabilizing temperature levels.
						See Physical Habitat strategies in this reach	See Physical Habitat strategies in this reach																	
	Etna Creek (562), Unnamed cr to S Br Root R	**Fillmore**	Nitrates	Very High: 752 lbs/day High: 332 lbs/day	<10 mg/L	Cover crops (340)	Watershed wide, corn silage and soybean acres		•					•				•	•		•	M	2045	Decreasing trend in nitrate levels. 20% reduction by 2025.
				Moderate: 119 lbs/day Low: 114 lbs/day		Nutrient Management (590)	Watershed wide	•	•					•				•						
				Very Low: 59 lbs/day		Increased Perennial Cover (645, 342, 643) CRP, RIM	Watershed wide, with focus on marginal lands and Shoreland		•			•						•	•					
	Forestville Creek (563), Unnamed cr to S Br Root R	**Fillmore**	*E. coli*	Very High: 106 billion orgs/day High: 45 billion orgs/day Mid: 27 billion orgs/day Low: 16 billion orgs/day	Geometric mean:126/100 ml Individual: 1,260/100 ml	SEMN Bacteria Implementation Plan (2007) See Key to Strategies Table[3]	Targeted to upstream sub watersheds where specific strategies apply		•	•	•				•			•				L	2045	Decreasing trend in bacteria levels.

HUC-10 Subwatershed	Waterbody and Location: Waterbody (ID)	Location and Upstream Influence Counties	Parameter (incl. non-pollutant stressors)	Water Quality: Current Conditions	Goals / Targets	Strategies	Estimated Scale of Adoption Needed	MDA	BWSR/SWCD	MPCA	County	DNR	MDH	SE Tech JPB	SE WRB	Cities	Townships	NRCS	TNC	TU	LSP	Priority Level	Timeline to reach WQ goal	Interim 10-yr Milestones
				Very Low: 8 billion orgs/day		Karst Sinkhole Treatment (527)	Sinkholes		•									•						
			Nitrates	Very High: 1,852 lbs/day High: 780 lbs/day	<10 mg/L	Cover crops (340)	Watershed wide, corn silage and soybean acres		•					•				•	•		•	**H**	2045	Decreasing trend in nitrate levels. 20% reduction by 2025.
				Mid: 474 lbs/day Low: 283 lbs/day		Nutrient Management (590)	Watershed wide	•	•					•				•						
				Very Low: 148 orgs/day		Increased Perennial Cover (645, 342, 643) CRP, RIM	Watershed wide, focus on marginal lands		•			•						•	•					
	South Branch (586), Headwaters to T102 R12W S16, south line	**Fillmore**	*E. coli*	Very High: 6.2 billion orgs/day	Geometric mean:126/100 ml Individual: 1,260/100 ml	SEMN Bacteria Implementation Plan (2007)	Targeted to upstream sub watersheds where specific strategies apply		•	•	•				•			•				L	2045	Decreasing trend in bacteria levels.
				High: 3.4 billion orgs/day		See Key to Strategies Table[3]																		
				Mid: 2.5 billion orgs/day Low: 1.9 billion orgs/day Very Low: 1.5 billion orgs/day		Karst Sinkhole Treatment (527)	Sinkholes		•									•						
	Etna Creek (597), T102 R13W S36, west line to Unnamed cr	**Fillmore**	Macroinvertebrates (Nitrates)	73% average nitrata tolerant taxa	Reduce nitrate tolerant species	Cover crops (340)	Watershed wide, canning crops and soybean acres		•					•				•	•		•	M	2045	Improved MIBI and FIBI. Decreasing trend in nitrate levels.
						Nutrient Management (590)	Watershed wide	•	•					•				•						
						Increased Perennial Cover (645, 342, 643) CRP, RIM	Watershed wide, with focus on marginal lands and Shoreland		•			•						•	•					

South Fork Root River

In the South Fork Root River Subwatershed, poor macroinvertebrate communities and high suspended sediment concentrations (turbidity) are the main issues (Figure 30). Critical areas are identified where these main issues are located. Strategies to address the issues in this subwatershed can be found in Table 16.

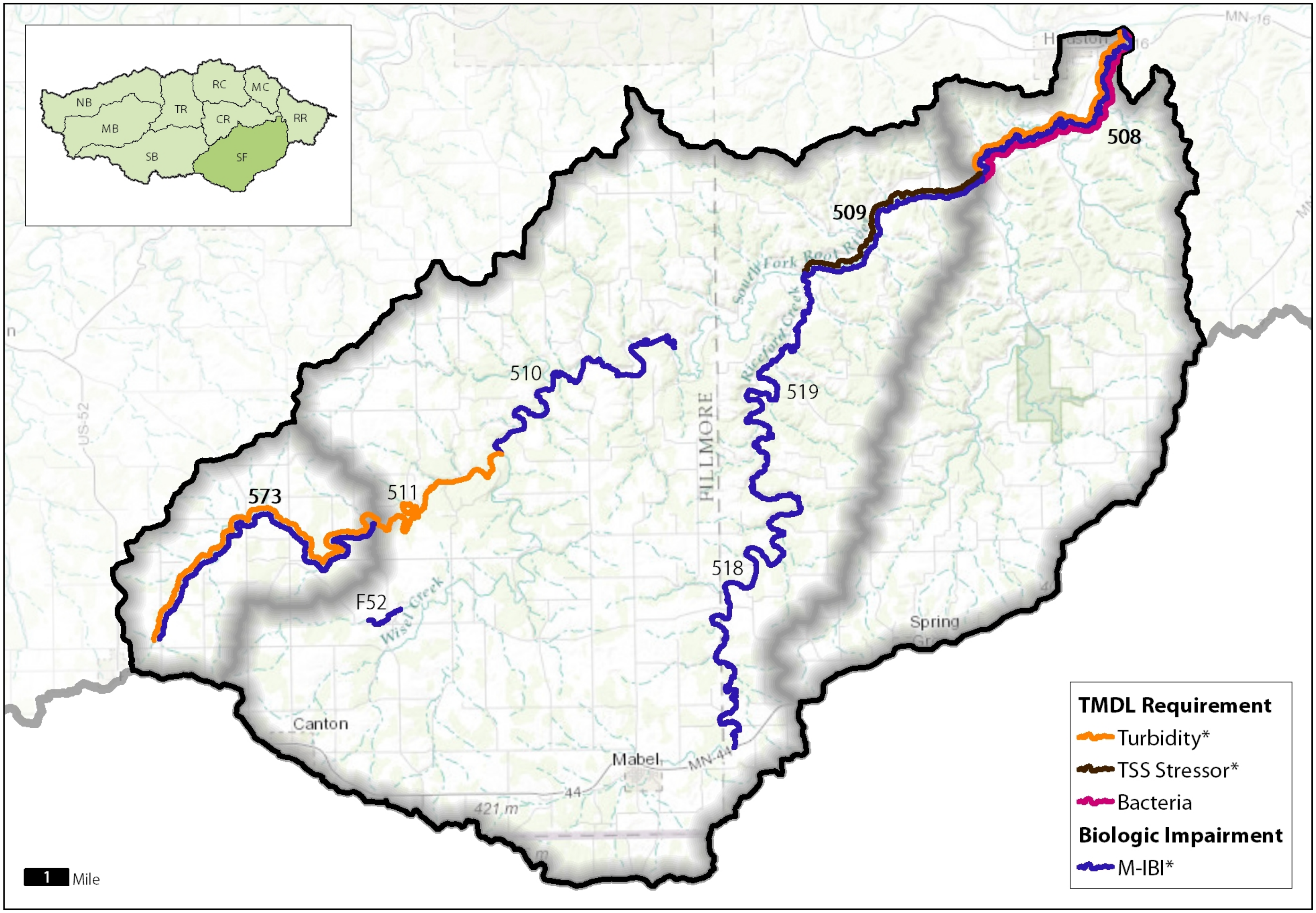


Figure 30. Impairments for bacteria, aquatic MBA, TSS and turbidity in the South Fork Subwatershed of the Root River. Last three-digits of impaired AUID appear next to stream reaches. Shaded area denotes drainage area of AUIDs identified as critical areas while the (*) in the legend denotes the parameters the critical area is based on.

Table 16. Implementation table showing an example of strategies and actions proposed for the South Fork Root River subwatershed that could achieve water quality targets.

HUC-10 Subwatershed	Waterbody and Location		Parameter (incl. non-pollutant stressors)	Water Quality		Strategies	Estimated Scale of Adoption Needed	Governmental Units with Primary Responsibility										Other Partners				Priority Level	Timeline to reach WQ goal	Interim 10-yr Milestones
	Waterbody (ID)	**Location** and Upstream Influence Counties		Current Conditions	Goals / Targets			MDA	BWSR/SWCD	MPCA	County	DNR	MDH	SE Tech JPB	SE WRB	Cities	Townships	NRCS	TNC	TU	LSP			
South Fork Root River	Root River, South Fork (508), Beaver Cr to Root R	**Houston**	Macroinvertebrates (Physical Habitat)	MIBI: 36.3; Threshold 46.8	Improve riparian zone; reduce bank erosion	See Key to Strategies Table[5]	Upstream subwatersheds		•	•		•		•	•			•	•	•	•	**H**	2045	Improved habitat rating and MIBI.
			Macroinvertebrates (Nitrate)	85% nitrate tolerant taxa	Reduce nitrate tolerant species	See Key to Strategies Table[1]	Upstream subwatersheds	•	•	•	•	•		•	•	•		•	•		•	**H**	2045	Improved MIBI. Decreasing trend in nitrate levels.
			E. coli	Very High: 934 billion orgs/day High: 658 billion orgs/day Mid: 547 billion orgs/day Low: 447 billion orgs/day Very Low: 262 billion orgs/day	Geometric mean:126/100ml Individual: 1,260/100 ml	SEMN Bacteria Implementation Plan (2007) See Key to Strategies Table[3]	Targeted to upstream sub watersheds where specific strategies apply		•	•	•			•				•				M	2045	Decreasing trend in bacteria levels.
						Septic System Compliance	Communities of Choice and Henrytown as well as Hidden Bluffs Campground			•								•						
			Suspended Sediment	Very High: 53 tons/day High: 37 tons/day Mid: 31 tons/day Low: 25 tons/day Very High: 15 tons/day	65 mg/L TSS met 90% of time Apr-Sep	See Key to Strategies Table[2]	Upstream subwatersheds	•	•		•	•		•	•			•	•	•	•	**H**	2025	Decreasing trend in sediment levels.
						Hayable buffers*	Riparian cropland		•			•		•					•					

HUC-10 Subwatershed	Waterbody and Location		Parameter (incl. non-pollutant stressors)	Water Quality		Strategies	Estimated Scale of Adoption Needed	Governmental Units with Primary Responsibility										Other Partners				Priority Level	Timeline to reach WQ goal	Interim 10-yr Milestones
	Waterbody (ID)	**Location** and Upstream Influence Counties		Current Conditions	Goals / Targets			MDA	BWSR/SWCD	MPCA	County	DNR	MDH	SE Tech JPB	SE WRB	Cities	Townships	NRCS	TNC	TU	LSP			
	Root River, South Fork (509), Riceford Cr to Beaver Cr.	**Houston**	Macroinvertebrates (Physical Habitat)	MIBI: 46.5; Threshold 46.8	Improve riparian zone; reduce bank erosion	See Suspended Sediment strategies for this reach	See TSS strategies for this reach															**H**	2045	Improved habitat rating and MIBI.
			Macroinvertebrates (Suspended Sediment)	Very High: 53 tons/day High: 37 tons/day Mid: 31 tons/day	65 mg/L TSS met 90% of time Apr-Sep	See Key to Strategies Table[2]	Upstream subwatersheds	•	•		•	•		•	•			•	•	•	•	**H**	2025	Decreasing trend in sediment levels. Increased TSS intolerant species
				Low: 25 tons/day		Streambank Protection and Stream Habitat Improvement (580, 395)	Localized stream reaches		•			•		•				•	•	•				
				Very Low: 15 tons/day		Hayable buffers*	Riparian cropland		•			•		•					•					
	Root River, South Fork (510), Wisel Cr to T102N R8W S2, east line	**Fillmore**	Macroinvertebrates (Physical Habitat)	MIBI: 33.1, 35.3; Threshold 46.1	Increase quality of habitat	Pasture Management/Prescribed Grazing (528)	Riparian Pastures		•					•							•	L	2045	Improved habitat and MIBI score
						Cover crops (340)	Corn silage and soybean acres		•					•				•	•		•			
						Streambank Protection and Stream Habitat Improvement (580, 395)	Localized stream reaches		•			•		•				•	•	•				
			Macroinvertebrates (Nitrate)	79% average nitrate tolerant taxa	Reduce nitrate tolerant species	Increased Perennial Cover (645, 342, 643) CRP, RIM	Watershed wide, with focus on marginal lands		•			•										M	2045	Improved MIBI. Decreasing trend in nitrate levels.
						Nutrient (N) Management	Watershed wide, with focus on row crop acres	•	•	•								•			•			
						Cover crops (340)	Corn silage, soybean acres		•									•	•		•			
	Riceford Creek (518), T101 R7W	**Houston,** Fillmore	Macroinvertebrates (Physical Habitat)	MIBI: 29.5, 62.2, 36.3; Threshold 46.1	Improve riparian zone; reduce bank erosion	Pasture Management/Prescribed Grazing (528)	Riparian Pastures		•					•				•				M	2045	Improved habitat rating and MIBI.

