Chippewa River Watershed Restoration and Protection Strategy Report

Minnesota Pollution Control Agency

April 2017

Connecting People Through Their River

Chippewa River Watershed Project

wq-ws4-24a

Disclaimer

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.

Credits

Kylene Olson, CRWP – author, planning and facilitation

Jennifer Hoffman, CRWP - author, analysis, planning and facilitation

Paul Wymar, MPCA – author, maps, analysis and workshop assistance

Joe Hauger, MPCA - planning and facilitation

Joanne Boettcher, MPCA - author, maps, analysis, planning and facilitation

Ashley Ignatius, Steven Wolf, Brandon Bohks, MPCA - GIS analysis

Chuck Regan, Ben Roush, MPCA – HSPF model support

Emily Siira, Ethan Jenzen, DNR Area Hydrologists – Hydrology analysis, Lake Protection and Restoration Strategies

WRAPS Participants (attended at least one workshop and or report review):

Alex Galt, USFWS

Amanda Strommer, Pope County Land and Resource Management

David Sill, BWSR

Deja Anton, Douglas County

Holly Kovarik, Pope SWCD

Jean Diggens, Chippewa SWCD

JoAnn Blomme, Chippewa County Land and Resource Management

Joe Montonye, Grant SWCD

Rick Gronseth, NRCS-Benson

Ryan Peterson, Kandiyohi SWCD

Sheri Gades, Swift SWCD

Steven Henry, Douglas SWCD

Will Clayton, Swift SWCD

Zach Bothun, Chippewa SWCD

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Key Terms

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.

Assessment: A MPCA process that determines whether an AUID meets water quality standards for one or more water quality parameters as required by the 1972 Clean Water Act (CWA). An AUID that does not meet the standard is impaired. This process uses the best data and best science to assess the condition of Minnesota's surface water.

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.

Critical Area: The portion of the watershed (HUC 10 or smaller scale) that disproportionately contributes pollutants and adversely causes impairments to waters of the state from anthropogenic activities

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 Chippewa River Watershed is assigned a HUC-8 of 07020005.

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).

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.

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.

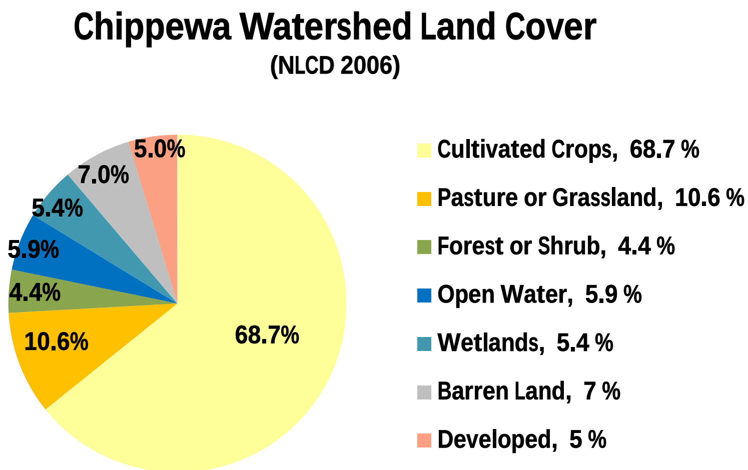
Trend: a statistical technique to aid interpretation of data. When a series of measurements of a process are treated as a time series, trend estimation can be used to make and justify statements about tendencies in the data, by relating the measurements to the times at which they occurred.

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

Trophic State Index (TSI): a number that summarizes a lake's overall nutrient richness. Nutrient richness ranges from clear lakes, low in nutrients (oligotrophic), to green lakes, with very high nutrient levels (hypereutrophic). The overall TSI rating of a lake can be calculated by using one of three parameters that indicate nutrient richness, Total Phosphorus, Chlorophyll-a or Transparency. The TSI calculations are based on data collected between June and September

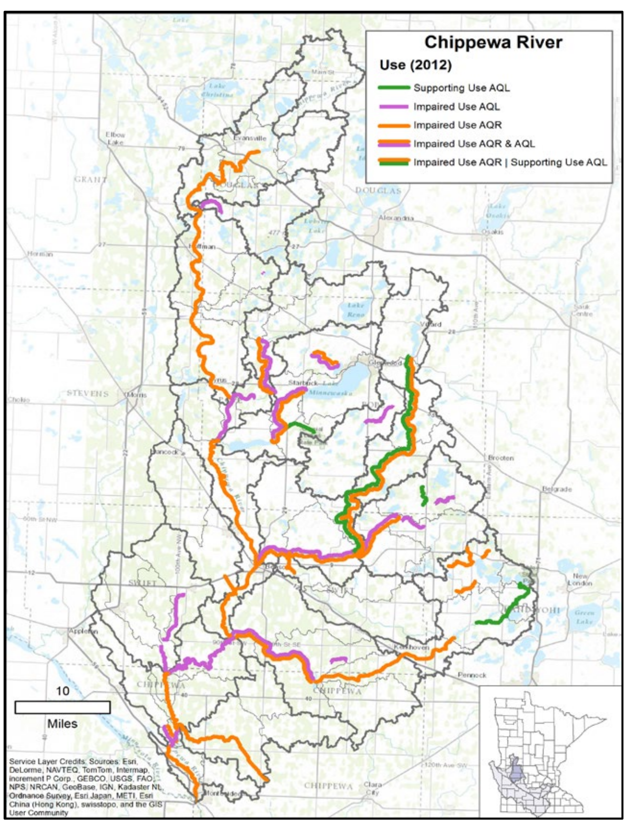
Executive Summary

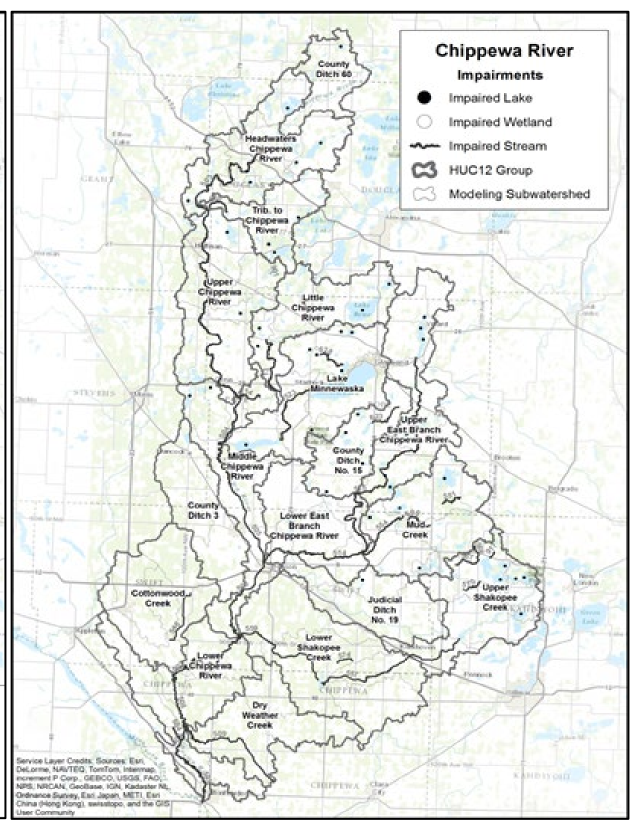
The Chippewa River Watershed in western Minnesota drains over 1.3 million acres to the Minnesota River. This Watershed Restoration and Protection Strategy (WRAPS) report summarizes the condition of surface water resources (i.e. lakes and streams), the scale and types of changes needed to restore and protect waters, and options and available tools to prioritize and target conservation work on the landscape in the Chippewa River Watershed. The work summarized in this WRAPS report will be expanded and revised every 10 years as part of the state of Minnesota's "Watershed Approach".



The identified pollutants in the Chippewa River Watershed are: sediment, phosphorus, nitrogen, bacteria and dissolved oxygen (DO). The identified stressors and conditions in the watershed are: low DO, altered hydrology and poor habitat. The maps on this page illustrate the stream reaches and lakes found to be impaired or supporting the water quality standards. Note that only a fraction of the total water bodies was tested or assessed. This does not imply that pollutants/stressors are only problematic where identified as impaired. Rather, the high percent of tested waters that were found to have problems indicates that the pollutants/stressors are likely common across the watershed.

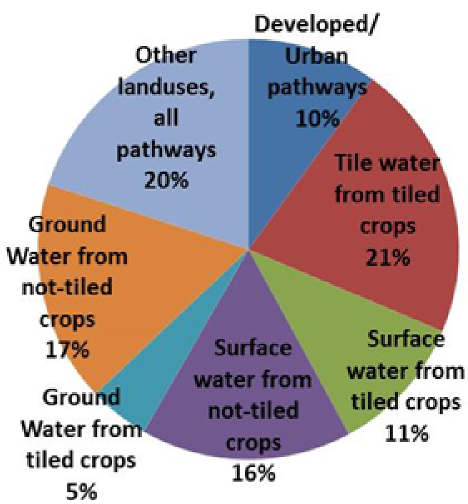
Additional information on the current status, known trends, reduction goals, and 10-year interim reduction targets is presented in Sections 2.5 and 2.6 and are summarized in Table 10.



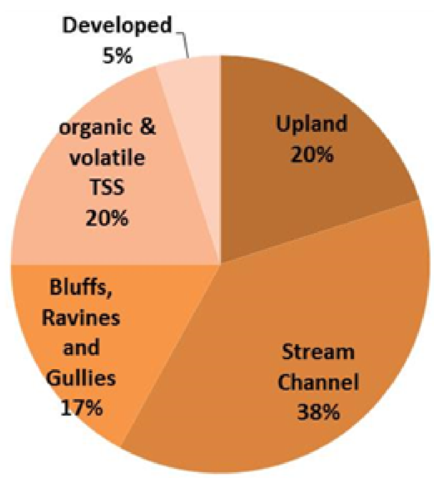


For each of the identified pollutants and stressors, a source assessment process was undertaken. The Chippewa River Watershed is one of the more data rich watersheds in Minnesota with some sites represented by 15+ years of flow and/or water quality data. Source assessment work focused on the monitoring data and pathways delivering the pollutants/stressors to water. Multiple lines of scientific evidence on sources were compiled. The WRAPS participants, composed of local and state conservation staff, reviewed the multiple lines of scientific evidence and developed a source assessment for the Chippewa River Watershed based on this evidence, applying their professional judgment and local knowledge of the watershed. Additional analyses were completed for the water source assessment. The final source assessments are presented in pie charts below. Refer to Section 2 for more details on source assessment work.

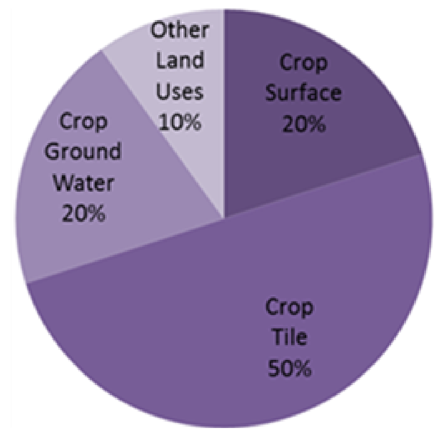
Water Sources



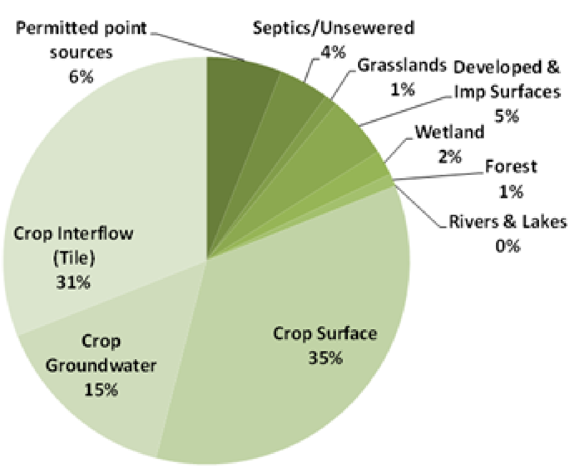
Sediment Sources



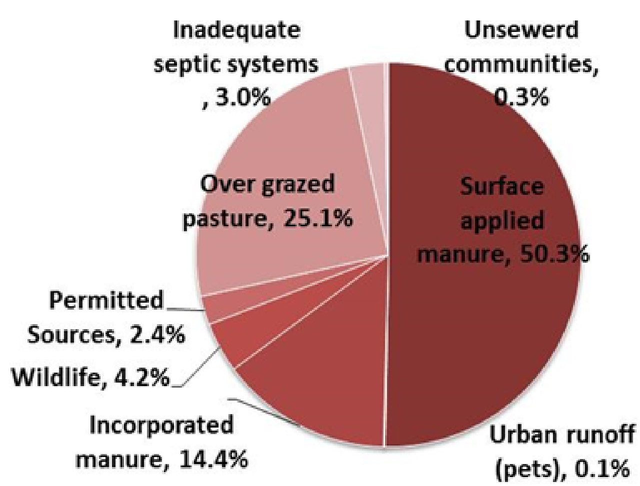
Nitrogen



Phosphorous Sources



Bacteria Sources



The WRAPS report should be the primary tool for local partners to use in planning or project conception. It includes details and products that came from civic engagement with watershed stakeholders and local government units. A general summary is as follows:

- Land uses that lack vegetation and/or create impervious conditions correlate to increased runoff and reduced water quality; areas with high concentrations of cultivated crops, industry, people, or animals tend to have water quality issues when impacts are not optimally managed.
- Cultivated land, in the Shakopee Creek and Dry Weather Creek Subwatersheds, is the source for the vast majority of the nitrogen load in the Chippewa River Watershed. With less than 20% of the nitrogen load leaving the land areas via runoff, the dominant transport mechanism is leaching loss to tiles or groundwater and management should be applied accordingly. The nitrogen load can be reduced by improving nutrient use efficiency, control and treatment of excess nitrogen via drainage management, and adding living cover such as perennials and cover crops.
- Sediment and Total Suspended Solids (TSS) issues are widespread throughout the watershed. Overall in the Chippewa River Watershed 38% of the TSS load is derived from streambank erosion, 20% is from Volatile Suspended Solids (algae, diatoms, decaying plant matter, etc.), 20% is from upland surface erosion, 17% is from ravine and gully erosion and 5% is from developed sources. While these are the overall percentages for the entire watershed, in individual subwatersheds the sources can vary drastically based on a number of factors: amount of cattle operations with uncontrolled access to the river or streams; amount of stream banks which have inadequate buffers; the degree which the hydrology has been altered; and if the stream or river flows directly through a highly eutrophic lake such as Lake Emily or Shakopee Lake.
- Point source phosphorus loads are important during low flow years and point source permits should reflect the wasteload allocations in the Chippewa River Watershed Total Maximum Daily Loads (TMDLs) Report. However, overall, only 6% of the phosphorus load is associated with point source and unsewered areas and failing septic systems account for additional 4%. 81% of the phosphorus source is related to agriculture (35% crop surface runoff, 31% crop tile water and 15% crop groundwater) with the vast majority of the phosphorus loading occurring during spring snowmelt as a result of fall application of fertilizer and wintertime application of manure.
- The high fecal coliform and *E. coli* levels are not geographically distinct; rather they are the result of prevalent issues relating to pathways. Continuous livestock access to streams through pastures along waterways is a pathway. Manure applied to cultivated fields is another pathway. These are exacerbated by inadequate buffers on many of the tributary streams and ditches. Additionally, ineffective septic systems are another known pathway.

Taken as a whole, the strategies state that to meet the water quality improvement goals in the Chippewa River Watershed, partners should work to fully implement the buffer rule, convert marginal cropland to perennial cover, expand application of cover crops and improve source control of nitrogen fertilizer.

A description of the watershed's needs to fully meet water quality goals is presented in Table 13. Because the timeline to meet water quality goals was estimated by the WRAPS participants to be

40 years, and the full range of technologies, programs, and markets is not established to support the wide scale changes needed to meet the goal, focus was placed on the 10-year interim targets. The 10-year targets are most useful for local planning efforts, because local plans are also redone every 10 years.

Determining the types of practices and scale needed to meet the 10-year targets relied primarily on the WRAPS participants, but involved modeling and correlation studies. These practices were recommended by the WRAPS participants after review of best management practice (BMP) effectiveness data (see Section 3.1, and Appendices 6.7, 6.7, and 6.9) and consideration of local conditions and preferences. Using these BMP tools and modeled scenarios as guidelines, an estimate of the adoption rates needed to meet the water quality targets was generated. A watershed wide list of practices was generated (Table 13). An excerpt of Table 13 is presented below. Refer to the full table and the associate key for details.

Information for local conservation planners, staff, and leadership to prioritize regions and practices for restoration and protection are summarized in Section 3. The presented conditions, reduction and protection goals, modeled pollutant yields, and other analyses presented in the report are key tools for future prioritization. Additional prioritizing and targeting work via the One Watershed, One Plan planning process will develop the priorities that consider surface water quality.

Land use/Source Type	**Watershed Restoration and Protection Strategies** estimated to meet 10-year target at specified adoption rates	Adoption Rate		
		% watershed to newly adopt (treated area)	40 year Goal to achieve water quality standards (treated acres)	10 year Target
Cultivated Crops	Nutrient management (for P & N)	10%	91,100	22,775
	Cover crops	5%	45,600	11,400
	Conservation tillage/residue management	10%	91,100	22,775
	Buffers, prairie strips*, border filter strips*	5.5%	50,100	12,525
	WASCOBS, terraces, flow-through basins (for surface runoff)*	1%	9,100	2,275
	Grassed waterway*	2%	18,200	4,550
	Treatment wetland (for tile drainage system)*	1%	9,100	2,275
	Crop rotation (including small grain)	10%	91,100	22,775
	Alternative tile intakes*	1%	9,100	2,275
	Wood chip bioreactor*	1%	9,100	2,275
	Saturated buffers*	1%	9,100	2,275
	Controlled drainage, drainage design*	1%	9,100	2,275
	Restored wetlands	0.5%	4,600	1,150
	Contour strip cropping (50% crop in grass)	0.5%	4,600	1,150
	Improved manure application, better setbacks & training	0.5%	4,600	1,150
	Conservation cover	0.1%	900	225
	Productive grassland conversion	3.0%	27,300	6,825
	Side inlet control to ditch (w serious erosion)*	0.5%	4,600	1,150
Pas-trues	Rotational grazing	10.0%	10,500	2,625
	Livestock exclusion	2.0%	2,100	525

* = Strategy footprint is greater than treated area

Legislative Requirements

There are specific legislative definitions and requirements associated with Clean Water Legacy legislation on WRAPS (ROS 2013). This table is provided to help reviewers ensure those requirements are adequately addressed.

Legislative Requirement		
Section	Description	Location in WRAPS report
13.1.1	Impaired and supporting waters	2.5, 6.1 and 6.2
13.1.2	Biotic stressors	2.5, 2.6 and 6.3
13.1.3	Watershed modeling summary	2.5, 3.1 and 6.9
13.1.3	Priority areas	2.5 and 2.6
13.1.4	NPDES-permitted point sources	6.4
13.1.5	Nonpoint sources	2.3, 2.5 and 2.6
13.1.6	Current pollutants and load reductions	2.5, 2.6, and 3.6
13.1.7	Monitoring plan	4.0
13.1.8	Strategy suites to meet pollutant reductions	3.1, 3.3, 3.4, 3.6
13.1.8.i	Water quality parameter of concern	2.5 and 2.6
13.1.8.ii	Current conditions	2.0 through 3.6
13.1.8.iii	Water quality goals and targets	2.5, 2.6 and 3.6
13.1.8.iv	Strategies by parameter	6.7 and 6.8
13.1.8.iv	Strategy adoption rates	3.6
13.1.8.v	Timeline to achieve water quality targets	2.5, 2.6 and 3.6
13.1.8.vii	Responsibility	3.6

Legislation also requires that the WRAPS and TMDL reports have a public comment period. An opportunity for public comment on the draft WRAPS report was provided via a public notice in the State Register from August 8, 2016, through September 7, 2016.

1 Background Information

1.1 Watershed Approach and WRAPS

Figure 1: The Watershed Approach 10-year cycle

The state of Minnesota uses a "*Watershed Approach*" (MPCA 2015a) to assess and address the water quality of each of the state's 80 major watersheds on a 10-year cycle. In each cycle of the Watershed Approach, rivers, lakes and wetlands across the watershed are monitored, pollution sources are identified, needed pollutant reductions are calculated, water body restoration and protection strategies are developed, and progress is tracked and reported as conservation practices are continually implemented. The Watershed Approach provides information to local partners, landowners, and other stakeholders to prioritize and target conservation practice implementation – to strategically address water quality in the watershed.

The ***purpose*** of this WRAPS report is to summarize the work done in this first application of the Watershed Approach in the Chippewa River Watershed, which started in 2009. The ***scope*** of the report is the restoration and protection of water bodies to meet aquatic life and aquatic recreation beneficial uses, as currently assessed by the MPCA. The primary ***audience*** for the WRAPS report is local planners, watershed policy and program decision makers, and conservation practice implementers; watershed residents, governmental agencies, and other stakeholders are also the intended audience. The WRAPS report describes what it will take to achieve the goals and targets. The WRAPS does not identify field specific BMP implementation decisions for specific land parcels.

Purpose	•Support local working groups and jointly develop scientifically-supported restoration and protection strategies to be used for subsequent implementation planning •Summarize Watershed Approach work done to date including the following reports: •*Chippewa River Watershed Monitoring and Assessment July 2012* •*Chippewa River Watershed Biotic Stressor Identification November 2015* •*Chippewa River Watershed Total Maximum Daily Load* •Chippewa River Watershed Project Monitoring Summaries 2006-2010
Scope	•Impacts to aquatic recreation and impacts to aquatic life in streams •Impacts to aquatic recreation in lakes
Audience	•Local working groups (local governments, SWCDs, watershed management groups, etc.) •State agencies (MPCA, DNR, BWSR, etc.)

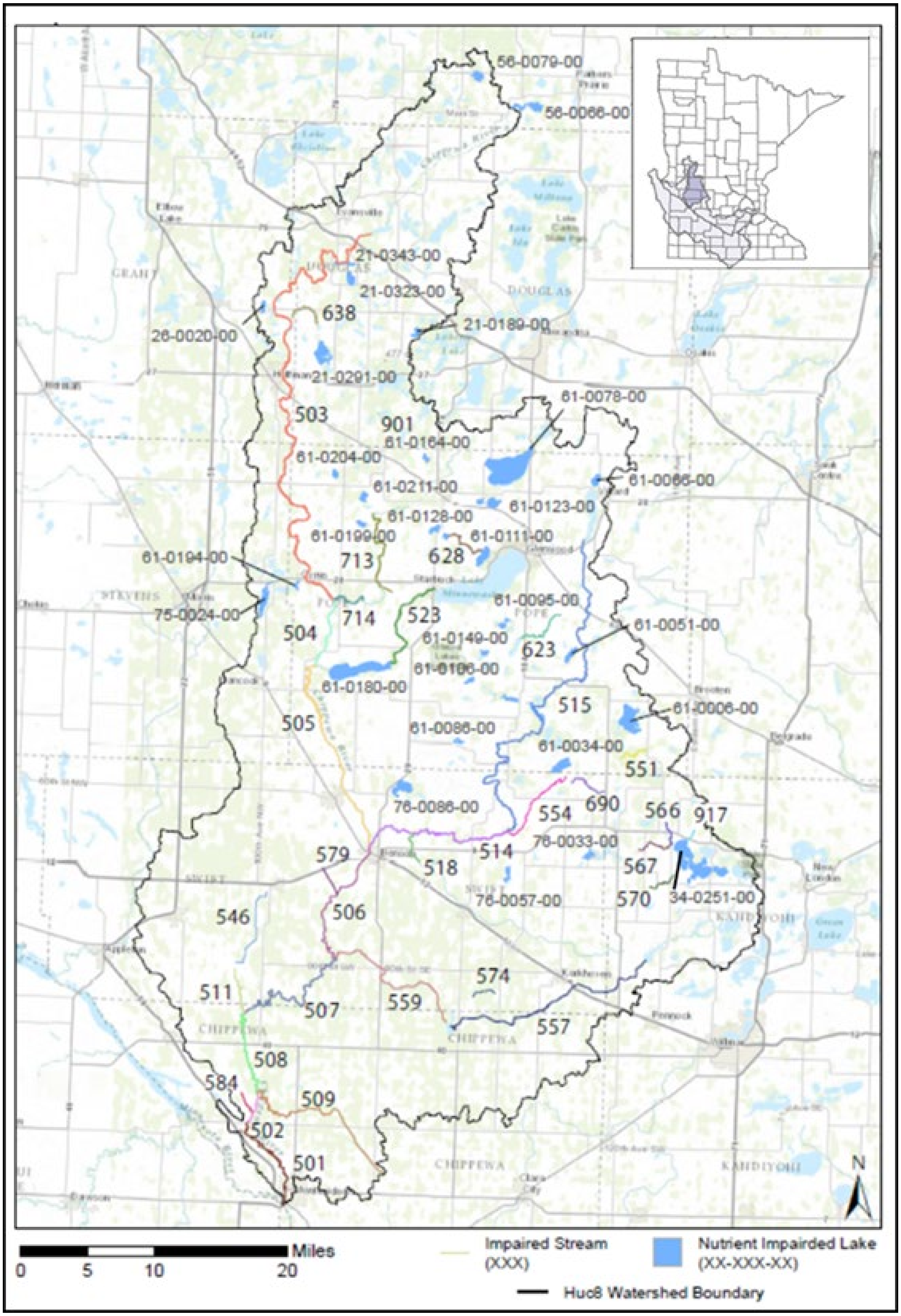


Figure 2: Impairments in the Chippewa River Watershed.

1.2 Watershed Description

The Chippewa River Watershed is 1 of 13 major tributaries to the Minnesota River. The headwaters of the Chippewa River are located in Otter Tail County and it flows 130 miles southwest to its mouth in Montevideo, where it joins the Minnesota River. The 1.3 million acre (2080 square miles) watershed lies between the Pomme de Terre River to the west and Hawk Creek, North Fork Crow, Sauk and Long Prairie Rivers to the east, with the last three discharging to the upper Mississippi rather than the Minnesota River like the Chippewa. The basin drains portions of eight counties. Several major tributaries including the Little Chippewa River, East Branch Chippewa River, Shakopee Creek and Dry Weather Creek contribute to the flow of the mainstem. Major lakes include: Emily, Minnewaska, Norway, Florida, Chippewa, Lobster, Reno, Aaron, Moses and Red Rock. These are important fisheries and recreational areas.

Roughly, 42,300 people live in the Chippewa River Watershed in 32 small towns and rural areas.

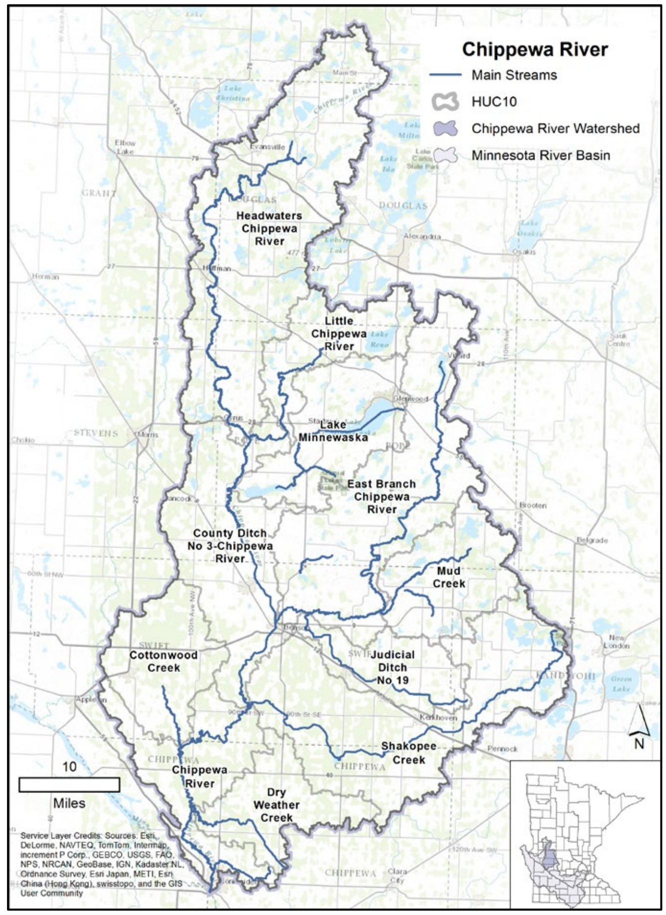


Figure 3: The Chippewa River Watershed and its location in Minnesota

1.3 Watershed Characteristics that Impact Water Quality

The information summarized here is intended to provide a conceptual understanding of both the natural conditions and human impacts that influence water quality. Specific pollutant source identification work is presented in Section 2.

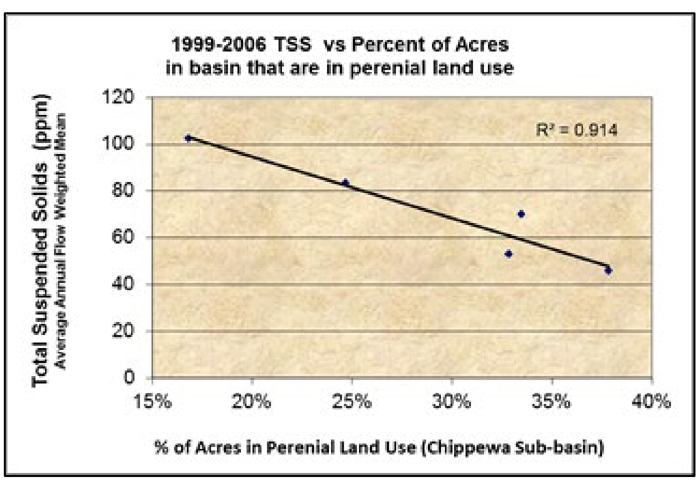


Figure 4: Total Suspended Solids (ppm) vs perennial land use in the Chippewa

The Chippewa River Watershed has many positive water quality aspects. It has a rich diversity of soils, wetlands and lakes as well as many perenial pastures and natural areas. In addition, there are many farmers, ranchers and landmanagers who have a strong ethic of land and resource conservation. Consequently, these factors have contributed to excellent water quality in many parts of the Chippewa River Watershed.

Even with a strong history of resource protection future care must be taken. General patterns have been observed in the Chippewa Watershed (www.chippewariver.org/water-quality--quantity). More intensive land use and lack of vegetation have been observed to increase runoff and reduce water quality; areas with high concentrations of cultivated crops, industry, people, or animals can have poor water quality when impacts are not properly managed. Similarly, areas with high concentrations of natural perennial vegetation (forest, grasses, wetlands, etc.) typically correlate to better water quality (Figure 4) (Jaradat 2011, Jaradat 2016, Lenhart 2011a, MPCA 2011a, Brooks et. al. 2013, Wischmeier, 1978).

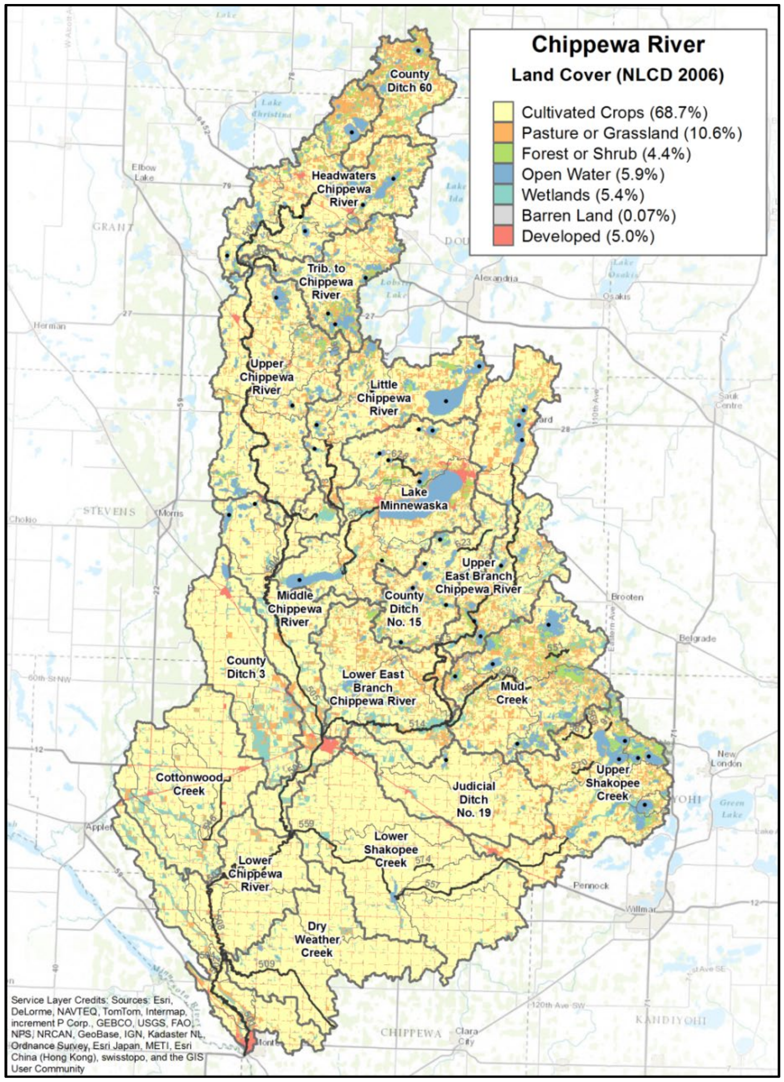


Figure 5: Chippewa River Watershed Land Use Map

Water quality measurements provide a useful picture of nutrient fate and land use in the Chippewa River Watershed. Nitrogen levels tend to be higher in watersheds with less perennial land uses in the Chippewa River Watershed. An example of this can be seen in Figure 6. The chart documents distinct measurements of nitrogen in two subwatersheds of the Chippewa River, Shakopee Creek and the Upper Chippewa. In Shakopee Creek, nitrogen levels start high during the spring melt period and normally drop

	Upper Chippewa	Shakopee Creek
Row Crop	60.30%	81.40%
Forest	9.10%	4.30%
Range	14.90%	6.70%
Urban	1.80%	1.70%
Water	9.60%	3.90%
Wetland	4.20%	1.90%
Other	0.10%	0.10%

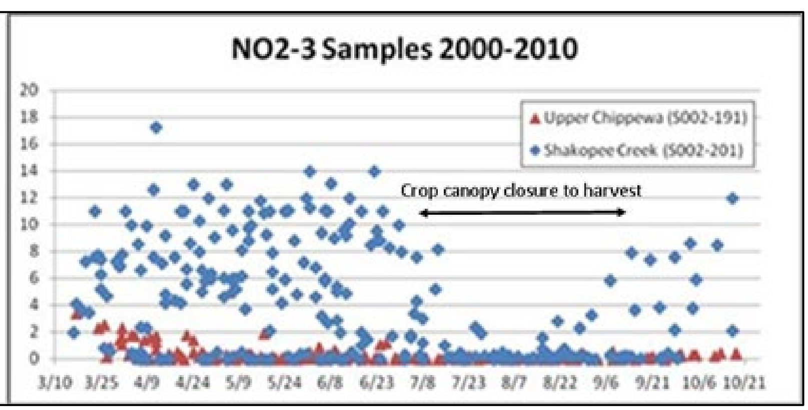


Figure 6: Comparison of NO2-3 samples (ppm) by date from two separate sub-basins of the Chippewa River Watershed

in July when the row crops mature. Nitrogen levels rise again in late August when the row crops stop growing. The Upper Chippewa, with its lower proportion of row crops and higher proportion of perennial land uses, does not see the same response.

Currently, in the Chippewa River Watershed the dominant land use is cultivated crops, with small portions of perennially vegetated landscapes and developed areas (Figure 5 and Table 1). The watershed contains roughly: 181,000 feedlot animal units (AUs), 3,700 wildlife AUs, and 42,300 humans. Point (municipal and industrial pollutant) sources consist of the 19 municipal WWTPs, 13 permitted industrial sites and 19 permitted Confined Animal Feeding Operations (CAFOs) (see Table 18 and Table 20 in the appendix).

Chippewa Land Cover Class	Total Acres	Percent Total Land Cover
Open Water	80,849	6.08%
Developed, Open Space	57,579	4.33%
Developed, Low Intensity	7,159	0.54%
Developed, Medium Intensity	2,041	0.15%
Developed, High Intensity	478	0.04%
Barren Land	899	0.07%
Deciduous Forest	53,426	4.02%
Evergreen Forest	1,208	0.09%
Mixed Forest	193	0.01%
Shrub/Scrub	2,349	0.18%
Herbaceuous	36,631	2.75%
Hay/Pasture	104,961	7.89%
Cultivated Crops	911,368	68.53%
Woody Wetlands	5,291	0.40%
Emergent Herbaceuous Wetlands	65,495	4.92%
Total Acres	**1,329,927**	**100%**

Table 1: Chippewa land use breakdown, NLCD 2011

The geology and soil makeup of the Chippewa River Watershed affect water quality in many complex ways. It includes a mixture of moraines, and till, lacustrine, and outwash plains. The eastern half of the Chippewa River Watershed, extending from approximately Evansville in the north to just below the town of DeGraff in the south, lies within the North Central Hardwood Forest ecoregion. This region is composed of well drained, loamy, silty, sandy and mucky soils with moderate to steep sloping landscapes (6% to 45%), producing a large potential for sediment delivery to streams. As such, water erosion potential within this section of the watershed is classified as moderate to high.

Lands in the western half of the Chippewa River Watershed fall within the Northern Glaciated Plains (NGP) Ecoregion. Three geologic settings define the NGP Ecoregion: the Big Stone Moraine on the far western edge; the Appleton-Clontarf Outwash Plain along the lower Chippewa River; and the Benson Lacustrine Plain within the south-central section of the watershed. Landscapes within the Big Stone moraine are characterized as rolling (6% to 12%), with well drained, silty and loamy soils. Water erosion potential within the moraine is generally classified as moderate. Lands within the Appleton-Clontarf outwash are characterized as being nearly level to gently sloping (2% to 6%), poorly drained, and extensively tiled. Water and wind erosion potentials are classified as moderate for this region. The Benson Lacustrine Plain is also nearly level (0% to 2%) and poorly drained. Soil textures in the lacustrine plain range from silty clay to silt loam. Water erosion potentials are high for lands adjacent to streams and much of the plain has the potential for significant wind erosion.

Because of the poorly drained natural condition in many parts of the southern watershed, large portions of the watershed's natural hydrology have been altered by adding artificial drainage to make settlement and farming possible. According to the Minnesota Department of Natural Resources (DNR), 79% of stream miles are altered in the Chippewa Watershed with no stream being unaffected by land use changes or channel impacts (DNR).

Unmitigated, impervious surfaces increase the total amount of water leaving the landscape and accelerate the transport of pollutants to streams and lakes. The net effect of tile drainage on the amount and timing of water delivery to streams is less certain, but has been implicated in some studies as part of the reason for river flow volume increases over time. Artificial drainage reduces the opportunities for nitrate losses that often naturally occur in deep soils and groundwater, and thus results in increased delivery of nitrate to rivers. (DNR 2015)

The shallow water table, interrelated to the poorly draining soils influences water quality, puts groundwater at higher risk of contamination. Pollutants added to the environment are able to reach the shallow groundwater before being consumed or breaking down. Once pollutants are in the shallow groundwater, the pollutants can travel to and become problematic in deeper aquifers and drinking water wells (the primary supply of drinking water in the watershed), streams, and wetlands.

More information on the Chippewa River Watershed can be found at: the *Rapid Watershed Assessment* (NRCS 2010); *Watershed Health Assessment Framework (WHAF)* (DNR 2013); and the Nutrient Planning Portal at Minnesota State University Mankato (MSUM).

1.4 Assessing Water Quality

Assessing water quality is a complex process with many steps including: developing water quality standards; monitoring the water; ensuring the monitoring data set is comprehensive and accurately represents the water; and professional review. A summary of some of these steps are included below. Refer to the MPCA water quality standards for more information and details (MPCAa).

Water Quality Standards

Water quality in a human-altered watershed is not expected to be as high as would exist under undisturbed, "natural background" conditions. However, water bodies are expected to support designated beneficial uses including fishing (aquatic life), swimming (aquatic recreation), and eating fish (aquatic consumption). Water quality standards (or simply, "standards") are set after extensive review of information and data about the safe level of pollutants for different beneficial uses.

Water Quality Assessment

To determine if water quality is supporting its designated use, data on the water body is compared to relevant standards. When pollutants/parameters in a water body exceed the water quality standard, the water body is considered impaired (MPCA 2011a). When pollutants/parameters in a water body meet the standard (usually when the monitored water quality is cleaner than the water quality standard), the water body is considered supporting of designated uses. If the monitoring data sample size is not robust enough to ensure that the data adequately/statistically represents the water body, or if monitoring results seem unclear regarding the condition of the water body, an assessment is delayed until further data are collected; this is referred to as an inconclusive or insufficient finding.

Monitoring Plan

Data from several water quality monitoring programs enables water quality assessment and creates a long-term data set to track progress towards water quality goals. The programs described below will continue to collect and analyze data in the Chippewa River Watershed as part of *Minnesota's Water Quality Monitoring Strategy* (MPCA 2011b). Data needs are considered by each program and additional monitoring is implemented when deemed necessary and feasible.

Intensive Watershed Monitoring (IWM; MPCA 2009) data provide a periodic but intensive "snapshot" of water quality throughout the watershed. This program collects water quality and biological data at roughly 75 stream and 25 lake monitoring stations across the watershed in 1 to 2 years, every 10 years. Monitoring sites are generally selected to provide comprehensive coverage of the watershed. This work is scheduled to start its second iteration in the Chippewa River Watershed in 2019.

Watershed Pollutant Load Monitoring Network (WPLMN; MPCAb) data provide a continuous and long-term record of water quality conditions at the major watershed and subwatershed scale. This program collects pollutant samples and flow data to calculate continuous daily flow, and sediment and nutrient loads. In the Chippewa River Watershed, there is a perpetual site near the outlet of the Chippewa River and three seasonal (spring through fall) subwatershed sites.

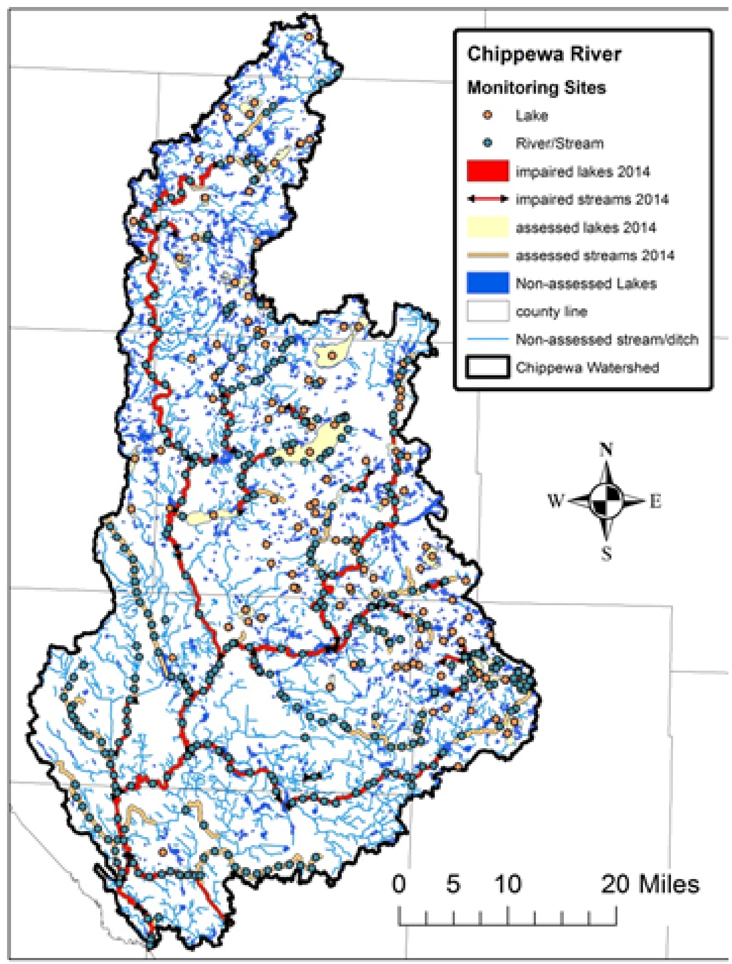


Figure 7: Water quality and biological life monitoring sites within the Chippewa River Watershed.

Citizen Stream and Lake Monitoring Program (MPCA 2013c) data provide a continuous record of water body transparency throughout much of the watershed. This program relies on a network of volunteers who make monthly lake and river measurements. Roughly, 43 volunteer-monitored locations exist in the Chippewa River Watershed.

The pesticide monitoring program of the Minnesota Department of Agriculture (MDA) has been monitoring agricultural chemical concentrations in surface water at several locations in the Chippewa River Watershed since 2006. Results can be found at the MDA website.

The Chippewa River Watershed Project (CRWP) also collects, analyzes and submits water quality data. Their information can be found at their website. This information is periodically stored at the MPCA Environmental Data Access (EDA) archive. The CRWP has been measuring transparency, DO, conductivity, pH, temperature, and buffer width at 250 sites every year since 2005. In 2009 and 2010, CRWP conducted stream bank erosion surveys at 71 sections of river. They also installed bank pins at 62 locations in order to monitor annual bank erosion rates.

Computer Modeling

With the watershed approach, monitoring for pollutants and stressors is generally extensive, but not every stream or lake can be monitored due to financial and logistical constraints. Computer modeling can extrapolate the known conditions of the watershed to areas with less monitoring data. Computer models, such as Hydrological Simulation Program – FORTRAN (HSPF [USGS 2013a]), represent complex natural phenomena with numeric estimates and equations that simulate natural features and processes. The HSPF incorporates stream pollutant monitoring data, land use, weather, soil type, etc. to estimate water sediment, flow, and nutrient conditions within the watershed. *Building a Picture of a Watershed* (MPCA 2014a) explains the model's uses and development. Information on the HSPF development, calibration, and validation in the Chippewa River Watershed are available*: HSPF Model Development and Hydrologic Calibration Report* and the *HSPF Water Quality Calibration and Validation Report.*

These model data provide a reasonable estimate of pollutant concentrations across watersheds. The output can be used to assess and predict the effectiveness of various conservation practice scenarios at a larger scale. It does not predict BMP effectiveness at the field or small watershed scale (smaller than HUC12). However, these data are not used for impairment assessments since monitoring data are required for those assessments.

2 Water Quality Conditions

The "condition" refers to the water bodies' status with regard to fishable and swimmable water quality standards. The standards represent the minimum condition needed to support fishable and swimmable water uses. This section summarizes condition information including water quality data and associated impairments. For water bodies found not able to support fishable, swimmable standards, the reason for these poor conditions – the pollutants and/or stressors – are identified. Refer to the Appendix for a table of impairments, stressors, and pollutants by stream reach and lake. More information on individual streams and lakes, including water quality data and trends can be reviewed on the Environmental Data Application (MPCA 2015b).

This report covers only impairments to aquatic recreation and aquatic life. Several lakes and stream reaches are impaired for aquatic consumption use (due to mercury and PCBs). The *Statewide Mercury TMDL* (MPCA 2007a) has been published and *Fish Consumption Advice* (MDH 2013) is available from the Minnesota Department of Health (MDH).

2.1 Condition Status: Are waters healthy for swimming and fishing?

Water bodies are monitored for specific parameters to make an assessment. For aquatic recreation assessment, rivers are monitored for bacteria and lakes are monitored for clarity and algae-fueling phosphorus. For aquatic life assessment, streams are monitored for both aquatic life populations and pollutants that are harmful to these populations. When monitored parameters (bacteria, phosphorus, fish populations, etc.) do not meet the water quality standard, the water body is designated impaired. The specific pollutants and/or stressors that are causing impairments in the Chippewa River Watershed are described below.

In 2009 and 2010, the Minnesota Pollution Control Agency (MPCA) conducted an intensive watershed monitoring (IWM) and assessment effort of the Chippewa River Watershed surface waters. Data from 134 stream reaches and 84 lakes were reviewed in this effort. Not all lake and stream reaches could be assessed due to insufficient data, modified channel condition or their status as limited resources waters. This review identified impairments from before 2009 as well as new impairments that came out of the IWM effort.

Of the sites that have sufficient data for assessment, 22 stream reaches are impaired due to impacts to aquatic life and 12 are impaired due to impacts to aquatic recreation throughout the watershed. Sixteen of these stream reaches were listed as impaired based upon the biological sampling of fish and or macroinvertebrate populations, and the rest of the reaches were found to be impaired based upon chemical monitoring of the reach’s water quality. See Table 15 in the Appendix for a list of the assessment status of stream reaches in the Chippewa River Watershed.

Of the 64 lakes that had sufficient data to be assessed for aquatic recreation, 30 lakes are fully supporting and 34 lakes are impaired. See Table 16 in the Appendix for a list of the assessment status of lakes in the Chippewa River Watershed.

2.2 Water Quality Trends

Statistical trends regarding water quality parameters in any one location cannot be determined without a substantial data set. Trends in water quality tend to be difficult to identify due to the “noisy” nature of environmental data – in other words, weather variation can cause large variations in environmental data and make trends difficult to identify. The Chippewa River Watershed is one of the more data rich watersheds in Minnesota with some sites represented by 15+ years of flow and/or water quality data. Nevertheless, it is still difficult to derive a sufficient dataset for statistically rigorous trend analysis. Complicating this analysis is the fact that a substantial amount of change has occurred across the landscape in terms of land use, farming practices, human populations, etc. These factors make analysis

Additional ***Chippewa River Watershed Resources***

Natural Resources Conservation Service (NRCS) Rapid Watershed Assessment
http://www.nrcs.usda.gov/wps/portal/nrcs/detail/mn/technical/dma/rwa/?cid=nrcs142p2_023601

Minnesota DNR Watershed Assessment Mapbook for the Chippewa River Watershed:
http://files.dnr.state.mn.us/natural_resources/water/watersheds/tool/watersheds/wsmb26.pdf

of the data difficult. These human action based trends as observed in the Minnesota River Basin are discussed in the Minnesota River Basin Trends Report (MSU 2009a). Statistical water quality trends have been analyzed in the Minnesota River Basin Statistical Trend Analysis (MSU 2009b). At this time, few statistically robust trends in water quality data have been observed in the Chippewa River Watershed. As more data are collected, additional trends in water quality in the Chippewa River Watershed should emerge. General correlations and patterns are occurring and these are described where appropriate in Sections 2.5 and 2.6 below.

2.3 Sources Overview

In order to develop appropriate strategies for restoring or protecting waterbodies, the stressors and sources impacting and threatening them, need to be identified and evaluated. Biological stressor identification (SID) is done for streams with either fish or macroinvertebrate biota impairments and encompasses both evaluation of pollutant and non-pollutant related factors as potential stressors (e.g., altered hydrology, fish passage, and habitat). Conventional pollutant impairment listings prompt a source assessment response with multiple lines of evidence including state and basin-level reports, model studies, TMDLs and field and watershed data. Professional judgement and local knowledge are also important to develop source assessments specifically for the Chippewa River Watershed. Section 3 provides further detail on stressors and pollutant sources.

Pollution and stressors are mostly from nonpoint sources in the Chippewa River Watershed. There are, however, a number of wastewater treatment plants (WWTPs), construction projects, and numerous feedlots that require National Pollutant Discharge Elimination System (NPDES) Permits. These Permit holders are identified in Table 18 in the Appendix.

The Watershed Approach is applied roughly every 10 to 12 years, each time striving for more refined and widespread analysis. Therefore, source assessments will be revisited and revised with each iteration to ensure that new data and science are incorporated.

2.4 Goals and Targets Overview

Long-term water quality goals reflect the pollution reductions that are necessary to restore and protect water bodies in a HUC-8 watershed as well as downstream waters (e.g. Minnesota River, Lake Pepin). Due to the scale of change required to achieve some of these goals, timelines can be decades long. Interim 10-year targets are developed to allow for adaptive management of strategies that best fit the political, social, economic and programmatic capacities of a watershed. This allows local resource professionals to focus efforts on conservation practices that have the best chance for success given current constraints. With each iteration of the Watershed Approach, goals, progress and local capacity (social, economic political, programmatic) will be reassessed and new 10-year targets will be set.

Specific goals are calculated for stream reaches and lakes when ample data exists to calculate a goal. Goals for areas without sufficient data reflect either the watershed-wide goal, which is calculated using the WPLMN data set as noted, or the goal reflects meeting the water quality standard (see Table 10, for the list of water bodies and reduction goals).

2.5 Identified Pollutants

The remainder of this section looks at each of the pollutants and stressors identified as the cause of impairments in the Chippewa River Watershed. Often times, pollutants and stressors, along with causes or sources can be complex and interconnected. An identified stressor can be more of an effect than a cause, and will therefore have additional stressors driving the problem. For instance, degraded habitat is a commonly identified stressor resulting in the lack of a healthy biological community. The cause of degraded habitat could be excess sediment; the cause of the excess sediment may be stream bank erosion; the cause of the stream bank erosion might be altered stream hydrology.

Information presented in this section is a compilation of many scientific analyses and reports. Information on the pollutants and stressors is summarized from the Chippewa River Watershed Monitoring Summary 2009-2010 (Wymar 2011) the *Chippewa River Watershed Monitoring and Assessment Report* (MPCA 2012a) and the *Chippewa River Stressor Identification Report*; (MPCA 2015c) the reader should reference those reports for additional details. Information on the necessary pollutant reductions is summarized from *TMDL* studies (MPCA 2013b) including the (Draft) Chippewa River Watershed TMDL (MPCA Draft) produced as part of the new Watershed Approach and older TMDLs: Turbidity TMDL for Chippewa River Watershed (MPCA 2014b) and Chippewa River Fecal Coliform TMDL Report (MPCA 2007b); and from additional studies and analyses as noted. To best estimate the pollutant sources and load allocations from each pollutant source within the Chippewa River Watershed area, a literature review was conducted and the WRAPS team participants were asked to review and discuss the multiple lines of evidence.

Sediment

Sediment in rivers and streams can be suspended (pollutant) and embedded (stressor) resulting in the loss of aquatic habitat due to sediment that travels along the streambeds. Sediment that is suspended in the rivers and streams impacts aquatic life by reducing visibility that reduces feeding, clogging gills that impairs respiration, and smothering substrate that limits reproduction. Sediment also fills in channels and thereby impacts downstream waters used for navigation (larger rivers) and recreation (lakes).

Table 2: Stream reaches assessed for sediment

AUID 07020005- (last 3 digits)	Assessment
509, 510, 512, 515, 516, 518, 539, 546, 551, 554, 557, 563, 564, 564, 566, 576, 577, 580, 581, 583, 584, 586, 594, 621, 623, 625, 627, 628, 630, 633, 634, 672, 673, 690, 691, 694, 695, 699, 712, 714, 904, 911, 916, 917, 921	Support/not a stressor
501, 502, 503, 504, 505, 506, 508, 514, 555, 559, 574, 578, 616, 660, 708, 709, 713, 901, 903	Impaired/stressor
507, 511, 521, 523, 528, 536, 547, 567, 570, 579, 585, 638, 661, 705	Inconclusive (need more data)

Status

Sediment has been identified as a pollutant and/or a stressor in those situations where it was identified as a likely cause of impaired biological communities across much of the Chippewa River Watershed. Nineteen stream reaches were directly impaired by sediment (i.e. the concentration of sediment exceeded the standard 65 ppm) and 9 of 16 bio-impaired stream reaches were stressed by sediment (i.e. the fish and macroinvertebrate populations indicate problems attributed to excess sediment). Forty-five stream reaches meet standards for sediment. Fourteen stream reaches needed more data (Table 2 and Table 15, which is located in section 6).

Trends

Currently the available data sets are not sufficient for a statistical trends analysis; even so, a general pattern may be occurring. Data from the six long term monitoring sites on the Chippewa River show that the river concentration often spikes above the 65mg/L standard. However, TSS flow weighted mean concentrations (FWMC) at the outlet of the major tributary watersheds of the Chippewa River show what appears to be a decrease in sediment over time during the 1999 to 2010 time period (Figure 8).

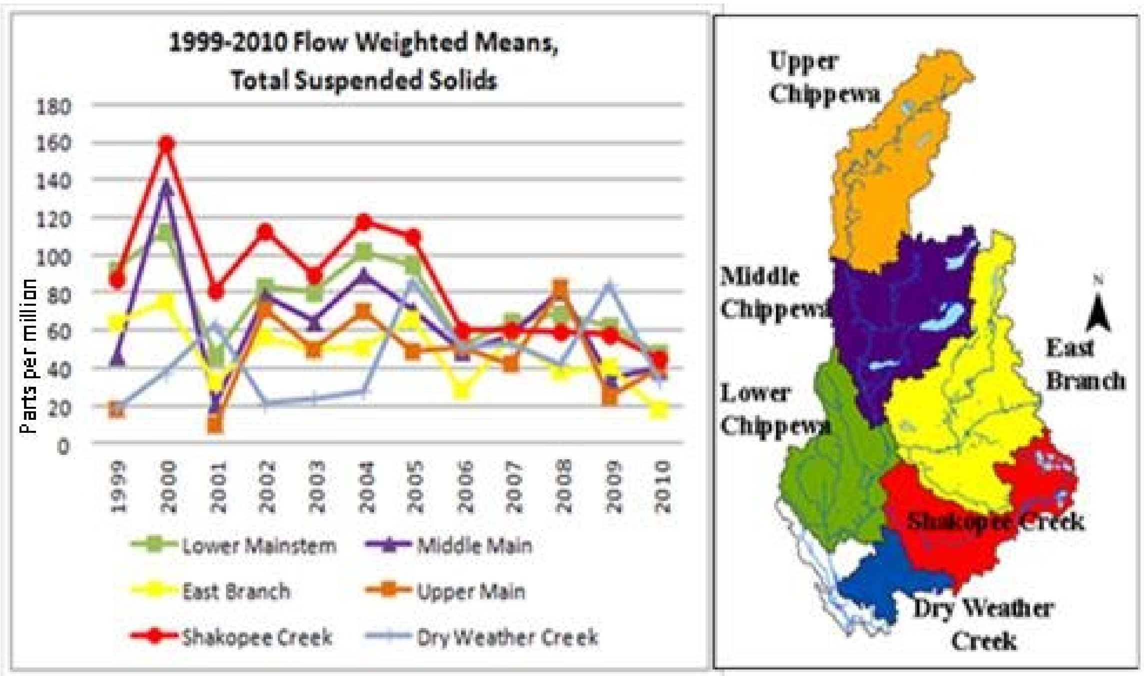


Figure 8: Flow Weighted Means of Chippewa and Tributary Stream

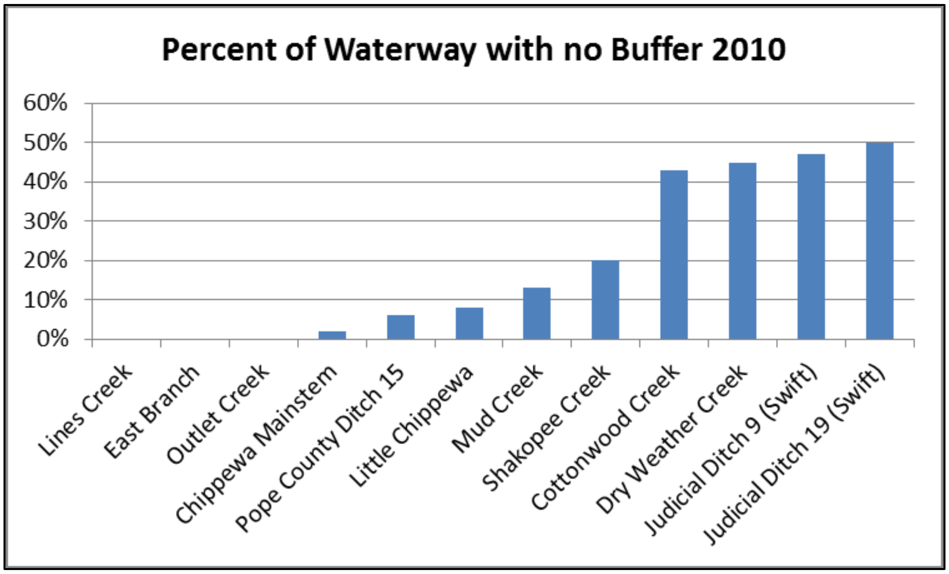


Figure 9: Percent of Waterway with no buffer 2010, CRWP

Additional monitoring data has documented consistent watershed conditions. Figure 9 (pg. 26) depicts the percent of the waterway with no buffer on 12 Chippewa River tributaries, a number that has not changed much since CRWP began monitoring it in 2001. A pattern is also evident when it comes to transparency, a surrogate for TSS (Figure 10). Red areas indicate consistently poor transparency levels; values represent average transparency score for all data (average 2006 through 2011). The CRWP has documented that sites tend to have consistent transparency from year to year.

Sources

The primary sources of sediment as discussed in *Identifying Sediment Sources in the Minnesota River Basin* (MPCA 2009b) can be summarized into four groups: fields, stream banks, bluffs and ravines.

1) Field (upland) contributions typically occur after rain events occur on bare soil and include field gully erosion, sheet/rill erosion, and residential/impervious surface contributions. 2-3) Stream banks and bluffs (channel and near channel) contributions are dominated by river bank/bluff erosion, which increases exponentially as river flow increases. While some degree of channel migration and associated bank/bluff erosion is natural, where stream degradation and aggradation are roughly in balance over time, increased river flow results in a general widening of the stream and causes excessive bank/bluff erosion. 4) Ravine contributions occur in locations where a flow path drops elevation drastically. The natural erosion rates of many ravines are exponentially increased as the amount of water traveling down the ravine is increased. Accelerated ravine erosion can often be observed where drainage outlets are placed to directly discharge at the top of a ravine. Permitted point source contributions of TSS load for the years of 2008 through 2012 were not a large contributor to the total watershed loading at less than 0.1% of the total watershed load.

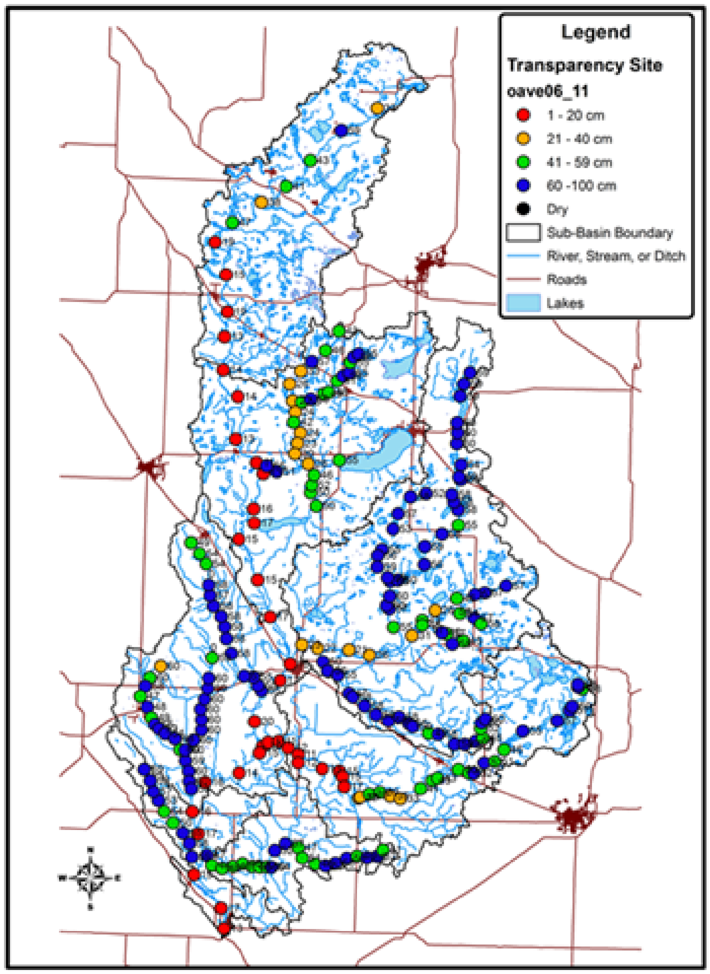


Figure 10: Chippewa River Transparency Profile,

In 2009, the MPCA used radioisotope fingerprinting to determine the average percentage contribution of upland eroded sediment in the Chippewa River Watershed. The study estimated that between 10% and 20% of sediment observed in the Chippewa River was derived from upland sources (MPCA 2009b).

To understand the contributions coming from stream bank erosion forty sections of stream were randomly selected, walked and field evaluated for bank condition and potential risk for and severity of erosion in 2009 and 2010. This data was used to establish a range of annual soil loss by stream order for Chippewa Subwatersheds (Figure 11).

A MPCA regression analysis of TSS contributions estimated that 38% of TSS loads in the Chippewa River were derived from streambank erosion. Volatile Suspended Solids, generally understood to be the organic component of TSS (algae, diatoms, decaying plant matter etc.), account for roughly 20% of any TSS sample (EQuIS monitoring data). Assuming 20% from upland and 5% from developed sources, this leaves around 17% for ravines and gullies (MPCA 2008b). There is some evidence to support this in the monitoring data. The Chippewa River Watershed Monitoring Summary 2009-2010 (Wymar 2011) indicated that the contributor with the highest TSS load/area observed is the Lower Mainstem. Evidence from Transparency Transects and monitoring sites previously located on Cottonwood Creek and Judicial Ditch 9/County Ditch 3 indicate that more than 95% of the TSS from the Lower Mainstem comes from the region immediately adjacent to the Chippewa River. This region is dominated by steep slopes and numerous gullies and ravines (Figure 12).