HUC-10 Subwatershed	Waterbody and Location		Parameter (incl. non-pollutant stressors)	Water Quality		Strategies	Estimated Scale of Adoption Needed	Governmental Units with Primary Responsibility										Other Partners				Priority Level	Timeline to reach WQ goal	Interim 10-yr Milestones
	Waterbody (ID)	**Location** and Upstream Influence Counties		Current Conditions	Goals / Targets			MDA	BWSR/SWCD	MPCA	County	DNR	MDH	SE Tech JPB	SE WRB	Cities	Townships	NRCS	TNC	TU	LSP			
	S19, south line to T102 R7W S30, north line					Cover crops (340)	Corn silage and soybean acres		•					•				•	•		•			
						Root River SWCD push up ponds*	Houston County, upper catchment areas (<20 ac, <12% slope) at field/bluff interface, target using LiDAR		•									•						
						Streambank Protection/Stream Habitat Improvement (580, 395)	Localized stream reaches; DNR Fisheries priorities		•			•		•				•		•				
						Hayable buffers	Riparian cropland		•			•		•					•					
			Macroinvertebrates (Nitrate)	65% average nitrate tolerant taxa	Reduce nitrate tolerant species	Increased Perennial Cover (645, 342, 643) CRP, RIM	Watershed wide, with focus on marginal lands		•			•										M	2045	Improved MIBI. Decreasing trend in nitrate levels
						Nutrient (N) Management	Watershed wide	•	•	•								•			•			
						Assess trout pond influence on nitrate levels	Sportsmen's Park Trout Ponds		•			•								•				
						Cover crops (340)	Corn silage, soybean acres		•									•	•		•			
	Riceford Creek (519), T102 R7W S19, south line to S Fk Root R	**Houston**, Fillmore	Macroinvertebrates (Physical Habitat)	MIBI: 46.8, 42.2; Threshold 46.8	Increase quality of habitat	Pasture Management/Prescribed Grazing (528)	Livestock producers utilizing riparian pastures		•					•				•				M	2045	Improved habitat rating and MIBI.
						Cover crops (340)	Target corn silage and soybean acres		•					•				•	•		•			
	Root River, South Fork (573), Headwaters to T102 R9W S27, east line	**Fillmore**	Macroinvertebrates (Physical Habitat)	MIBI: 5.8; Threshold 46.8	Increase quality of habitat	See turbidity strategies for this reach	See turbidity strategies for this reach															**H**	2045	Improved habitat rating and MIBI.
			Macroinvertebrates (Nitrate)	94% average nitrate tolerant taxa	Reduce nitrate tolerant species	Increased Perennial Cover (645, 342, 643) CRP, RIM	Watershed wide, with focus on marginal lands		•			•											2045	Improved MIBI. Decreasing trend in nitrate

HUC-10 Subwatershed	Waterbody and Location		Parameter (incl. non-pollutant stressors)	Water Quality		Strategies	Estimated Scale of Adoption Needed	Governmental Units with Primary Responsibility										Other Partners				Priority Level	Timeline to reach WQ goal	Interim 10-yr Milestones
	Waterbody (ID)	**Location** and Upstream Influence Counties		Current Conditions	Goals / Targets			MDA	BWSR/SWCD	MPCA	County	DNR	MDH	SE Tech JPB	SE WRB	Cities	Townships	NRCS	TNC	TU	LSP			
						Nutrient (N) Management (590)	Watershed wide, with focus on row crop acres	•	•	•								•			•	H		levels.
						Cover crops (340)	Corn silage, soybean acres		•									•	•		•			
			Macroinvertebrates (Dissolved Oxygen)	Elevated phosphorus; chronically low flow conditions. low % of DO intoleratnt taxa	Reduce phosphorus levels; Root River avg 10 low DO intolerant taxa	For phosphorus, see turbidity strategies for this reach	See turbidity strategies for this reach															H	2045	Improved MIBI. Stabilized DO levels.
						Nutrient Management (590)	Watershed wide	•	•					•				•						
						Feedlot runoff control (635, 367)/ag waste storage (313)	Registered feedlots with open lots not in compliance with 7020		•	•	•			•				•						
						Urban stormwater practices	Harmony		•					•		•								
			Suspended Sediment	Very High: 5.4 tons/day High: 1.3 tons/day	65 mg/L TSS met 90% of time Apr-Sep	Prescribed grazing (528)	Riparian Pastures		•			•		•				•		•		H	2025	Decreasing trend in sediment levels.
				Moderate: 0.5 tons/day		Cover crops (340)	Corn silage and soybean acres		•					•				•	•		•			
				Low: 0.2 tons/day		Karst sinkhole treatment (527)	Sinkholes		•									•						
				Very Low: 0.02 tons/day		Streambank Protection/Stream Habitat Improvement (580, 395)	Localized stream reaches; DNR Fisheries priorities		•			•		•				•		•				
	Sorenson Creek (F52), Unnamed cr to Unnamed cr	**Fillmore**	Macroinvertebrates (Physical Habitat)	MIBI: 39.9; Threshold 46.8	Increase quality of habitat	Cover crops (340)	Corn silage and soybean acres		•					•				•	•		•	L	2045	Improved habitat rating and MIBI.
						Karst sinkhole treatment (527)	Sinkholes		•									•						
			Macroinvertebrates (Nitrate)	84% nitrate tolerant individuals	Reduce nitrate tolerant species	Increased Perennial Cover (645, 342, 643) CRP, RIM	Watershed wide, with focus on marginal lands		•			•						•	•			L	2045	Improved MIBI. Decreasing

HUC-10 Subwatershed	Waterbody and Location		Parameter (incl. non-pollutant stressors)	Water Quality		Strategies	Estimated Scale of Adoption Needed	Governmental Units with Primary Responsibility										Other Partners				Priority Level	Timeline to reach WQ goal	Interim 10-yr Milestones
	Waterbody (ID)	**Location** and Upstream Influence Counties		Current Conditions	Goals / Targets			MDA	BWSR/SWCD	MPCA	County	DNR	MDH	SE Tech JPB	SE WRB	Cities	Townships	NRCS	TNC	TU	LSP			
						Nutrient (N) Management	Watershed wide	•	•	•				•				•			•			trend in nitrate levels
						Cover crops (340)	Corn silage, soybean acres		•					•				•	•		•			
	Bridge Creek (F54)	**Fillmore, Houston**	Macroinvertebrates (Physical Habitat)	MIBI: 5.71; Threshold 46.1	Increase quality of habitat	Streambank Protection/Stream Habitat Improvement (580, 395)	Localized stream reaches; DNR Fisheries priorities		•			•		•				•		•		L	2045	Improved habitat rating and MIBI

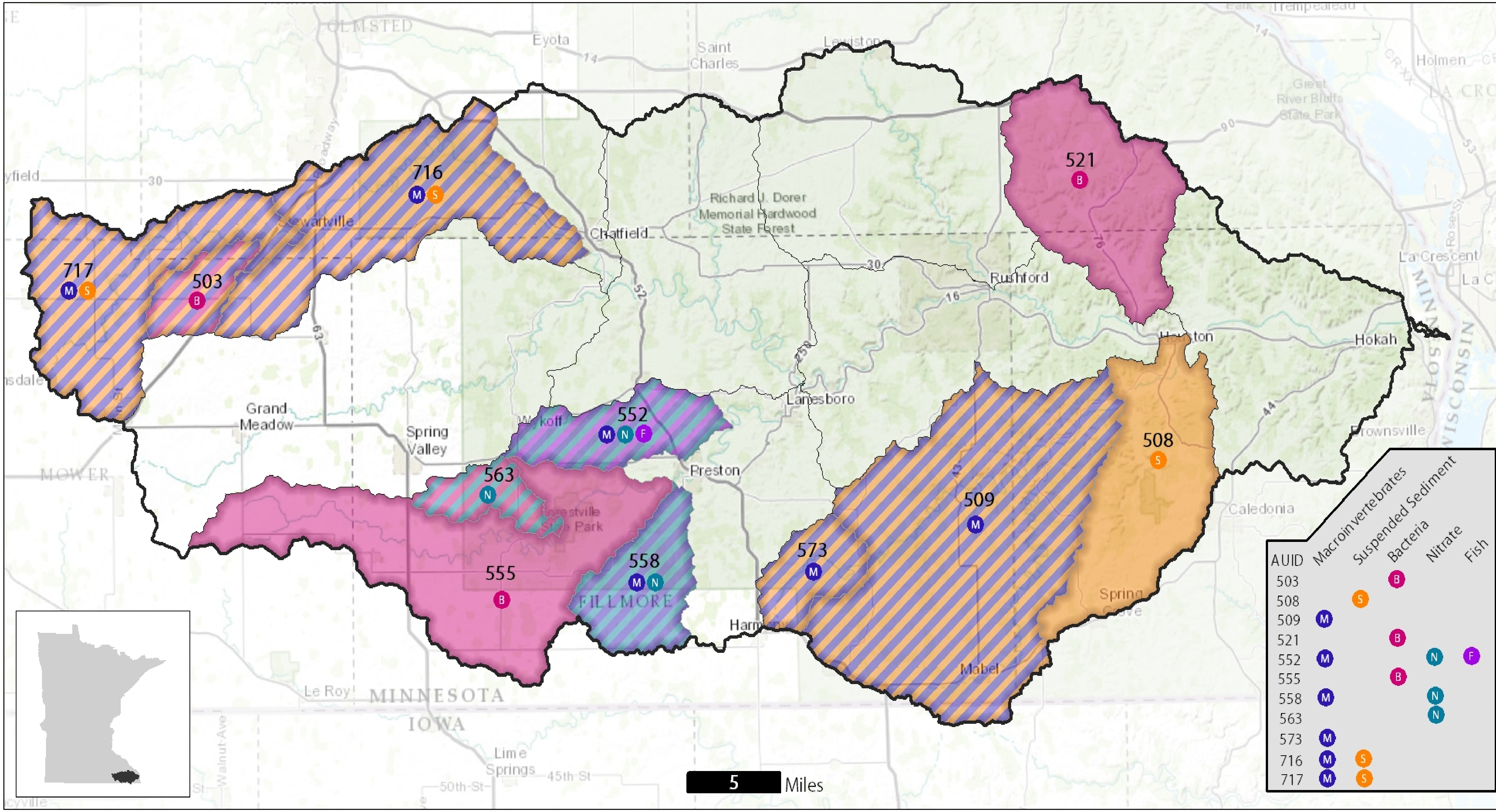


Figure 31. Critical areas across the Root River Watershed. Color of shaded drainage areas indicates parameter(s) the critical area determination is based on. Last three digits of AUID number are shown on map to correlate to implementation tables. The legend also shows what parameter(s) each AUID drainage area is a critical area for.

4. Monitoring Plan

Future monitoring in the RRW will be according to the watershed approach framework. The IWM strategy utilizes a nested watershed design allowing the aggregation of watersheds from a course to a fine scale. The foundation of this comprehensive approach is the 80 major watersheds within Minnesota. Streams are segmented by HUC. The IWM occurs in each major watershed once every 10 years (MPCA 2012). The *Root River Watershed Monitoring and Assessment Report* provides detailed discussion of IWM and how it will be applied going forward (it will be repeated in the RRW in 2018).

Load monitoring at the five locations (four gages to monitor 10 HUC level watershed, and one at the 8-HUC outlet) in the RRW is on-going and will be used to track implementation effectiveness of sediment, nitrogen, and phosphorus loads in the RRW; these sites are instrumented and gauged to track flow volumes, and are intensively monitored by the MPCA staff and local government partners.

For bacteria, the *Revised Regional Total Maximum Daily Load Evaluation of Fecal Coliform Bacteria Impairments in the Lower Mississippi River Basin in Minnesota* (MPCA 2007) includes a monitoring section that describes activities and responsibilities pertaining to the greater regional examination of pathogens in surface water, of which the RRW is a part.

Future Needs

While the RRW has already been the location of karst and groundwater related studies, more is needed to fully understand the system. The MGS groundwater study outlined additional work that was beyond the scope of their project.

> “Being able to predict the impact of changing land use practices on baseflow nitrate concentrations would be facilitated by quantitative estimates of the proportion of contributions to baseflow of shallow, nitrate-enriched water relative to deeper, nitrate-poor water in variable hydrogeologic settings. Strategies to protect deep aquifers that are currently nitrate-poor would be improved by a better understanding of the manner in which nitrate is transported beneath aquitards. The rate at which processes such as denitrification occur in variable hydrogeologic settings is also uncertain, and could be an important factor in controlling the rate at which deeper aquifers may become enriched in nitrate” (Runkel et al. 2013).

The HSPF Modeling will be updated and will incorporate new load monitoring data to better model sediment. Additional SWAT analysis may also be completed on more subwatersheds. There is still a need to determine a better method to analyze karst conditions and incorporate into the HSPF model. If this is available the next time the RRW goes through the watershed approach cycle, it will be pursued. Otherwise, follow-up on MGS recommendations could be followed.

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Appendices

Appendix A. Minnesota Department of Health – Wellhead protection planning status for community public water supply systems within subdivisions of the Root Watershed.

HUC 12 Watershed Code	HUC 12 Watershed Name	Communities with Completed Wellhead Protection Plans	Communities Actively Engaged in Wellhead Protection Planning	Communities Yet to Engage in Wellhead Protection, with Estimated Start Date
070400080207	Bear Creek			
070400080805	Beaver Creek		Spring Grove	
070400080407	Camp Creek	Harmony		
070400080403	Canfield Creek			
070400080105	Carey Creek			
070400080703	City of Houston-Root River	Houston	Rushford, Rushford Village	
070400080702	City of Peterson-Root River		Peterson, Rushford, Rushford Village	
070400080204	City of Racine-Bear Creek	Racine		
070400080106	City of Stewartville-North Branch Root River		Stewartville	
070400080701	City of Whalan-Root River			
070400080902	Cystal Creek			

HUC 12 Watershed Code	HUC 12 Watershed Name	Communities with Completed Wellhead Protection Plans	Communities Actively Engaged in Wellhead Protection Planning	Communities Yet to Engage in Wellhead Protection, with Estimated Start Date
070400080206	Deer Creek	Grand Meadow		
070400080409	Duschee Creek			
070400080402	Etna Creek-South Branch Root River			
070400080102	Evanger Church	Sargeant		
070400080404	Forestville Creek			
070400080101	Headwaters North Branch Root River	Dexter		Haven Hutterian Brethren
070400080401	Headwaters South Branch Root River		Ostrander	
070400080203	Kedron Creek			
070400080602	Lower Money Creek			
070400080504	Lower Rush Creek		Rushford	
070400080806	Lower South Fork Root River	Houston		
070400080303	Lynch Creek-Root River		Chatfield	
070400080208	Middle Branch Root River			
070400080502	Middle Rush Creek			
070400080803	Middle South Fork			

HUC 12 Watershed Code	HUC 12 Watershed Name	Communities with Completed Wellhead Protection Plans	Communities Actively Engaged in Wellhead Protection Planning	Communities Yet to Engage in Wellhead Protection, with Estimated Start Date
	Root River			
070400080107	Mill Creek		Chatfield	Chosen Valley Mobile Home Park
070400080108	North Branch Root River		Chatfield	
070400080201	North Fork Bear Creek			
070400080503	Pine Creek	Utica		
070400080301	Rice Creek		Fountain	
070400080804	Riceford Creek		Mabel	
070400080103	Robinson Creek			
070400080904	Root River		Hokah	
070400080901	Silver Creek			
070400080410	South Branch Root River	Preston	Lanesboro	
070400080202	South Fork Bear Creek	Grand Meadow		
070400080205	Spring Valley Creek		Spring Valley	
070400080903	Thompson Creek		Hokah	
070400080305	Torkelson Creek-Root River			

HUC 12 Watershed Code	HUC 12 Watershed Name	Communities with Completed Wellhead Protection Plans	Communities Actively Engaged in Wellhead Protection Planning	Communities Yet to Engage in Wellhead Protection, with Estimated Start Date
070400080405	Town of Forestville-South Branch Root River			
070400080104	Town of High Forest-North Branch Root River			
070400080304	Town of Pilot Mound-Money Creek			
070400080302	Trout Run			
070400080601	Upper Money Creek			
070400080501	Upper Rush Creek	Lewiston, Utica		
070400080801	Upper Souh Fork Root River	Harmony		
070400080408	Watson Creek	Preston	Wykoff	
070400080406	Willow Creek	Preston		Greenleafton
070400080802	Wisel Creek	Canton		

Appendix B. Projects and Activities in the Root River Watershed.