Streambank Soil Loss by Subwatershed		Annual Soil Loss (ton/yr)		Monthly Soil Loss (ton/yr)	
Subwatershed	Stream Miles	Low Rate	High Rate	Low Rate	High Rate
East Branch	491.99	15,289	42,616	1,275	3,551
Lower Chippewa	404.48	8,932	30,941	746	2,577
Middle Chippewa	474.62	14,643	42,859	1,220	3,573
Shakopee Creek	409.99	9,593	49,092	800	4,091
Upper Chippewa	361.99	8,037	27,199	670	2,267

Figure 11: Estimated annual bank loss by subwatershed (Chippewa Turbidity TMDL)

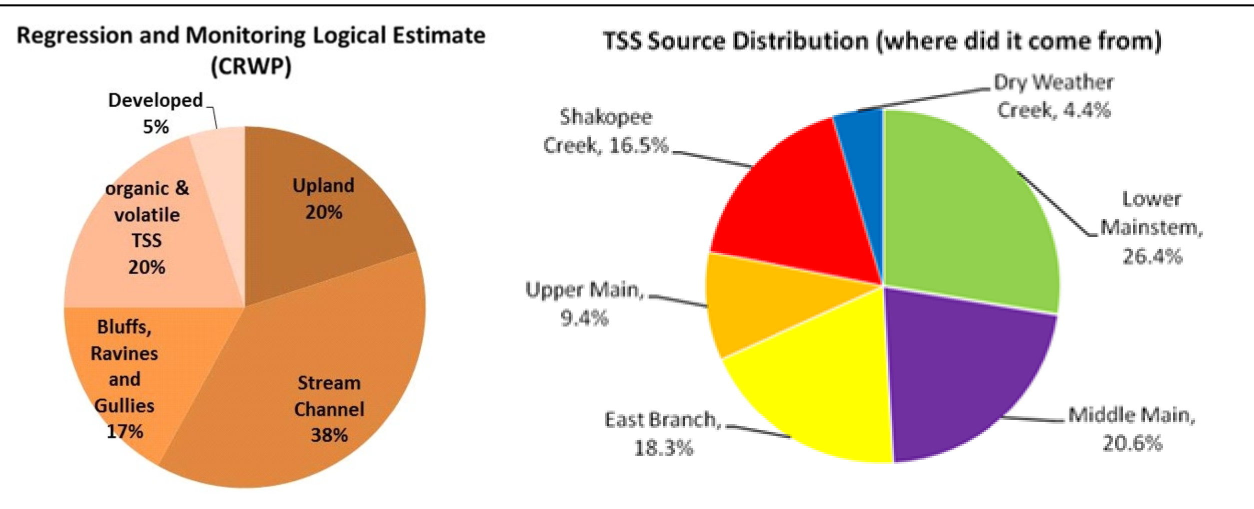


Figure 12: TSS source distribution
Regression and monitoring logical estimate (left) 2001-2010 monitoring data by watershed (right)

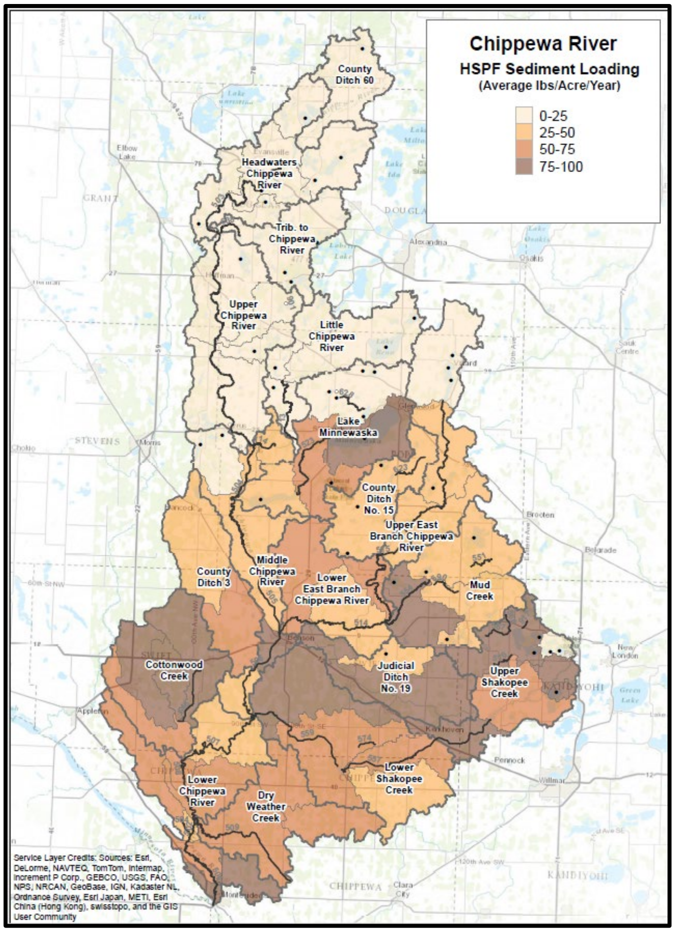


Figure 13: HSPF model analysis of source of TSS pollution

Critical Areas

The following is a compilation of TSS based monitoring observations and professional assessments made by the WRAPS participants specifically looking at problem areas for TSS. The information is grouped together by the six major subwatersheds of the Chippewa River Watershed. These major watersheds correlate to the HUC10 level.

Upper Chippewa (702000501): TSS levels are supporting until the river reaches Peterson Lake from there TSS increases significantly and never recovers. Monitoring data from the CRWP and the MPCA consistently identify this region as where the water quality trouble starts on the West Branch of the Chippewa River. Algae and carp are possible factors in Peterson Lake. Given that the water quality never recovers after this lake suggests that TSS contributions from the surrounding landscape from this point on are also elevated Annual transect surveys regularly document numerous cattle operation with uncontrolled access to the river. Fine particulates dislodged by these cattle likely contribute to mid-season water samples. Buffer rates are generally high along the main river channel but many tributary streams and ditches remain with inadequate buffers. Furthermore, this region is defined by steep slopes and row crops; surface runoff from unprotected sloping terrain into unbuffered small streams is a likely pathway to the Chippewa for TSS

Middle Chippewa (0702000502, 0702000503, 0702000507): areas along the river in this watershed have many gullies and field erosion in the steep areas. Buffer rates are relatively high along the main river channel but the tributary streams and ditches tend to lack adequate buffers.

The Little Chippewa River faces intense pressure from cattle with prolonged and unrestricted access to the creek. This causes the turbidity levels and Total Suspended Volatile Solids (TSVS) levels to be high. The hot summer months see high TSVS levels. The Little Chippewa River transfers the majority of its flow downstream to Lake Emily where it then contributes to the poor water quality seen in the Chippewa River. This is not to say that livestock should be removed from the watershed. Well managed livestock farming should be encouraged. The pastures and hay that they require provide a water quality benefit. The perennial grasses in well managed pastures and hay fields infiltrate rainfall, moderate stream flows and provide wildlife benefits. Cattle access to the flowing waterways of the Little Chippewa needs to be more carefully controlled to prevent cattle standing in the stream and on eroding stream banks and causing a downstream impairment.

As the Chippewa River nears Clontarf, the river banks show stress of having been channelized. The unstable layers of alluvial sand, silt and clay in conjunction with altered hydrology lead to significant streambank loss. Estimates of streambank loss are in the hundreds of tons per mile (net loss).

Lake Emily is a significant problem lake in this subwatershed requiring restoration. Lake Emily is a hypereutrophic lake, with TSI values for TP and Secchi in the hypereutrophic range and chlorophyll-a in the eutrophic range. Lake Emily has a history of significant algae blooms. These algae blooms translate downstream into significant TSVS and TSS problems.

East Branch (0702000504, 0702000505, 0702000506): While there are stream and lake impairments within the East Branch Subwatershed, its overall TSS contribution to the Chippewa River shows it as a fairly stable system. The most downstream segment of the East Branch before it joins the Chippewa mainstem consistently faces sediment and turbidity problems. Recent surveys have shown that the source for this is largely natural but is being exacerbated by human activities. There are areas along the river in this watershed that have gullies and field erosion in the steep areas. The high OP levels associated with the mainly row-cropped JD19 subwatershed appear to be driving algae blooms in the summer months in this reach.

Lower Chippewa (0702000507, 0702000509, 0702000511): This watershed has issues with TSS, and turbidity. Intensive monitoring has revealed that the main TSS contributing areas of this subwatershed are not Cottonwood Creek nor Judicial Ditch 3 and 9, but rather the region around the main channel of the Chippewa River. The area from Benson to Highway 40 is responsible for the majority of this watershed's TSS contribution. Streambank, ravine and gully erosion along the river are thought to be the most likely sources. It is believed that these are being driven by a lack of upland water retention practices. A strong emphasis on stabilizing these sources should be the focus of any implementation plan in this critical area.

Shakopee Creek (0702000508): The Shakopee Creek Watershed faces major issues with TSSs, turbidity and transparency. Due to this watershed's topography and heavy soils, there are many open tile intakes. These open intakes move TSS runoff directly to the Creek. Based on monitoring data, the 261 acre Shakopee Lake is linked to 39% of the TSS being contributed by the Shakopee Creek Watershed. The lake is plagued by sediment, nutrients, algae and carp. Water flowing out of Shakopee Lake is orders of magnitude worse than the water going in, even during low flow conditions. Part of the TSS problem is the result of high levels of nutrients driving algae blooms, which in turn contribute to the volatile portion of TSS (TSVS). Significant persistent bank erosion problems downstream of the lake are a direct result of the dam. The region downstream of the lake has a higher portion of ditches with no buffer than the rest of the watershed.

Possible solutions to the Shakopee Lake issue include but are not limited to redesigning the failing concrete spillway to allow the passage of bed load and enable the lake to periodically dry out. This could be accomplished by replacing the spillway with a V-notch weir type structure or a rock weir/rapids type structure. Passing bed load would decrease downstream channel entrenchment. Allowing the lakebed to dry out would compact lake sediments and allow new vegetation to sprout in exposed mudflats reducing sediment and nutrient suspension. Another benefit of either of these options would be the reestablishment of fish passage; the current dam serves as a fish barrier. Both of these structural approaches have the flexibility of design to allow either the maintenance of the current shallow lake, or the complete drawdown of the lake and subsequent replacement with adjacent wetlands and a section of meandering stream.

Dry Weather Creek (0702000510): This watershed has high levels of TSS pollutant loading during rain events. It also has the least number of ditch banks with buffers and the lowest portion of lakes, wetlands, grass and woodlands. As a result of this watershed's topography and heavy soils there are many open tile intakes that move TSS runoff directly to the Creek.

Goal & 10-year Target

The Chippewa River Watershed-wide goal is 25% reduction in TSS concentration and load. This goal is also the adopted goal for any region that does not have data to calculate an individual goal. This goal represents a drop in the (2002 through 2012) TSS FWMC from 70 to 53 mg/L at the Chippewa River Highway 40 site (assuming the water yield remains the same). This goal is more aggressive than the newer TSS water quality standard (65 ppm). A goal of 56 ppm was established for the Chippewa River Watershed Turbidity TMDL (MPCA 2014b) prior to the establishment of the new TSS standard. The watershed wide goal of 25% reduction will meet the 10-year target for the Sediment Reduction Strategy for the Minnesota River Basin (MPCA 2015d). Individual subwatershed goals were calculated from TMDL data and can be found in Table 13 found in section 3.6

The Chippewa River Watershed-wide 10-year target is 56 mg/L. It should be noted that 2010 FWMC data indicate that the Chippewa River Watershed is well on its way to meeting the target. Local conservation professionals attribute this success to a long history of solid commitment by local farmers and land managers to adopt practical BMPs that minimize erosion. Further strategies and methods to prioritize regions to address TSS are summarized in Section 3.

Phosphorus

Phosphorus is an important nutrient for plants and animals. It impacts aquatic life by changing food chain dynamics, impacting fish growth and development, decreasing DO, and increasing algae. High phosphorus impacts aquatic recreation in lakes by fueling excessive algae growth, making waters undesirable or even dangerous to swim in due to the potential presence of toxic blue-green algae. High phosphorus can also elevate TSS through TSVS, and DO can be lowered due to algae decay.

Status

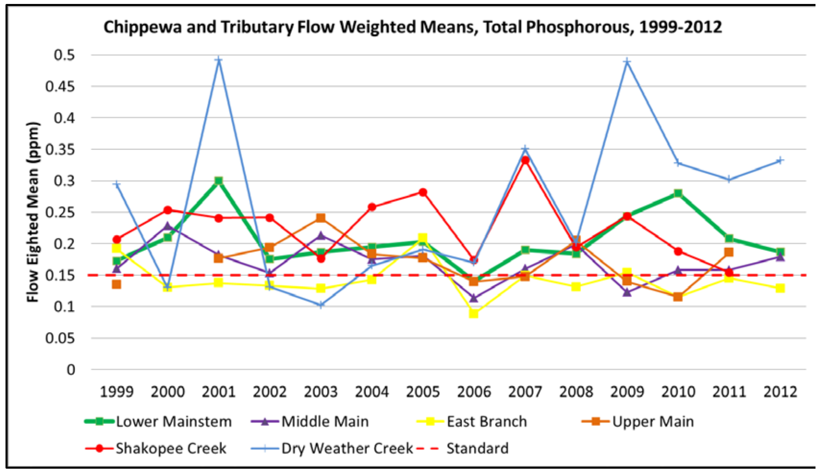


Figure 14: Chippewa phosphorus Flow Weighted Means

Nine of the sixteen bio-impaired stream reaches are stressed by phosphorus (i.e. the fish and macroinvertebrate populations indicate problems attributed to excess phosphorus). Of the 86 analyzed lakes, 34 were impaired by phosphorus, 30 were supporting standards for phosphorus, and 22 needed more data to make a scientifically-conclusive finding (Table 3 and Table 17 located in section 6.3). Once new stream eutrophication standards are applied, many streams will likely be assessed as impaired by phosphorus (i.e. concentrations will be above the standard).

Data from the six main monitoring sites on the Chippewa River consistently show that the river concentrations exceed the new stream eutrophication standard of 0.15 mg/L, as do the annual flow weighted means (Figure 14). The Highway 40 site on the Chippewa River has a flow-weighted mean total phosphorus (TP) concentration of 0.184 mg/L from 2008-2012. From a statewide perspective, the phosphorus concentration and yield per acre are moderately high in the Chippewa River.

Table 3: Stream reaches where phosphorus was identified as a stressor and lakes assessed for phosphorus

Stream AUID 07020005- (last 3 digits)	Assessment
551, 554, 554, 546	Not a stressor
503, 638, 713, 523, 628, 623, 714, 505, 559, 502, 507, 508, 584	Stressor
Lake ID Numbers	Assessment
Amelia, Aaron, Andrew, Benson (Ben), Camp, Chippewa, Florida, Florida Slough, Freeborn, Games, Hoff, Johnson (Kittelson), Linka, Little Chippewa, Little Oscar (Main), Maple, Marlu, Minnewaska, Moses, Nelson (Main Lake), Rachel, Round, Scandinavian, Signalness (Mountain), South Oscar, State, Turtle, Unnamed, Villard, Whiskey	Support/not a stressor
Gilbert, Ann, Block, Danielson Slough (Cyrus), Edwards, Emily, Gilchrist, Hanson (Woodpecker), Hassel, Hollerberg, Irgens (Irgen), Jennie, Johanna, John, Jorgenson, Leven, Long, Long, Malmedal, Mary, McIver, Middle, Monson, Norway, Pelican, Rasmuson, Red Rock, Reno, Simon, Steenerson, Strandness, Swenoda, Thompson, Wicklund (Abrahamson)	Impaired/ stressor
Benson, Church, Devils, East Sunburg, Fanny, Goose, Hefta, Indian (Kelly), Lower Elk, Mary, Moore, Pike, Private, Stowe, Sunburg, Swenson, Terrace Mill Pond, Unnamed, Unnamed, Venus, Wallin (Wollan), West Sunberg	Inconclusive (need more data)

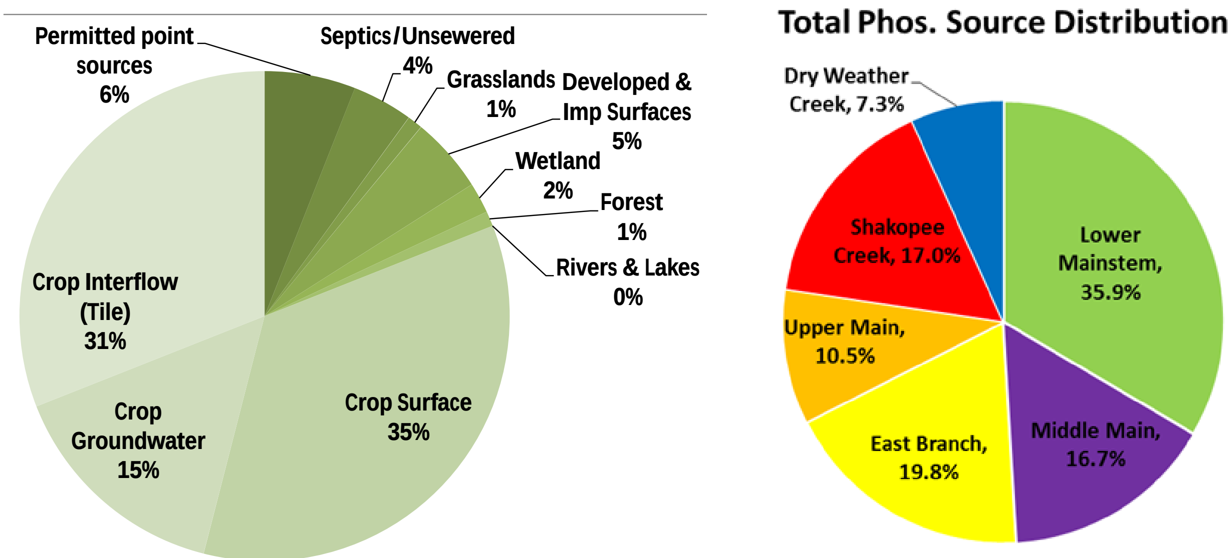


Figure 17: WRAPS team estimate of phosphorus sources in the Chippewa and monitoring distribution 2001-2010.

Sources

The HSPF estimates the subwatershed TP yields (Figure 16). These estimates can help inform prioritization efforts by estimating which regions of the watershed are contributing larger yields.

In the Chippewa River Watershed, most phosphorus that reaches water bodies is from nonpoint sources. According to the MPCA point source data in years 1996 through 2012, 5.4% of phosphorus was from point sources. A numeric estimate of phosphorus sources was created by the WRAPS team after review of multiple lines of evidence, applying local knowledge and professional judgement (Figure 17).

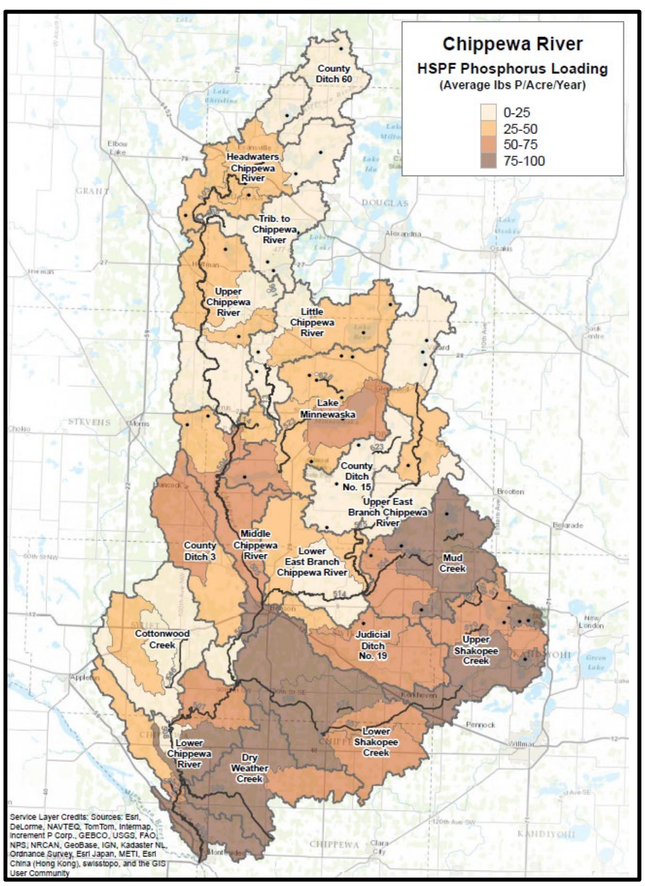


Figure 16: HSPF estimates of phosphorus (TP) yields

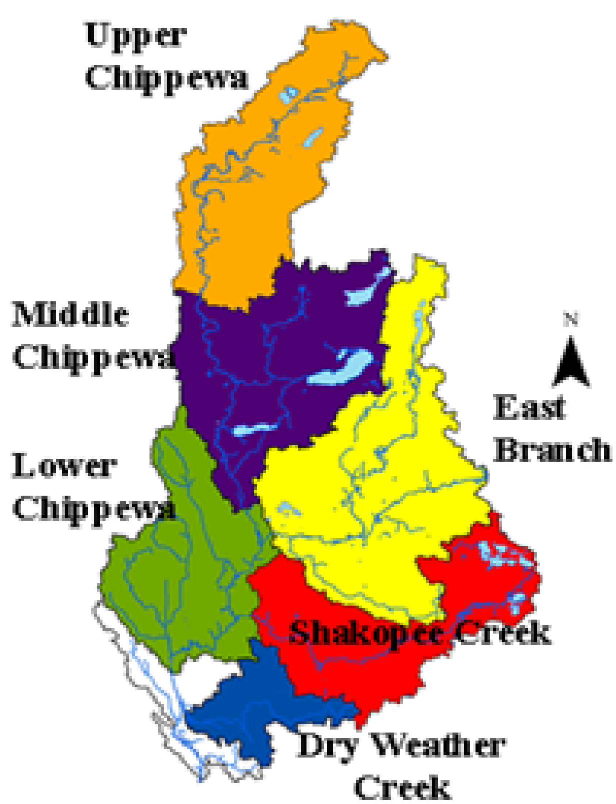


Figure 15: Chippewa River Sub-Basins

The single largest phosphorus source was estimated to be crop surface runoff. Most of the phosphorus leaving agricultural fields is from applied fertilizer and manure.

In the Chippewa River Watershed, phosphorus is delivered to streams by WWTPs, urban storm water, agriculture, direct discharges of sewage and natural sources. As stated previously, much of the watershed is agricultural, particularly in the lower sections where phosphorus concentrations are often elevated. In the southern third of the Chippewa River Watershed, orthophosphorus ((OP) the portion of TP that is dissolved in water) is a significantly higher portion of the TP profile. This is particularly true in the early part of the season during the spring snow melt. TP samples taken during this period in the areas with more row cropping tend to be higher than regions with less row crop land use (Figure 18).

Tile line delivery of phosphorus is considerable as well. The fact remains that pattern tile and areas with alternative tile intakes deliver less phosphorus than areas with open tile intakes (Figure 19). Contrary to popular belief, even tile systems with no surface inlets deliver phosphorus albeit at much lower concentrations.

Critical Areas

The following is a compilation of phosphorus based monitoring observations and professional assessments made by the WRAPS team specifically looking at problem areas for phosphorus. The information is grouped together by the six major subwatersheds of the Chippewa River Watershed. These major watersheds correlate to the HUC10 level.

Upper Chippewa (702000501): This region has a number of lakes that sit on the Chippewa River or drain to it. Many of these lakes are impaired or are facing localized pollution threats. The HSPF and monitoring data indicate that elevated levels of phosphorus are a stressor to local aquatic populations. Buffer rates are generally high along the main river channel but many tributary streams and ditches have inadequate buffers.

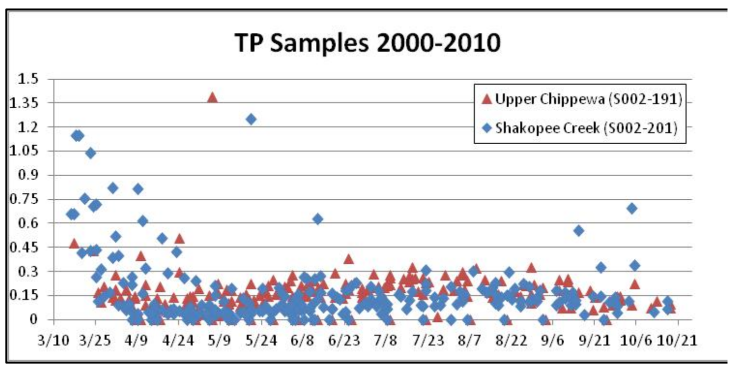


Figure 18: TP point measurements for Upper Chippewa and Shakopee Creek 2000-10 (MPCA)

Middle Chippewa (0702000502, 0702000503, 0702000507): This subwatershed has high TP problems. Turbidity, transparency and TSVS tend to rise in this region during the hot months. These effects are likely the result of elevated phosphorus driving algal growth in the stream and lakes. The region has numerous gullies and steep eroded banks. A lack of adequate buffers on the smaller streams and

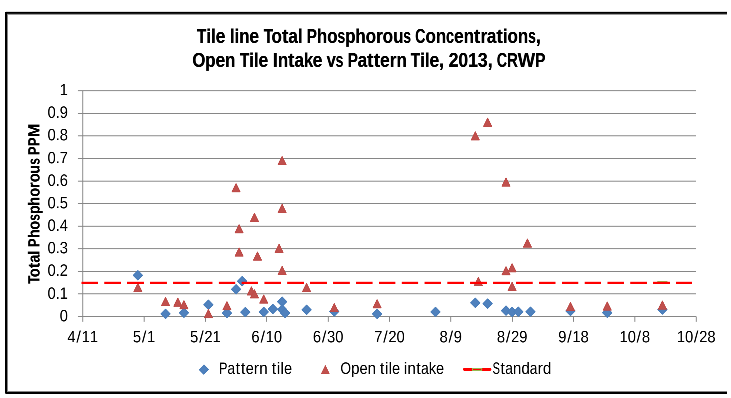


Figure 19: Tile line delivery of phosphorus Chippewa River Partnership (CRWP)

ditches combined with field erosion are also common to this region. These physical conditions all contribute to the efficient delivery of phosphorus to the river.

The Middle Chippewa region has numerous impaired lakes, which have a history of algae blooms. The associated low DO levels are seen downstream in the Chippewa River.

East Branch (0702000504, 0702000505, and 0702000506): While there are stream and lake impairments within the East Branch Subwatershed, its overall pollutant load contribution to the Chippewa River shows it as a fairly stable system. Localized issues of TP, OP, and turbidity exceedances impact this subwatershed. The high OP levels associated with the mainly row-cropped JD19 subwatershed need to be addressed. Efforts for better management of livestock manure (pasture, feedlot, application) and addressing non-compliant septic systems are needed to address the lake impairments.

Lake Leven, Lake Gilchrist and Simon Lake are noted lakes of impairment in this region. Strategies for Lake Leven, due to the predominance of the Judicial Ditch 4 (JD4) system, should be placed on enhancing this ditch to provide improved water quality through the use of BMPs to address the lack of wetlands, streambank destabilization, cattle in the river, and minimal buffers. Strategies for restoring Lake Gilchrist by reducing overall watershed loadings should focus on agricultural BMPs that will reduce tillage, alleviate the impact of open tile inlets, and address the lack of buffers. Enhanced feedlot BMPs and nutrient management plans will need to be developed and implemented. Watershed load reduction activities described above can be used to reduce TP loading to impaired Lake Swenoda and improve in-lake water quality. Strategies for Simon Lake are focused on utilizing conservation cover and livestock management with improved grazing systems to reduce runoff loading.

Lower Chippewa (0702000507, 0702000509, and 0702000511): This subwatershed faces multiple sources of phosphorus. Intensive monitoring has revealed that the main nutrient contributing are not Cottonwood Creek nor Judicial Ditch 3 and 9, but rather the region around the main channel of the Chippewa River. The area from Benson to Highway 40 is responsible for the majority of this subwatersheds TP contribution. Bank and gully erosion and the prevalence of open tile intakes are the primary sources. The TP level is also an issue of agricultural practice, and the practice of fall application of fertilizer and winter application of manure are clearly seen in the monitoring data as TP levels rise only when there is a spring snow melt.

Shakopee Creek (0702000508): The Shakopee Creek Subwatershed faces major issues with phosphorus and in particular, OP. Based on monitoring data, the 261 acre Shakopee Lake is linked to 19% of the phosphorus being contributed by the Shakopee Creek Watershed. The lake is plagued by nutrients, algae and carp. Water flowing out of Shakopee Lake is orders of magnitude worse than the water going in, even during low flow conditions.

The high TP level is also an issue of agricultural practice, and the practice of fall application of fertilizer and winter application of manure are clearly seen in the monitoring data as TP levels rise only when there is a spring snow melt (Figure 18). The lack of buffers (38% of the watershed has no buffer, Figure 9) and the prevalence of open tile intakes prevent TP from being filtered from the river. In particular, areas downstream of Shakopee Lake should be a critical area of focus. The region downstream of the lake has been found to yield 70% of the subwatershed's water and a disproportionate amount of this watershed's phosphorus pollution (54% OP, 38% TP) in addition this region has a higher portion of ditches without any buffer than the rest of the watershed.

The headwaters of the Shakopee Creek Watershed (HUC12 – 070200050801) include a chain of very popular and economically important lakes. Two of these lakes Norway Lake and Middle Lake have been assessed as impaired while the others are still supporting of water quality standards. The phosphorus levels of these lakes are directly impacted by two ditches (CD 27 and CD29) that drain row crop dominated landscapes. In addition, phosphorus is contributed from lake homes as a result of lawn and lot management and inadequate or failing septic systems.

Dry Weather Creek (0702000510): This watershed has the highest levels of OP pollutant loading in the watershed. It also has the least number of ditch banks with buffers and the lowest portion of lakes, wetlands, grass and woodlands.

Goals & 10-year Targets

The watershed-wide goal is a 32% reduction in the 2008 through 2012 FWMC and load. This represents a drop in the FWMC from 0.221 mg/L to 0.15 mg/L. This meets the new River Eutrophication Standard (0.15 mg/L) for southern Minnesota streams (MPCA 2014c). Individual lake goals were calculated from TMDL data. This watershed-wide goal is consistent with the Minnesota Nutrient Reduction Strategy (MPCA 2015e).

The Chippewa River Watershed-wide 10-year target of 12% reduction in TP FWMC for streams and lakes was selected. Strategies and methods to prioritize regions to address phosphorus are summarized in Section 3. The Minnesota Nutrient Reduction Strategy (MPCA 2015e) calls for a target of 45% reduction and already credits the state as achieving a 33% reduction, so the remaining reduction of 12% for the watershed will help meet the overall reduction goal of 45% by 2025.

Nitrogen

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

Table 4: Stream reaches assessed for Nitrogen Stressor

Assessed AUID 07020005- (last 3 digits)	Assessment
503, 713, 523, 628, 551, 554 623, 714, 505, 546, 502, 507, 508, 584	Support/not a stressor
559	Impaired/stressor
638	Inconclusive (need more data)

Status

High nitrogen was identified as a stressor (Table 4, and Table 15 located in Section 6) in 1 of 16 bio-impaired stream reaches. Fourteen investigated reaches were not impacted by nitrogen, and one of the stream reaches needed more information. Nitrogen is only investigated when a bio-impairment is identified; so excessive nitrogen conditions may be more widespread than appears and are likely problematic in highly tiled areas (refer to source assessment). Once new stream eutrophication standards are applied, many streams will likely be assessed as impaired by nitrogen (i.e. concentrations will be above the standard).

Data from most of the Chippewa River and its tributaries shows the flow weighted means to be below the targets established in the state level Nutrient Reduction Strategy and are likely to be below levels being considered in aquatic life nitrogen criteria. Two tributaries of the Chippewa River stand apart from this trend and consistently show that the river concentration exceeds these targets (Figure 20), with 2008 through 2012 flow-weighted mean concentrations of Shakopee Creek and Dry Weather Creek are 6.1 and 7.2 mg/L respectively. From a statewide perspective, the nitrogen concentration and yield per acre are moderately high in the Chippewa River.

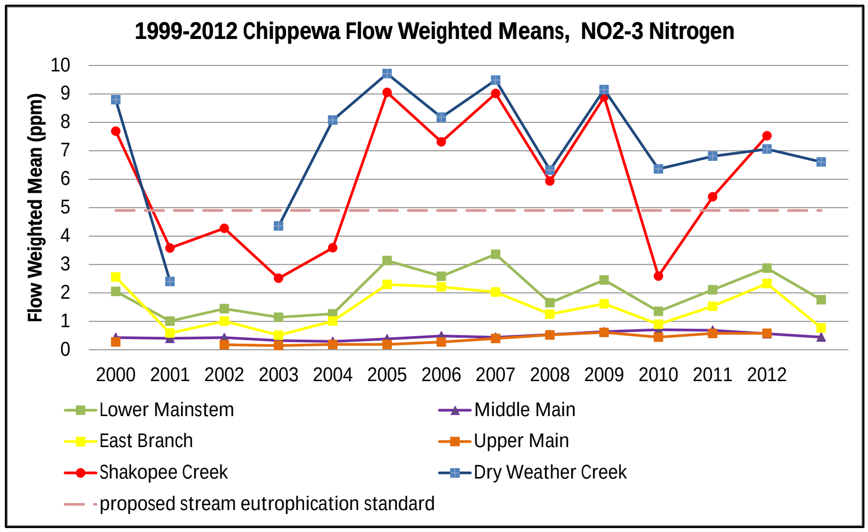


Figure 20: Chippewa flow weighted means, Nitrogen

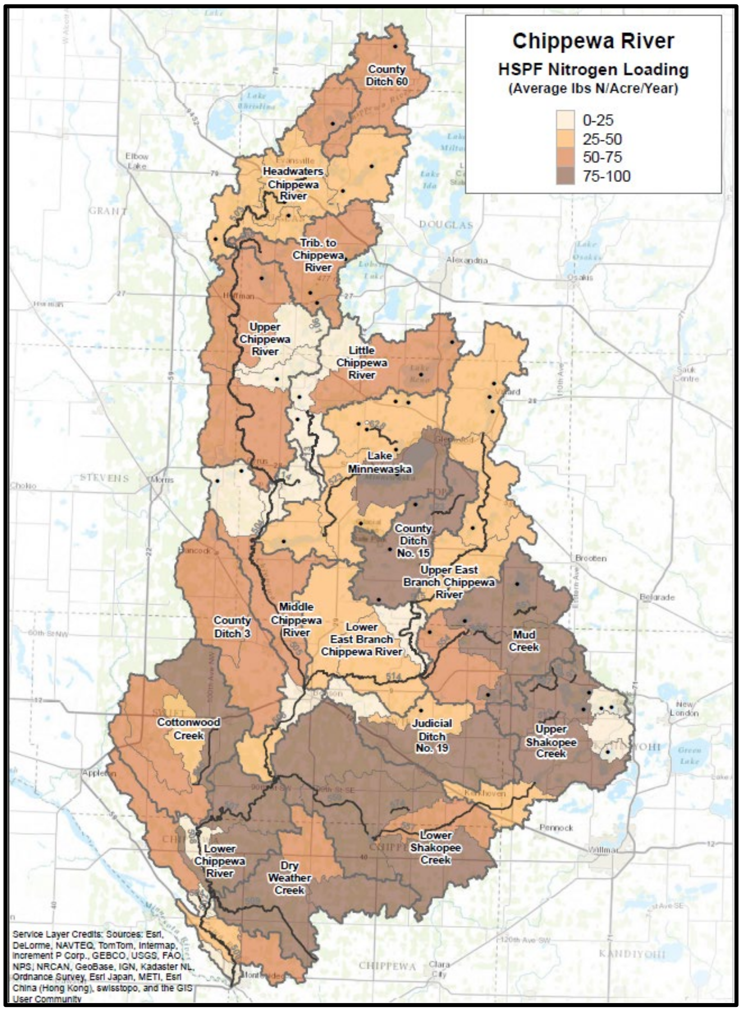


Figure 21: HSPF estimates of the subwatershed total nitrogen (TN) yields

Sources

In the Chippewa River Watershed, most nitrogen that reaches water bodies is from nonpoint sources. In the years 2000 through 2012, 0.32% of nitrogen was from point sources. A numeric estimate of nitrogen sources was created by the WRAPS team (Figure 22) after review of multiple lines of evidence, applying local knowledge and professional judgement. The single largest nitrogen source was estimated to be crop tile drainage. Most of the nitrogen leaving agricultural fields was deemed to be from applied fertilizer, land applied manure and mineralized organic matter in the soil.

The HSPF model estimates the subwatershed total nitrogen (TN) yields (Figure 21). These estimates can help inform prioritization efforts by showing what regions of the watershed are contributing larger loads per region. Discovery Farms Minnesota data from farm fields with tile drainage provides another line of evidence that supports this assessment (Figure 23). Another less robust line of evidence is the Chippewa River tile line data, while only two sites and three years' worth of data it adds a degree of local confirmation of the Discovery Farms findings. 2014 through 016 monitoring conducted by CRWP found that tile served by open tile intakes and pattern tile systems (no open intakes) yielded high concentrations of nitrogen to the receiving ditches (CRWP 2016**Error! Reference source not**

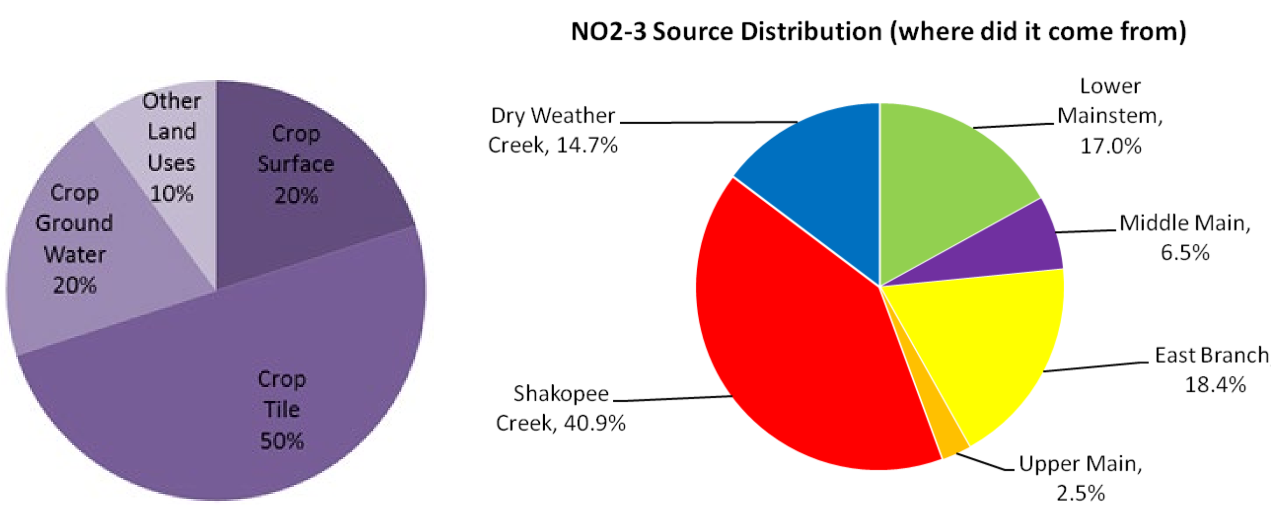
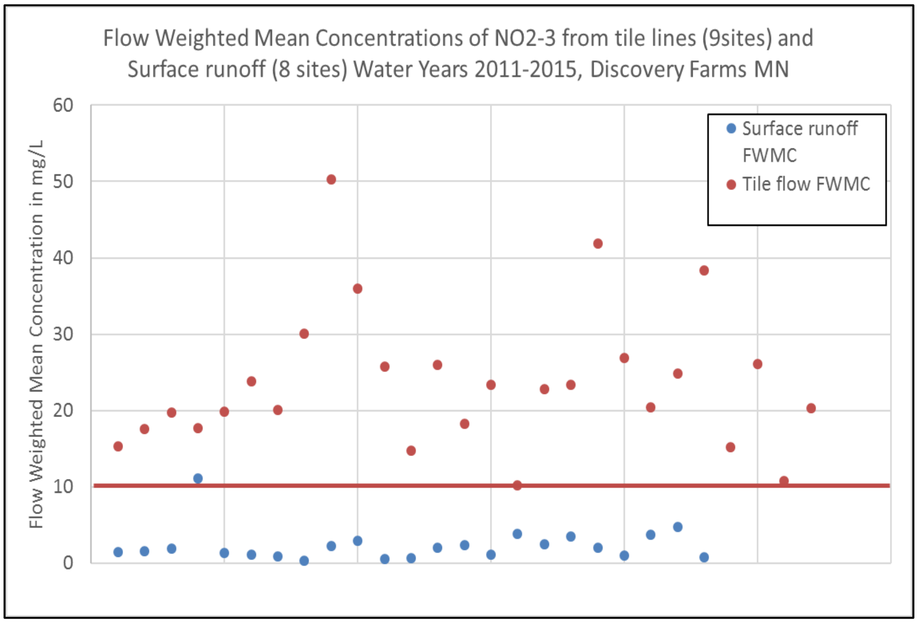


Figure 22: Nitrogen Contributions Chippewa River Watershed



Available Tile data - WY11-15 Discovery Farms MN – 9 locations		NO2-3 FWMC
Subsurface Tile	AVG FWMC	23.44
	MEDIAN FWMC	21.62
	MIN FWMC	10.21
	MAX FWMC	50.25

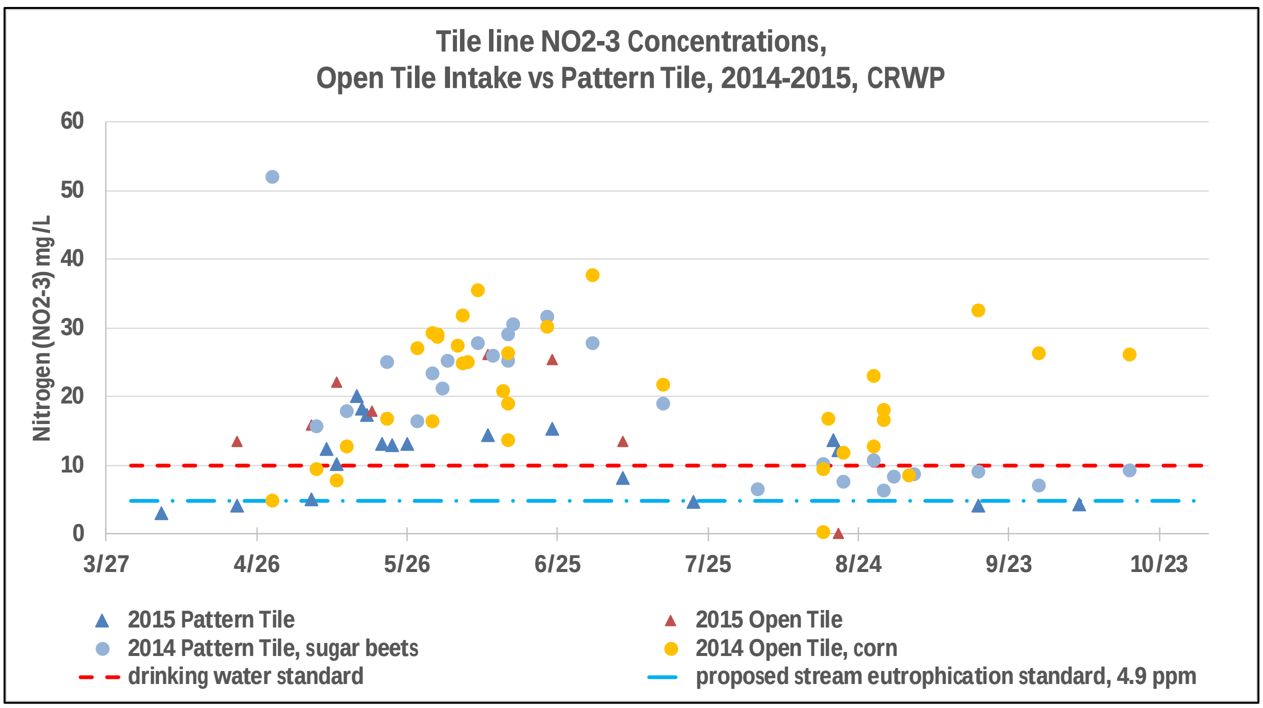


Figure 23: Tile line delivery of Nitrogen, Discovery Farms (Discovery Farms 2016) and CRWP Monitoring (CRWP 2016)

found.). As a way to put this data into a relative perspective of nitrates observed both the Chippewa and Discovery Farms Minnesota sites approached concentrations found in human urine (47.6 ppm).

Critical Areas

Shakopee Creek (0702000508): The Shakopee Creek Subwatershed contributes a disproportionate amount of the Chippewa River's nitrogen (NO2-3). Based on monitoring data (CRWP), the Shakopee Creek Watershed delivers 41% of the Nitrogen from 16% of the watershed. Furthermore, the region downstream of Shakopee Lake (the lower third of the subwatershed, downstream of Shakopee Lake) contributes 61% of Shakopee Creek's nitrogen. This region's primary land use is row crops. The soils are densely tile drained and ditched. Buffer surveys indicate that 20% of the ditches have no vegetative buffer.

Dry Weather Creek (0702000510): This subwatershed has the highest concentration of nitrogen (NO2-3) in the Chippewa River Watershed. Dry Weather Creek has 5% of the Chippewa's land but contributes 15% of the nitrogen. This subwatershed is dominated by row crops. It has no towns and the lowest portion of lakes, wetlands, grass and woodlands. It also has the least number of ditch banks with buffers, 42% of the ditch banks surveyed had no buffer.

Goal & 10-year Target

The proposed watershed-wide goal is the proposed River Eutrophication Standard (MPCA 2014c) (4.9 ppm). Two HUC10 watersheds are not meeting the proposed standard, Shakopee Creek and Dry Weather Creek. In Shakopee Creek, a 20% reduction in the baseline 2008-2012 FWMC and load is the selected goal. This represents a drop in the FWMC from 6.1 mg/L to 4.9 mg/L. In Dry Weather Creek a 32% reduction in the baseline 2008-2012 FWMC and load is the selected goal. This represents a drop in the FWMC from 7.2 mg/L to 4.9 mg/L.

A 10-year target reduction of 10% was selected for the TN FWMC for Shakopee Creek and Dry Weather Creek. The rest of the Chippewa River Watershed is currently achieving the proposed River Eutrophication Standard. Although a reduction for the rest of the watershed is not needed, their target is to continue to meet the proposed River Eutrophication Standard. Strategies and methods to prioritize regions to address nitrogen are summarized in Section 3.

Fecal Bacteria

Fecal bacteria (*E. coli* or fecal coliform) 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. Fecal bacteria are living organisms that can be present in upstream locations due to upstream sources, yet die before reaching downstream waters where they may not be detected.

Status

Fecal bacteria are problematic across much of the watershed. Fecal bacteria have been identified as a pollutant in 21 stream reaches (Table 15 located in Section 6). None of the sampled stream reaches were found to be supporting of fecal bacteria standards, and five stream reaches needed more data.

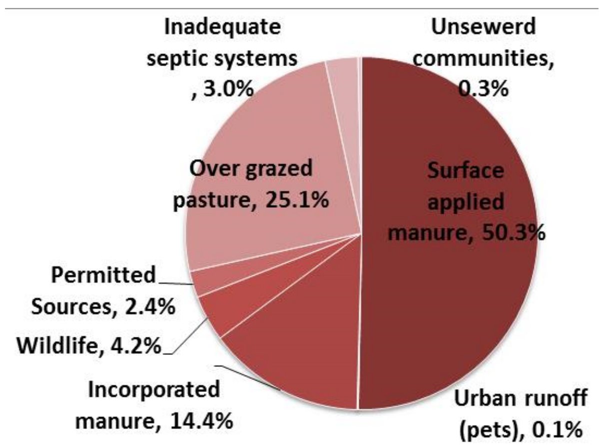


Figure 24: Sources of fecal bacteria in the Chippewa River

Sources

Specific 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 a weak positive relationship to fecal bacterial contamination in streams (Table 5). Bacteria sourcing can be very difficult due to the bacteria's ability to persist, reproduce, and migrate in unpredictable ways. Therefore, the factors associated with bacterial presence provide some confidence to bacterial source estimates.

Fecal bacteria source identification is further confounded because some bacteria may be able to survive and reproduce in streams as reported in *Growth, Survival, and Genetic Structure of E. coli found in Ditch Sediments and Water at the Seven Mile Creek Watershed* (MDA2010). This study traced substantial numbers of bacteria to cattle sources, while no samples could be traced to human sources. Because there is currently a lack of ample study on in-stream reproduction and fecal bacteria pose significant risks to human health, the percent of the bacterial load attributed to this source is conservatively estimated at zero for this analysis.

A numeric estimate of bacterial sources was created by the WRAPS team (Figure 24) after review of multiple lines of evidence applying this local knowledge and professional judgement. Domesticated animal manure accounts for the majority of fecal bacteria in the Chippewa River Watershed.

Table 5: Bacteria sourcing

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

Most of the manure that is applied to fields originates from feedlot operations. Pastures and winter grazing of crop stubble represent a second significant source of manure in the Chippewa River Watershed. The locations of feedlot headquarters are registered. However, the exact location where manure is spread is not necessarily known. Because transportation costs increase as the distance between the feedlot facility and fields where manure is applied, manure is frequently applied relatively close to feedlot facilities. For this reason, the number of feedlot AUs per region (Figure 25) is one line of evidence that can be helpful for targeting feedlot-originated manure management on fields. Additional considerations including slope, proximity to surface water, application location and timing, and infield practices are also important considerations.

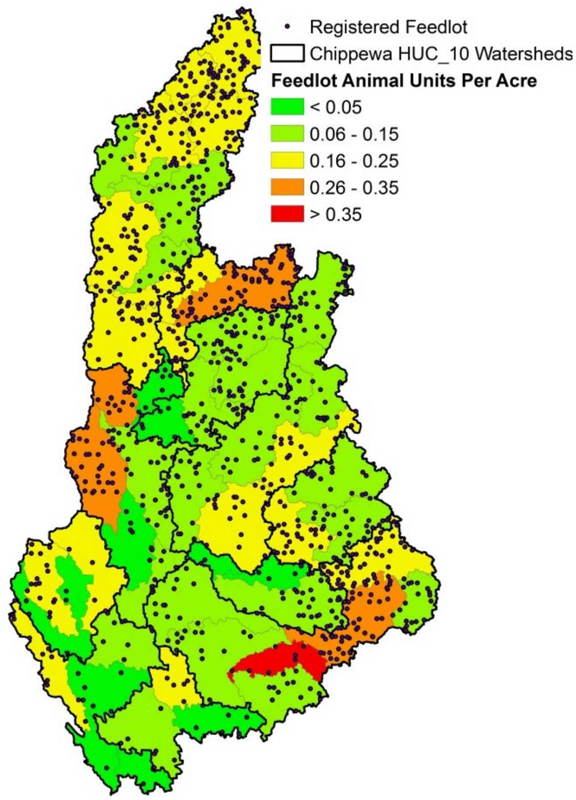


Figure 25: The number of feedlot animal units per region

In the Chippewa River Watershed, there are 205 feedlots located within 1000 feet of a lake or 300 feet of a stream or river, an area generally defined as shoreland. One hundred eighty-five of these feedlots in shoreland have an open lot(s). Open lots present a potential pollution hazard if the runoff from the open lots is not treated prior to reaching surface water. Four of the feedlots in shoreland are operating under an Open Lot Agreement (OLA) with the MPCA. These feedlot sites have been identified as actually having a potential pollution hazard and have or will install short term measures to minimize untreated manure runoff until permanent measures can be installed.

Critical Areas

Surveys and consistent monitoring have documented that fecal coliform levels are high throughout the Chippewa River Watershed. The high fecal coliform levels are not geographically distinct; rather they are the result of prevalent issues relating to pathways. Continuous livestock access to the river through pastures along waterways is a pathway. Manure applied to cultivated fields is another pathway. These are exacerbated by inadequate buffers on many of the tributary streams and ditches. Additionally, ineffective septic systems are another known pathway.

It is notable that of the eight counties in the Chippewa River Watershed, Chippewa and Stevens Counties both do not have the "point of sale" (POS) septic system compliance inspection requirement. The POS inspection is one of the very few ways older SSTS are inspected to ensure they are in compliance and not an imminent public health threat. Each year counties are required to submit annual reports to the MPCA regarding SSTS activity within their respective county. While only aggregate information is reported by county and thus actual location of individual SSTS is not known, there is a large amount of failing and imminent public health threat classified SSTS system in the eight counties in the Chippewa River Watershed; excluding Grant, Kandiyohi, Otter Tail and Stevens counties as they only have a small portion of their county in the watershed. The remaining four counties, Chippewa, Douglas, Pope and Swift, have a reported 17,535 SSTS located within these counties. Of the 17,535 SSTS, 3,773 are considered failing and an additional 2,118 are considered imminent public health threats.

Goal & 10-year Target

The watershed-wide goal for fecal bacteria reduction was calculated by averaging the individual bacteria reduction goals. The watershed goal is to reduce fecal bacteria to meet the standard (126 colony forming units per 100 mL) (MPCA 2014d). Strategies and methods to prioritize regions to address bacteria are summarized in Section 3.

Dissolved Oxygen

Low DO impacts aquatic life primarily by limiting respiration, which contributes to stress and disease and can cause death.

Status

Low DO was identified as a stressor in 10 of 16 analyzed stream reaches. Two stream reaches meet DO water quality standards, and several stream reaches require more data to make an assessment.

Sources

Low DO in water bodies is caused by: 1) excessive oxygen use, which is often caused by the decomposition of excessive algae, which is fueled by excess phosphorus, and/or 2) too little re-oxygenation, which is often caused by minimal turbulence or high water temperatures. Low DO levels can be exacerbated in over-widened channels because these streams move more slowly and have more direct sun warming.

Critical Areas

Data gathered by the CRWP during the Surface Water Assessment stage of the Watershed Approach identified eight critical areas where DO readings were lower than the 5 mg/L standard more than 10% of the time. These areas are identified in (Figure 26) as red circles. Each data point represents at least 20 samples.

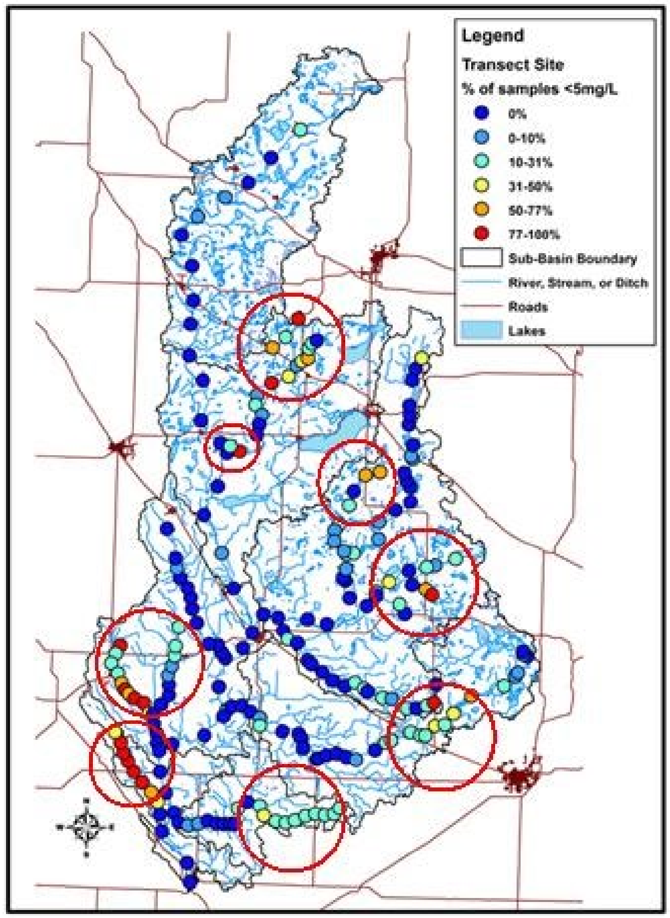


Figure 26: Percent of DO Samples below 5 mg/L, 2009-2010: critical areas are areas in the watersheds containing exceedances greater than 10%

10-year Targets

Because this stressor is primarily a response to other stressors, the 10-year target for DO is to meet the altered hydrology and phosphorus targets, since these are the primary drivers of DO problems in the watershed (i.e. excessive algae and extended periods of low water). This goal is revisable and will be revisited in the next iteration of the Watershed Approach. Strategies and methods to prioritize regions to address altered hydrology and phosphorus are summarized in Section 3.

2.6 Stressors to Aquatic Life

Stream reaches that were found to be impaired for impacts to aquatic life where investigated through a weight of evidence approach (Caddis EPA 2012) to determine what the most likely stressors to aquatic life are at the sites in question. For a more detailed analysis, see the Chippewa SID Report (MPCA 2015c). What follows is a general description of the stressors identified in the SID report.

Altered Hydrology

Hydrology is the study of the distribution and circulation of water on and below the earth's surface and in the atmosphere (USGS 2014b). Hydrology is interconnected in a landscape; for example, the rate of evapotranspiration (ET) on the land impacts the amount of water reaching a stream. Changes in river flow are the result of other hydrologic alterations. Altered hydrology refers to changes in hydrologic parameters including: river flow, precipitation, drainage, impervious surfaces, wetlands, river paths, vegetation, soil conditions, evaporation, evapotranspiration, etc. Altered hydrology can directly harm aquatic life by affecting the amount of water in the water body; both too little and too much stream flow can harm aquatic life. Stream flow naturally varies over time, which is good for the plants and animals that are in the aquatic environment, but when this pattern is altered too much it has been found to negatively impact aquatic life (Caddis EPA 2012). Furthermore, altered hydrology accelerates the movement and amount of other pollutants and stressors (nutrients, sediment, etc.) to water bodies.

Tile drainage is an example of a hydrological alteration; tile drainage removes excess soil water, providing for better field access with heavy equipment and favorable conditions for plant roots, and also allows water that might otherwise run off the land in surface runoff to percolate into the soil. This change in the way that water moves off the land can change the total volume and timing of water inputs to rivers. In addition to changing water storage in the soil profile, drainage can remove the temporary surficial storages that are natural to the prairie pothole landscape. These surficial wetlands not only create a hydrology shock absorber, but they also serve as a source of habitat and support to invertebrates and eventually migrating wildlife. Changes in stream flow are symptoms of this and other changes in hydrologic parameters.

Table 6: Stream reaches where altered hydrology was identified as a stressor

AUID 07020005- (last 3 digits)	Assessment
551, 584	Not a stressor
502, 503, 505, 507, 508, 523, 546, 559, 628, 638, 714	Stressor
554, 623, 713	Inconclusive (need more data)

Status

Altered hydrology was a commonly identified stressor to aquatic life in the Chippewa River Watershed, found to affect 12 of 16 investigated stream reaches (Table 6 and Table 17, in the appendix). Both high and low river flow conditions were identified as problematic in the watershed. Since altered hydrology is not a considered a pollutant by itself, it is only investigated when a bio-impairment is identified. The sources of altered hydrology (discussed later in this section) are common across the watershed. Therefore, altered hydrology is likely negatively impacting water quality watershed-wide, despite being identified as a stressor in only select locations.

Trends

The Chippewa River's annual flow has almost quadrupled, the annual peak flow has nearly doubled and the runoff ratio (or the percentage of precipitation that ends up as river flow) has increased by 375% over the last 80 years (Figure 27). Over this same period, there have been low level changes in precipitation but much human induced

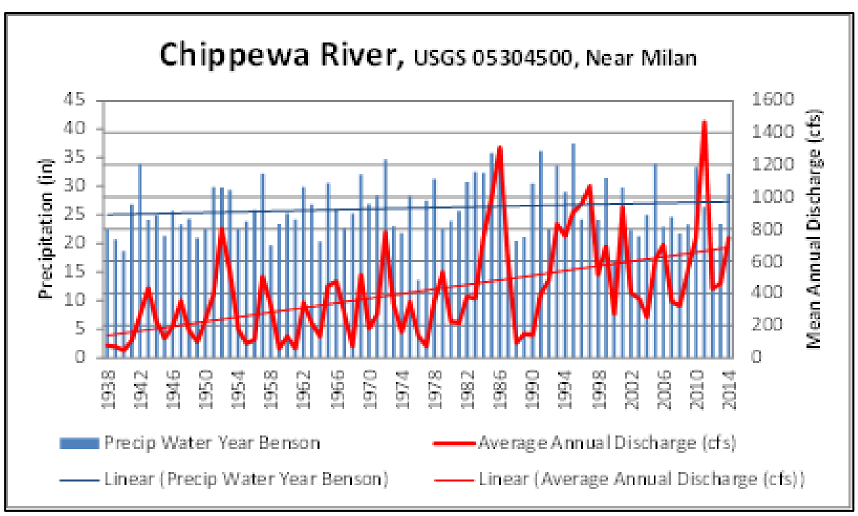


Figure 27: Mean Annual Discharge and Annual Precipitation over time, 1938-2014. Data Sources: USGS and UMN

hydrological alteration. More detail on hydrology conditions and trends is presented in the Chippewa River Hydrologic Analysis (DNR 2015).

Many of the hydrologic alterations in the Chippewa River Watershed began in the late 19th to early 20th century. Reduced surface storage, increased conveyance, increased impervious surfaces, increased effective drainage area, and modified crop rotations supporting soybeans over perennial grasses and small grains have all altered the dynamics of watershed hydrology. In addition, these changes have generally increased the annual water discharged from these watersheds, while also dramatically altering the return interval for various flow stages (Schottler 2014). This has led to a constant increase over time in the percent of rainfall that ends up in the river, or runoff ratio (Figure 28).

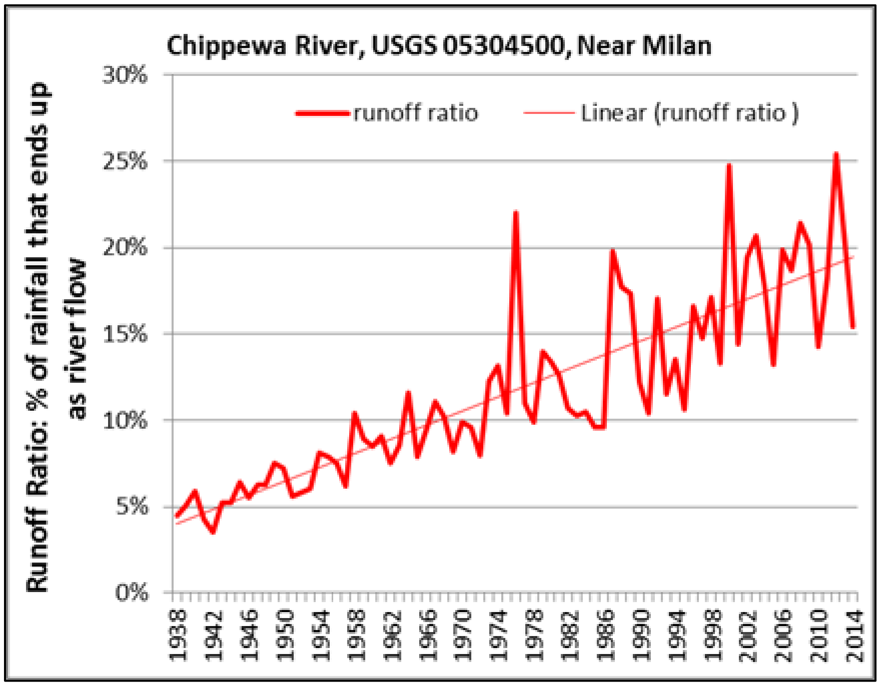


Figure 28: Runoff ratio over time. Data Sources: USGS and UMN.