Root River Field to Stream Partnership (Minnesota Department of Agriculture)

The Root River Field to Stream Partnership is designed to help southeastern Minnesota farmers and policy-makers better understand the relationship between agricultural practices and water quality.

The Root River Field to Stream Partnership started in 2009. This partnership includes farmers and their advisers, the MDA, Minnesota Agricultural Water Resource Center, The Nature Conservancy, Monsanto, Fillmore, Mower and Houston County SWDC, and academic researchers. The purpose of this project is to conduct intensive surface and groundwater monitoring at multiple scales in order to provide an assessment of the amount and sources of nutrients and sediment delivered to the watershed outlet and also to determine the effectiveness of agricultural BMPs. Monitoring is occurring both at the edge of agricultural fields and at in-stream locations. Monitoring at these two locations will help improve the understanding of how practices on the land affect water quality on a larger scale.

http://www.mda.state.mn.us/protecting/cleanwaterfund/onfarmprojects/rootriverpartnership.aspx

Healthy Forests, Healthy Waters Program (Minnesota Department of Natural Resources)

This is a private land assistance program still under development and uses CWF dollars. These funds are to be directed towards private lands with a forestry emphasis.

Root River Sediment Budget Project (Winona State University, Utah State University)

Sediment is a natural part of river ecosystems. Yet, in excess quantities, or in cases where the type of sediment contributed to a river has been severely altered (e.g. gravel inputs eliminated, silt and clay inputs increased), sediment can severely degrade water quality and aquatic ecosystem health. This problem is exceedingly common.

While previous research has advanced our understanding of water-sediment dynamics, several key questions remain. This research project will:

1. Provide specific information regarding sediment sources and transport pathways in the RRW.
2. Determine how water and sediment dynamics have changed over time.
3. Provide guidance for BMPs aimed at reducing sediment delivery to the Root River.

Researchers will compile existing data, and generate several new, critical datasets to develop a comprehensive assessment of sediment-related impairments in the RRW.

Excessive sedimentation is among the top water quality concerns in the RRW. This concern must be addressed in order to protect the agricultural economy, tourism and outdoor industries that are so important to this area. This project is set to be completed in 2016.

http://www.mda.state.mn.us/protecting/cleanwaterfund/research/sedimentrootriver.aspx

Lower Mississippi River Habitat Partnership (Department of Natural Resources)

This Partnership of over 20 agencies and organizations seeks to protect and enhance habitat along the Mississippi River Corridor through wetland restoration and enhancement; goat prairie restoration; and water level management, island construction, and backwater dredging.

Major tributaries, including the Root and Zumbro Rivers, were channelized and leveed in their lower reaches near the Mississippi River in the early 1900s, isolating them from their floodplains except during high water events. Forests, wetlands, and prairies behind the levees were converted to agriculture or urban uses. Over 15,000 acres of native habitats were lost, fragmenting the natural habitat corridors that connected the Mississippi River to its tributaries and their watersheds that were essential to the many species of fish and wildlife that roamed this area. This was especially damaging to high quality wetlands that were found in these floodplains.

http://www.legacy.leg.mn/projects/lower-mississippi-river-habitat-partnership

Area Soil Health Technician

The Area Soil Health Technician works with producers, canning companies, crop consultants and local staff in 11 southeast Minnesota counties to promote the use of soil health practices, such as cover crops, managed grazing and precision ag practices (plant tissue testing, soil N testing, variable rate technology for fertilizer applications, split N applications, etc.). This position is funded with a FY2014 BWSR Clean Water Fund Shared Services Grant through the southeast Minnesota SWCD Technical Support Joint Powers Board which ends in December 2017. Currently, work is ongoing with over 100 producers that are implementing the soil health practices mentioned above on about 30,000-acres in the 11 counties, many of whom are receiving cost share through EQIP. Another key part of this job is to train other local SWCD and NRCS staff on soil health practices. This involves helping organize and presenting at local field days. Several field days were held throughout the region in the fall of 2015. The technician has also helped develop NRCS practice standards for many of the soil health practices; cover crops in particular. And, there will be technician oversight of $100,000 in incentive payments from an LCCMR grant for cover crop demonstrations in SE Minnesota with implementation likely beginning in 2016.

Southeast Minnesota Nitrogen BMP Outreach Program and Nutrient Management Planners

Southeast Minnesota Nitrogen BMP Outreach Program is a MDA Program looking at ways to reduce nitrate groundwater contamination in southeastern Minnesota through assisting crop producers in adapting N fertilizer BMPs to their operations. Assistance will come in the form of support for: 1) on-farm N fertilizer BMP demonstrations; 2) on-farm N management assessments; 3) advanced scientific on-farm N fertilizer BMP trials; and 4) farmer-to-farmer N management learning groups. This program will be active in Goodhue, Wabasha, Olmsted, Winona, Fillmore, and Houston counties. The two NMP specialists housed at SWCDs will be working on this project half time.

Southeast Minnesota Nitrogen Planning (MPCA)

Nitrate pollution of groundwater is a regional problem in southeast Minnesota; every county water plan lists it as a priority concern. In 2010, a partnership of MPCA, the MDA, Fillmore County SWCD and Winona State University (WSU) worked with numerous landowners to provide additional information (i.e. soil water nitrate values, field assessments, etc.) in support of efforts to optimize nitrogen management. This information will inform watershed management strategies for the Root, Whitewater, Zumbro, Cannon and direct tributary watersheds of southeast Minnesota: it will help discern which land uses and management scenarios lose the most nitrate, and which BMPs are most effective in reducing those losses.

Southeastern Minnesota watersheds present a unique setting in which karst geology plays a crucial role: pollutants from various land uses move vertically down through bedrock with minimal or no soil filtration before entering ground and surface waters. Nitrate-nitrogen contamination of groundwater, especially shallow private wells, has long been a local concern.

In surface water, over the past 30 to 55 years, nitrate-nitrogen is the only pollutant that has shown a steadily rising concentration throughout southeastern Minnesota based on MPCA monitoring data.

A network of about 50 lysimeters was established in 2013 on 15 sites to compare nitrate movement through the soil profile beneath a variety of land uses, soils and geology found in southeastern Minnesota. These include agriculture, forest, prairie, urban, residential and golf course settings. In some locations, the lysimeters are nested with other monitoring at the field and watershed scales that allows for a more comprehensive study of nitrate transport in karst.

Root River One Watershed One Plan Pilot Watershed (BWSR)

The *One Watershed, One Plan* vision is to align local planning and implementation with state strategies over a 10-year transition period into plans built largely around the state's major watersheds. The pilot program will allow local government units developing the first plans to test operating procedures to achieve that vision. Final policies and procedures are anticipated to be adopted by BWSR in early 2016.
BWSR - One Watershed, One Plan

Additional Root River Watershed Resources

1. USDA Natural Resources Conservation Service (NRCS) Rapid Watershed Assessment for the Root River Watershed (2007):
   http://www.nrcs.usda.gov/Internet/FSE_DOCUMENTS/nrcs142p2_007652.pdf

2. Minnesota Department of Agriculture's Minnesota Nitrogen Fertilizer Management Plan (2015)

   http://www.mda.state.mn.us/chemicals/fertilizers/nutrientmgmt/~/media/Files/chemicals/nfmp/nfmp2015.pdf

3. Minnesota Department of Natural Resources Online Watershed Health Assessment Framework (WHAF) tool: http://arcgis.dnr.state.mn.us/ewr/whaf/Explore/#.

   And the related Assessment Mapbook for the RRW:
   http://files.dnr.state.mn.us/natural_resources/water/watersheds/tool/watersheds/wsmb43.pdf

4. Minnesota Department of Natural Resources Watershed Priorities for the RRW. DNR, 2015. Available upon request for review.

   Summary: This document was prepared by the Department of Natural Resources (DNR) Division of Ecological and Water Resources. Region 3 staff from DNR Divisions (Fisheries, Wildlife, Parks and Trails and Ecological and Water Resources) were engaged in several meetings to develop watershed priorities for the RRW. The meetings focused on gathering input from staff based upon professional judgment from their combined experience and local knowledge from working within the watershed.

   The information was presented in a series of tables organized by Division and reflects different priorities based on the mission of each Division. Information presented in the tables is organized by the 10-digit hydrologic unit code (HUC) number and associated name, along with the appropriate 12-digit HUC subwatershed name(s).

5. Minnesota Geological Survey: Geologic Controls on Groundwater and Surface Water Flow in Southeastern Minnesota and its Impact on Nitrate Concentrations in Streams: Local Project Area Report (http://conservancy.umn.edu/handle/11299/162613)

   Abstract: This report summarizes the results of part of a MGS investigation conducted for the MPCA designed to support watershed planning efforts in southeast Minnesota. The broader project provides better understanding of the geologic controls on nitrate transport in the region, including nitrate in groundwater that is the source of baseflow to streams. This report describes a local scale subproject focused on a relatively small part of the RRW in Fillmore County. We conducted new mapping that provides a more detailed depiction of the geologic conditions in a three dimensional electronic format suitable for groundwater-surface water modeling. In addition, we used existing maps and reports along with new field data collected during the course of this project to improve the hydrostratigraphic characterization of the bedrock. This led to a more comprehensive understanding of the hydrostratigraphic attributes of bedrock that forms the Upper Carbonate Plateau, which dominates the landscape in the local project area. Cross sections within the local project area are used to illustrate how nitrate is transported in the ground and surface water system.

6. Identifying and Quantifying Sediment Sources and Sinks in the Root River, Southeastern Minnesota. Thesis covering sediment fingerprinting work by Justin Stout (2012).

7. Southeast Minnesota Landscape Plan: A Regional Plan to Guide Sustainable Forest Management (Minnesota Forest Resources Council – MFRC 2014) http://mn.gov/frc/docs/2014_SE_Landscape_Plan-Public_Comment_DRAFT-2.pdf

8. Root River Landscape Stewardship Plan (DNR 2013) http://www.fillmoreswcd.org/documents/RootRiverLandscapeStewardship_final.pdf

9. Local Water Management Plans for all counties within the RRW:

   d. Fillmore County: http://www.fillmoreswcd.org/localWater.html

   e. Houston County: http://co.houston.mn.us/Environmental_Services.aspx

f. Mower County: http://www.co.mower.mn.us/files/PZES/Water_Plan/Mower%20County%20Local%20Water%20Management%20Plan.pdf

g. Winona County: http://www.co.winona.mn.us/page/2851

h. Olmsted County: http://www.co.olmsted.mn.us/planning/environment/Pages/WaterPlan.aspx

i. Dodge County: http://www.co.dodge.mn.us/departments/wells_and_water_quality.php

Appendix C. Assessment status and stressors of stream reaches in the Root River Watershed, presented by level 10 HUC, generally from east to west.

Sub watershed name (HUC 10)	AUID (07040008-)	Use Class	Designated Use											
			Aquatic Life										Aquatic Recreation	Drinking Water
			Aquatic Life Decision	Potential Parameters			Potential Stressors						Bacteria	Nitrate
				Fish IBI	Macroinvertebrate IBI	Turbidity	Temperature	Dissolved Oxygen	Nitrate	Suspended Sediment (TSS)	Physical Habitat	Physical Connectivity		
Root River (Lower)	501	2B	**EX**	FS	EX	**EX**	N	N	Y	Y	Y	N	**EX****	
	502	2B	EX	FS	EX	EX	N	N	Y	Y	Y	N		
	507	1B, 2A, 3C	FS	EX	FS	IF							EX	FS
	571	1B, 2A, 3C	FS	FS	FS									
	640	2B	EX	EX	EX		IF	N	IF	IF	Y	N		
	643	1B, 2A, 3C	FS	FS	FS									
	650	1B, 2A, 3C	FS	FS	EX									
	653	1B, 2A, 3C	FS	FS	FS									
	655	1B, 2A, 3C	FS	FS	FS									
	520	2B	EX	FS	EX	SID	N	N	IF	Y	Y	N		
	522	2B	EX	FS	EX	SID	N	N	IF	Y	Y	N		

City of Rushford Root River	527	2B	**EX**	FS	EX	**EX**	N	N	IF	Y	Y	N		
	589	1B, 2A, 3C	FS	FS	FS	IF								
	620	1B, 2A, 3C	FS	FS	FS									
	621	1B, 2A, 3C	FS	FS	FS									
	623	1B, 2A, 3C	FS	FS	FS									
	638	1B, 2A, 3C	FS	FS	FS									
	658	1B, 2A, 3C	FS	FS	FS									
	659	1B, 2A, 3C	EX	FS	EX		N	N	N	IF	Y	N		
Trout Run Root River	528	2B	EX	FS	EX	SID	N	N	IF	Y	Y	N	IF	
	530	2B	IF			FS							IF	
	534	2B	EX	FS	EX		N	IF	IF	N	Y	N	**EX**	
	581	1B, 2A, 3C	EX	EX	EX		IF	N	Y	IF	Y	IF		
	605	2B	EX	FS	EX		N	IF	IF	N	IF	N		
	F48	1B, 2A, 3C	EX	FS	EX		N	IF	IF	N	IF	N		
	G86	1B, 2A, 3C	FS	FS	F									
	G87	1B, 2A, 3C	EX	FS	EX		N	IF	Y	N	Y	N		
	G88	1B, 2A, 3C	FS	FS	EX	EX							EX	
Middle Branch Root River	506	2B	EX	FS	EX		N	N	IF	IF	Y	N	EX	
	540	2B	EX	EX	EX	FS	N	N	Y	IF	Y	N		
	541*	1B, 2A, 3C	EX	FS	EX		N	N	Y	N	Y	N		
	542	2B	FS	FS	FS	FS							EX	
	544	2B	EX	FS	EX		N	N	IF	IF	Y	N		
	545	2B	FS	FS	FS	FS								

	546	2B	FS	FS	FS								EX	
	548	1B, 2A, 3C	EX	EX	EX	FS	Y	IF	Y	IF	Y	N	EX	IF
	584	2B	FS	FS										
	713	2B	IF	FS	FS									
	B96	2B	FS	FS	FS									
Money Creek	521	2B	**EX**	FS	FS	**EX**							EX**	
	631	1B, 2A, 3C	EX	EX	FS	IF	Y	N	N	IF	Y	Y		FS
	636	1B, 2A, 3C	FS	FS	FS									
	B02	2B	IF			FS								
North Branch Root River	503	2B	FS	FS	FS	FS							EX**	
	535	2B	FS	FS	FS	EX							EX	
	536	1B, 2A, 3C	NA	NA	NA	FS							EX	FS
	696	2B	FS	FS	FS	FS								
	706	2B	EX	FS	EX		N	IF	IF	IF	Y	N		
	716	2B	**EX**	FS	EX	**EX**	N	N	IF	Y	Y	N		
	717	2B	**EX**	FS	EX	**EX**	N	Y	IF	Y	Y	N		
	F41	2B	FS	EX	EX									
	F46	2B	EX	EX	EX		N	IF	IF	N	Y	N		
Rush Creek	523	1B, 2A, 3C	IF	NA	NA	FS							EX	FS
	524	1B, 2A, 3C	EX	FS	EX	FS	N	IF	Y	N	Y	N		
	526	2B	EX	FS	EX		N	IF	IF	IF	Y	N		
	576	2B	EX	FS	EX		N	IF	IF	IF	Y	N		
	608	1B, 2A, 3C	FS	FS	FS									
	609	1B, 2A, 3C	FS	FS	FS	FS								
	685	1B, 2A, 3C	FS	FS	FS									

South Branch Root River	550	1B, 2A, 3C	EX	FS	EX	SID	N	IF	Y	Y	N	N	EX	FS
	552	1B, 2A, 3C	EX	EX	EX	SID	Y	N	Y	Y	Y	N	EX	EX
	553	1B, 2A, 3C	FS	FS	FS									
	554	1B, 2A, 3C	**EX**			**EX**								
	555	1B, 2A, 3C	**EX**	FS	FS	**EX**							EX**	EX
	556	1B, 2A, 3C	**EX**	FS	EX	**EX**	N	N	Y	IF	N	N		
	557	2B	FS	FS	FS	IF							IF	
	558	1B, 2A, 3C	EX	FS	EX	IF	N	N	Y	N	Y	N	EX	EX
	559	1B, 2A, 3C	EX	EX	EX		Y	IF	Y	IF	Y	N		
	560	1B, 2A, 3C	IF	FS	FS	IF								
	561	2B	**EX**	NA	NA	**EX**								
	562	1B, 2A, 3C	IF			IF								EX
	563	1B, 2A, 3C	**EX**	FS	FS	**EX**							EX	EX
	586	2B	**EX**	NA	NA	**EX**							EX**	
	597	1B, 2A, 3C	EX	FS	EX		N	N	Y	N	IF	N		EX
	599	1B, 2A, 3C	FS	FS	FS									
	678	1B, 2A, 3C	FS	FS	FS									
	F08	1B, 2A, 3C	IF	EX	EX									
	508	2B	EX	FS	EX	EX	N	N	Y	Y	Y	N	EX	
	509	2B	EX	FS	EX	SID	N	N	IF	Y	Y	N		
	510	1B, 2A, 3C	EX	FS	EX		IF	N	Y	IF	Y	N		FS

South Fork Root River	511	1B, 2A, 3C	**EX**	FS	FS	**EX**								
	512	1B, 2A, 3C	FS	FS	FS									
	513	2B	FS	FS	FS									
	515	2B	IF	FS	EX									
	518	1B, 2A, 3C	EX	FS	EX		N	IF	Y	IF	Y	N		
	519	2B	EX	FS	EX		N	N	N	IF	Y	N		
	568	1B, 2A, 3C	FS	FS	FS									
	570	1B, 2A, 3C	FS	FS	FS									
	572	2B	FS	FS	FS	FS								
	573	2B	EX	EX	EX	EX	IF	Y	Y	Y	Y	N		
	616	1B, 2A, 3C	FS	FS	FS									
	617	1B, 2A, 3C	FS	FS	FS									
	632	1B, 2A, 3C	FS	FS	FS									
	633	1B, 2A, 3C	FS	FS	FS									
	F49	2B	FS	FS										
	F52	2B	EX	FS	EX		N	IF	Y	N	Y	N		
	F54*	1B, 2A, 3C	EX	FS	EX		N	IF	IF	IF	Y	N		

Key:	
FS	Full Support
EX	Exceeded Criteria during 2012 assessment
EX	Exceeded Criteria prior to 2012 assessment

Summary:	FS	EX	IF
Aquatic Recreation	--	19	3
Drinking Water	6	6	1

N	Not a stressor to fish and/or macroinvertebrates	Aquatic Life	41	47	8	
Y	Stressor to fish and/or macroinvertebrates	Fish IBI	77	12	0	
IF	Insufficient information	Macroinvertebrate IBI	42	44	7	
SID	IF but stressor identification determined TMDL is needed	Turbidity	13	17	13	
NA	Not assessable with current criteria					
*	AUIDs undergoing use class change and not included in current watershed TMDL					
**	Impairments TMDL calculation approved in report previous to 2015					

Appendix D. Permitted Point Sources in the Root River Watershed.

Refer to the RRW TMDL Report (MPCA 2015) for more information. Stormwater permit holders were not included in this table.

HUC-10 Subwatershed	Point Source			Pollution Allocation (Yes/No)
	Name	Permit #	Type	
0704000809 **Root River (Lower Portion)**	Hokah WWTP	MN0021458	Municipal	Yes
0704000807 **City of Rushford**	Jennie-O Turkey Store - Benson Farm	MNG440036	CAFO	No
	Houston WWTP	MN0023736	Municipal	Yes
	Peterson WWTP	MN0024490	Municipal	Yes
	Rushford WWTP	MN0024678	Municipal	Yes
	MDNR Peterson State Fish Hatchery	MN0061221	Industrial	Yes
0704000803 **Trout Run**	Eric Ruen Farm - Sec 11	MNG441292	CAFO	No
	Jennie-O Turkey Store - Fay Farm	MNG440037	CAFO	No
0704000802 **Middle**	Minnesota Family Farms - S2	MNG441059	CAFO	No

HUC-10 Subwatershed	Point Source			Pollution Allocation (Yes/No)
	Name	Permit #	Type	
Branch Root River	Minnesota Family Farms - Nursery 1	MNG441059	CAFO	No
	Jon & Glenn Oehlke Farms	MNG440068	CAFO	No
	Jennie-O Turkey Store - Chatfield Farm	MNG440035	CAFO	No
	Spring Valley WWTP	MN0051934	Municipal	Yes
	Grand Meadow WWTP	MN0023558	Municipal	Yes
	Wykoff WWTP	MN0020826	Municipal	Yes
	Racine WWTP	MN0024554	Municipal	Yes
0704000801	Larson Products Inc Sec 5	MNG440330	CAFO	No
	Schoenfelder Farms LLP - Blue Ridge East	MN0070289	CAFO	No
	Dexter WWTP	MNG580228	Municipal	Yes
	MNDOT High Forest Rest Area	MN0044377	Municipal	Yes

HUC-10 Subwatershed	Point Source			Pollution Allocation (Yes/No)
	Name	Permit #	Type	
North Branch Root River	Haven Hutterian Brethren	MNG580071	Municipal	Yes
	Chatfield WWTP	MN0021857	Municipal	Yes
	Stewartville WWTP	MN0020681	Municipal	Yes
	Stewartville MS4 (future)	NA	Municipal	Yes
	Great River Energy - Pleasant Valley	MN0067717	Industrial	Yes
	Milestone Materials - Panhandle (Station 121)	MNG400081	Industrial (Mining)	Yes
	Milestone Materials - Stewartville I-90 (Station 120)	MNG400081	Industrial (Mining)	Yes
0704000805 **Rush Creek**	Smith Farms of Rushford Inc	MNG440455	CAFO	No
	Jennie-O Turkey Store - Lingenfelter	MNG440038	CAFO	No

HUC-10 Subwatershed	Point Source			Pollution Allocation (Yes/No)
	Name	Permit #	Type	
	MNDOT Enterprise Rest Area	MN0048844	Municipal	Yes
	Lewiston WWTP	MN0023965	Municipal	Yes
0704000804 **South Branch Root River**	Wilson Hog Properties LLC	MNG4412130	CAFO	No
	Mensink Family LLC	MNG441177	CAFO	No
	Hellickson Swine - Home	MNG440416	CAFO	No
	Ridgeland Farm - Finisher	MNG440077	CAFO	No
	Allan & Kevin Marzolf Farm	MNG440076	CAFO	No
	CCPC Swine LP	MNG440939	CAFO	No
	Lanesboro Sales Commission	MNG440958	CAFO	No
	Ostrander WWTP	MN0024449	Municipal	Yes
	Preston WWTP	MN0020745	Municipal	Yes
	Fountain WWTP	MN0050873	Municipal	Yes
	Lanesboro WWTP	MN0020044	Municipal	Yes

HUC-10 Subwatershed	Point Source			Pollution Allocation (Yes/No)
	Name	Permit #	Type	
	Foremost Farms USA Cooperative	MN0001333	Industrial	No
	POET Biorefining - Preston	MN0064017	Industrial	Yes (Individual stormwater allocation)
	Lanesboro Public Utilities - Light Plant	MNG255021	Industrial	No
	MDNR Lanesboro State Fish Hatchery	MN0004430	Industrial	Yes
0704000808 South Fork Root River	Johnson Rolling Acres Farm - Sec 21	MNG441129	CAFO	No
	Mabel WWTP	MN0020877	Municipal	Yes
	Canton WWTP	MN0023001	Municipal	Yes

Appendix E. Allocation summary for all completed sediment, nitrate and bacteria TMDLs in the Root River watershed.

10 HUC Name	Listed Waterbody Name (AUID 07040008-)	Pollutant	Flow Zone	E. coli allocations (billions orgs/year) Sediment (TSS) allocations (tons/day) Nitrate allocations (lbs/day)			
				Wasteload Allocation		Load Allocation	Margin of Safety
				Permitted WW	Permitted SW (CSW/ISW/MS4	Watershed Load	
Root River (Lower portion)	Root River (501)	TSS	Very High	10.07	2.13	457.10	52.14
			High	10.07	1.04	219.82	25.66
			Mid	10.07	0.77	161.57	19.16
			Low	10.07	0.62	129.20	15.54
			Dry	10.07	0.48	98.33	12.10
		E. coli	Very High	0.86	NA	329.40	82.81
			High	0.86	NA	155.76	44.47
			Mid	0.86	NA	113.32	18.15
			Low	0.86	NA	63.96	23.29
			Dry	0.86	NA	40.65	13.94

10 HUC Name	Listed Waterbody Name (AUID 07040008-)	Pollutant	Flow Zone	E. coli allocations (billions orgs/year) Sediment (TSS) allocations (tons/day) Nitrate allocations (lbs/day)			
				Wasteload Allocation		Load Allocation	Margin of Safety
				Permitted WW	Permitted SW (CSW/ISW/MS4	Watershed Load	
	Root River (502)	TSS	Very High	10.07	1.98	415.03	47.45
			High	10.07	1.00	205.77	24.09
			Mid	10.07	0.69	140.14	16.77
			Low	10.07	0.58	103.07	12.63
			Dry	10.07	0.31	59.39	7.75
	Thompson Creek (507)	*E. coli*	Very High	NA	NA	17.00	1.89
			High	NA	NA	1.64	0.18
			Mid	NA	NA	0.59	0.07
			Low	NA	NA	0.40	0.04
			Dry	NA	NA	0.15	0.02
City of Rushford-Root	Root River	TSS	Very High	9.05	2.14	365.38	41.84

10 HUC Name	Listed Waterbody Name (AUID 07040008-)	Pollutant	Flow Zone	E. coli allocations (billions orgs/year) Sediment (TSS) allocations (tons/day) Nitrate allocations (lbs/day)			
				Wasteload Allocation		Load Allocation	Margin of Safety
				Permitted WW	Permitted SW (CSW/ISW/MS4	Watershed Load	
River	(520)		High	9.05	1.01	169.59	19.96
			Mid	9.05	0.65	107.55	13.03
			Low	9.05	0.45	72.91	9.16
			Dry	9.05	0.27	41.61	5.66
	Root River (522)	TSS	Very High	9.29	2.26	365.01	41.84
			High	9.29	1.06	169.30	19.96
			Mid	9.29	0.69	107.27	13.03
			Low	9.29	0.47	72.65	9.16
			Dry	9.29	0.28	41.35	5.66
	Root River (527)	TSS	Very High	9.25	2.59	364.72	41.84
			High	9.25	1.22	169.18	19.96