Flow data taken by the United States Geological Survey (USGS) has documented a significant change in the runoff/precipitation relationships on the landscape within the Chippewa River Watershed, resulting in increased streamflow since 1983. This relationship is evident in a comparison of monthly average flows between the two periods (Figure 29). Discharges for all month's post 1982 indicate increased discharge. As there are annual precipitation amounts both greater than 75th and lower than 25th percentiles, moderate/severe drought and moist years and significant high flow intervals in both the 1937 to 1982 and 1983 to 2012 periods, this increase in average monthly discharge cannot solely be attributed to precipitation change, nor related to disproportionate weighting from a single high flow

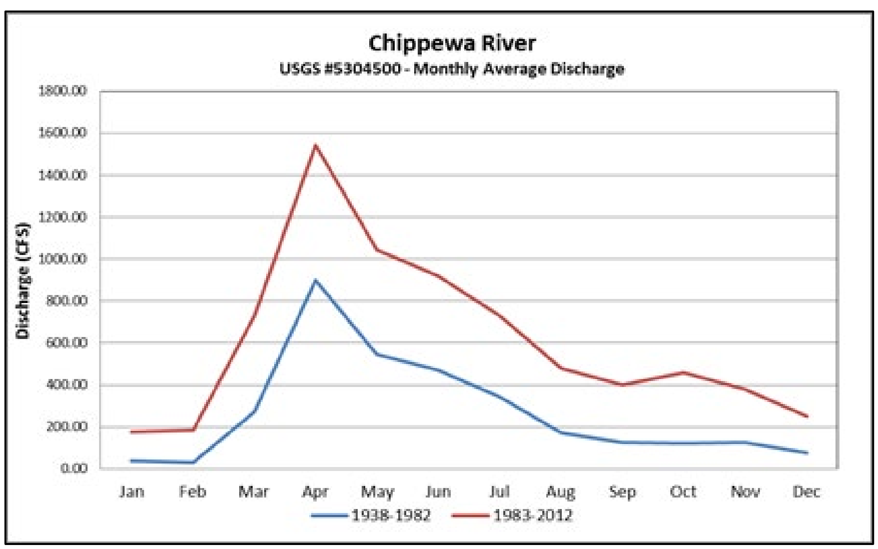


Figure 29: Comparison of Monthly Average Discharge and between two time periods at Highway 40

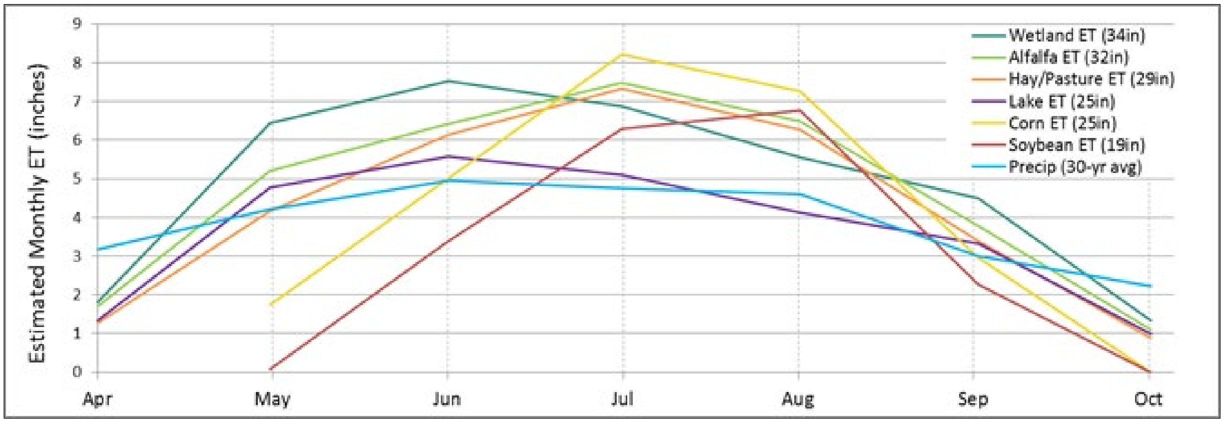


Figure 30: Monthly evapotranspiration rates of common crops and wetlands

period. This information indicates significant hydrologic alteration within the watershed that is changing the runoff/precipitation relationship watershed wide (see appendices, DNR).

Hydrologic alterations continue today as a result of economic realities and natural patterns. These include: increases in tiled acres, tile density, modifications to increase drainage coefficients, increasing impervious surfaces, loss of perennial cover including Conservation Reserve Program (FSA 2013) and changes in precipitation patterns. These changes can be seen in the river as an increase in the amount/percentage of precipitation that ends up as river flow called the runoff ratio. The changes reflect hydrologic changes in the watershed that have been designed to intercept rainfall and move it off the land more quickly. Since European settlement, perennial prairies and wetlands were replaced first by diverse crops and then by corn and soybeans. The monthly ET rates of more common crops are different and the timing of ET throughout the year has shifted (Figure 30). These changes affect the hydrology of the watershed.

Sources

The increase in river flow between mid and late 20th century is primarily due to human changes to the landscape. Significant causes of increased river flow include increased drainage, wetland loss, precipitation changes, and decreased/shifted ET due to cropping changes (Schilling and Helmers 2008; Schilling 2008; Lenhart et al. 2011a; Wang and Hejazi 2011; Schottler et al. 2013).

Changes in the amount and timing of ET affect hydrology. Figure 30 illustrates the monthly average ET of crops, grass, and wetlands and the monthly average precipitation. The monthly average precipitation corresponds more closely to the ET of perennial crops such as hay and alfalfa. Contrastingly, corn and soybeans use much less water than precipitation supplies in the spring and much more than is supplied later in the summer. Therefore, a landscape that is almost exclusively corn and soybeans is less synced with historic precipitation patterns, and more prone to exacerbate high flows in the spring and low flows in the later summer.

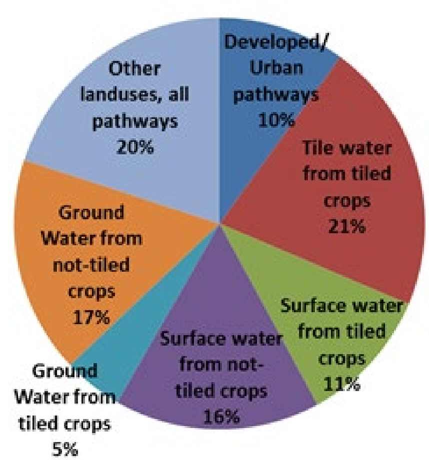


Figure 31: Estimate of the land use pathways that water travels before reaching a water body. Estimates 31% of the watershed (45% of crops) is tiled drained.

Numeric estimates of the land uses delivering water to water bodies were created after review of multiple lines of evidence, applying local knowledge and professional judgement. This process led to a water portioning calculator that was used to estimate the contributions from different pathways from the largest land uses (Figure 31, Page 47).

A map of hydrologic alteration is displayed in Figure 32. The map represents the extent to which natural streams were straightened by human activity, thereby reducing the hydrologic storage of the land. It is based on the altered watercourses dataset and refers to the length of stream segments that were altered in relation to the length of those that meander naturally. Overall the Chippewa River Watershed's average score for altered hydrology was 21.15 with zero being the low and 100 being the high.

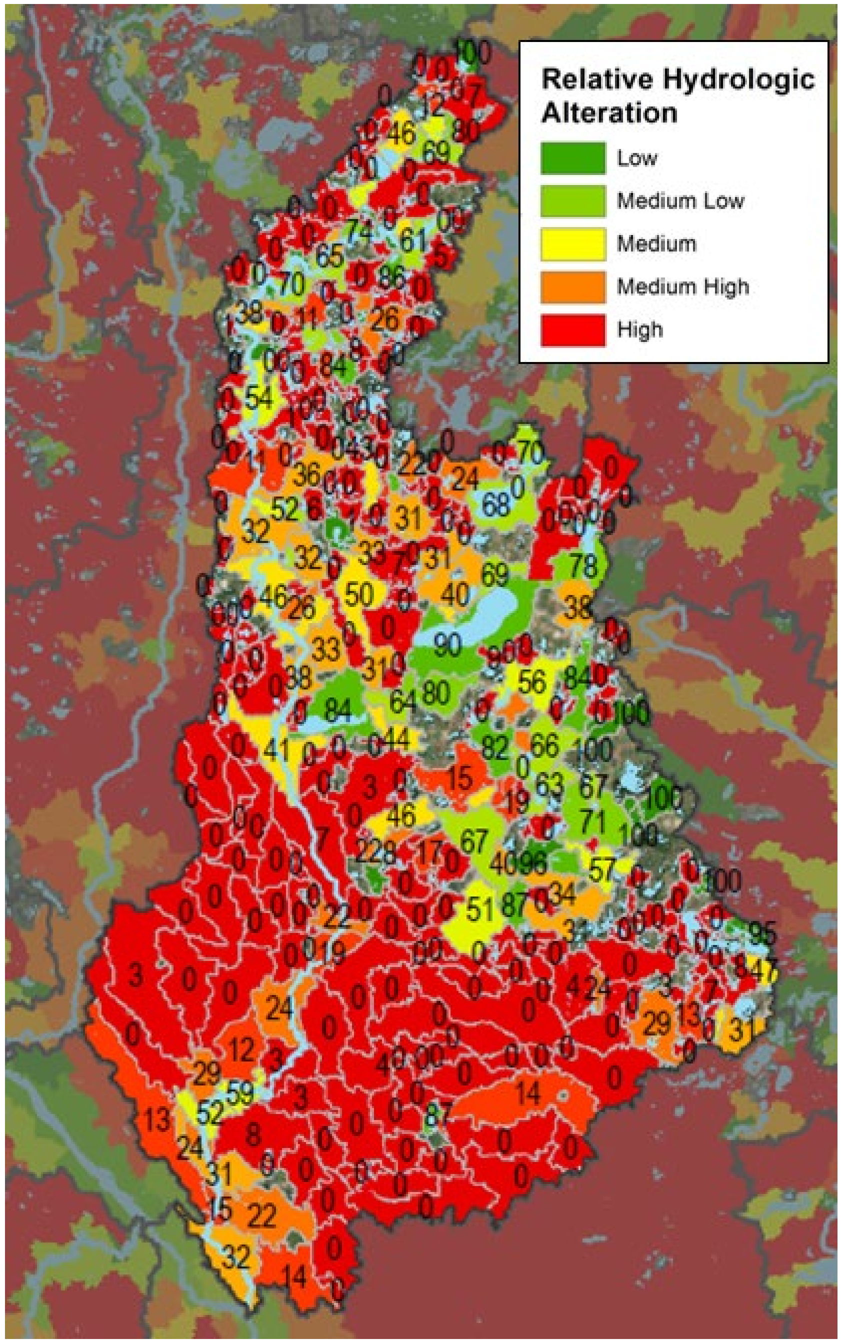


Figure 32: Extent to which natural streams were straightened by human activity, (source DNR 2013).

According to CRWP, tile line monitoring data in the Chippewa River Watershed suggests that tile line output in the southern portion of the watershed is tied to the hydrology of the ditches and streams where they are found. In addition to driving the stream flow, these tile lines are short circuiting the natural hydrological flow path that would have naturally removed sediment and nutrient pollutants from the water. This is especially so in the case of tile systems with open tile inlets (CRWP 2016).

Impacts

Hydrology impacts many different elements of a watershed. How, when, how much and where water flows affect the biology, water chemistry, economics and geomorphology of a watershed. A landscape without water storage is more sensitive to drought and often experiences extremely low flow conditions depriving fish and other aquatic species of habitat. Following precipitation events, a watershed with efficient drainage deliver more of its water to the river quicker and causing more streambank erosion. Bypassing the natural drainage patterns of a landscape tends to result in worse water quality as sediments and nutrients are not removed from the water through natural processes.

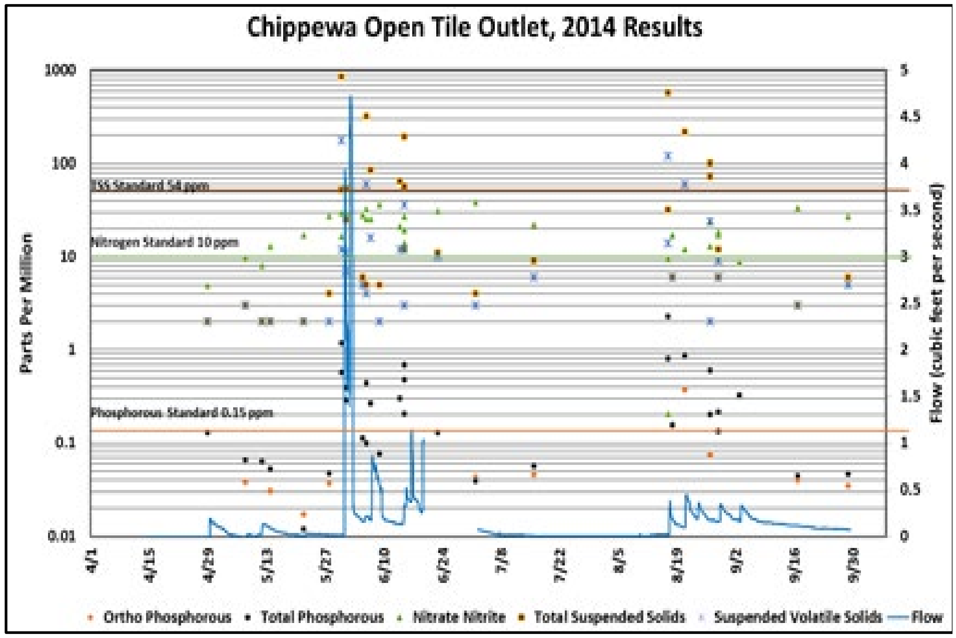


Figure 33: Delivery of water, nutrients and TSS from tile line flow

Altered hydrology is most often seen in the stream banks of a river. Higher and more frequent peak flows reshape the stream channel and cause repeated bank and channel scouring. The more frequent and higher flows can also increase the rate of down cutting in the stream channel. A 2009 CRWP survey of 1006 stream banks at 51 different stream reaches found 64% of the banks were at a moderate to severe risk of erosion. These findings are yet another piece of evidence that altered hydrology is having negative consequences in the Chippewa River Watershed.

Goal & 15-year Target

The overall goal is to restore the watershed's geomorphological stability. This is best achieved by: focusing on decreasing two-year peak flows since these are considered the key channel forming flow regimes, shifting flow timing to the dry season, and maintaining the biologically and geomorphologically-important dynamic properties of the natural hydrograph. Strategies to accomplish these tasks must increase ET to reduce the total flow volume, restore water storage in the soil where possible and in surface holding areas, and infiltrate water on the landscape to increase ground water contributions (base flow) to streams during dry periods. Strategies and methods to prioritize regions to address altered hydrology are summarized in Section 3.

A 15-year target was selected by the WRAPS team of a 25% reduction in two-year peak flow and a 5% increase in dry season baseflow. This target is based on historic flow trends, the scale and timing of the watershed-level sediment reduction strategy, and the identified stressors. A 15-year target was chosen over a 10-year target because the 15-year timeline will bring the Chippewa River in line with the timeline of the *Sediment Reduction Strategy for the Minnesota River Basin* (MPCA 2015d)

For water quality conditions to improve, the way that water is moved off the landscape will need to be addressed. The need to address erosive flows of streams and rivers has been identified as a need in the larger Minnesota River Basin as described in, the *Sediment Reduction Strategy for the Minnesota River Basin* (MPCA 2015d) and it has been identified as a stressor with a causal relationship to poor habitat in the Chippewa River Watershed SID Report. An increase in dry season base flow needs to be addressed to support healthy biological aquatic communities in the Chippewa River Watershed. Low flow and the lack of water in streams and lakes that have not historically experienced them have been identified as stressors to aquatic populations and a driving force in the biological impairments of these streams.

Habitat

Poor or lack of, habitat is a stressor of the physical habitat structure including geomorphic characteristics and vegetative features (Griffith et al. 2010). Habitat is only investigated as a stressor when a bio-impairment is identified. Physical habitat is often interrelated to other stressors (e.g., sediment, flow, DO). Poor habitat impacts aquatic life by reducing the amount of suitable habitat needed for all aspects of aquatic life: feeding, shelter, reproduction, etc. Poor habitat can be the result of many kinds of disturbance. Specific habitats that are required by a healthy biotic community can be minimized or altered by practices on the landscape by way of resource extraction, agriculture, forestry, urbanization, and industry. These landscape alterations can lead to reduced habitat availability, such as decreased riffle habitat, or reduced habitat quality, such as embedded gravel substrates. Biotic population changes can result from decreases in availability or quality of habitat by way of altered behavior, increased mortality, or decreased reproductive success (Griffith et al. 2010).

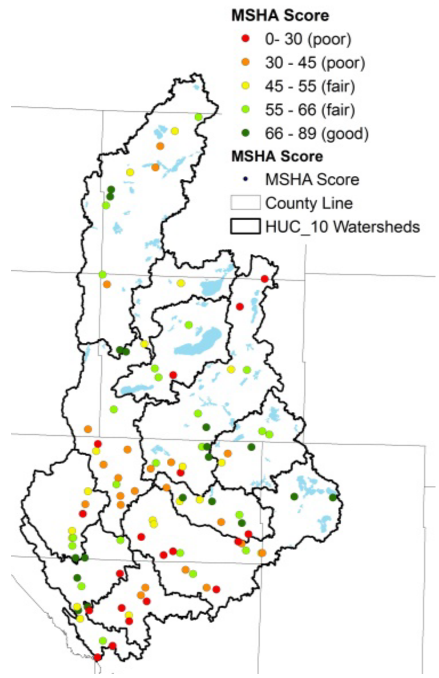


Figure 34: MPCA Stream Habitat Assessment (MSHA) scores.

Status

Poor habitat was identified as a stressor in 9 of the 16 bio-impaired streams (Table 17, in Section 6.3). Habitat was sufficient for aquatic life in seven of the bio-impaired streams (Figure 34). Although habitat is only investigated when a bio-impairment is identified, the MPCA Stream Habitat Assessment (MSHA) (MPCA 2014e) scores are fairly low across much of the watershed, indicating that many more habitat-stressed bio-impairments may be found in the future.

Sources

The identified physical habitat issues (Table 7) show a complex, interconnected set of factors that are driven by primarily a couple stressors. Excessive sedimentation and/or channel instability was identified in all five streams; additional issues such as limited depth variability and sparse in-stream cover are closely related to channel instability and sediment issues. This stressor is primarily the result of altered hydrology, which causes bank instability and increased channel migration, which then chokes streams with the produced excess sediment, limiting or eliminating necessary habitat. A minimal or degraded riparian zone and/or poor surrounding land use was identified for all five habitat-impaired streams; additional issues including lack of shading are closely related to land use and riparian buffer issues. Riparian areas can be damaged by the effects of altered hydrology that cause excessive bank erosion or can be due to changing the natural vegetation (typically forest or prairie) to a different land use. In summary, most of the habitat problems are driven by altered hydrology and poor riparian land uses.

Table 7: The identified problems with physical habitat identified in the *Chippewa River Stressor ID Report* (MPCA 2015c)

Stream AUID (last 3 digits)	Identified physical habitat issues
Mud Creek (554)	Poor substrate and barriers to fish passage
Chippewa River (505)	Poor channel stability, excessive fine sediment on stream bottom, moderate to heavy bank erosion, poor surrounding land use, poor cover.
Shakopee Creek (559)	Excessive fine sediment on stream bottom, hydrologic alteration, bank instability and poor surrounding land use
Cottonwood Creek (546)	Excessive fine sediment on stream bottom, stream bed instability, hydrologic alteration, bank instability and poor surrounding land use
Chippewa River (502)	Upstream hydrologic alteration, the presence of downstream dams and, poor surrounding land use and poor buffer management.
Chippewa River (507)	Hydrologic alteration and bank instability.
Chippewa River (503)	Poor channel stability, bank erosion, poor surrounding land use, poor cover.
Little Chippewa River (713)	Surrounding land use and poor buffer management fine channel substrate, livestock impact.
Trappers Run (628)	Poor hydrology (no flow), low number of habitat types for fish.

Goal and 10-year Target

Currently, the 101 MSHA scores in the watershed range from 16 to 88.3, with an average score of 50.7. Scores tended to be fair to poor with a good score in some locations. The target for habitat is for the average MSHA score in the watershed to be greater than 66 (“good”). This goal represents a 30% increase in the average MSHA score. The 10-year target is a 15% increase in the MSHA score. Since scores are mostly due to surrounding land use, altered hydrology and degraded riparian zones, these stressors should be addressed to meet the 10-year target. Strategies and methods to prioritize regions to address habitat are summarized in Section 3.

3 Restoration and Protection

This section summarizes scientifically-supported strategies to restore and protect waters and information on the social dimension of restoration and protection. Based on the scientifically-supported strategies, the condition and pollutant source identification work, and professional judgment, a team of local and state conservation and planning staff (referred to as the "WRAPS team") selected restoration and protection strategies to meet the water quality targets.

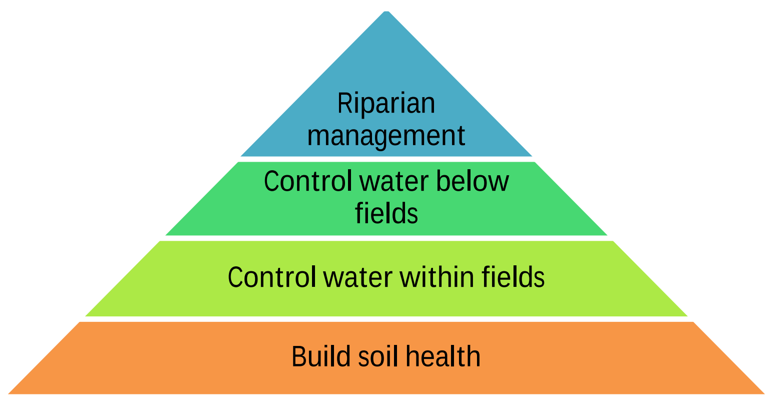
Using the selected restoration and protection strategies, the MPCA with local conservation planning staff can prioritize areas and spatially target specific BMPs or land management strategies using GIS or other tools, as encouraged by funding entities and Clean Water Legacy legislation on WRAPS (ROS 2013).

3.1 Scientifically-Supported Strategies to Restore and Protect Waters

This section summarizes studies and data on land management and BMP effects on water quality. This information is more technical in nature, but these summaries may be helpful to landowners, decision makers, and citizens to understand the impact of various strategies and BMPs on water quality.

To address the widespread water quality impairments in agriculturally-dominated watersheds such as the Chippewa River Watershed, comprehensive and layered BMP suites are likely necessary. A conceptual model displaying this layered approach is presented by Tomer et al. (2013; Figure 35). Another model to address widespread nutrients is presented in the *Minnesota Nutrient Reduction Strategy* (MPCA 2015e), which calls for four major steps involving millions of acres statewide: 1) increase fertilizer use efficiencies, 2) increase and target living cover, 3) field erosion control, and 4) drainage water retention. A third example of a comprehensive, layered approach is being demonstrated with a "Treatment Train" approach in the Elm Creek Watershed (ENRTF 2013), which has demonstrated layered strategies including: 1) upland: cover crops and nutrient management, 2) tile treatment: treatment wetlands and controlled drainage, and 3) in-stream: woody debris and stream geomorphology restoration.

Figure 35: Conceptual model to address water quality in agricultural watersheds



Agricultural BMPs

Since the Chippewa River Watershed land use and pollutant source contributions are generally dominated by agriculture, reducing pollutant/stressor contributions from agricultural sources is a high priority. A comprehensive resource for agricultural BMPs is *The Agricultural BMP Handbook for Minnesota* (MDA 2012). Hundreds of field studies of agricultural BMPs are summarized in the handbook, which has been summarized in Appendix 6.8. This summary table also contains a "relative effectiveness" which was estimated by conservation staff. For clarifications, the reader should reference the handbook.

Additional field data has been compiled by Iowa and Minnesota for review in their respective state nutrient reduction strategies. This information is included in the Appendix 6.6.

MDA's Nitrogen Fertilizer Management Plan (NFMP)

NFMP was developed to prevent and mitigate the effects of nitrogen fertilizer on groundwater quality. Activities associated with implementing the NFMP include private well water testing, education and outreach opportunities, nitrogen BMP survey, and voluntary agricultural BMP adoption and implementation of perennial cover in targeted high risk areas. Implementation strategies for the NFMP are dependent upon the results of the private well testing results. With the geologic characteristics found within the watershed, the NFMP can support restoration and protection of losses through groundwater and crop tile, which may be contributing to surface water impacts. The most recent version of the report (2015) can be found online at: http://www.mda.state.mn.us/~/media/Files/chemicals/nfmp/nfmp2015.pdf.

Urban and Residential BMPs

Cities and watershed residents also impact water quality. A comprehensive resource for urban and residential BMPs is the *Minnesota Stormwater Manual* (MPCA 2014f). This resource is in electronic format and includes links to studies, calculators, special considerations for Minnesota, and links regarding industrial and stormwater programs. Failing and unmaintained septic systems can pollute waters. Information and BMPS for Septic Systems is provided by EPA (EPA 2015).

Stream, Gully and Ravine Erosion Control

By-and-large, wide scale stabilization of eroding stream banks gullies and ravines is cost-prohibitive. Instead, first addressing altered hydrology (e.g. excessive, concentrated flows) from the landscape can help decrease wide scale stream and ravine erosion problems as discussed in *the Minnesota River Valley Ravine Stabilization Charrette* (E&M 2011) and the Minnesota River Basin Sediment Reduction Strategy (MPCA 2015d). Improving activities directly adjacent to the stream/ravine (e.g. buffers) can also decrease erosion as summarized in *How to Control Streambank Erosion* (ISU 2006). In some cases, however, high value property may need to be protected, or a ravine/stream bank may be experiencing such severe erosion that stabilization of the stream bank or ravine is necessary.

In the Lower Chippewa River Subwatershed streambank, gully and ravine erosion within the river corridor make up the majority of the TSS contributed from this area. In many cases, this type of erosion is not having a negative economic impact on the landowners. In addition, due to the cumulative upstream impact on downstream areas the downstream landowners do not feel it is in their power to fix the issue. A different policy needs to be brought to bear on this issue of responsibility. A deliberate, targeted approach to this region needs to be undertaken, one that identifies vulnerable areas and focuses on addressing the flow pathways that concentrate flow through them. Upstream water retention and downstream structures need to be coordinated and designed to minimize the erosion potential in a cooperative way. Consistent, dependable funding and technical knowledge need to be provided to address these issues.

Lake Watershed Improvement

Initial activity for lake impairments should focus on reducing external loading. Strategies to protect and restore lakes include both strategies to minimize pollutant contributions from the watershed and strategies to implement practices immediately adjacent to and in the lake. Strategies to minimize pollutant contributions from the watershed focus mostly on agricultural and/or stormwater BMPs, depending on the land use and pollutant contributions of the watershed. The DNR supplies detailed information on strategies to implement adjacent to and in the lake via Shoreland Management guidance (DNR 2014b).

What follows is a list of watershed strategies that prevent phosphorus from getting to the lake and are a necessary basis for any restoration work. This is not an exhaustive list nor is all of the strategies applicable or appropriate for all lakes or regions.

- Manage nutrients – carefully planning for and applying phosphorus fertilizers decreases the total amount of phosphorus runoff from cities and fields.
- Examples: crop nutrient management, city rules on phosphorus fertilizer use, etc.
- Reduce erosion – preventing erosion keeps sediment (and attached phosphorus) in place. Examples: construction controls, vegetation (see below)
- Increase vegetation – more vegetative cover on the ground uses more water and phosphorus and decreases the total amount of runoff coming from fields and cities. Examples: cover crops, grass buffers, wetlands, prairie gardens/restorations, channel vegetation, etc.
- Install/restore basins – capturing runoff and decreasing peak flows in a basin allows the sediment (and attached phosphorus) to settle out. Examples: water and sediment control basins, wetlands, etc.
- Improve soil health – soils that are healthy need less fertilizer and hold more water. Examples: reduce/no-till fields, diversified plants in fields and yards
- Lake Shore-specific Strategies – These strategies are a subset of watershed strategies that can be directly implemented by lake-shore residents.
- Eco-friendly landscaping – poor landscape design and impervious surfaces increase runoff and loading of nutrients into lakes. Examples: aerate, rain barrels or cisterns, rain gardens, permeable pavers, sprinkler and drainage systems, maintain septic systems, etc.
- Manage upland buffer zone vegetation – Upland buffer zone vegetation selection can greatly affect nutrient absorbance, watering needs, erosion potential, need for drainage, etc. Examples: properly landscape, maintain canopy and address terrestrial invasive species that may prevent re-generation of native trees, proper turf grass no mow lawns in highly utilized areas and planting native grasses and forbs with deep root systems in underutilized areas of lawn, reduce watering needs, controlled fertilization and grass clippings.
- Naturalize transition buffer zone – a natural transition buffer zone increases absorption of nutrients and decreases erosion potential of the water-shore interface. Examples: balance

natural landscaping by minimizing recreational impact area, utilize natural materials for erosion control bioengineering using wood or biodegradable materials in combination with stabilizing native vegetation to restore a shoreline, minimize beach blankets, draw down water levels for consecutive seasons to allow existing seed banks to develop deep rooted native vegetation or plant diverse mixes of grasses, sedges, forbs, shrubs and trees to create a complex root mass to hold the bank soils, preserve and restore native emergent aquatic vegetation sedges, rushes, forbs, shrubs and trees, do not remove natural wood features that supply cover and food sources for aquatic species and invertebrates while serving as a wave break along the shoreline.

- Preserve aquatic buffer zone – The aquatic buffer zone is difficult to restore, so the best approach is preservation and providing best opportunity for aquatic plants through watershed improvements to increase water quality. Draw down water levels to allow natural seed banks of emergent and aquatic vegetation to establish naturally, supplement more plant diversity with lower water levels as restoration of emergent and aquatic vegetation have higher success rates.

  Examples: reduce recreational impact area, minimize control of all types of aquatic plants, reduce dock footprint, preserve and/or restore native emergent and floating-leaf aquatic plants.

In-Lake Management Strategies

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

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

- Invasive species control of plants and/or animals – invasive species alter the ecology of a lake and can decrease diversity of habitat when a healthy native diversity exists in a lake. Removing native vegetation or incorporating non-native vegetation into landscaping can allow for invasive species to establish and spread taking over larger blocks of native species that maintain the natural systems health, therefore reducing disturbance to near shore habitat is important. Examples: prevention, early detection, lake vegetation management plan (LVMP)

- Chemical treatment to seal sediments – re-suspension of nutrients through wind action can cause internal nutrient loading. Examples: alum treatments. Consider the long term effectiveness in shallow lakes that experience wind driven turning, where stratification of the lake does not occur. Incorporating establishment of lake shore habitat is important to absorb phosphorus in the lake as part of a long term approach to phosphorus level management.
- Dredging – Sedimentation after years of poor watershed practices increases nutrient laden sediments and decreases depth. Dredging should only be considered when the source of the sediment and the banks of the lake are stable to prevent sediment from redepositing. Dredging can: create channels for access, increase habitat diversity, and accommodate recreational use.

Computer Model Results

Computer models provide a scientifically based estimate of the cumulative benefits of specific pollutant reduction scenarios when applied to known watershed conditions. Models represent complex natural phenomena with equations and numeric estimates of natural features, which can vary substantially between models. Because of these varying assumptions and estimates, each model has its strengths and weaknesses and can provide differing results. For these reasons, multiple model results were used as multiple lines of evidence by the WRAPS team.

Chippewa 10% - HSPF, APSIM, InVest and economic analysis

The CRWP and the Land Stewardship Project (LSP) co- coordinate the Chippewa 10% Project (C10). The C10 engages farmers, landowners, scientists and conservationists to advance solutions including more continuous living cover in agriculture that can protect and restore our waters for fishing, hunting, swimming, and recreation, provide good wildlife habitat and be profitable for farmers. Other partners who worked with the C10 include: the Agricultural Research Service's North Central Soil Conservation Research Lab (ARS), University of Minnesota Extension Service and University of Minnesota's West Central Research and Outreach Center (LSP 2016).

The C10 team used stream monitoring data, GIS and local knowledge to choose three focal areas (roughly the East Branch, Shakopee Creek and the Middle Mainstem) and to develop "working lands" scenarios for greater conservation (for more detail see Appendix 6.9). The scenarios are "what if" opportunities to understand the potential impacts of diversifying ecologically sensitive (and likely economically marginal) corn and soybean fields to perennials, longer crop rotations or other conservation practices. Additionally, scenarios include enhancing grazing from a continuous system (less conservation and profit) to management intensive rotational grazing; reduced nitrogen in corn; and cover crops for high quality corn and soybean fields. These scenarios are patterned after the farmer networks that the C10 has developed (cover crops, grazing enhancements and other conservation approaches with BMPs). About 114,000 acres of sensitive lands were identified through GIS, not including enhanced grazing on existing grasslands.

The C10 team then modeled these scenarios in the three focal areas. HSPF modeling of the scenarios in the focal areas led to about 5% more of the watershed in continuous living cover and achieved significant reductions in TSS, TP and nitrogen (Table 8). The model suggests that if 10% more continuous living cover could be achieved in the watershed as a whole it could meet state goals for nitrogen and TP reduction (Minnesota Nutrient Strategy) and make significant progress toward required reductions for TSS loads in Chippewa River Watershed streams and as well as the Chippewa River discharge downstream.

Table 8: HSPF results for C10 scenarios, select critical areas Chippewa River Watershed (RESPEC 2015)

Cumulative Scenario C1, C2, C3, C4, and C5 Change in Concentration from Base Condition				
Location	Variable	Base Concentration (mg/L)	Scenario C5 Concentration (mg/L)	Percent Change
East Branch (HSPF Reach 137)	Total Nitrogen	1.87	1.43	-23.7%
	Total Phosphorus	0.12	0.1	-21.8%
	Total Suspended Solids	31.85	24.23	-23.9%
Middle Main (HSPF Reach 116)	Total Nitrogen	1.59	1.39	-12.7%
	Total Phosphorus	0.14	0.12	-13.9%
	Total Suspended Solids	30.63	25.89	-15.5%
Shakopee (HSPF Reach 149)	Total Nitrogen	3.49	2.55	-27.0%
	Total Phosphorus	0.19	0.14	-24.5%
	Total Suspended Solids	46.44	37.93	-18.3%
Chippewa Outlet (HSPF Reach 106)	Total Nitrogen	2.18	1.89	-13.5%
	Total Phosphorus	0.16	0.15	-10.1%
	Total Suspended Solids	37.78	32.61	-13.7%

Equally important, the C10 Research team analyzed profitability of rotations, perennials and cover. An economic analysis by Louisiana State University Agricultural Center was developed to compare the overall changes in costs and returns from implementing the scenarios noted above. Depending on markets, equipment availability, contract grazers in the neighborhood, knowledge and willingness, these systems were shown to be more profitable over a 10-year period than the unchanged corn soybean rotations. Implementing Scenario C would likely lead to increased revenues over expenses on average for farmers in the Chippewa River Watershed who implemented relevant components from Scenario C of 9% or $5 million per year across the watershed on 65,000 acres.

3.2 Monitoring Based Analysis

Many different monitoring activities have been undertaken in the Chippewa River Watershed. These methods have had a direct geographical significance to help prioritize restoration and protection activities (these methods are listed below). The data produced are then combined and analyzed to best determine sources and regions of concern.

Continuous Load Monitoring at Tributary Outlet Sites

The CRWP has been continuously monitoring water quality at six tributary outlet sites in the Chippewa River Watershed since 1998. Data generated from automated stream flow equipment is combined with the 25-30 annual water quality samples to compute annual pollutant loads. The loads are converted to pounds per acre, as seen in Table 9, to determine which tributaries have the highest rates of pollution for the pollutants analyzed.

Table 9: Pollutant contributions of tributaries to the Chippewa River

Chippewa River Tributaries, Average Monitoring Results, Flow Weighted Mean Concentration and Pounds/Acre/Year, 2000-2010 CRWP								
	Parameter	Chippewa Outlet	Lower Chippewa	Middle Mainstem	East Branch	Upper Chippewa	Shakopee Creek	Dry Weather Creek
FWMC mg/L	TSS	74.18	74.18	65.74	46.48	49.09	86.58	47.64
	NO2-3	1.95	1.95	0.48	1.36	0.35	5.65	7.09
	OP	0.07	0.07	0.05	0.05	0.04	0.06	0.11
	TP	0.21	0.21	0.17	0.14	0.17	0.24	0.25
lbs/acre	TSS	44.05	83.75	13.71	8.74	4.25	7.97	1.73
	NO2-3	1.27	1.78	0.13	0.27	0.04	0.58	0.23
	OP	0.06	0.17	0.01	0.01	0.00	0.01	0.00
	TP	0.15	0.19	0.04	0.03	0.02	0.05	0.01
	acres	1,201,394	195,438	485,095	323,629	227,383	197,107	67,758

These initial loadings are used to direct additional problem investigation monitoring and longitudinal surveys that further break down these tributaries geographically and identify the sources of pollution and the areas needing protection. Problem investigation monitoring and longitudinal surveys have led to very specific understandings and recommendations as to where the pollution source areas are and what kinds of restoration and protection strategies would be most effective.

Correlation analysis

A CRWP 2008 study comparing Chippewa Subwatershed average flow weighted means of TSS and NO2-3 against percent land cover found a significant relationship between perennial vegetation land cover and high water quality. In general the trends indicated that the more area that is neither urban nor row crop agriculture result in lower TSS and NO2-3 flow weighted means. The percent value needed to achieve the goal of 58 ppm TSS and 1 ppm NO2-3 was calculated to be 34% perennial land cover (Figure 36).

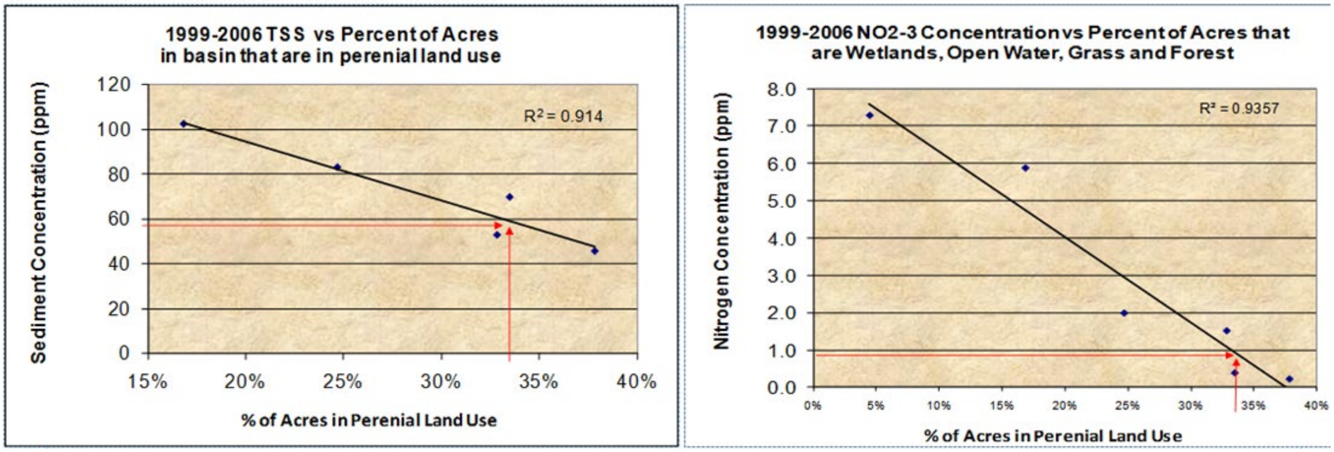


Figure 36: CRWP correlation of land cover to average flow weighted mean

Problem Investigation Monitoring

Problem investigation monitoring involves investigating problem areas located upstream of the outlet monitoring sites or areas of suspected pollution threats. This type of monitoring allows specific causes of impairments to be determined and the ability to quantify inputs of pollution from the contributing sources. This is directly tied to the practices and locations needed to protect or improve a water body so water quality standards are met.

Case Example: Shakopee Creek. Continuous load monitoring identified Shakopee Creek as being one of the more significant pollution sources for the watershed. A problem investigation monitoring plan was devised with the MPCA to establish and maintain two new monitoring sites on Shakopee Creek for three years. These three year sites documented that the majority of the nitrogen pollution observed was coming from the lower third of the watershed and that about 40% of the TSS pollution was actually coming from a hyper-eutrophic lake as a result of nuisance algae blooms and invasive carp. Transparency surveys supported these findings and pointed toward another problem area further upstream as well (CRWP).

Longitudinal Surveys

A longitudinal survey is a landscape-extensive monitoring method that reveals the pattern of water quality in a river or stream. Readings are taken at each road crossing (242 sites in the Chippewa River Watershed) following a stream from its headwaters to its outlet. Transparency readings, DO, temperature, conductivity, and pH are taken extensively over the course of the tributary. The data reveals geographically relevant water quality trends that are now being used to identify priority areas for effective use of project efforts.

The DO data generated from the Chippewa River was analyzed to show how often a site was lower than the standard (5mg/L). Sites that were lower than the standard more than 10% of the time were then targeted for further investigation. It has been noted by CRWP staff that the conditions observed in 2009 and 2010 have continued to be observed through to the present.

Buffer Surveys

Monitoring of buffer strips along the main stem and tributaries of the Chippewa River Watershed is conducted during the longitudinal surveys cited above. The conditions of the buffers are documented along approximately 775 miles of the Chippewa and its tributaries. This information is then used to target areas for protecting what is already there and promoting further adoption of buffers (Figure 37).

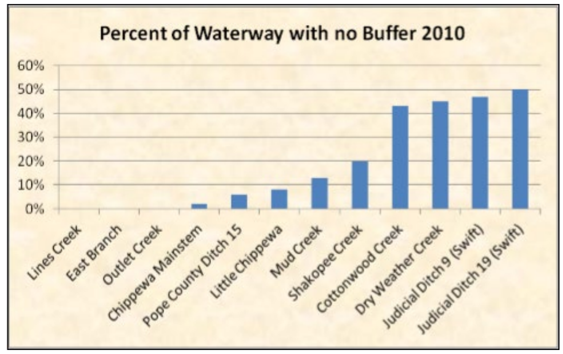


Figure 37: Buffer survey results.

Bank Erosion Surveys

Bank Erosion Surveys were established by the CRWP in 2009. Sixty-two locations were monitored through 2012. At each site, 600 feet of stream or ditch bank have been surveyed. Two scientific methods for assessing the potential for bank erosion are utilized: The Bank Erosion Hazard Index (BEHI) and the Wisconsin Bank Condition Severity Rating Method. These sites provide useful ground truth to the understanding of geomorphological issues such as the impacts of channel alteration and aquatic habitat stability (Figure 38). They also give a field estimate of bank erosion. This information is useful when considering monitoring results and interpreting TSS sources.

Subwatershed and stream order	Stream miles	Estimated Rates (tons/mi/yr)		Annual Soil Loss (tons/yr)		Monthly Soil Loss (tons/month)	
		Low Rate	High Rate	Low Rate	High Rate	Low Rate	High Rate
East Branch							
1st order	271.62	1	10	272	2,716	23	226
2nd order	77.99	10	50	780	3,900	65	325
3rd order	82.2	100	200	8,220	16,439	685	1,370
4th order	45.07	100	300	4,507	13,522	376	1,127
5th order	15.1	100	400	1,510	6,039	126	503
East Branch Total		491.99	15,289	42,616	1,275	3,551	
Lower Chippewa							
1st order	222.15	1	10	222	2,222	19	185
2nd order	78.59	10	50	786	3,929	66	327
3rd order	49.2	50	100	2,460	4,920	205	410
4th order	19.89	100	300	1,989	5,967	166	497
5th order	16.15	100	400	1,615	6,461	135	538
6th order 18.6	18.6	100	400	1,860	7,442	155	620
Lower Chip total	404.48			8,932	30,941	746	2,577
Middle Chippewa							
1st order	268.29	1	10	268	2,683	22	224
2nd order	69.54	10	50	695	3,477	58	290
3rd order	90.1	100	200	9,010	18,019	751	1,502
4th order	46.7	100	400	4,670	18,680	389	1,557
Middle Chip total	474.62			14,643	42,859	1,220	3,573
Shakopee Creek							
1st order	225.99	1	10	226	2,260	19	188
2nd order	100.37	10	50	1,004	5,019	84	418
3rd order	55.19	100	500	5,519	27,595	460	2,300
4th order	14.71	100	500	1,471	7,354	123	613
5th order	13.73	100	500	1,373	6,864	114	572
Shakopee Cr total	409.99			9,593	49,092	800	4,091
Upper Chippewa							
1st order	211.21	1	10	211	2,112	18	176
2nd order	80.59	10	50	806	4,029	67	336
3rd order	23.41	100	300	2,341	7,022	195	585
4th order	46.79	100	300	4,679	14,036	390	1,170
Upper Chip total	361.99			8,037	27,199	670	2,267

Figure 38: Estimated Annual and Monthly Soil Loss by Subwatershed.

Environmental Benefit Index (EBI) - Ecological Ranking Tool

This Environmental Benefits Index (EBI) is a composite score of multiple ecological benefits. A higher score is indicative of better condition and a low score is indicative of a poorer condition. The EBI is applicable for targeting use in two major ways in the Chippewa River Watershed. The first is as confirmation on a broad scale of what is seen with the monitoring data analysis. The averaging of scores on a minor subwatershed scale as seen in Figure 7, is valuable in reaffirming the areas of protection that have been identified. The majority of lakes and stream reaches in need of protection efforts are in the headwaters regions of the major tributaries and more so in the upper 1/3 of the Chippewa River Watershed. Conservation practices such as conservation cover and wetland restorations would have a greater ecological impact if situated here. The second way EBI can be utilized in continual geographic targeting is for ranking priority based on expected ecological benefits when multiple willing landowners in a selected subwatershed may be interested in a pollutant reducing conservation practice (Figure 39).

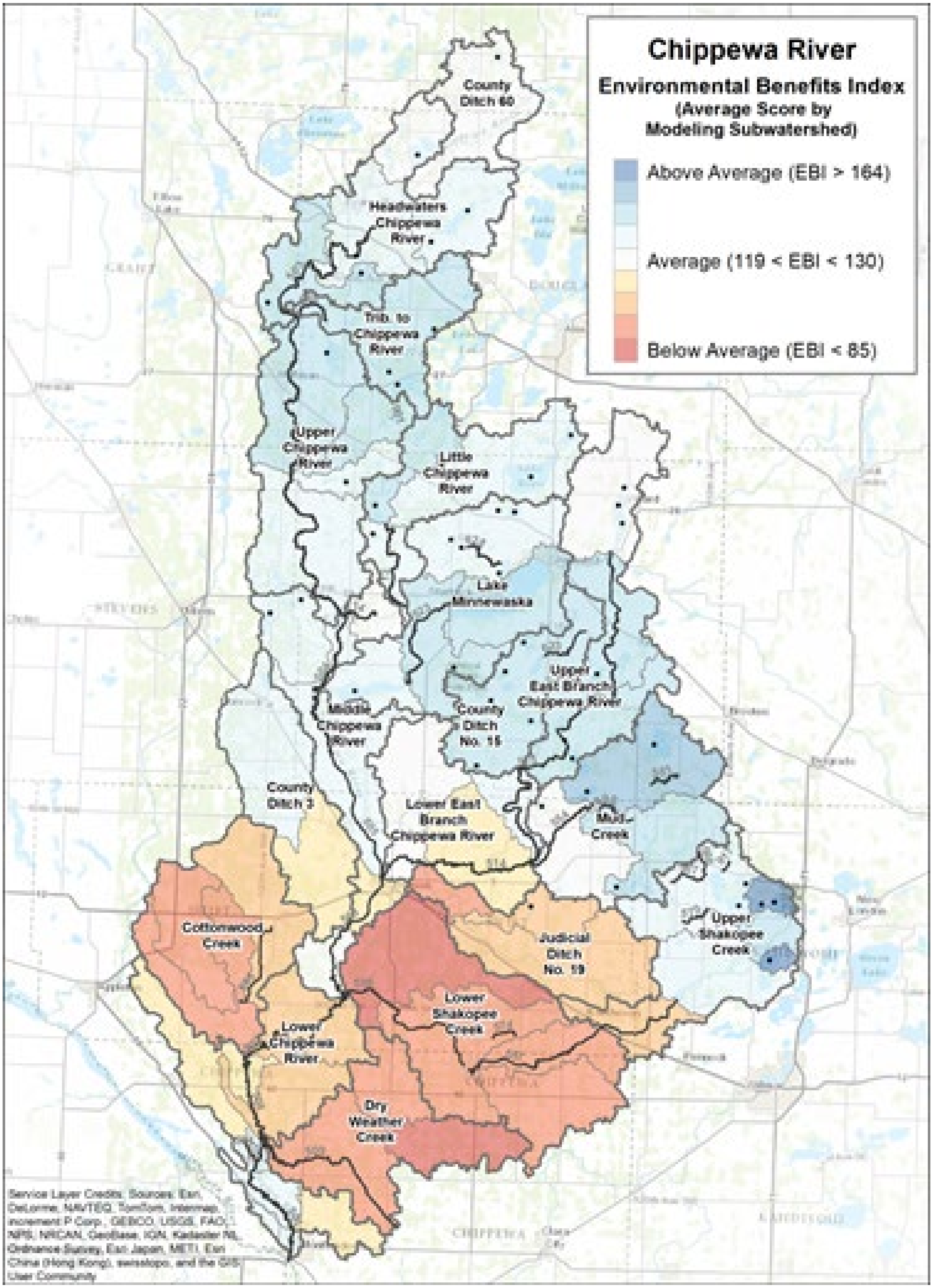


Figure 39: EBI for Chippewa River Watershed.
Grey lines are subwatershed boundaries, black dots represent monitored lakes and black lines are impaired streams.

3.3 Social Dimension of Restoration and Protection

Only a few of the pollutant sources are controlled through federal and state regulatory policies. Most of the needed changes will come from community and individual decisions supported by engagement, education and incentive programs. As a result, communities and individuals ultimately hold the power to restore and protect waters in the Chippewa River Watershed. For this reason, the Clean Water Council (MPCA 2013b) recommended that agencies integrate civic engagement with watershed projects (MPCA 2010a).

Zonation Values-based Model

Resident values of natural resources were collected through the Zonation (University of Helsinki 2015) analysis process (results illustrated in Figure 40). Generally, the results of this analysis show participant support for the restoration of near water resources. The map identifies several areas deemed significant by the zonation process. High rankings were given to riparian lands across the watershed, specifically riparian lands and floodplain areas of the Chippewa River, tributaries to the Chippewa River, and riparian lands of the Minnesota River near Montevideo. These areas are critical to the protection and restoration of water quality. High scores were also given to lands stretching from south of Lake Minnewaska southeast to the lake area north of Willmar. There are multiple benefits of conservation work in this area, including creation of wildlife prairie habitat, protection of groundwater resources, reduction in soil erosion, and improvement in water quality. In addition, high priority lands were identified to the west of Benson. Opportunities for drinking water supply protection, riparian land restoration, and improvement and protection of fish and wildlife habitat are present in this area. Finally, the lakeshed of Lake Minnewaska was identified as a key area. High pollutant loading occurs in this area, and focusing restoration efforts here will provide water quality benefits and add to the protection of Lake Minnewaska.

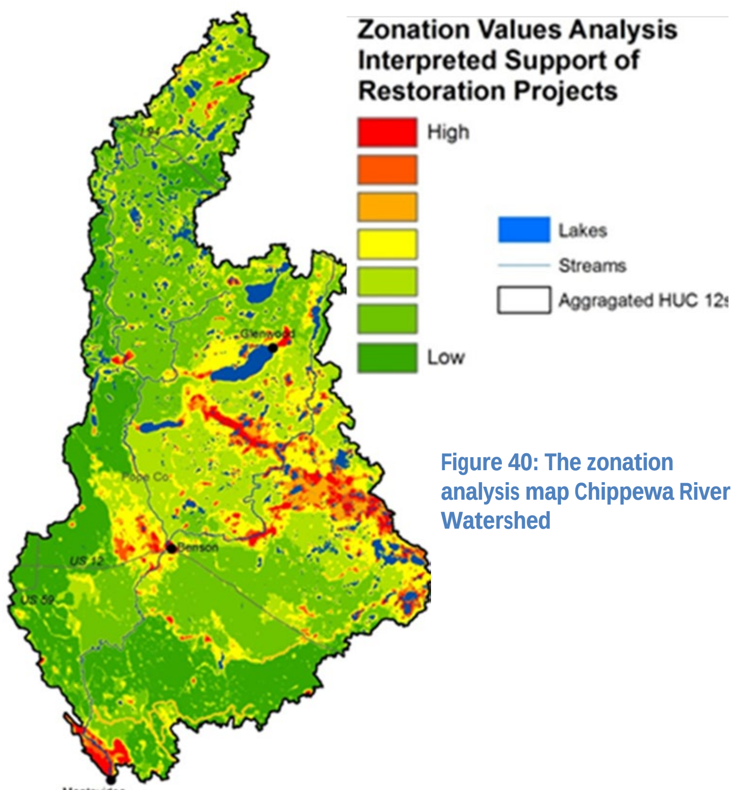


Figure 40: The zonation analysis map Chippewa River Watershed

The zonation analysis is able to interpret the conservation values of people by surveying them. Then, the zonation model translates the values represented in the surveys to the landscape using many GIS data sets.

Public participation was sought in the development of the zonation values. As part of this process, participants decided on what landscape features were valued and the ranking of those valued features within the model. A pairwise questionnaire survey was used, and the results identified the water quality component of the value model inputs as the highest weight. As a final step, WRAPS participants and the WRAPS team were given the opportunity to revise the model results to create a map that will be used to help identify areas within the watershed for potential future conservation investments. This synthesis step captured the knowledge and experiences of the people interested in and informed about the stresses, risks, and vulnerability of water resources within the watershed. See the Appendix (Section 6.9) for details on methods and results.

Future planning and implementation will need significant additional focus on public/private engagement to increase awareness of the impairments and threats in the watershed, as well as the most effective solutions for those water quality concerns. In addition to government's role in supporting positive change, individuals, private organizations and businesses have significant influence. Their participation must be secured to support the changes needed in this watershed.

Online Survey

Another tool that was used to engage citizens and gather information and views on water quality, pollutant sources and implementation strategies was an online survey. The electronic survey was open for approximately six weeks during August and September 2012. During this time, 64 respondents participated in the six-question survey. It is recognized that this is a small sample population that was self-selecting and the results have limitations in representing the entire Chippewa River Watershed and its many subsets of stakeholders. However, the opinions and views generated by the survey should be taken into account as part of the complex strategy development needed for directing activities and meaningful actions for a healthy and viable watershed community.

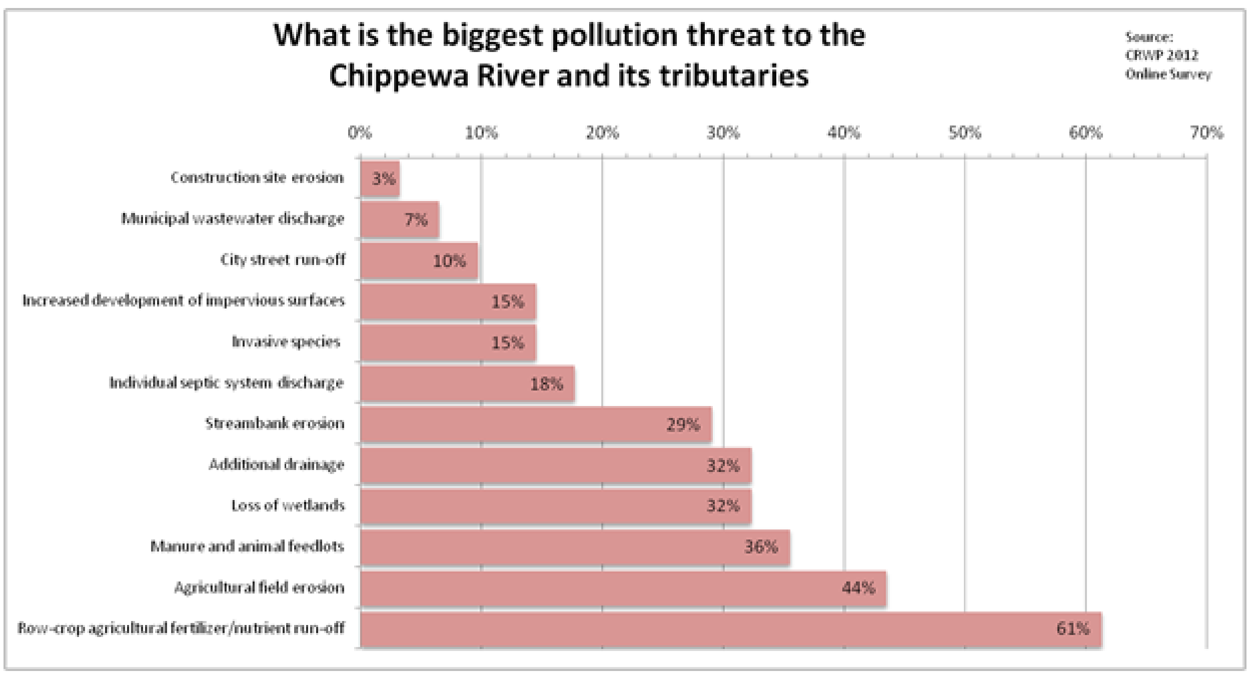


Figure 41: Perceived pollution threats from citizen opinion surveys

Participants were asked to rank the following uses of the Chippewa River Watershed: Fishing, Swimming, Drainage, Canoeing/Kayaking/Boating, and Wildlife/Aquatic Habitat in order of valued importance. Nearly 60% of the respondents chose Wildlife and Aquatic Habitat as their most valued use of the watershed. Fifty percent of the respondents chose drainage as their least valued use.

In an effort to identify perceived pollutant sources in the Chippewa River Watershed, respondents were asked to choose their top three pollution threats as shown in Figure 41. The highest response was row-crop agricultural fertilizer/nutrient run-off. Municipal sources such as wastewater, street run-off and construction were not perceived as pollution threats to the Chippewa River Watershed.

Respondents were asked to indicate their opinion: strongly disagree, disagree, neutral, agree, or strongly agree to a list of statements. Nearly 80% of those responding agreed or strongly agreed to the statement that the Chippewa River's water quality is impaired. Over 60% agreed or strongly agreed that the Chippewa River has been adequately monitored to determine water quality impairments. Roughly, 50% agreed or strongly agreed that the sources of pollution to the Chippewa River have been correctly identified. These opinions would suggest that previous monitoring and assessment work done in the Chippewa River and carried forth in the WRAPS are on track with the public's opinions. The statements and opinions are shown in Figure 42.

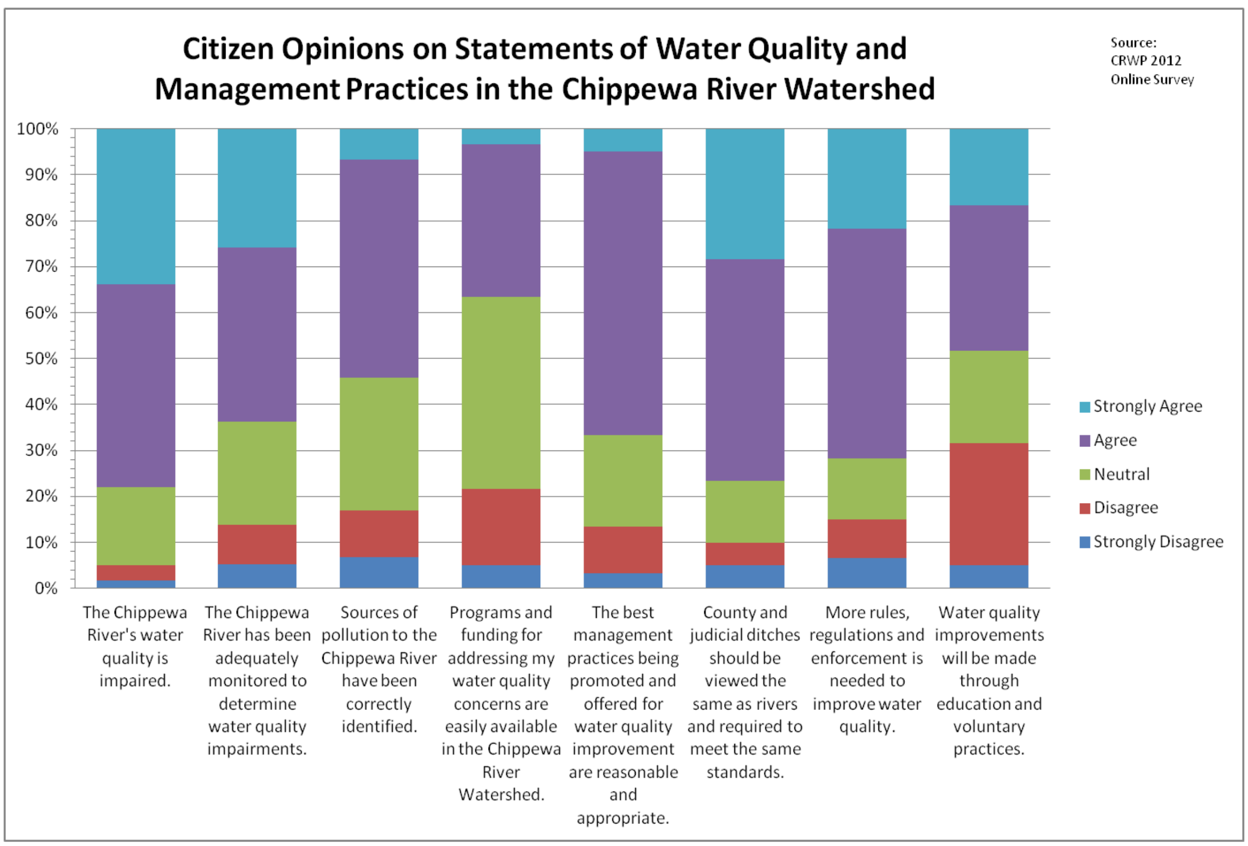
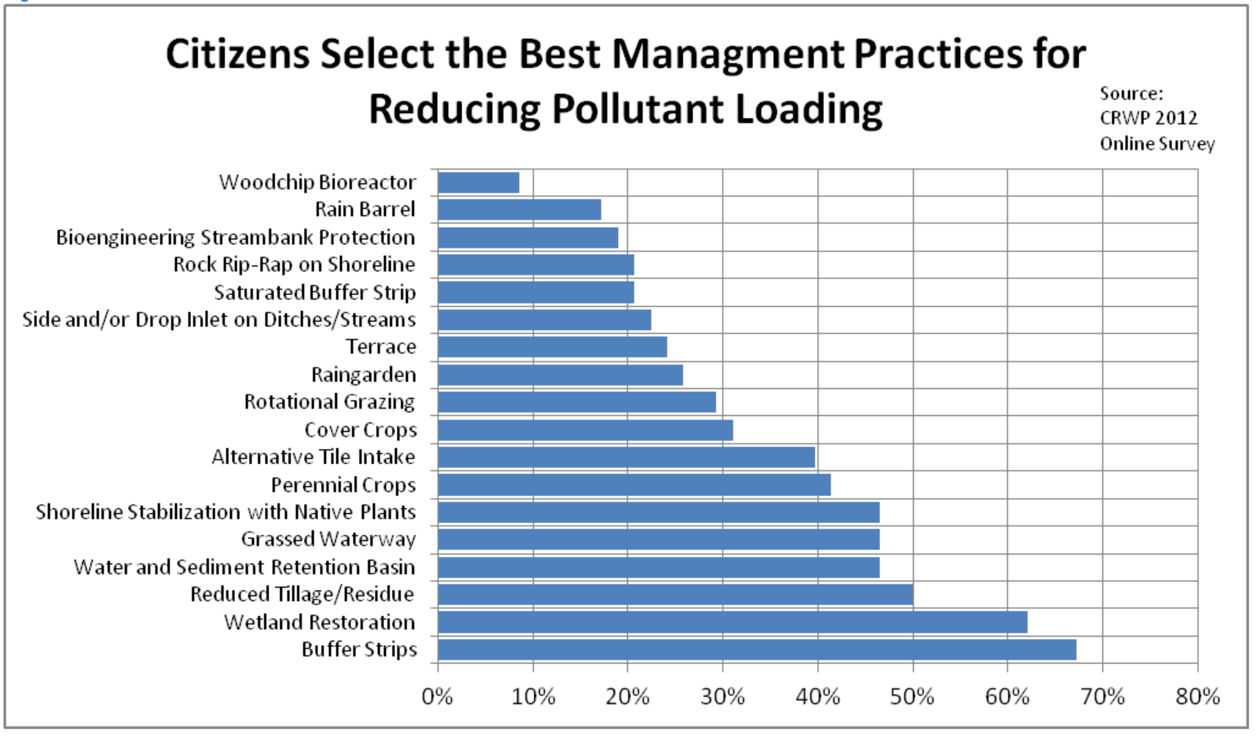


Figure 42: Results of citizen opinion surveys conducted in the Chippewa River Watershed.

The survey was also used to gauge which BMPs are favored by the surveyed citizens. Respondents were asked to select practices from the provided list that would be best for reducing pollutant loading and that they might be willing to utilize for specific site conditions (Figure 43) for results. Respondents could choose as many practices as they believed to be appropriate. As somewhat expected given the design of the question and the complexity of watershed management, the responses did not point to a "silver bullet" practice to reducing pollutant loading, but do give direction on practices and strategies that would be options and accepted. It is interesting to note that over 60% of the respondents chose buffer strips and wetland restorations as doing the best job at reducing pollutant loading. Buffer strips and wetland restorations are marketed and incentivized through a variety of conservation programs by various local, state and federal agencies. This highlights one of the paradoxes of watershed management, the practices that are favored by resource professionals and watershed residents are not always in sync with the landowners who have the power to implement them. Future CE efforts in this regard should therefore focus on understanding the rationale of those who are in the position of implementing projects.

Future CE activities need to either work harder to sell the less popular BMPs or given the voluntary nature of nonpoint source pollution BMPs find ways to work with target populations to develop and implement BMPs that fit the target population's needs. Increased engagement, especially one on one interaction, does cause changes in perspective by both the land managers and the resource professionals. It does lead to trust between the two parties while also developing new and more effective solutions.

Figure 43: Citizens selection of BMPs.



Another lesson taken from the CE activities is that regional differences exist and that resource concerns and the solutions to them have regional preferences. Organizing and engaging the public through regional networks may be an effective way of fostering local leadership and successful local solutions.

Future Citizen Engagement Efforts

With the many efforts already happening in the Chippewa River Watershed over the past several years, it will be critical to continue those efforts and provide information and opportunities for citizens to be a part of the WRAPS implementation strategies and local water planning. The Local Work Group (LWG) should continue to convene so that efforts can be focused and communication lines remain open between the conservation partners and subsequently the local citizens on the water quality needs and projects in the Chippewa River Watershed. The LWG can be a sounding board for means of integrating the WRAPS information into local water planning and for pursuing funding for WRAPS implementation.

Concentrated efforts towards one on one interviews and conversations with landowners must be expanded. These efforts need to identify views, values and goals. This is necessary to build trust and relationships that are key to engaged citizens and landowners. This will engage and empower landowners who are willing and capable of making well informed decisions on water quality.

Efforts are planned for the further establishment and development of landwowner networks surrounding different areas of land use change/BMP inlcuding nitrogen management, grazing, and cover crops. These networks provide the opportunity for adapting conservation ideas to local conditions and lead to more conservation by the local landowners. Other opportunities such as events, dialogues, tours and workshops will be held as needed.