10 HUC Name	Listed Waterbody Name (AUID 07040008-)	Pollutant	Flow Zone	E. coli allocations (billions orgs/year) Sediment (TSS) allocations (tons/day) Nitrate allocations (lbs/day)			
				Wasteload Allocation		Load Allocation	Margin of Safety
				Permitted WW	Permitted SW (CSW/ISW/MS4	Watershed Load	
			Mid	9.25	0.79	107.21	13.03
			Low	9.25	0.54	72.62	9.16
			Dry	9.25	0.32	41.36	5.66
Trout Run-Root River	Trout Run Creek (G88)	*E. coli*	Very High	NA	NA	143.06	15.90
			High	NA	NA	110.04	12.23
			Mid	NA	NA	95.36	10.60
			Low	NA	NA	58.69	6.52
			Dry	NA	NA	47.68	5.30
	Root River, Middle Branch (528)	TSS	Very High	7.74	2.23	207.44	24.16
			High	7.74	0.86	79.83	9.83
			Mid	7.74	0.48	44.61	5.87

10 HUC Name	Listed Waterbody Name (AUID 07040008-)	Pollutant	Flow Zone	E. coli allocations (billions orgs/year) Sediment (TSS) allocations (tons/day) Nitrate allocations (lbs/day)			
				Wasteload Allocation		Load Allocation	Margin of Safety
				Permitted WW	Permitted SW (CSW/ISW/MS4	Watershed Load	
			Low	7.74	0.25	22.71	3.41
			Dry	7.74	0.09	7.25	1.68
	Root River, Middle Branch (534)	*E. coli*	Very High	19.87	36.45	3008.86	340.58
			High	19.87	14.31	1180.87	135.01
			Mid	19.87	8.36	689.84	79.79
			Low	19.87	4.68	386.70	45.70
			Dry	19.87	2.15	177.21	22.14
Middle Branch Root River	Root River, Middle Branch (506)	*E. coli*	Very High	10.45	NA	1526.88	170.81
			High	10.45	NA	630.87	71.26
			Mid	10.45	NA	385.25	43.97
			Low	10.45	NA	227.19	26.40

10 HUC Name	Listed Waterbody Name (AUID 07040008-)	Pollutant	Flow Zone	E. coli allocations (billions orgs/year) Sediment (TSS) allocations (tons/day) Nitrate allocations (lbs/day)			
				Wasteload Allocation		Load Allocation	Margin of Safety
				Permitted WW	Permitted SW (CSW/ISW/MS4	Watershed Load	
			Dry	10.45	NA	115.30	13.97
	Bear Creek (542)	*E. coli*	Very High	0.78	NA	660.61	73.49
			High	0.78	NA	272.43	30.36
			Mid	0.78	NA	167.65	18.71
			Low	0.78	NA	99.41	11.13
			Dry	0.78	NA	52.30	5.90
	Deer Creek (546)	*E. coli*	Very High	4.97	NA	381.01	42.89
			High	4.97	NA	156.66	17.96
			Mid	4.97	NA	95.65	11.18
			Low	4.97	NA	55.39	6.71
			Dry	4.97	NA	27.72	3.63

10 HUC Name	Listed Waterbody Name (AUID 07040008-)	Pollutant	Flow Zone	E. coli allocations (billions orgs/year) Sediment (TSS) allocations (tons/day) Nitrate allocations (lbs/day)			
				Wasteload Allocation		Load Allocation	Margin of Safety
				Permitted WW	Permitted SW (CSW/ISW/MS4	Watershed Load	
	Spring Valley Creek (548)	*E. coli*	Very High	4.46	NA	197.35	22.42
			High	4.46	NA	80.15	9.40
			Mid	4.46	NA	47.76	5.80
			Low	4.46	NA	27.43	3.54
			Dry	4.46	NA	12.31	1.86
Money Creek	Money Creek (521)	*E. coli*	Very High	NA	NA	6.10	1.56
			High	NA	NA	4.14	0.85
			Mid	NA	NA	3.55	0.26
			Low	NA	NA	2.95	0.30
			Dry	NA	NA	2.42	0.30
North Branch	Robinson Creek	*E. coli*	Very	NA	NA	4.72	1.21

10 HUC Name	Listed Waterbody Name (AUID 07040008-)	Pollutant	Flow Zone	E. coli allocations (billions orgs/year) Sediment (TSS) allocations (tons/day) Nitrate allocations (lbs/day)			
				Wasteload Allocation		Load Allocation	Margin of Safety
				Permitted WW	Permitted SW (CSW/ISW/MS4	Watershed Load	
Root River	(503)		High				
			High	NA	NA	1.80	0.84
			Mid	NA	NA	1.15	0.27
			Low	NA	NA	0.49	0.32
			Dry	NA	NA	0.16	0.13
	Root River, North Branch (535)	*E. coli*	Very High	9.42	43.11	1633.67	187.36
			High	9.42	15.55	598.98	67.60
			Mid	9.42	7.97	302.30	34.64
			Low	9.42	4.08	150.01	17.71
			Dry	9.42	1.74	58.52	7.55
	Mill Creek	*E. coli*	Very High	NA	NA	52.57	5.84

10 HUC Name	Listed Waterbody Name (AUID 07040008-)	Pollutant	Flow Zone	E. coli allocations (billions orgs/year) Sediment (TSS) allocations (tons/day) Nitrate allocations (lbs/day)			
				Wasteload Allocation		Load Allocation	Margin of Safety
				Permitted WW	Permitted SW (CSW/ISW/MS4	Watershed Load	
	(536)		High	NA	NA	4.53	0.50
			Mid	NA	NA	1.22	0.14
			Low	NA	NA	0.97	0.11
			Dry	NA	NA	0.74	0.08
	Root River, North Branch (716)	TSS	Very High	0.68	3.17	109.59	12.60
			High	0.68	0.94	32.78	3.82
			Mid	0.68	0.55	18.83	2.23
			Low	0.68	0.31	10.81	1.31
			Dry	0.68	0.17	5.77	0.74
	Root River, North Branch (717)	TSS	Very High	0.55	0.12	47.25	5.32
			High	0.55	0.04	13.96	1.62

10 HUC Name	Listed Waterbody Name (AUID 07040008-)	Pollutant	Flow Zone	E. coli allocations (billions orgs/year) Sediment (TSS) allocations (tons/day) Nitrate allocations (lbs/day)			
				Wasteload Allocation		Load Allocation	Margin of Safety
				Permitted WW	Permitted SW (CSW/ISW/MS4	Watershed Load	
			Mid	0.55	0.02	7.91	0.94
			Low	0.55	0.01	4.42	0.55
			Dry	0.55	0.01	2.24	0.31
Rush Creek	Rush Creek (523)	*E. coli*	Very High	1.31	NA	357.77	39.90
			High	1.31	NA	257.74	28.78
			Mid	1.31	NA	212.72	23.78
			Low	1.31	NA	179.27	20.06
			Dry	1.31	NA	138.32	15.51
South Branch Root River	Root River, South Branch (550)	*E. coli*	Very High	2.81	NA	1651.98	183.87
			High	2.81	NA	744.48	83.03
			Mid	2.81	NA	459.30	51.35

10 HUC Name	Listed Waterbody Name (AUID 07040008-)	Pollutant	Flow Zone	E. coli allocations (billions orgs/year) Sediment (TSS) allocations (tons/day) Nitrate allocations (lbs/day)			
				Wasteload Allocation		Load Allocation	
				Permitted WW	Permitted SW (CSW/ISW/MS4	Watershed Load	Margin of Safety
			Low	2.81	NA	288.58	32.38
			Dry	2.81	NA	155.63	17.60
		TSS	Very High	0.93	0.02	13.52	1.61
			High	0.93	0.02	5.61	0.73
			Mid	0.93	0.02	3.11	0.45
			Low	0.93	0.02	1.62	0.28
			Dry	0.93	0.02	0.46	0.15
	Watson Creek (552)	*E. coli*	Very High	0.30	NA	178.74	19.89
			High	0.30	NA	81.23	9.06
			Mid	0.30	NA	49.56	5.54
			Low	0.30	NA	29.66	3.33

10 HUC Name	Listed Waterbody Name (AUID 07040008-)	Pollutant	Flow Zone	E. coli allocations (billions orgs/year) Sediment (TSS) allocations (tons/day) Nitrate allocations (lbs/day)			
				Wasteload Allocation		Load Allocation	Margin of Safety
				Permitted WW	Permitted SW (CSW/ISW/MS4	Watershed Load	
			Dry	0.30	NA	15.08	1.71
		TSS	Very High	0.01	0.02	1.56	0.17
			High	0.01	0.02	0.70	0.08
			Mid	0.01	0.02	0.42	0.05
			Low	0.01	0.02	0.25	0.03
			Dry	0.01	0.02	0.13	0.02
		Nitrate	Very High	5.18	3.13	3127.45	348.07
			High	5.18	1.43	1421.19	158.49
			Mid	5.18	0.87	867.07	96.92
			Low	5.18	0.52	518.96	58.24
			Dry	5.18	0.27	263.86	29.89

10 HUC Name	Listed Waterbody Name (AUID 07040008-)	Pollutant	Flow Zone	E. coli allocations (billions orgs/year) Sediment (TSS) allocations (tons/day) Nitrate allocations (lbs/day)			
				Wasteload Allocation		Load Allocation	Margin of Safety
				Permitted WW	Permitted SW (CSW/ISW/MS4)	Watershed Load	
	Root River, South Branch (554)	TSS	Very High	0.05	0.01	14.23	1.59
			High	0.05	<0.01	5.33	0.60
			Mid	0.05	<0.01	3.36	0.38
			Low	0.05	<0.01	2.26	0.26
			Dry	0.05	<0.01	1.23	0.14
	Root River, South Branch (555)	TSS	Very High	<0.01	<0.01	6.66	0.74
			High	<0.01	<0.01	2.90	0.32
			Mid	<0.01	<0.01	1.70	0.19
			Low	<0.01	<0.01	1.02	0.11
			Dry	<0.01	<0.01	0.53	0.06
		Nitrate	Very	2.51	13.34	13,338.31	1482.31

10 HUC Name	Listed Waterbody Name (AUID 07040008-)	Pollutant	Flow Zone	E. coli allocations (billions orgs/year) Sediment (TSS) allocations (tons/day) Nitrate allocations (lbs/day)			
				Wasteload Allocation		Load Allocation	Margin of Safety
				Permitted WW	Permitted SW (CSW/ISW/MS4	Watershed Load	
			High				
			High	2.51	5.81	5807.97	645.61
			Mid	2.51	3.42	3420.33	380.32
			Low	2.51	2.05	2045.11	227.51
			Dry	2.51	1.08	1074.22	119.64
		E. coli	Very High	0.01	NA	18.00	5.15
			High	0.01	NA	10.54	2.22
			Mid	0.01	NA	8.61	0.86
			Low	0.01	NA	5.98	1.11
			Dry	0.01	NA	4.61	0.97
	Root River, South Branch	TSS	Very High	<0.01	<0.01	3.45	0.38

10 HUC Name	Listed Waterbody Name (AUID 07040008-)	Pollutant	Flow Zone	E. coli allocations (billions orgs/year) Sediment (TSS) allocations (tons/day) Nitrate allocations (lbs/day)			
				Wasteload Allocation		Load Allocation	Margin of Safety
				Permitted WW	Permitted SW (CSW/ISW/MS4)	Watershed Load	
	(556)		High	<0.01	<0.01	1.53	0.17
			Mid	<0.01	<0.01	0.87	0.10
			Low	<0.01	<0.01	0.53	0.06
			Dry	<0.01	<0.01	0.27	0.03
	Canfield Creek (557)	Nitrate	Very High	NA	3.27	3263.27	362.95
			High	NA	1.45	1443.72	160.57
			Mid	NA	0.89	885.25	98.46
			Low	NA	0.54	534.74	59.48
			Dry	NA	0.28	280.02	31.14
	Willow Creek (558)	E. coli	Very High	NA	NA	238.97	26.55
			High	NA	NA	106.64	11.85

10 HUC Name	Listed Waterbody Name (AUID 07040008-)	Pollutant	Flow Zone	E. coli allocations (billions orgs/year) Sediment (TSS) allocations (tons/day) Nitrate allocations (lbs/day)			
				Wasteload Allocation		Load Allocation	Margin of Safety
				Permitted WW	Permitted SW (CSW/ISW/MS4	Watershed Load	
			Mid	NA	NA	66.34	7.37
			Low	NA	NA	39.89	4.43
			Dry	NA	NA	20.57	2.29
		Nitrate	Very High	NA	4.18	4177.04	464.58
			High	NA	1.87	1864.01	207.32
			Mid	NA	1.16	1159.62	128.98
			Low	NA	0.70	697.22	77.55
			Dry	NA	0.36	359.51	39.99
	Etna Creek (562)	Nitrate	Very High	NA	0.68	676.53	75.25
			High	NA	0.30	299.26	33.28
			Mid	NA	0.17	171.77	19.11

10 HUC Name	Listed Waterbody Name (AUID 07040008-)	Pollutant	Flow Zone	E. coli allocations (billions orgs/year) Sediment (TSS) allocations (tons/day) Nitrate allocations (lbs/day)			
				Wasteload Allocation		Load Allocation	Margin of Safety
				Permitted WW	Permitted SW (CSW/ISW/MS4	Watershed Load	
			Low	NA	0.10	103.08	11.47
			Dry	NA	0.05	53.69	5.97
	Forestville Creek (563)	Nitrate	Very High	NA	1.67	1665.50	185.24
			High	NA	0.70	701.36	78.01
			Mid	NA	0.43	425.94	47.37
			Low	NA	0.25	254.44	28.30
			Dry	NA	0.13	133.41	14.84
		E. coli	Very High	NA	NA	95.28	10.59
			High	NA	NA	40.12	4.46
			Mid	NA	NA	24.37	2.71