3.4 Selected Strategies to Restore and Protect Waters

The strategies presented in Table 10 show the types of practices and associated adoption rates estimated to meet the water quality goals and 10-year targets. The parties responsible for making, facilitating, and overseeing the changes associated with the 10-year targets were identified by the WRAPS team. In other words, the strategies provide “what” to do and “who” should do it. These strategies need to be refined in local planning processes to determine the “how” the strategies will get done and “where” the practices need to go.

As far as where practices need to go to meet water quality goals, the presented strategies need to be implemented across the watershed. However, the adoption rates in any one region will not necessarily match the watershed-wide adoption rates due to regional differences. Furthermore, not all strategies are appropriate for all locations or all communities. The strategies and regional adoption rates should be customized during locally led prioritizing and targeting work (see Prioritizing and Targeting section below for more guidance).

Data and models indicate that comprehensive and integrated BMP suites are necessary to bring waters in the Chippewa River Watershed into supporting status. Strategies Table 12A presents a rough narrative estimate of the landscape and pollutant source changes that are necessary for all waters to meet long term water quality goals.

For immediate planning and other local needs, specific strategies estimated to meet the 10-year water quality targets are presented in Strategies Table 10. These strategies and the relative adoption rate were selected by the WRAPS team. With the next iteration of the watershed approach, progress towards these targets can be assessed and new targets for the following decade can be created. In Table 10, pollutant/stressor-specific suites of strategies apply watershed-wide; because 68% of the watershed is in agricultural lands, these strategies apply mostly to agricultural lands. However, there are additional suites of strategies specifically for cities/residents, lake watersheds, etc. since these locations have specialized concerns and opportunities.

3.5 Protection Considerations

Water bodies that meet water quality standards should be protected to maintain or improve water quality. Furthermore, water bodies that have not been assessed should not be allowed to degrade. The strategies presented in Table 10 – set at the whole watershed scale - are intended to not only restore but also protect waters in the watershed. Similar to customizing regional adoption rates of the watershed-wide strategies, strategies and adoption rates should reflect the relative amount of protection needed and any site-specific considerations.

Healthy Watersheds

The science of watershed health is based on a whole-system approach. Ecological processes interact to provide services such as clean air and water, available groundwater, and diverse plant and animal communities. The science of health explores how all the parts work together to provide a "healthy watershed". The DNR uses a five-component framework to describe watersheds as systems. This framework is based on the interplay of biology, hydrology, geomorphology, connectivity, and water quality. Systems solutions – those that address the root cause of the problem and result in multiple benefits – protect and restore ecosystem functions and increase long term ecosystem resilience in the face of more extreme weather events associated with a changing climate, land use, and other stressors.

Healthy watersheds provide a variety of ecological services that have high value and may be impossible to recreate once compromised. Research continually demonstrates that protecting healthy watersheds can reduce capital costs for water treatment plants and reduce damage to property and infrastructure due to flooding, thereby avoiding future costs. Additionally, protecting healthy watersheds can generate revenue through property value premiums, recreation, and tourism.

Desired Watershed Conditions

To reach the clean water goal, water quality work must focus on the following aspects of healthy watersheds:

- Upland areas are strategically protected, restored, or enhanced so that hydrologic processes (storage, infiltration) deliver clean surface water and sustainable groundwater supplies.
- Floodplains and riparian areas are connected (to their respective waterbodies, each other, and upland vegetation), composed of appropriate vegetation, and function to filter pollutants and prevent erosion.
- Hydrologic processes (e.g., storage, infiltration, and conveyance) are appropriate for a given watershed's setting (e.g., precipitation, soils, slopes, natural vegetation) so that watershed responses (e.g., peak flows, annual water yield, low flows) do not result in disproportionate floods, drought, or pollutant loading that degrades rivers, lakes, streams and wetlands.

- Use of groundwater is sustainable and does not harm ecosystems, water quality, or the ability of future generations to meet their needs. (Groundwater Management Strategic Plan (DNR 2016a))

Prioritizing Protection

All waters that currently meet water quality standards, as well as those not yet assessed, should be protected from future degradation. These waters vary in their degree of sensitivity to change and this should be considered in protection strategies. Protection for waters that meet water quality standards can be prioritized considering the following attributes:

- waters meeting water quality standards but with downward trends in water quality
- waters having known or anticipated future water quality threats
- waters with suspected but not confirmed impairments
- shallow lakes, which are especially sensitive to nutrient loading or watershed activities
- high quality or unique waters deserving special attention

Watershed Health Assessment Framework

Watershed Health Assessment Framework

The Watershed Health Assessment Framework (WHAF) provides a comprehensive overview of the ecological health of Minnesota's watersheds. By applying a consistent statewide approach, the WHAF expands our understanding of processes and interactions that create healthy and unhealthy responses in Minnesota's watersheds. Health scores are used to provide a baseline for exploring patterns and relationships in emerging health trends. Explore the WHAF tool and learn more about watershed health here: http://www.dnr.state.mn.us/whaf/index.html.

Lakes of Phosphorus Sensitivity Significance

Excess phosphorus loading is a threat to many of Minnesota's lakes, and reducing or maintaining low nutrient pollution loads will be critical to achieving the state's clean water goals. The DNR has created a ranked priority lake list based on sensitivity to additional phosphorus loading and the significance of that sensitivity.

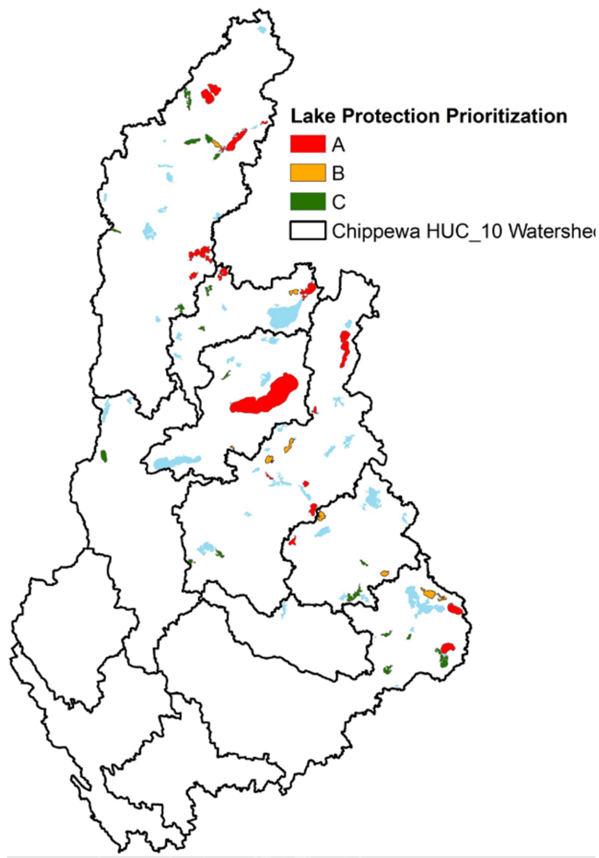


Figure 44: Chippewa lakes of phosphorus sensitivity significance

Phosphorus loading reduction targets were computed for 2,194 lakes using the latest available water quality data. In addition, a limnology based model was used to estimate each lake's sensitivity. The goal was to identify lakes that were not resilient to additional phosphorus loading; the most sensitive lakes identified would most likely see substantial declines in water clarity with increasing nutrient pollution load. The sensitivity significance, or the significance of water clarity changes due to eutrophication, included lake size and other factors related to the importance of focusing immediate protection or restoration efforts. These estimates and rankings were used to identify lakes that may benefit from well-designed phosphorus reduction projects. These results are not appropriate for those lakes listed by the MPCA as impaired. More information can be found at the DNR Lakes of Phosphorus Sensitivity Significance page.

The top 10 lakes of phosphorus sensitivity significance in the Chippewa River Watersheds are: Rachel (21-160), Florida (34-217), Chippewa (21-145), Aaron (21-242), Minnewaska (61-130), Scandinavian (61-41), Linka (61-37), Maple (21-79), Amelia (61-64), and Moses (21-245). See Figure 44.

Lakes of Biological Significance

The DNR has created a list of high quality lakes based on dedicated biological sampling that can be used to focus protection efforts. Lakes were rated and grouped for each of the following communities: aquatic plants, fish, birds, and amphibians. Lakes were assigned one of three biological significance classes (outstanding, high, or moderate). Many Minnesota lakes have not been sampled for plants and/or animals, so the list will be periodically revised as additional data becomes available. More information can be found here: https://gisdata.mn.gov/fa_IR/dataset/env-lakes-of-biological-signific

Twenty two lakes were assessed in the Chippewa River Watershed. Of these, seven were classified as outstanding or high biological significance. Outstanding: Johanna (61-6), Swan (34-285), Round (75-52). High: Chippewa (21-145), Amelia (61-64), Maple (21-79), and Hassel (76-86).

High Priority Shallow Lakes

There are more than 5000 shallow lakes over 50 acres in size in Minnesota. These lakes have permanent or semi-permanent water regimes and are typically dominated by wetland habitat (less than 15 feet deep). These lakes provide critical waterfowl and wildlife habitat and are particularly vulnerable to changes in water quality and land use. Active management of shallow lakes includes drawdowns, herbicide treatments, rotenone treatments or other manipulations of fish communities, and managing run-off through wetland and grassland restoration.

Four lakes in the Chippewa River Watershed are designated wildlife lakes and are being activity managed by the DNR. They are: Hassel (76-86), Jennie (21-323), Simon (61-34), and Middle (34-208). Other lakes that are partially located within a federal Waterfowl Protection Area (WPA) or state Wildlife Management Area (WMA) and therefore have the potential to be actively managed in the future are: Irgens (61-211), Danielson Slough (61-194), McIver (61-199), Sunburg (34-359), Florida Slough (34-204), and Hollerberg (76-57).

Lakes Near Water Quality Thresholds

In an attempt to compare the numerous monitored lakes of the Chippewa River Watershed, lakes with sufficient data were listed in order ranked by their water chemistry data as compared to the appropriate lake eutrophication standards. This identifies lakes with the best water quality, which would need to be protected from future risks of degradation and lakes with the worst water quality that need remediation. However, this system of ranking does not provide context for which lakes should be addressed first and how money should be spent. Prioritization of activates in the watershed should be targeted on lakes with the most potential for a positive change in water quality. Lakes with the best water quality may not be at risk of degradation while other lakes have been altered so far beyond water quality standard that they may never support aquatic recreation use again. Although important these lake may not be top priority with in a watershed. Better candidates may be lakes that are vulnerable or near the water quality standard. These lakes could benefit the most from implementation of BMPs that may return lakes to conditions that meet water quality standards or prevent them from exceeding water quality standards in the first place.

Land Use Decisions

The integration of land use decision-making and water planning can lead to healthier watersheds and better water quality. Through land use programs-Shoreland, Floodplain, Wild & Scenic Rivers, and other river-related programs, the DNR can assist local units of government in coordinating these efforts.

Improvements to existing Shoreland and Floodplain regulations may include:

- Expand shoreland to “lakeshed”
- Revise development standards (impervious surface, stormwater treatment, density, buffer restoration, conservation design) based on water quality and water quality trends
- Standardize evaluation procedures and mitigation requirement for all shoreland variances
- Use shoreline assessments/scoring to guide development review and to condition approval
- Collaborate with adjacent communities sharing same water bodies to develop consistent standards
- Establish stronger setbacks in dynamic, actively eroding areas (meander belts, bluffs, riverbends)
- Recognize and protect the natural beneficial functions of floodplains
- When fill is used, require compensatory storage
- Design bridges and culverts to connect floodplains, reduce streambank erosion, and allow peak flood flows
- Identify and plan for future flood risk, using new climate data

Ground Water Protection

Additional protection concerns in the watershed relate to ground water protection. The main supply of drinking water to the residents and businesses in the Chippewa River Watershed is groundwater – either from private wells, community wells, or a rural water supplier. Public water suppliers in the watershed that have undergone wellhead protection planning have identified some areas where the groundwater supply is not directly influenced by surface water in the watershed. The public water supplies have low vulnerability to contamination, which means that deep aquifers are fairly protected. The communities of Benson, Cyrus, Glenwood, Hoffman, Montevideo, Starbuck, and Watson have vulnerable drinking water systems. Contaminants on the surface can move into the drinking water aquifers more quickly in these areas. There is also the potential for contamination through unused and abandoned wells. Ensuring abundant and high quality supplies of groundwater is critical; especially in light of altered hydrology and the impacts on groundwater recharge.

One useful tool for groundwater protection is the MDA's 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. Based on the map found at the following website, http://www.mda.state.mn.us/townshiptesting, there are several townships within the watershed that have vulnerable groundwater areas and significant row crop acres. Between 2014 and 2019, the MDA will offer free nitrate tests to approximately 70,000 private well owners (within 250 to 300 townships statewide).

Protection Strategies Considerations

Urban and agricultural BMPs can be implemented to restore impaired waters and reduce the risk of degradation of unimpaired waters. Therefore, the same BMPs/actions may be considered a protection or restoration strategy depending on the targeted location it is being applied. These practices often provide multiple water quality benefits and ecosystem services. For example, the establishment of a vegetative buffer along a watercourse improves soil health, filters out excess nutrients and chemicals, and enhances habitat for aquatic and terrestrial wildlife. A useful goal is to develop "no harm" strategies that are beneficial across the board and include hydrology. An example of this would be emphasizing the value of healthy soils including building soil organic matter, which has many benefits including hydrology. See Table 10 for a list of strategies.

Anticipated Outcomes

The implementation of protection and restoration strategies in a prioritized and targeted manner is anticipated to result in measurable water quality improvements over time. Before this occurs intermediate outcomes will likely result in improvements to overall watershed health. These outcomes may require, but are not limited to:

- Implementation dollars are invested in the highest priority locations
- Structures are properly designed and located so they improve water quality and do not cause unintended consequences
- Better local ordinances and more enforcement of ordinances that protect riparian areas, floodplains, and critical areas
- Culverts and bridges are properly located, designed and implemented so they enhance stream stability, improve water quality and habitat, and do not cause unintended consequences
- Restored and rehabilitated reaches of stream use natural channel design principles based on appropriate reference conditions

3.6 Strategies Table

Table 10: Restoration and Protection Strategies

HUC-10 Subwatershed	Waterbody and Location		Parameter (incl. non-pollutant stressors)	Water Quality		Strategies and Governmental Units with Primary Responsibility • = Priority Restoration & Protection Strategy, •• = High Priority Restoration & Protection Strategy,																					Estimated Scale of Adoption Needed	Timeline to Achieve Water Quality Targets	Interim 10-yr Milestones
	Waterbody (ID)	**Location** and Upstream Influence Counties		Current Conditions	Goals / Targets	Conservation Cover A,B,G	Wetland Restoration A,B,D,F,G,H	Cover Crops A,BG,I	Conservation Tillage A,B,G	Nutrient Management A,B,C,G,I	Crop Rotation A,B,I	Contour Buffer Strips A,B,G	Grassed Waterway A,B,G	Drainage Water Management AB,C,G,I	Water & Sediment Control Basin/Terrace A,B,G	Streambank Stabilization A,B,D,G	Grade Stabilization A,B,D,G	Livestock Management A,B,C,G	Riparian and/or Ditch System Buffers A,B,C,D	Urban Practices A,B,C,E,K	Septic System Compliance C,E,J	In-Lake Practices B,C,D,E,J	Lakeshore Practices A,B,C,D,J	Aquatic Connectivity C,D	social capacity building A-J	Other			
Upper Mainstem (0702000501- Headwaters Chippewa River)	Chippewa River (-503)	**Douglas,** Grant, Ottertail	Turbidity (TSS)	18.0 Ave. Ton/day	42% reduction	•	•	•	••		•	•	•	••	••	•	•	•	•	•					•	•	subwatershed wide adoption of these varied strategies to treat 74,239 acres	40 years	18,560 acres
			Bacteria	224 CFU geomean June-Aug	44% reduction					••								••		•	••				•	•			
			Dissolved Oxygen	Reach Stressed	increase, minimize fluctuation	•	•	•	••	•	•							•		•	•				•	•			
			Phosphorus	61% of samples exceeded the 0.15 mg/L standard	13% reduction in concentrations/loads (FWMC from 0.17 to 0.15 mg/L)	•	•	•	••	•	•	•	•		••	•	•	•	•	•	•				•	•			
			Connectivity	Several barriers	Remove fish barriers																			•	•	•			
			Altered Hydrology	Increasing trend in peak events and extreme low flow	Decrease peak flows and increase low flows	•	•	•	•		•			••		•									•	•			
			Habitat	Stressed in distinct locations	Fix where there are problems											•			••						•	•			
	Unnamed Creek between Quam and Venus Lake (-638)	Grant	Phosphorus	Phosphorus stressing aquatic populations	20% reduction concentrations/loads	•	•	•	•	•	•	•	•		•	•	•	•	•	•	•				•	•			
			Turbidity	Turbidity stressing aquatic populations. 13% of samples exceeded the standard	Reduce exceedance of the standard below 10% and reduce river sediment concentration /loads by 20%	•	•	•	•		•	•	•	•	•	•	•	•	•	•					•	•			

HUC-10 Subwatershed	Waterbody and Location		Parameter (incl. non-pollutant stressors)	Water Quality		Strategies and Governmental Units with Primary Responsibility • = Priority Restoration & Protection Strategy, •• = High Priority Restoration & Protection Strategy,																					Estimated Scale of Adoption Needed	Timeline to Achieve Water Quality Targets	Interim 10-yr Milestones
	Waterbody (ID)	**Location** and Upstream Influence Counties		Current Conditions	Goals / Targets	Conservation Cover A,B,G	Wetland Restoration A,B,D,F,G,H	Cover Crops A,BG,I	Conservation Tillage A,B,G	Nutrient Management A,B,C,G,I	Crop Rotation A,B,I	Contour Buffer Strips A,B,G	Grassed Waterway A,B,G	Drainage Water Management AB,C,G,I	Water & Sediment Control Basin/Terrace A,B,G	Streambank Stabilization A,B,D,G	Grade Stabilization A,B,D,G	Livestock Management A,B,C,G	Riparian and/or Ditch System Buffers A,B,C,D	Urban Practices A,B,C,E,K	Septic System Compliance C,E,J	In-Lake Practices B,C,D,E,J	Lakeshore Practices A,B,C,D,J	Aquatic Connectivity C,D	social capacity building A-J	Other			
			Altered Hydrology	Increasing trend in peak events and extreme low flow	Decrease peak flows and increase low flows	•	•	•	•		•			•		•									•	•			
	Unnamed Creek Freeborn Lake Inlet (-901)	Douglas	Turbidity-TSS	119.01 Ave. Ton/day	35% reduction	•	•	•	•		•	•	•	•	•	•	•	•	•	•					•	•			
	Block Lake (56-0079)	Otter Tail	Nutrients	1191 lbs. TP.	71% reduction to 343 lbs.	•	•	•	•	•	•	•	•		•	•	•	•	•	•	•				•	•	In coordination with the upland treatments watershed wide, 10% of the lake shed acres treated by appropriate strategies and 50% of lakeshore treated with restoration strategies	25 years	20% of lakeshore acres treated and 1/4 of the impaired lakes reach supporting status
	Gilbert Lake (21-0189)	Douglas	Nutrients	564 lbs. TP	31% reduction to 387 lbs.	•	•	•	•	•	•	•	•		•	•	•	•	•	•	•				•	•			
	Jennie Lake (21-0323)	Douglas	Nutrients	693 lbs. TP	82% reduction to 136 lbs.	•				•	•							•	•			•			•	•			
	Long Lake (21-0343)	Douglas	Nutrients	16,029 lbs. TP	57% reduction to 6,938 lbs.	•				•								•	•						•	•			
	Red Rock Lake (21-0291)	Douglas	Nutrients	6,911 lbs. TP	88% reduction to 809 lbs.					•								•	•				•		•	•			
	Thompson Lake (26-0020)	Grant	Nutrients	1,605 lbs. TP	88% reduction to 188 lbs.																				•	•			
	Wicklund (Abrahams	Pope	Nutrients	2,042 lbs. TP	75% reduction to 515 lbs.																				•	•			

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	Conservation Cover A,B,G	Wetland Restoration A,B,D,F,G,H	Cover Crops A,BG,I	Conservation Tillage A,B,G	Nutrient Management A,B,C,G,I	Crop Rotation A,B,I	Contour Buffer Strips A,B,G	Grassed Waterway A,B,G	Drainage Water Management AB,C,G,I	Water & Sediment Control Basin/Terrace A,B,G	Streambank Stabilization A,B,D,G	Grade Stabilization A,B,D,G	Livestock Management A,B,C,G	Riparian and/or Ditch System Buffers A,B,C,D	Urban Practices A,B,C,E,K	Septic System Compliance C,E,J	In-Lake Practices B,C,D,E,J	Lakeshore Practices A,B,C,D,J	Aquatic Connectivity C,D	social capacity building A-J	Other	Estimated Scale of Adoption Needed	Timeline to Achieve Water Quality Targets	Interim 10-yr Milestones
	Strategies and Governmental Units with Primary Responsibility: • = Priority Restoration & Protection Strategy, •• = High Priority Restoration & Protection Strategy,																												
	on) Lake (61-0204)																												
	Aaron Lake (21-0242)	Douglas	Nutrients	Support, TP levels do not exceed the standard	Maintain levels that do not exceed the standard					•									•		•		•		•	•	The overall watershed restoration will aid in the protection of these lakes. Each lakeshed will strive to retain current levels of land use diversity and acres in conservation.	20 years	
	Chippewa Lake (21-0145)	Douglas	Nutrients	Support, TP levels do not exceed the standard	Maintain levels that do not exceed the standard					•									•		•		•		•	•			
	Freeborn Lake (21-0162)	Douglas	Nutrients	Support, TP levels do not exceed the standard	Maintain levels that do not exceed the standard					•									•		•		•		•	•			
	Little Chippewa Lake (21-0212)	Douglas	Nutrients	Support, TP levels do not exceed the standard	Maintain levels that do not exceed the standard					•									•		•		•		•	•			
	Little Oscar (Main) Lake (21-0156)	Douglas	Nutrients	Support, TP levels do not exceed the standard	Maintain levels that do not exceed the standard					•									•		•		•		•	•			
	Moses Lake (21-0245)	Douglas	Nutrients	Support, TP levels do not exceed the standard	Maintain levels that do not exceed the standard					•									•		•		•		•	•			
	South Oscar Lake (21-0257)	Douglas	Nutrients	Support, TP levels do not exceed the standard	Maintain levels that do not exceed the standard					•									•		•	•			•	•			

HUC-10 Subwatershed	Waterbody and Location		Parameter (incl. non-pollutant stressors)	Water Quality		Strategies and Governmental Units with Primary Responsibility • = Priority Restoration & Protection Strategy, •• = High Priority Restoration & Protection Strategy,																					Estimated Scale of Adoption Needed	Timeline to Achieve Water Quality Targets	Interim 10-yr Milestones
	Waterbody (ID)	**Location** and Upstream Influence Counties		Current Conditions	Goals / Targets	Conservation Cover A,B,G	Wetland Restoration A,B,D,F,G,H	Cover Crops A,BG,I	Conservation Tillage A,B,G	Nutrient Management A,B,C,G,I	Crop Rotation A,B,I	Contour Buffer Strips A,B,G	Grassed Waterway A,B,G	Drainage Water Management AB,C,G,I	Water & Sediment Control Basin/Terrace A,B,G	Streambank Stabilization A,B,D,G	Grade Stabilization A,B,D,G	Livestock Management A,B,C,G	Riparian and/or Ditch System Buffers A,B,C,D	Urban Practices A,B,C,E,K	Septic System Compliance C,E,J	In-Lake Practices B,C,D,E,J	Lakeshore Practices A,B,C,D,J	Aquatic Connectivity C,D	social capacity building A-J	Other			
	Whiskey Lake (21-0216)	Douglas	Nutrients	Support, TP levels do not exceed the standard	Maintain levels that do not exceed the standard					•									•		•	•			•	•			
Middle Mainstem (0702000502-Little Chippewa River) (0702000503-Lake Minnewaska) (0702000507-County Ditch 3 Chippewa River)	Chippewa River (-504)	Pope	Turbidity (TSS)	31.8 Ave. Ton/day	55% reduction	•	••	•	••		•	•	•	••	••	••	•	••	••	•					•	•	subwatershed wide adoption of these varied strategies to treat 95,169 acres	40 years	23,792 acres
	Chippewa River (-505)	Swift	Bacteria	139 CFU geomean Jun-Aug	9% reduction													•		•	•				•	•			
			Turbidity-TSS	51.19 Ave. Ton/day	49% reduction	•	•	•	••		•	•	•	•	••	•	•	•	•	•					•	•			
			Dissolved Oxygen	Intermittent low DO	Decrease episodes of low DO	•	•	•	•	•								•		•	•				•	•			
			Phosphorus	56% of TP samples exceeded the standard	13.5% reduction in river concentration FWMC from 0.17 to 0.15 mg/L	•	•	•	•	•	•	•	•		••	•	•	•	•	•	•				•	•			
			Altered Hydrology	Increasing trend in peak events and extreme low flow	Decrease peak flows and increase low flows	•	•	•	•		•	•		•											•	•			
			Habitat	MSHA average score is 45	46% increase in average MSHA score (score from 45 to 66)											•			•						•	•			
	Chippewa River (-506)	Swift	Bacteria	186 CFU geomean Jun-Aug	62.1% reduction													•		•	•				•	•			

HUC-10 Subwatershed	Waterbody and Location		Parameter (incl. non-pollutant stressors)	Water Quality		Strategies and Governmental Units with Primary Responsibility • = Priority Restoration & Protection Strategy, •• = High Priority Restoration & Protection Strategy,																					Estimated Scale of Adoption Needed	Timeline to Achieve Water Quality Targets	Interim 10-yr Milestones
	Waterbody (ID)	**Location** and Upstream Influence Counties		Current Conditions	Goals / Targets	Conservation Cover A,B,G	Wetland Restoration A,B,D,F,G,H	Cover Crops A,BG,I	Conservation Tillage A,B,G	Nutrient Management A,B,C,G,I	Crop Rotation A,B,I	Contour Buffer Strips A,B,G	Grassed Waterway A,B,G	Drainage Water Management AB,C,G,I	Water & Sediment Control Basin/Terrace A,B,G	Streambank Stabilization A,B,D,G	Grade Stabilization A,B,D,G	Livestock Management A,B,C,G	Riparian and/or Ditch System Buffers A,B,C,D	Urban Practices A,B,C,E,K	Septic System Compliance C,E,J	In-Lake Practices B,C,D,E,J	Lakeshore Practices A,B,C,D,J	Aquatic Connectivity C,D	social capacity building A-J	Other			
	Outlet Creek (-523)	Pope	Bacteria	134 CFU geomean Jun-Aug	57.2% reduction													•		•	•				•	•			
			Phosphorus	29% of TP samples exceeded the standard	Reduce exceedances to less than 10%	•	••	•	•	••	•	•	•		••	••	•	•	••	•	•				•	•			
			Turbidity	11% exceedance	2% reduction	•	••	•	•		•	•	•	••	••	••	•	•	••	•					•	•			
			Altered Hydrology	Increasing trend in peak events and extreme low flow	Decrease peak flows and increase low flows	•	••	•	•		•	•		••											•	•			
	Little Chippewa River (-530)	Pope	Turbidity-TSS	3.78 Ave. Ton/day	28% reduction	•	••	•	•		•	•	•	••	••	••	•	•	••	•					•	•			
	Trapper Run Creek (-628)	Pope	Bacteria	260 CFU geomean Jun-Aug	66.3% reduction													•			•				•	•			
			Dissolved Oxygen	24% of samples exceeded the standard	Decrease episodes of low DO by 59%	•	••	•	••	••								•			•				•	•			
			Phosphorus	The lakes of this reach are exceeding their standard	35-54% reduction	•	••	•	••	••	•	•	•		••	•	•	•	••		•				•	•			
			Connectivity	Several barriers including low flow	Remove fish barriers																			•	•	•			
			Altered Hydrology	Extended periods of low to no flow	Decrease the periods of no to low flow	•	••	•	••		•	•		••											•	•			

HUC-10 Subwatershed	Waterbody and Location		Parameter (incl. non-pollutant stressors)	Water Quality		Strategies and Governmental Units with Primary Responsibility • = Priority Restoration & Protection Strategy, •• = High Priority Restoration & Protection Strategy,																					Estimated Scale of Adoption Needed	Timeline to Achieve Water Quality Targets	Interim 10-yr Milestones
	Waterbody (ID)	**Location** and Upstream Influence Counties		Current Conditions	Goals / Targets	Conservation Cover A,B,G	Wetland Restoration A,B,D,F,G,H	Cover Crops A,BG,I	Conservation Tillage A,B,G	Nutrient Management A,B,C,G,I	Crop Rotation A,B,I	Contour Buffer Strips A,B,G	Grassed Waterway A,B,G	Drainage Water Management AB,C,G,I	Water & Sediment Control Basin/Terrace A,B,G	Streambank Stabilization A,B,D,G	Grade Stabilization A,B,D,G	Livestock Management A,B,C,G	Riparian and/or Ditch System Buffers A,B,C,D	Urban Practices A,B,C,E,K	Septic System Compliance C,E,J	In-Lake Practices B,C,D,E,J	Lakeshore Practices A,B,C,D,J	Aquatic Connectivity C,D	social capacity building A-J	Other			
			Habitat	MSHA =58, low flows are poor habitat	Improve by 14% increase to MSHA of 66											•			••						•	•			
	Little Chippewa River (-713)	Pope	Turbidity	Exceeded the TSS standard	Reduce exceedances of standard to <10%	•	•	•	••		•	•	•	••	••	••	••	••	•	•					•	•			
			Bacteria	340 CFU geomean May-Aug	80.3% reduction													••		•	•				•	•			
			Dissolved Oxygen	DO levels very close to standard	Decrease episodes of low DO	•	•	•	••	•								••		•	•				•	•			
			Phosphorus	45% of samples exceeded the standard	18% reduction, FWMC from 0.182 to 0.150 mg/L	•	•	•	••	•	•	•	•		••	••	••	••	•	•	•				•	•			
			Habitat	MSHA =51	Improve by 28%, increase to MSHA of 66											•			•						•	•			
	Little Chippewa River (-714)	Pope	Dissolved Oxygen	46% exceedance of the standard	Reduce exceedances to less than 10%	•	•	•	••	•								••		•	•				•	•			
			Phosphorus	HSPF modeled 91% exceedance	Reduce exceedances to less than 10%	•	•	•	••	••	•	•	•		••	•	•	••	•	•	•				•	•			
			Altered Hydrology	Extended periods of low flow, low DO driver	Decrease the periods of low flow	•	•	•	•		•	•		••											•	•			
	Irgens Lake (61-0211)	Pope	Nutrients	4,020 lbs. TP	77% reduction to 935 lbs.					•									•				•		•	•	In coordination with the upland treatments	25 years	20% of lakeshore
	Jorgenson Lake	Pope	Nutrients	848 lbs. TP	86% reduction to 117 lbs.					•									•				•		•	•			

HUC-10 Subwatershed	Waterbody and Location		Parameter (incl. non-pollutant stressors)	Water Quality		Strategies and Governmental Units with Primary Responsibility • = Priority Restoration & Protection Strategy, •• = High Priority Restoration & Protection Strategy,																					Estimated Scale of Adoption Needed	Timeline to Achieve Water Quality Targets	Interim 10-yr Milestones
	Waterbody (ID)	**Location** and Upstream Influence Counties		Current Conditions	Goals / Targets	Conservation Cover A,B,G	Wetland Restoration A,B,D,F,G,H	Cover Crops A,BG,I	Conservation Tillage A,B,G	Nutrient Management A,B,C,G,I	Crop Rotation A,B,I	Contour Buffer Strips A,B,G	Grassed Waterway A,B,G	Drainage Water Management AB,C,G,I	Water & Sediment Control Basin/Terrace A,B,G	Streambank Stabilization A,B,D,G	Grade Stabilization A,B,D,G	Livestock Management A,B,C,G	Riparian and/or Ditch System Buffers A,B,C,D	Urban Practices A,B,C,E,K	Septic System Compliance C,E,J	In-Lake Practices B,C,D,E,J	Lakeshore Practices A,B,C,D,J	Aquatic Connectivity C,D	social capacity building A-J	Other			
	(61-0164)																										watershed wide, 10% of the lake shed acres treated by appropriate strategies and 50% of lakeshore treated with restoration strategies		
	McIver Lake (61-0199)	Pope	Nutrients	1,372 lbs. TP	79% reduction to 283 lbs.					•									•				•		•	•			
	Lake Reno (61-0078)	Pope	Nutrients	2,064.2 lbs. TP	36% reduce to 1,319 lbs.				•					•					•		•	•	•		•	•			
	Lake Ann (61-0122)	Pope	Nutrients	12,113 lbs. TP	90% reduce to 1,184 lbs.				•	•				•				•	•		•				•	•			
	Lake Emily (61-0123)	Pope	Nutrients	18,270 lbs. TP	35% reduce to 11,872 lbs.		•		•	•				•		•			•		•	•	•		•	•[2]			
	Lake John (61-0123)	Pope	Nutrients	2,140 lbs. TP	70% reduction to 634 lbs.					•									•				•		•	•			
	Lake Malmedal (61-0162)	Pope	Nutrients	1,467.4 lbs. TP	72% reduction to 416 lbs.	•		•		•									•			••			•	•			
	Lake Pelican (61-0111)	Pope	Nutrients	2,580 lbs. TP	35% reduce to 1,669 lbs.				•					•				•			•		•		•	•			
	Strandness Lake (61-0128)	Pope	Nutrients	1,838.6 lbs. TP	54% reduction to 840 lbs.				•	•								•							•	•			
	Danielson Slough (61-0194)	Pope	Nutrients	1993 lbs. TP	52% reduction to 959 lbs.	•	•	•	•	•	•	•	•		•	•	•	•	•						•	•			