10 HUC Name	Listed Waterbody Name (AUID 07040008-)	Pollutant	Flow Zone	E. coli allocations (billions orgs/year) Sediment (TSS) allocations (tons/day) Nitrate allocations (lbs/day)			
				Wasteload Allocation		Load Allocation	Margin of Safety
				Permitted WW	Permitted SW (CSW/ISW/MS4	Watershed Load	
			Low	NA	NA	14.55	1.62
			Dry	NA	NA	7.63	0.85
	Root River, South Branch (586)	*E. coli*	Very High	0.01	NA	7.66	2.19
			High	0.01	NA	4.48	0.94
			Mid	0.01	NA	3.65	0.37
			Low	0.01	NA	2.54	0.47
			Dry	0.01	NA	1.96	0.41
South Fork Root River	Root River, South Fork (508)	*E. coli*	Very High	1.21	NA	590.67	65.77
			High	1.21	NA	491.25	54.72
			Mid	1.21	NA	400.81	44.67
			Low	1.21	NA	234.25	26.16

10 HUC Name	Listed Waterbody Name (AUID 07040008-)	Pollutant	Flow Zone	E. coli allocations (billions orgs/year) Sediment (TSS) allocations (tons/day) Nitrate allocations (lbs/day)			
				Wasteload Allocation		Load Allocation	Margin of Safety
				Permitted WW	Permitted SW (CSW/ISW/MS4	Watershed Load	
			Dry	1.21	0.05	47.75	5.31
		TSS	Very High	0.03	0.03	33.63	3.74
			High	0.03	0.03	27.97	3.11
			Mid	0.03	0.02	22.83	2.54
			Low	0.03	0.01	13.36	1.49
			Dry	0.03	0.05	47.70	5.31
	Root River, South Fork (509)	TSS	Very High	0.03	0.08	47.70	5.31
			High	0.03	0.06	33.60	3.74
			Mid	0.03	0.06	27.95	3.11
			Low	0.03	0.05	22.81	2.54
			Dry	0.03	0.04	13.35	1.49

10 HUC Name	Listed Waterbody Name (AUID 07040008-)	Pollutant	Flow Zone	E. coli allocations (billions orgs/year) Sediment (TSS) allocations (tons/day) Nitrate allocations (lbs/day)			
				Wasteload Allocation		Load Allocation	Margin of Safety
				Permitted WW	Permitted SW (CSW/ISW/MS4	Watershed Load	
	Root River, South Fork (573)	TSS	Very High	NA	<0.01	4.82	0.54
			High	NA	<0.01	1.19	0.13
			Mid	NA	<0.01	0.47	0.05
			Low	NA	<0.01	0.19	0.02
			Dry	NA	<0.01	0.02	<0.01

Appendix F. Root River HSPF and SWAT Models Summary Document.

Hydrologic models were used to support decision-making for potential sediment and nutrient reduction strategies in the Root River Basin. An HSPF (Hydrological Simulation Program – FORTRAN) for the entire RRW was developed and supported by SWAT data from three subwatersheds within the RRW.

The EPA funded HSPF modeling in the Root River beginning in 2011. The construction and calibration of the HSPF model was overseen by Dr. Jonathan Butcher, Tetra Tech, Inc. This effort was part of a larger Gulf of Mexico hypoxia reduction project. Consequently, the model was constructed with a focus on discharge from the mouth of the (HUC-8) Root River with less emphasis on subwatersheds. The following describes calibration and results of these models. The MPCA Watershed Approach process, while working at the HUC-8 scale, focuses restoration and protection strategies at a smaller HUC-10/12 digit scale. The RRW model will be refreshed during the next "cycle" of the Watershed Approach focusing on subwatershed scale outputs.

HSPF Development

The HSPF models allow for advanced hydrologic simulation of a basin through multiple sources of spatial and temporal observed data. The model was developed and continues to be supported by the EPA and has been consistently used in peer-reviewed watershed studies. More on HSPF can be found at http://www.pca.state.mn.us/index.php/view-document.html?gid=21398. This model was completed by the engineering firm Tetra Tech, Inc. in 2013 and all data is part of the public domain. For information regarding these models or for any data/reports relating to them, please contact Dr. Charles Regan (chuck.regan@state.mn.us) or Ben Roush (benjamin.roush@state.mn.us) at the MPCA.

Subwatershed Delineation and Land Segment Development

The watershed was separated into subwatersheds based on hydrography data (from GIS analysis) and could also be adjusted based on specific stream concerns (such as impairments). Pervious and impervious land segments within each subwatershed divide the subwatersheds into distinct sections based on land use, soil properties, and tillage practices. This data was compiled from multiple federal, state, and local organizations. Precipitation data was gathered and processed with the National Weather Service's Next Generation Radar (NEXRAD) which allows for a high degree of spatial and temporal accuracy.

Calibration - Hydrology

Three USGS and five Minnesota DNR field stations generated data used for hydrologic calibration. Initial hydrologic parameters were also taken from an HSPF model of the Le Sueur River basin. Seasonal precipitation reporting, limited time periods of gauge recording, and unknown impacts of karst systems together made hydrological calibration challenging. Data collection years varied at different stations, but occurred between 1994 and 2010.

The Root HSPF model has been deemed well calibrated and validated, except for simulation of specific individual run-off events. This may be attributed partly to problems with the NEXRAD data and because of problems in modeling karst topography, even with adjustments made in karst parameters (contact Dr.

Charles Regan or Ben Roush for more information on karst modeling). Therefore, the Root HSPF is best calibrated for long periods of time as opposed to impacts of specific precipitation events.

Calibration – Sediment/Nutrients

Calibration focused on water quality monitored at four Minnesota DNR stations. All data were collected between 2008 and 2010. Increased time series water quality data would be preferred when refreshing future models. The smaller-scale SWAT models (described below) were used to ensure accurate representation of the effects of agricultural cropping, tillage, and fertilization practices in the basin-scale HSPF model.

Sediment

Sediment calibration involved both observed sediment concentrations and inferred daily TSS loads (based on calculations of TSS concentration multiplied by flow). Upland sediment erodibility was based on USLE K factors adjusted for the Root basin. Sheet, rill, and gully erosion were limited in the Root basin because of highly permeable soils and subsurface drainage (karst and/or tile drainage). Much of the surface water volume drains vertically into near surface fractured limestone.

The channel simulation represents transport, deposition, and scour of three sediment size classes (sand, silt, and clay). The behavior of cohesive sediment (silt and clay) is a function of the hydraulic energy or shear stress exerted on the stream bed and banks.

Channel sediment was collected and analyzed for each reach to ensure proper characterization of sediment behavior and because of changes in bed composition throughout the basin. Division between in-stream and field sediment sources was based on sediment fingerprinting research done by Dr. Patrick Belmont using natural radioisotope ^{10}Be and ^{210}Pb tracers that provide evidence on the amount of time that a sediment source has been sequestered from contact with the atmosphere.

Nutrients

Ammonia, nitrate-nitrogen, orthophosphate, and organic matter were simulated, with the latter two simulated with sediment-associated factors. Nitrate-nitrogen calibration was challenging in subsurface conduits (karst features). It was necessary to increase interflow concentrations in the eastern agricultural areas while increasing groundwater concentrations in the most heavily karsted areas in the center of the watershed. Spatial changes in denitrification rates presented by different soil types resulted in further geographic challenges in nitrate-nitrogen calibration.

Sediment/Nutrient Calibration Results

For both sediment and nutrient simulation, the model was effective in simulating general trends and seasonal changes. Not all extreme values were accurately simulated, however. Based on Tetra Tech, Inc. metrics for model success, "a majority of the constituents and [calibration] stations achieved a good or very good fit." Situations in which constituents were poorly modeled occurred because of influence by specific high flow events.

Karst Simulation

Karst features, significant subsurface water flow paths over large areas of the Root Watershed, were also accounted for in the model as a separate set of stream reaches that ran parallel to surface reaches. Existing dye tracing studies, remote sensing images, and GIS were used to identify karst locations and connections, including some that lead out of the basin. However, it is likely many karst features with no surface expression were not identified and further, their subsurface pathways are not well characterized.

Because of these unknown karst pathways, the secondary parallel karst network "significantly increases potential for [model] uncertainty," according to Dr. Jonathan Butcher, Tetra Tech, Inc. The necessarily imperfect location of karst features and corresponding pathways made simulation of karst hydrology challenging (personal communication, Dr. Jonathan Butcher, Tetra Tech, Inc.). Additionally, small order upstream reaches in the model were often simulated as having zero base-flow when there were field observations to the contrary.

Model Adjustments for Karst

Natural karst conduits have a maximum volume capacity, a characteristic that surface stream channels do not share as they are unrestricted and can therefore flood. It was deemed acceptable to allow the karst conduits to "overflow" like open channels, however, as this water would be stored on the surface or in the soil profile regardless and therefore the downstream hydrograph would still be accurate.

Water quality processes in karst pathways had to be altered as well. Water quality loadings are normally transported through surface and subsurface runoff and are exposed to rainfall, evaporation, atmospheric interaction, sediment, or algal growth processes. These processes were disabled for karst reaches. In addition, no sediment was simulated in karst stream reaches although sediment is occasionally observed discharging from springs.

SWAT Development

Smaller-scale SWAT modeling in the Root was conducted to characterize the impacts of agricultural management practices. The SWAT models were developed by Dr. Brent Dalzell at the University of Minnesota in conjunction with Tetra Tech, Inc. and were completed in 2012. SWAT models are similar to HSPF in many respects, but have a focus on agriculture and are considered to be better at simulating specific farming practices but not in-stream hydrological processes. For example, SWAT does a good job approximating sediment erosion rates, but not pollutant transport (e.g. DO, TSS, etc.). SWAT models only simulate on a daily time-step as well, while HSPF can simulate continuous data.

Three HUC-10 subwatersheds were selected – North Branch Root River, Money Creek, and the South Fork Root River based upon availability of data and geographic diversity. The South Fork basin contained the most surface karst features. The standard SWAT model code was enhanced to better represent transport through karst connections. Water quality loading data from these models were used to guide the calibration processes of HSPF model.

Calibration

NEXRAD was also used in these models for the collection of basin-wide meteorological conditions. Hydrologic and water quality calibration stations were located at the outlet of each subbasin. Calibration only took place between 2008 and 2010 because of data availability constraints.

Load averages for nutrients, sediment and flow were all predicted very well by the models. However, as expected with the daily temporal resolution of SWAT, specific, often high-flow events were poorly represented.

Karst Simulation

A primary issue with many karst simulations in SWAT is that surface flow is not allowed a direct interaction with groundwater flow. Instead, water is simulated as percolation into aquifers. Therefore, land management changes in the SWAT scenarios are not linked with physical and chemical changes in groundwater.

Several changes in SWAT coding were added in order to account for karst. Model code was adjusted so dissolved P could be transported in tile drainage. Sinkholes were represented by ponds within the model and given a very small drainage area and large hydraulic conductivity. Karst seepage was also adjusted as to be faster than soil seepage.

Model Scenarios

Along with the baseline application to existing conditions using observed data, the HSPF and SWAT models were used to simulate seven scenarios designed to determine the effect of land use change and varying nutrient application strategies on watershed water quality. These were:

1. Cover crop (rye) in corn-soybean and continuous corn fields, planted on October 23, harvested on April 30.
2. Increased nitrogen fertilizer application to 160 lbs-N/ac on corn-soybean rotations and 200 lbs-N/ac on continuous corn. (The standard model had 125 lbs-N/ac on corn-soybean and 170 lbs-N/ac on continuous corn.)
3. Apply buffer stripes on stream corridors with slopes less than 3%.
4. Decreased nitrogen fertilizer application to 110 lbs-N/ac on corn-soybean rotations and 150 lbs-N/ac on continuous corn.
5. For corn-soybean rotation fields, change N fertilizer application from May 4 to October 28.
6. For corn-soybean rotation fields, 50% of N fertilizer is applied on May 4 and the rest is applied in on June 4.
7. Addition of perennial vegetative strips to agricultural toe slopes in order to protect shallow groundwater flow.

Model Results

HSPF – General Loading Data

Pollutants loads from specific land cover types are shown in *Table 1*. 84.6% of total N transported to the stream was inorganic, and 58.9% of P will be inorganic. Land with manure treatment is 28% of the total N load and 35% of the total P load.

Table 1: Pollutant Loading

	Developed	**Water/Wetland**	**Forest**	**Pasture**	**Row Crop**	**Total**
N (tons/yr)	268.86	33.89	175.37	1284.95	5936.47	7699.54
N (lb/ac/yr)	9.58	5.67	1.50	7.89	27.25	
P (tons/yr)	11.59	0.26	34.38	78.49	246.99	371.71
P (lb/ac/yr)	0.41	0.04	0.29	0.48	1.13	

Figure 1 demonstrates how HSPF sediment loading data can be used with the MPCA water quality data by comparing the subwatersheds with high sediment loading and location of stream reaches impaired for TSS.

Comparison of HSPF and SWAT

The SWAT and HSPF results had the most similar values at Money Creek and the North Branch Root River. In agricultural, forest, and pasture land, phosphorus loading from HSPF data were generally within the interquartile range of the SWAT values. Urban grass phosphorus loads were lower in HSPF than SWAT, but the small areas of this land type make this less concerning.

Nitrogen loads in urban grass were again lower in HSPF than SWAT. In Money Creek, SWAT also had higher nitrogen in pasture than HSPF. For all three SWAT watersheds, loading rates were high in urban and forest lands. *Figure 2* (page 6) compiled HSPF and SWAT nitrate loading to the stream in each subbasin for the Root Watershed.

There were significant differences between the SWAT and the HSPF model in terms of upland sediment. This occurs because SWAT does not have the ability to simulate complex channel erosion, and therefore attributes more sedimentation to upland areas.

HSPF Scenario Results

Figure 3 (pg. 6) shows the decrease in flow-weighted mean of suspended sediment when scenario 1 is compared to the observed (or 'base') conditions. There is a greater decrease of sediment in the western portion of the watershed and therefore application of cover crops might be more valuable in those areas.

Figure 1: HSPF sediment loading and TSS impairments

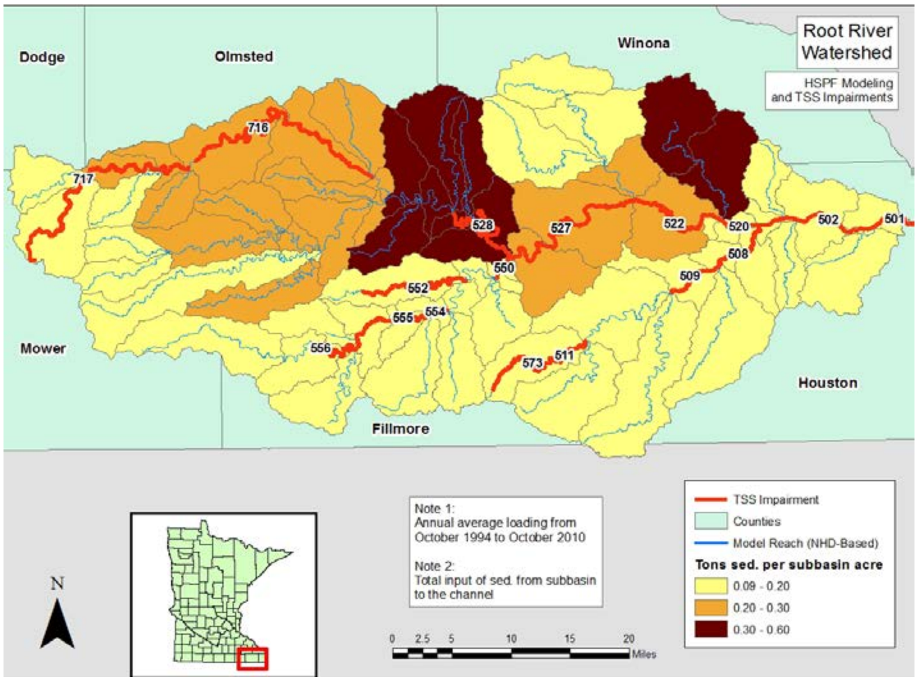


Figure 2: HSPF and SWAT nitrate loading.

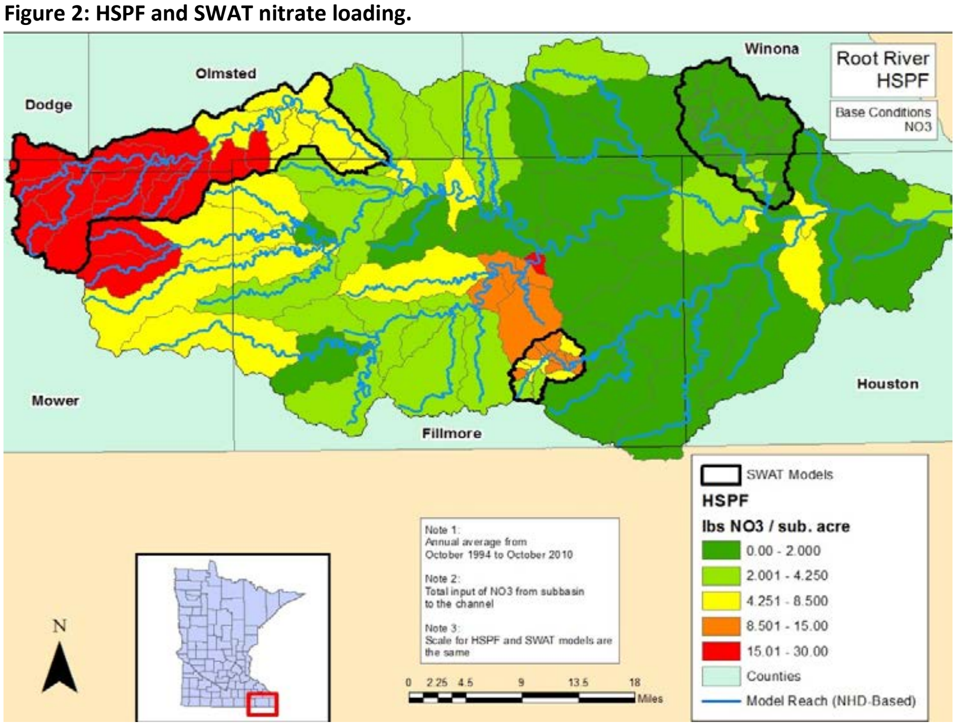
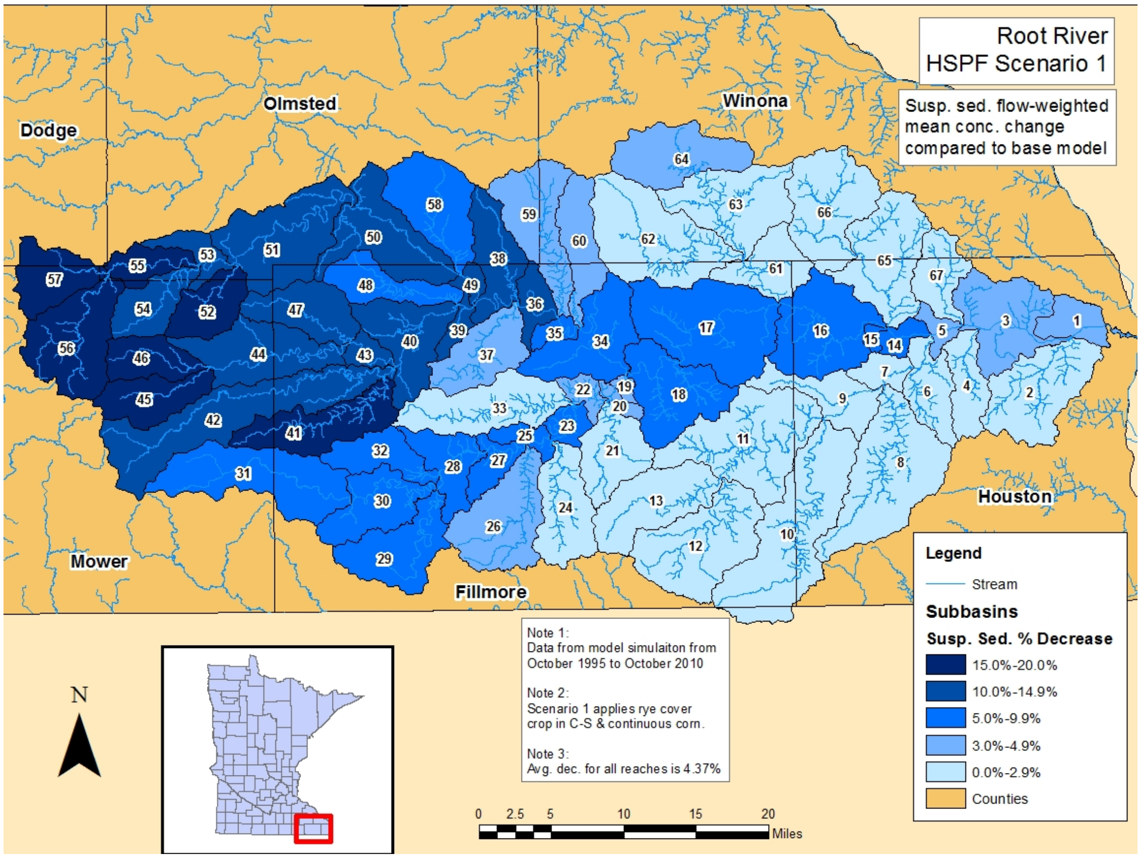


Figure 3: Suspended Sediment Decrease For Scenario 1



Side-by-side comparisons of HSPF scenarios with the base modeled simulation can be used to help determine appropriate land management decisions. *Table 2* demonstrates changes in nitrate and sediment stream output in each HSPF scenario compared to the observed, base model.

Table 2: Total nitrate (NO3) and sediment at the stream outlet of the Root watershed from October 1, 1995 to October 1, 2010 for the baseline HSPF model conditions and seven scenarios.

Scenario	NO3 (lbs)	% Change from Baseline	Sediment (tons)	% Change from Baseline
Baseline	194,770,600	-	4,523,723	-
S1	186,944,800	-4.02%	4,315,129	-4.61%
S2	203,282,500	4.37%	4,521,885	-0.04%
S3	191,904,200	-1.47%	4,221,325	-6.68%
S4	192,470,100	-1.18%	4,526,157	0.05%
S5	190,754,800	-2.06%	4,544,203	0.45%
S6	189,393,000	-2.76%	4,519,215	-0.10%
S7	190,115,200	-2.39%	4,450,150	-1.63%

Scenario 1 (the addition of cover crop to the watershed), results in the largest reduction of nitrate levels for the watershed. Scenario 2 obviously results in increased nitrate in the Root Watershed as it is a simulation of additional nitrogen fertilizers on agricultural acres. Interestingly, scenario 4 – representing a decrease in nitrogen fertilizer application – only results in a 1.18% reduction to total nitrate leaving the watershed. With the exception of cover crops, watershed output of nitrate is not large with the modeled scenarios.

Scenario 3 (the application of buffer strips to stream corridors) produced the largest decrease of sediment, with a 6.68% reduction in tons of sediment leaving the Root Watershed. The scenarios dealing with nitrogen application rates or timing (scenarios 1, 2, 4, 5, and 6) show very little sediment change because those practices obviously do not address sediment loss. Scenario 1 was the second best option for sediment reduction, with a 4.61% decrease in sediment loading. Because scenario 1 was effective for both nitrate and sediment reduction it would be appropriate to promote cover crops (in general) in the Root Watershed as a measure to improve water quality and nutrient reduction goals.

Examining nitrate and sediment output from HUC-10 watersheds is also useful for localized prioritization to address nutrient and sediment reduction aims. *Tables 3* and *4* below demonstrate these reductions in nitrate and sediment, respectively, in the HUC-10 watersheds of the Root.

Note, for example, that scenario 1 (cover crop application) results in 9.9% reduction in nitrate in the South Fork Root River but only results in approximately 1% reductions in nitrogen reductions in the North Branch and Middle Branch (*Table 3*). When examining sediment reductions however, cover crops result in 12% reductions for the North and Middle Branch, while the South Fork would only reduce sediment by 0.88% (*Table 4*). Scenario 3 (buffer strip application) also showed massive results in sediment reduction in the North and Middle Branch (~18%), along with large reductions in sediment in Trout Run (12.69%) (*Table 4).*

Table 3: Total nitrate (NO3) at the stream outlet of the Root basin HUC-10 watersheds from October 1, 1995 to October 1, 2010 for the baseline HSPF model conditions and seven scenarios.

Total Pounds Nitrate (NO3) (for modeling period)									
HUC-10: 0704000-	801	802	803	804	805	806	807	808	809
Name	North Branch Root	Middle Branch Root	Trout Run-Root	South Branch Root	Rush Creek	Money Creek	Rushford-Root	South Fork Root	Root (mouth)
HSPF basin	149	139	134	119	161	165	114	106	101
Base	31,707,020	48,036,400	98,790,600	49,899,700	12,686,100	1,488,119	171,924,000	19,381,940	194,770,600
S1	31,397,760	47,553,400	97,987,100	45,584,400	12,227,120	1,447,947	166,150,200	17,462,940	186,944,800
S2	33,483,580	50,484,400	103,642,800	51,481,900	13,294,950	1,507,838	179,485,900	20,118,690	203,282,500
S3	30,953,920	46,961,000	96,886,300	49,150,500	12,584,380	1,468,257	169,161,500	19,285,960	191,904,200
S4	31,528,120	48,187,400	98,723,000	48,828,600	12,367,580	1,477,872	170,272,100	18,850,250	192,470,100
S5	31,224,530	47,367,300	97,469,300	48,592,400	12,293,130	1,473,920	168,612,000	18,815,750	190,754,800
S6	30,666,620	46,607,100	95,956,700	48,713,900	12,313,210	1,475,411	167,220,400	18,844,640	189,393,000
S7	31,071,800	47,310,900	96,791,000	48,759,900	12,253,290	1,440,670	168,113,700	18,608,280	190,115,200
Percent Change from Base									
S1	-0.98%	-1.01%	-0.81%	-8.65%	-3.62%	-2.70%	-3.36%	-9.90%	-4.02%
S2	5.60%	5.10%	4.91%	3.17%	4.80%	1.33%	4.40%	3.80%	4.37%
S3	-2.38%	-2.24%	-1.93%	-1.50%	-0.80%	-1.33%	-1.61%	-0.50%	-1.47%
S4	-0.56%	0.31%	-0.07%	-2.15%	-2.51%	-0.69%	-0.96%	-2.74%	-1.18%
S5	-1.52%	-1.39%	-1.34%	-2.62%	-3.10%	-0.95%	-1.93%	-2.92%	-2.06%
S6	-3.28%	-2.98%	-2.87%	-2.38%	-2.94%	-0.85%	-2.74%	-2.77%	-2.76%
S7	-2.00%	-1.51%	-2.02%	-2.28%	-3.41%	-3.19%	-2.22%	-3.99%	-2.39%

Table 4: Sediment at the stream outlet of the Root basin HUC-10 watersheds from October 1, 1995 to October 1, 2010 for the baseline HSPF model conditions and seven scenarios.

Total Tons Sediment (for modeling period)									
HUC-10: 0704000-	801	802	803	804	805	806	807	808	809
Name	North Branch Root	Middle Branch Root	Trout Run-Root	South Branch Root	Rush Creek	Money Creek	Rushford-Root	South Fork Root	Root (mouth)
HSPF basin	R:149	R:139	R:134	R:119	R:161	R:165	R:114	R:106	R:101
Base	618,770	604,019	1,938,699	426,216	382,349	427,781	3,927,124	581,930	4,523,723
S1	543,870	530,090	1,767,522	406,828	374,318	424,145	3,721,310	576,796	4,315,129
S2	617,145	602,361	1,935,025	427,439	382,485	427,813	3,924,941	582,236	4,521,885
S3	504,806	490,421	1,692,659	392,883	371,131	423,334	3,628,187	573,562	4,221,325
S4	619,704	604,952	1,940,788	426,040	382,607	427,857	3,929,549	581,882	4,526,157
S5	627,516	612,916	1,958,453	426,855	382,482	427,813	3,947,760	582,088	4,544,203
S6	615,811	600,997	1,932,009	427,470	382,605	427,857	3,922,197	582,242	4,519,215
S7	596,912	584,297	1,879,808	419,371	379,689	426,534	3,856,237	578,210	4,450,150
Percent Change from Base									
S1	-12.10%	-12.24%	-8.83%	-4.55%	-2.10%	-0.85%	-5.24%	-0.88%	-4.61%
S2	-0.26%	-0.27%	-0.19%	0.29%	0.04%	0.01%	-0.06%	0.05%	-0.04%
S3	-18.42%	-18.81%	-12.69%	-7.82%	-2.93%	-1.04%	-7.61%	-1.44%	-6.68%
S4	0.15%	0.15%	0.11%	-0.04%	0.07%	0.02%	0.06%	-0.01%	0.05%
S5	1.41%	1.47%	1.02%	0.15%	0.03%	0.01%	0.53%	0.03%	0.45%
S6	-0.48%	-0.50%	-0.35%	0.29%	0.07%	0.02%	-0.13%	0.05%	-0.10%
S7	-3.53%	-3.27%	-3.04%	-1.61%	-0.70%	-0.29%	-1.81%	-0.64%	-1.63%

Appendix G. Key for Strategies Column in Table 7, Table 8, Table 9, Table 10, Table 11, Table 13, Table 14, Table 15.

Impairment	Strategy	Description
	Nonpoint Source	
[1]Nitrogen impairments for the main stem of the river and major tributaries	MN Nutrient Reduction Strategy (2013) • Increase fertilizer use efficiency (recommended fertilizer rates, placement and timing of application, nitrification inhibitors) • Increase and target living cover (cover crops, perennial buffers, forage and biomass planting, perennial energy crops, conservation easements and land retirement) • Drainage water retention and treatment (constructed wetlands, controlled drainage, bioreactors, two-stage ditches) • Wastewater treatment Other strategies: Feedlot runoff control/ag waste storage Onsite septic system upgrades Soil health management	Main stem impairment strategies will be targeted to the upstream HUC-12 watersheds which have nitrate impairments; if those tributaries meet the water quality standard, the main stem and major tributaries should also. Targeting efforts will utilize the recent MGS report "Geologic Controls on Groundwater and Surface Water Flow in Southeastern Minnesota and Their Impact on Nitrate Concentrations in Streams" (Runkel, et al 2013). Streams with "locally derived baseflow" have higher nitrate concentrations where land use and precipitation changes have a direct effect on springs and baseflow. These conditions provide an opportunity to target BMPs in these catchments and springsheds resulting in more immediate nitrate reductions.
[2]Turbidity impairments for the main stem of the river and the major tributaries	Soil erosion control practices; soil health practices to improve water infiltration; water and sediment storage practices; streambank	Main stem impairment strategies will be targeted to the upstream HUC-12 watersheds which have turbidity impairments; if those tributaries meet the water quality standard, the main stem and major tributaries should also.

Impairment	Strategy	Description
	protection/stabilization practices	From the Stressor ID report: *Results from work done by Belmont (2013) utilizing sediment fingerprinting data show that a "substantial percentage and likely the majority of suspended sediment in the Root River today is derived from stream banks and floodplains (estimated range of 40-80%)". In addition, work by Belmont points out that the main stem of the Root is a "dynamic alluvium system" which can act as a sediment source or sink at different times. The yield of sediment from the watershed is dependent on the "magnitude and frequency of floods" and there are "many near channel sources of sediment". Changing hydrology is noted as a potential driver of this. Belmont's work shows that not only is the Root River increasing baseflows, but high flows have increased over recent decades as well. High flows tend to control geomorphic dynamics of channels. "When high flows systematically increase, the channel will tend to enlarge (by widening and/or deepening) and will tend to increase lateral migration rates (i.e., erosion of one bank and deposition that may or may not keep pace on the opposite bank). These findings are therefore consistent with our finding that near channel erosion contributes a significant proportion of sediment."* Additionally, *"… the majority of the changes which will improve the macroinvertebrate community in the mainstem Root River are needed on an entire watershed-wide scale, and will take many years to implement. Most changes that are localized may not have success, or be sustainable if the larger river system contributions are not addressed."*
[3]E. coli and fecal coliform impairments for the main stem of the river and the major tributaries	SE MN Bacteria Implementation Plan (2007) Feedlot management, manure management, grazing management, SSTS compliance	Main stem impairment strategies will be targeted to the upstream HUC-12 watersheds which have E. coli or fecal coliform impairments; if those tributaries meet the water quality standard, the main stem and major tributaries should also. Due to the ubiquitous nature of bacterial contamination in regional waters, strategies apply region wide and can be found at http://www.pca.state.mn.us/index.php/view-document.html?gid=8013. Unless otherwise noted, these practices will apply in all reaches impaired for E. coli, fecal coliform or total coliform where needs are identified.
[4]Restoration and Protection Strategies for areas of high biodiversity and high quality perennial vegetation, i.e. Landscape Protection	Root River Landscape Stewardship Plan (2013)	Restoration strategies for forest, prairie and oak savannah include protection of unique plant and animal communities. Activities in these areas include technical and financial assistance for landowners, conservation easements and fee title acquisition

Impairment	Strategy	Description
[5]Physical habitat impairments affecting fish and macroinvertebrates in the lower Root River watershed and major tributaries	Soil erosion control practices; soil health practices to improve water infiltration; water and sediment storage practices; streambank protection/stabilization practices.	Main stem impairment strategies will be targeted to the upstream HUC-12 watersheds which have TSS or turbidity impairments. As stated in the Stressor ID report: *"… the majority of the changes which will improve the macroinvertebrate community in the mainstem Root River are needed on an entire watershed-wide scale, and will take many years to implement. Most changes that are localized may not have success, or be sustainable if the larger river system contributions are not addressed."*
	Lower Mississippi River Habitat Restoration Partnership (DNR LSOHC funding proposals submitted for fiscal years 2011 and 2012)	The LSOHC proposal includes strategies for fee acquisition, easement acquisition and habitat restoration of the existing forests and wetlands in the lower Root River floodplain areas in order to restore floodplain forests and wetlands, enhance wildlife habitat, and reconnect the river with the floodplain to utilize the functions of the floodplain for water quality and quantity benefits.
*Turbidity, TSS and Physical Habitat impairments in the western headwaters	Root River SWCD push up ponds* Hayable buffers* Side inlet buffers* Flow reduction practices (modified 410)*	These practices do not have standards and specifications in the NRCS FOTG. They are either in use (push up ponds, side inlet buffers) or proposed for use (flow reduction practices-modified 410) and have been effective and met a need that the NRCS practices do not. The practices listed with a FOTG practice number have been scientifically evaluated for their effectiveness for pollution reduction. However, they may not be the only practices that are effective. Other non-standard practices may be developed for use in particular geographic areas or in particular types of landscape or land use settings.
Watershed wide	NPDES point source compliance	All NPDES-permitted sources shall comply with conditions of their permits, which are written to be consistent with any assigned wasteload allocations
Watershed wide	Shoreland ordinance buffer compliance	The DNR Shoreland Ordinance has been adopted by all the counties in the watershed. All but Houston County require a 50-foot vegetated buffer along DNR protected waters; Houston County's buffer requirement is 10 feet. Some practices that can be used for a buffer are Riparian Herbaceous Cover (390), Riparian Forest Buffer (391) and Filter Strip (393).
Watershed wide	Grassed Waterways (412)	A shaped or graded channel that is established with suitable vegetation to carry surface water at a non-erosive velocity to a stable outlet to convey runoff from terraces, diversions, or other water concentrations without causing erosion or flooding,

Impairment	Strategy	Description
		reduce gully erosion, and protect/improve water quality.
Watershed wide	Contour Farming (330) on slopes >6%	Using ridges and furrows formed by tillage, planting and other farming operations to change the direction of runoff from directly downslope to around the hillslope to reduce sheet and rill erosion, reduce transport of sediment and other solids and the contaminants attached to them, and increase water infiltration.
Watershed wide	Water and sediment storage practices (410, 600,638, 378)	410 Grade Stabilization Structure: A structure used to control the grade and head cutting in natural or artificial channels to stabilize the grade and control erosion in natural or artificial channels, with a combination of earth embankments, mechanical spillways and full-flow or detention-type structures to prevent the formation or advance of gullies, enhance environmental quality and reduce pollution hazards, and lower water from a field elevation, surface drain, or waterway with a side-inlet structure to a channel. 600 Terrace: An earth embankment, or a combination ridge and channel, constructed across the field slope to reduce erosion by reducing slope length and retain runoff for moisture conservation, 638 Water and Sediment Control Basin: An earth embankment or a combination ridge and channel generally constructed across the slope and minor watercourses to form a sediment trap and water detention basin to improve farmability of sloping land, reduce watercourse and gully erosion, trap sediment, reduce and manage onsite and downstream runoff, and improve downstream water quality. 378 Pond: A water impoundment made by constructing an embankment or by excavating a pit or dugout to provide water for livestock, fish and wildlife, recreation, fire control, develop renewable energy systems, and other related uses, and to maintain or improve water quality.
Watershed wide	Residue Management (329, 345)	329 Residue and Tillage Management No Till/Strip Till 345 Residue and Tillage Management Mulch Till: Managing the amount, orientation and distribution of crop and other plant residues on the soil surface year-round, while limiting soil-disturbing activities to only those necessary to place nutrients, condition residue and plant crops to reduce sheet and rill erosion, reduce wind erosion, improve soil organic matter content, reduce CO2 losses from the soil, reduce soil particulate emissions, increase plant available

Impairment	Strategy	Description
		moisture, and provide food and escape cover for wildlife.
Watershed wide	Civic Engagement	Making resourceFULL decisions and taking collective action on public issues through processes of public discussion, reflection and collaboration.
Nitrate Turbidity/TSS	Increased Perennial Cover (645, 342, 643) CRP, RIM	645 Upland Wildlife Management: Provide and manage upland habitats and connectivity within the landscape for wildlife by treating upland wildlife habitat concerns identified during the conservation planning process that enable movement or provide shelter, cover and food in proper amounts, locations and times to sustain wild animals that inhabit uplands during a portion of their life cycle. 342 Critical Area Planting: Establishing permanent vegetation on sites that have or are expected to have high erosion rates, and on sites that have physical, chemical or biological conditions that prevent the establishment of vegetation with normal practices to stabilize areas with existing or expected high rates of soil erosion by water, stabilize areas with existing or expected high rates of soil erosion by wind, and restore degraded sites that cannot be stabilized through normal farming practices. 643 Restoration Management Declining Habitat: Restoring and conserving rare or declining native vegetative communities and associated wildlife species to restore land or aquatic habitats degraded by human activity, provide habitat for rare and declining wildlife species by restoring and conserving native plant communities, increase native plant community diversity, and to manage unique or declining native habitats. CRP (Conservation Reserve Program) RIM (Reinvest in Minnesota)
Nitrate Dissolved Oxygen	Nutrient (N)/Manure Management (590)	Managing the amount, source, placement, form and timing of the applications of plant nutrients and soil amendments to budget and supply nutrients for plant production, properly utilize manure or organic by-products as a plant nutrient source, minimize agricultural nonpoint source pollution of surface and ground water resources, rotect air quality by reducing nitrogen emissions (ammonia and NOx compounds) and the formation of atmospheric particulates, and maintain or improve the physical, chemical and biological condition of soil.
Nitrate	Cover Crops (340)	Crops including grasses, legumes, forbs, or other herbaceous plants established for seasonal cover and conservation purposes to reduce erosion from wind

Impairment	Strategy	Description
Turbidity/TSS Physical Habitat		and water, increase soil organic matter, capture and recycle or redistribute excess nutrients in the soil profile, promote biological nitrogen fixation and reduce energy use, increase biodiversity, and suppress weeds.
Turbidity/TSS E. coli/Fecal coliform/Total coliform Physical Habitat	Pasture Management/Managed Grazing (528)	Managing the harvest of vegetation with grazing and/or browsing animals to improve or maintain desired species composition and vigor of plant communities, improve or maintain quantity and quality of forage for grazing and browsing animals' health and productivity, and improve or maintain surface and/or subsurface water quality and quantity.
Turbidity/TSS Physical Habitat	Streambank Protection (580) and Stream Habitat Improvement (395)	580 Streambank and Shoreline Protection: Treatment(s) used to stabilize and protect banks of streams or constructed channels, and shorelines of lakes, reservoirs, or estuaries to prevent the loss of land or damage to land uses, or facilities adjacent to the banks of streams or constructed channels, shoreline of lakes, reservoirs, or estuaries including the protection of known historical, archeological, and traditional cultural properties; maintain the flow capacity of streams or channels; reduce the offsite or downstream effects of sediment resulting from bank erosion; and improve or enhance the stream corridor for fish and wildlife habitat, aesthetics, recreation. 395 Stream Habitat Improvement and Management: Maintain, improve or restore physical, chemical and biological functions of a stream, and its associated riparian zone, necessary for meeting the life history requirements of desired aquatic species to provide suitable habitat for desired fish and other aquatic species, and to provide stream channel and associated riparian conditions that maintain stream corridor ecological processes and hydrological connections of diverse stream habitat types important to aquatic species.
Turbidity/TSS Physical Habitat E. coli/Fecal coliform/Total coliform	Karst Sinkhole Treatment (527)	The treatment of sinkholes in karst areas to reduce contamination of groundwater resources, and/or to improve farm safety.
E. coli/Fecal coliform/Total coliform Dissolved Oxygen Nitrate	Feedlot runoff control (635, 367) Ag waste storage (313)	635 Vegetated Treatment Area 367 Roofs and Covers 313 Waste Storage Facility: A waste storage impoundment made by constructing an embankment and/or excavating a pit or dugout, or by fabricating a structure to temporarily store wastes such as manure, wastewater, and contaminated runoff as a

Impairment	Strategy	Description
		storage function component of an agricultural waste management system.
Turbidity/TSS Physical Habitat	Wetland Restoration (657)	The return of a wetland and its functions to a close approximation of its original condition as it existed prior to disturbance on a former or degraded wetland site to restore wetland function, value, habitat, diversity, and capacity to a close approximation of the pre-disturbance conditions by restoring conditions conducive to hydric soil maintenance, wetland hydrology (dominant water source, hydroperiod, and hydrodynamics), native hydrophytic vegetation (including the removal of undesired species, and/or seeding or planting of desired species), and original fish and wildlife habitats.
Turbidity/TSS Temperature Dissolved Oxygen	Urban stormwater practices	Rain gardens, rain barrels, pervious paving, street sweeping, stormwater storage and treatment, sand/salt/snow storage, etc.