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	Waterbody (ID)	**Location** and Upstream Influence Counties		Current Conditions	Goals / Targets	Conservation Cover A,B,G	Wetland Restoration A,B,D,F,G,H	Cover Crops A,BG,I	Conservation Tillage A,B,G	Nutrient Management A,B,C,G,I	Crop Rotation A,B,I	Contour Buffer Strips A,B,G	Grassed Waterway A,B,G	Drainage Water Management AB,C,G,I	Water & Sediment Control Basin/Terrace A,B,G	Streambank Stabilization A,B,D,G	Grade Stabilization A,B,D,G	Livestock Management A,B,C,G	Riparian and/or Ditch System Buffers A,B,C,D	Urban Practices A,B,C,E,K	Septic System Compliance C,E,J	In-Lake Practices B,C,D,E,J	Lakeshore Practices A,B,C,D,J	Aquatic Connectivity C,D	social capacity building A-J	Other			
	Long Lake (75-0024)	Stevens	Nutrients	2,798 lbs. TP	59% reduction to 1,651 lbs.	•	•	•	•	•	•	•	•		•	•	•	•	•						•	•			
	Maple Lake (21-0079)	Douglas	Nutrients	Support, TP levels do not exceed the standard	Maintain levels that do not exceed the standard																•		•		•	•[1]	The overall watershed restoration will aid in the protection of these lakes. Each lakeshed will strive to retain current levels of land use diversity and acres in conservation.	20 years	All currently supporting lakes remain supporting
	Rachel Lake (21-0160)	Douglas	Nutrients	Support, TP levels do not exceed the standard	Maintain levels that do not exceed the standard														•				•		•	•			
	Turtle Lake (21-0090)	Douglas	Nutrients	Support, TP levels do not exceed the standard	Maintain levels that do not exceed the standard														•				•		•	•			
	Lake Minnewaska (61-0130)	Pope	Nutrients	Support, TP levels do not exceed the standard	Maintain levels that do not exceed the standard										•					•	•		•		•	•			
	Signalness (Mountain) Lake (61-0149)	Pope	Nutrients	Support, TP levels do not exceed the standard	Maintain levels that do not exceed the standard	•													•		•		•		•	•			
East Branch (0702000504-Mud Creek) (0702000505-JD 19)	Chippewa River, East Branch (-514)	Swift	Bacteria	148 CFU May-Sep	15% reduction													•			•				•	•	subwatershed wide adoption of these varied strategies to treat 115, 419 acres	40 years	28,855 acres
			Turbidity (TSS)	39.61 Ave. Ton/day	44% reduction	•	••	•	••		•	•	•	••	••	•	•	•	••						•	•			
	Chippewa River, East Branch (-515)	Pope	Bacteria	138 CFU May-Sep	67% reduction													•			•				•	•			

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	Waterbody (ID)	**Location** and Upstream Influence Counties		Current Conditions	Goals / Targets	Conservation Cover A,B,G	Wetland Restoration A,B,D,F,G,H	Cover Crops A,BG,I	Conservation Tillage A,B,G	Nutrient Management A,B,C,G,I	Crop Rotation A,B,I	Contour Buffer Strips A,B,G	Grassed Waterway A,B,G	Drainage Water Management AB,C,G,I	Water & Sediment Control Basin/Terrace A,B,G	Streambank Stabilization A,B,D,G	Grade Stabilization A,B,D,G	Livestock Management A,B,C,G	Riparian and/or Ditch System Buffers A,B,C,D	Urban Practices A,B,C,E,K	Septic System Compliance C,E,J	In-Lake Practices B,C,D,E,J	Lakeshore Practices A,B,C,D,J	Aquatic Connectivity C,D	social capacity building A-J	Other			
(0702000506-East Branch)	Mud Creek (-518)	Swift	Bacteria	*E. coli* exceeds safe levels	17.8% reduction													•			•				•	•			
	Mud Creek (-551)	Pope	Dissolved Oxygen	17% of samples exceeded standard	Reduce exceedances to <10%	•	••	•	••	••								•			•				•	•			
			Connectivity	Several culverts act as barriers to fish	Fix the culverts allow for fish passage																			•	•	•			
	Mud Creek (-554)	Swift	Dissolved Oxygen	11% of DO samples exceeded, 12,930 lbs./year TP	Decrease exceedances to <10%, 25% TP reduction	•	••	•	••	••								•			•				•	•			
			Bacteria	17,356 billion org	84.7% reduction													•			•				•	•			
			Connectivity	Several barriers to fish passage	Remove barriers to fish passage																			•	•	•			
	Unnamed Creek-County Ditch 15 (-623)	Pope	Dissolved Oxygen	45% of samples exceeded the standard	Decrease exceedances to less than 10%	•	••	•	••	••								•			•				•	•			
			Phosphorus	Phosphorus stressing fish populations	Reduce phosphorus delivery to lakes and stream by 20% (HSPF)	•	••	•	••	••	•	•	•		••	•	•	•	••		•				•	•			
			Habitat	Poor quality habitat stressing aquatic species MSHA=poor	Improve habitat score to good, improve low water levels														••					•	•	•			
	Edwards Lake (61-0106)	Pope	Nutrients	1,180 lbs. TP	72% reduction to 325 lbs.	•	•	•	•	•	•	•	•		•	•	•	•	•						•	•	In coordination with the	25 years	20% of

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	Waterbody (ID)	**Location** and Upstream Influence Counties		Current Conditions	Goals / Targets	Conservation Cover A,B,G	Wetland Restoration A,B,D,F,G,H	Cover Crops A,BG,I	Conservation Tillage A,B,G	Nutrient Management A,B,C,G,I	Crop Rotation A,B,I	Contour Buffer Strips A,B,G	Grassed Waterway A,B,G	Drainage Water Management AB,C,G,I	Water & Sediment Control Basin/Terrace A,B,G	Streambank Stabilization A,B,D,G	Grade Stabilization A,B,D,G	Livestock Management A,B,C,G	Riparian and/or Ditch System Buffers A,B,C,D	Urban Practices A,B,C,E,K	Septic System Compliance C,E,J	In-Lake Practices B,C,D,E,J	Lakeshore Practices A,B,C,D,J	Aquatic Connectivity C,D	social capacity building A-J	Other			
	Lake Gilchrist (61-0072)	Pope	Nutrients	8434.4 lbs. TP	48% reduce to 4,363 lbs.			•	•	•				•				•	•		•	•	•		•	•	upland treatments watershed wide, 10% of the lake shed acres treated by appropriate strategies and 50% of lakeshore treated with restoration strategies		
	Hanson (Woodpecker) Lake (61-0080)	Pope	Nutrients	4,370 lbs. TP	55% reduce to 1953 lbs.	•	•	•	•	•	•	•	•		•	•	•	•	•						•	•			
	Lake Hassel (76-0086)	Swift	Nutrients	8,535 lbs. TP	77% reduce to 1,930 lbs.																	•	•		•	•			
	Lake Leven (61-0066)	Pope	Nutrients	2,396 lbs. TP	35% reduce to 1,560 lbs.	•	•			•				•		•		•	•				•		•	•			
	Lake Mary (61-0099)	Pope	Nutrients	464 lbs. TP	58% reduction to 192 lbs.	•	•	•	•	•	•	•	•		•	•	•	•	•				•		•	•			
	Rasmuson Lake (61-0086)	Pope	Nutrients	836 lbs. TP	78% reduction to 185 lbs.	•	•	•	•	•	•	•	•		•	•	•	•	•				•		•	•			
	Lake Steenerson (61-0095)	Pope	Nutrients	3,503 lbs. TP	Reduce TP to meet standard	•	•	•	•	•	•	•	•		•	•	•	•	•				•		•	•			
	Lake Swenoda (61-0051)	Pope	Nutrients	452 lbs. TP	49% reduction to 231 lbs.				•					•					•				•		•	•			

HUC-10 Subwatershed	Waterbody and Location		Parameter (incl. non-pollutant stressors)	Water Quality		Strategies and Governmental Units with Primary Responsibility • = Priority Restoration & Protection Strategy, •• = High Priority Restoration & Protection Strategy,																					Estimated Scale of Adoption Needed	Timeline to Achieve Water Quality Targets	Interim 10-yr Milestones
	Waterbody (ID)	**Location** and Upstream Influence Counties		Current Conditions	Goals / Targets	Conservation Cover A,B,G	Wetland Restoration A,B,D,F,G,H	Cover Crops A,BG,I	Conservation Tillage A,B,G	Nutrient Management A,B,C,G,I	Crop Rotation A,B,I	Contour Buffer Strips A,B,G	Grassed Waterway A,B,G	Drainage Water Management AB,C,G,I	Water & Sediment Control Basin/Terrace A,B,G	Streambank Stabilization A,B,D,G	Grade Stabilization A,B,D,G	Livestock Management A,B,C,G	Riparian and/or Ditch System Buffers A,B,C,D	Urban Practices A,B,C,E,K	Septic System Compliance C,E,J	In-Lake Practices B,C,D,E,J	Lakeshore Practices A,B,C,D,J	Aquatic Connectivity C,D	social capacity building A-J	Other			
	Lake Johanna (61-0006)	Pope	Nutrients	3,008lbs. TP	44% reduction to 1,678 lbs.	•	•	•	•	•	•	•	•		•	•	•	•	•				•		•	•			
	Monson Lake (76-0033)	Swift	Nutrients	377 lbs. TP	34% reduction to 248 lbs.	•	•	•	•	•	•	•	•		•	•	•	•	•				•		•	•			
	Simon Lake (61-0034)	Pope	Nutrients	2,532 lbs. TP	72% reduction to 708 lbs.	•												•					•		•	•			
	Lake Hollerberg (76-0057)	Pope	Nutrients	1,053 lbs. TP	52% reduction to 506lbs.	•	•	•	•	•	•	•	•		•	•	•	•	•				•		•	•			
	Lake Amelia (61-0064)	Pope	Nutrients	Support, TP levels do not exceed the standard	Maintain levels that do not exceed the standard						•								•		•		•		•	•			
	Lake Benson (61-0097)	Pope	Nutrients	Support, TP levels do not exceed the standard	Maintain levels that do not exceed the standard						•								•						•	•			
	Hoff Lake (61-0092)	Pope	Nutrients	Support, TP levels do not exceed the standard	Maintain levels that do not exceed the standard						•								•						•	•			
	Lake Linka (61-0037)	Pope	Nutrients	Support, TP levels do not exceed the standard	Maintain levels that do not exceed the standard						•								•		•		•		•	•			

HUC-10 Subwatershed	Waterbody and Location		Parameter (incl. non-pollutant stressors)	Water Quality		Strategies and Governmental Units with Primary Responsibility • = Priority Restoration & Protection Strategy, •• = High Priority Restoration & Protection Strategy,																					Estimated Scale of Adoption Needed	Timeline to Achieve Water Quality Targets	Interim 10-yr Milestones
	Waterbody (ID)	**Location** and Upstream Influence Counties		Current Conditions	Goals / Targets	Conservation Cover A,B,G	Wetland Restoration A,B,D,F,G,H	Cover Crops A,BG,I	Conservation Tillage A,B,G	Nutrient Management A,B,C,G,I	Crop Rotation A,B,I	Contour Buffer Strips A,B,G	Grassed Waterway A,B,G	Drainage Water Management AB,C,G,I	Water & Sediment Control Basin/Terrace A,B,G	Streambank Stabilization A,B,D,G	Grade Stabilization A,B,D,G	Livestock Management A,B,C,G	Riparian and/or Ditch System Buffers A,B,C,D	Urban Practices A,B,C,E,K	Septic System Compliance C,E,J	In-Lake Practices B,C,D,E,J	Lakeshore Practices A,B,C,D,J	Aquatic Connectivity C,D	social capacity building A-J	Other			
	Lake Marlu (61-0060)	Pope	Nutrients	Support, TP levels do not exceed the standard	Maintain levels that do not exceed the standard						•								•		•		•		•	•	The overall basin restoration will aid in the protection of these lakes. Each lakeshed will strive to retain current levels of land use diversity and acres in conservation.	20 years	
	Nelson (Main Lake) Lake (61-0101)	Pope	Nutrients	Support, TP levels do not exceed the standard	Maintain levels that do not exceed the standard						•								•						•	•			
	Round Lake (61-0048)	Pope	Nutrients	Support, TP levels do not exceed the standard	Maintain levels that do not exceed the standard						•								•		•		•		•	•			
	Lake Scandinavian (61-0041)	Pope	Nutrients	Support, TP levels do not exceed the standard	Maintain levels that do not exceed the standard						•								•		•		•		•	•			
	State Lake (61-0062)	Pope	Nutrients	Support, TP levels do not exceed the standard	Maintain levels that do not exceed the standard						•								•						•	•			
	Lake Villard (61-0067)	Pope	Nutrients	Support, TP levels do not exceed the standard	Maintain levels that do not exceed the standard						•								•		•		•		•	•			
	Camp Lake (76-0072)	Swift	Nutrients	Support, TP levels do not exceed the standard	Maintain levels that do not exceed the standard						•								•		•		•		•	•			
	Johnson (Kittelson) Lake (61-0010)	Pope	Nutrients	Support, TP levels do not exceed the standard	Maintain levels that do not exceed the standard						•								•						•	•			

HUC-10 Subwatershed	Waterbody and Location		Parameter (incl. non-pollutant stressors)	Water Quality		Strategies and Governmental Units with Primary Responsibility • = Priority Restoration & Protection Strategy, •• = High Priority Restoration & Protection Strategy,																					Estimated Scale of Adoption Needed	Timeline to Achieve Water Quality Targets	Interim 10-yr Milestones
	Waterbody (ID)	**Location** and Upstream Influence Counties		Current Conditions	Goals / Targets	Conservation Cover A,B,G	Wetland Restoration A,B,D,F,G,H	Cover Crops A,BG,I	Conservation Tillage A,B,G	Nutrient Management A,B,C,G,I	Crop Rotation A,B,I	Contour Buffer Strips A,B,G	Grassed Waterway A,B,G	Drainage Water Management AB,C,G,I	Water & Sediment Control Basin/Terrace A,B,G	Streambank Stabilization A,B,D,G	Grade Stabilization A,B,D,G	Livestock Management A,B,C,G	Riparian and/or Ditch System Buffers A,B,C,D	Urban Practices A,B,C,E,K	Septic System Compliance C,E,J	In-Lake Practices B,C,D,E,J	Lakeshore Practices A,B,C,D,J	Aquatic Connectivity C,D	social capacity building A-J	Other			
	Unnamed Lake (near Brooten) (61-0013)	Pope	Nutrients	Support, TP levels do not exceed the standard	Maintain levels that do not exceed the standard														•		•		•		•	•			
Lower Mainstem (0702000507- County Ditch 3 Chippewa River) (0702000509- Cottonwood Creek) (0702000511- Chippewa River)	Chippewa River (-501)	Chippewa	Bacteria	Standard exceeded from Jun-Sept.	46% reduction													•		•	•				•	•	subwatershe d wide adoption of these varied strategies to treat 94,752 acres	40 years	23,688 acres
			Turbidity	25% of TSS samples exceeded standard	Reduce TSS exceedances to <10%	•	•	•	••		•	•	•	••	•	•	•	•	••	•					•	•			
	Chippewa River (-502)	Chippewa	Dissolved Oxygen	Stressor to fish and invertebrate communities	Need more DO samples, improve DO stability	•	•	•	••	••								•		•	•				•	•			
			Phosphorus	Stressor to fish and invertebrate communities	Reduce exceedances of 0.15mg/L to less than 10% of samples	•	•	•	••	••	•	•	•		•	•	•	•	••	•	•				•	•			
			Turbidity	Stressor to fish and invertebrate communities	Reduce exceedances of 65mg/L TSS to less than 10% of samples	•	•	•	••		•	•	•	••	•	•	•	•	••	•					•	•			
			Connectivity	Two dams downstream of AUID blocking fish passage	Reconnect via fish passage bi-pass																			•	•	•			
			Altered Hydrology	Unstable hydrology stressing aquatic species	25% decrease in 2-year peak flow and duration, and increase base flow	•	•	•	••		•	•		••											•	•			
			Habitat	MSHA =45	Improve by 47% increase to MSHA of 66											•			••						•	•			

Strategies and Governmental Units with Primary Responsibility: • = Priority Restoration & Protection Strategy, •• = High Priority Restoration & Protection Strategy,

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	Conservation Cover A,B,G	Wetland Restoration A,B,D,F,G,H	Cover Crops A,BG,I	Conservation Tillage A,B,G	Nutrient Management A,B,C,G,I	Crop Rotation A,B,I	Contour Buffer Strips A,B,G	Grassed Waterway A,B,G	Drainage Water Management AB,C,G,I	Water & Sediment Control Basin/Terrace A,B,G	Streambank Stabilization A,B,D,G	Grade Stabilization A,B,D,G	Livestock Management A,B,C,G	Riparian and/or Ditch System Buffers A,B,C,D	Urban Practices A,B,C,E,K	Septic System Compliance C,E,J	In-Lake Practices B,C,D,E,J	Lakeshore Practices A,B,C,D,J	Aquatic Connectivity C,D	social capacity building A-J	Other	Estimated Scale of Adoption Needed	Timeline to Achieve Water Quality Targets	Interim 10-yr Milestones
	Chippewa River (-507)	Swift	Turbidity	Stressor to invertebrate communities	Reduce exceedances of 65mg/L TSS to less than 10% of samples	•	•	•	••		•	•	•	••	•	•	•	•	••	•					•	•			
			Phosphorus	Stressor to invertebrate communities	Reduce exceedances of 0.15mg/L to less than 10% of samples	•	•	•	••	••	•	•	•		•	•	•	•	••	•	•				•	•			
			Altered Hydrology	Unstable hydrology stressing aquatic species	25% decrease in 2-year peak flow and duration, and increase base flow	•	•	•	••		•	•		••											•	•			
	Chippewa River (-508)	Chippewa	Bacteria	Stressor to invertebrate communities	Reduce exceedances of 65mg/L TSS to less than 10% of samples													•		•	•				•	•			
			Turbidity (TSS)	119.1 Ave. Ton/day	54% reduction	•	•	•	••		•	•	•	••	•	•	•	•	••	•					•	•			
			Phosphorus	Stressor to invertebrate communities	Reduce exceedances of 0.15mg/L to less than 10% of samples	•	•	•	••	••	•	•	•		•	•	•	•	••	•	•				•	•			
			Altered Hydrology	Unstable hydrology stressing aquatic species	25% decrease in 2-year peak flow and duration, and increase base flow	•	•	•	••		•	•		••											•	•			
	Cottonwood Creek (-511)	Swift	Bacteria	*E. coli* exceeds standard levels, 6,221 billion CFU/day	80% reduction													•		•	•				•	•			
	Cottonwood Creek	Swift	Altered Hydrology	Unstable hydrology stressing aquatic species	25% decrease in 2-year peak flow and duration, and increase base flow	•	•	•	••		•	•		••											•	•			

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	Conservation Cover A,B,G	Wetland Restoration A,B,D,F,G,H	Cover Crops A,BG,I	Conservation Tillage A,B,G	Nutrient Management A,B,C,G,I	Crop Rotation A,B,I	Contour Buffer Strips A,B,G	Grassed Waterway A,B,G	Drainage Water Management AB,C,G,I	Water & Sediment Control Basin/Terrace A,B,G	Streambank Stabilization A,B,D,G	Grade Stabilization A,B,D,G	Livestock Management A,B,C,G	Riparian and/or Ditch System Buffers A,B,C,D	Urban Practices A,B,C,E,K	Septic System Compliance C,E,J	In-Lake Practices B,C,D,E,J	Lakeshore Practices A,B,C,D,J	Aquatic Connectivity C,D	social capacity building A-J	Other	Estimated Scale of Adoption Needed	Timeline to Achieve Water Quality Targets	Interim 10-yr Milestones
	(-546)		Habitat	Poor Habitat stressing fish population	Improve habitat from poor to good											•			••						•	•			
	County Ditch 3 (-579)	Swift	Bacteria	*E. coli* exceeds standard	52% reduction													•		•	•				•	•			
	Unnamed Creek (Lines) (-584)	Chippewa	Dissolved Oxygen	Stressor to fish and invertebrate communities, 3460 lbs./year TP	Need more DO samples, improve DO stability, 32% TP reduction	•	•	•	••	•								•		•	•				•	•			
			Bacteria	*E. coli* exceeds standard, 1,257 billion CFU/day	76% reduction													•		•	•				•	•			
			Phosphorus	Stressor to fish and invertebrate communities	Reduce exceedances of 0.15mg/L to less than 10% of samples	•	•	•	••	•	•	•	•		•	•	•	•	••	•	•				•	•			
			Connectivity	Several perched culverts form barrier to fish passage	Reconnect stream via proper culvert installation																			•	•	•			
Shakopee Creek 0702000508	Shakopee Creek (557)	Swift	Bacteria	*E. coli* exceeds standard, 28,416 billion CFU/day	75% reduction													•		•	•				•	•	subwatershed wide adoption of these varied strategies to treat 86,855 acres	40 years	21,714 acres
	Shakopee Creek (-559)	Swift	Turbidity (TSS)	23.38 Ave. Ton/day	76% reduction	•	•	•	••		•	•	•	••	•	•	•	•	••	•					•	•			
			Bacteria	*E. coli* exceeds standard	Reduce exceedances of standard to acceptable levels													•		•	•				•	•			

Strategies and Governmental Units with Primary Responsibility: • = Priority Restoration & Protection Strategy, •• = High Priority Restoration & Protection Strategy,

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	Conservation Cover A,B,G	Wetland Restoration A,B,D,F,G,H	Cover Crops A,BG,I	Conservation Tillage A,B,G	Nutrient Management A,B,C,G,I	Crop Rotation A,B,I	Contour Buffer Strips A,B,G	Grassed Waterway A,B,G	Drainage Water Management AB,C,G,I	Water & Sediment Control Basin/Terrace A,B,G	Streambank Stabilization A,B,D,G	Grade Stabilization A,B,D,G	Livestock Management A,B,C,G	Riparian and/or Ditch System Buffers A,B,C,D	Urban Practices A,B,C,E,K	Septic System Compliance C,E,J	In-Lake Practices B,C,D,E,J	Lakeshore Practices A,B,C,D,J	Aquatic Connectivity C,D	social capacity building A-J	Other	Estimated Scale of Adoption Needed	Timeline to Achieve Water Quality Targets	Interim 10-yr Milestones
						Strategies and Governmental Units with Primary Responsibility • = Priority Restoration & Protection Strategy, •• = High Priority Restoration & Protection Strategy,																							
			Nitrogen	Stressor to fish communities	Reduce exceedances of 4.9 mg/L to less than 10% of samples		•	•		••				••				•	••	•	•				•	•			
			Phosphorus	Stressor to fish communities	Reduce exceedances of 0.15mg/L to less than 10% of samples	•	•	•	••	••	•	•	•		•	•	•	•	••	•	•				•	•			
			Connectivity	Dam to Shakopee lake is a barrier and stressor to fish populations	Allow for fish passage to Shakopee Lake																			•	•	•			
			Altered Hydrology	Unstable hydrology stressing aquatic species	25% decrease in 2-year peak flow and duration, and increase base flow	•	•	•	••		•	•		••											•	•			
			Habitat	Poor Habitat stressing fish population	Improve habitat from poor to good, consider impacts of dam on downstream bank erosion											•			•						•	•			
	Unnamed ditch-JD 29 (-566)	Kandiyohi	Bacteria	*E. coli* exceeds standard, 449.3 billion CFU/day	64% reduction													•		•	•				•	•			
	County Ditch 29 (-567)	Kandiyohi	Bacteria	*E. coli* exceeded standard in 42% of samples, 1,051.55 billion CFU/day	60.6% reduction													•		•	•				•	•			
	County Ditch 27 (-570)	Kandiyohi	Bacteria	*E. coli* exceeded standard in 52% of samples, 5,495.5 billion CFU/day	81.9% reduction													•		•	•				•	•			

Strategies and Governmental Units with Primary Responsibility

• = Priority Restoration & Protection Strategy, •• = High Priority Restoration & Protection Strategy,

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	Conservation Cover A,B,G	Wetland Restoration A,B,D,F,G,H	Cover Crops A,BG,I	Conservation Tillage A,B,G	Nutrient Management A,B,C,G,I	Crop Rotation A,B,I	Contour Buffer Strips A,B,G	Grassed Waterway A,B,G	Drainage Water Management AB,C,G,I	Water & Sediment Control Basin/Terrace A,B,G	Streambank Stabilization A,B,D,G	Grade Stabilization A,B,D,G	Livestock Management A,B,C,G	Riparian and/or Ditch System Buffers A,B,C,D	Urban Practices A,B,C,E,K	Septic System Compliance C,E,J	In-Lake Practices B,C,D,E,J	Lakeshore Practices A,B,C,D,J	Aquatic Connectivity C,D	social capacity building A-J	Other	Estimated Scale of Adoption Needed	Timeline to Achieve Water Quality Targets	Interim 10-yr Milestones
	Unnamed Creek (-574)	Swift	Turbidity (TSS)	0.7 Ave. Ton/day	9% reduction	•	•	•	••		•	•	•	••	•	•	•	••	•	•					•	•			
	Unnamed Creek-Huse Creek (-917)	Kandiyohi	Bacteria	*E. coli* exceeded standard in 50% of samples, 209 billion CFU/day	48% reduction													•		•	•				•	•			
	Shakopee Creek (-512)	Kandiyohi	Turbidity (TSS)	Support	Maintain levels that do not exceed the standard	•	•												•		•		•		•	•	Land use and current conservation strategies remain in place in the contributing watershed to this stream segment	20 years	Retains supporting status.
	Middle Lake (34-0208)	Kandiyohi	Nutrients	514 lbs. TP	Reduce TP to meet standard																•		•		•	•	In coordination with the upland treatments watershed wide, 10% of the lake shed acres treated by appropriate strategies and 50% of lakeshore treated with	25 years	20% of lakeshore acres treated
	Norway Lake (34-0251)	Kandiyohi	Nutrients	West Norway Lake 7509 lbs. TP East Norway Lake 2500 lbs. TP	-West Norway Lake 47% reduction to 3,987 lbs. TP -East Norway Lake 27% reduction to 1,828 lbs. TP	•	••	•	••	•	•	•	•	•	•	•		•	•		•	•	•		•	•			

HUC-10 Subwatershed	Waterbody and Location		Parameter (incl. non-pollutant stressors)	Water Quality		Strategies and Governmental Units with Primary Responsibility • = Priority Restoration & Protection Strategy, •• = High Priority Restoration & Protection Strategy,																					Estimated Scale of Adoption Needed	Timeline to Achieve Water Quality Targets	Interim 10-yr Milestones
	Waterbody (ID)	**Location** and Upstream Influence Counties		Current Conditions	Goals / Targets	Conservation Cover A,B,G	Wetland Restoration A,B,D,F,G,H	Cover Crops A,BG,I	Conservation Tillage A,B,G	Nutrient Management A,B,C,G,I	Crop Rotation A,B,I	Contour Buffer Strips A,B,G	Grassed Waterway A,B,G	Drainage Water Management AB,C,G,I	Water & Sediment Control Basin/Terrace A,B,G	Streambank Stabilization A,B,D,G	Grade Stabilization A,B,D,G	Livestock Management A,B,C,G	Riparian and/or Ditch System Buffers A,B,C,D	Urban Practices A,B,C,E,K	Septic System Compliance C,E,J	In-Lake Practices B,C,D,E,J	Lakeshore Practices A,B,C,D,J	Aquatic Connectivity C,D	social capacity building A-J	Other			
																											restoration strategies		
	Lake Andrew (34-0206)	Kandiyohi	Nutrients	Support, TP levels do not exceed the standard	Maintain levels that do not exceed the standard					•				•					•		•		•		•	•	The overall watershed restoration will aid in the protection of these lakes. Each lakeshed will strive to retain current levels of land use diversity and acres in conservation.	20 years	All currently supporting lakes remain supporting
	Lake Florida (34-0217)	Kandiyohi	Nutrients	Support, TP levels do not exceed the standard	Maintain levels that do not exceed the standard					•				•					•		•		•		•	•			
	Games Lake (34-0224)	Kandiyohi	Nutrients	Support, TP levels do not exceed the standard	Maintain levels that do not exceed the standard					•				•					•		•		•		•	•			
Dryweather Creek 0702000510	Dryweather Creek (-509)	Chippewa	Bacteria	151 CFU geomean *E. coli*	20% reduction													•	•		•				•	•	subwatershed wide adoption of these varied strategies to treat 34,568 acres	40 years	8,641 acres of each page

Strategy Table Key

***** The strategy footprint is only a fraction of the treated acres, which should be considered when comparing adoption rates. For example: grassed waterway will not take 14,100 acres out of production, but will treat 14,100 acres. It is intended to treat the water from many more acres than the strategy footprint. So the actual acres converted to grassed waterways would be a fraction (e.g. 1/20th or 1/100th) of the treated acres.

Table 11 Governmental Units with Responsibility

A	Chippewa River Watershed Project (CRWP)
B	Soil and Water Conservation District (SWCD)
C	County-Commissioners, Environmental Services, Feedlot Staff, Water Planners, Ditch Inspectors
D	Minnesota Department of Natural Resources (DNR)
E	Minnesota Pollution Control Agency (MPCA)
F	Board of Water and Soil Resources (BWSR)
G	Natural Resources Conservation Service (NRCS)
H	U.S. Fish and Wildlife Service (USFWS)
I	Minnesota Department of Agriculture (MDA)
J	Lake Associations
K	City Government

Table 12: Key for Strategies Column

Strategy	Practices Included	Predicted Benefits
Conservation Cover (327)		Establishment of grasses on previously row cropped lands and taken out of production generally through a government program. Well managed grasses can be effective in erosion control, lowering nutrient loss, mitigating hydrology, and improving habitat.
Wetland Restoration (651)		Water quality is enhanced in wetlands by the collection and filtration of sediment, nutrients, pesticides and bacteria in runoff or subsurface drainage. Downstream flooding may be reduced through storage of water, particularly frequent floods
Cover Crops (340)		Cover crops can provide soil erosion protection, reduce nutrient runoff, improve soil health and fertility and positively impact the water holding capacity of the soil.
Conservation Tillage (329,345,348)		Conservation tillage is the practice of leaving crop residue on the soil surface through reduced tilling practices including no-till, strip till, ridge till, mulch till. The avoidance of mold board plowing is critical. Increased residue cover can reduce erosion, nutrient runoff, and increase soil health.
Nutrient Management (590)		Nutrient management refers to the management of the amount, method, and timing of applications of fertilizers, manure, and other soil amendments. The nutrients that have the greatest impact on water quality are nitrogen (N) and Phosphorus (P) and should be targeted through management planning
Crop Rotation (328)	Growing crops in a planned sequence on the same field with emphasis on including a grass/hay rotation or incorporation of cover crop.	When applied, this practice supports the reduction of sheet, rill, and wind erosion, improved soil quality, increased cropping system diversity, increased water holding capacity, and providing food and cover for wildlife including pollinator forage, cover, and nesting.
Contour Buffer Strips (332)	Contour buffer strips	Contour buffer strips slow the flow of water, thereby facilitating infiltration and diffuse flow, reducing sheet and rill erosion, and reducing the transport of sediment and associated contaminants to downstream water bodies.

Strategy	Practices Included	Predicted Benefits
Grassed Waterway (412)	Grassed waterways	Grassed waterways are vegetated channels through fields that provide a means for concentrated flows to drain from a field without causing erosion. They can be installed on most fields but are especially effective in controlling gully erosion on steeper slopes.
Drainage Water Management	Alternative Tile Intakes, Tile System Design, Saturated Buffers, Controlled Drainage(554), Woodchip Bioreactor, Treatment Wetland, Sediment Basin (358), Side Inlet Control to Ditch(410), Two Stage Ditch	This suite of practices are applicable for addressing flow and pollutant loading associated with subsurface and open ditch drainage.
Streambank Stabilization	Streambank Stabilization	The primary benefit of streambank stabilization is reduced erosion with related benefits of maintained adequate flow conveyance, and improvements for habitat, recreation and aesthetics. If possible, designs with vegetation and bioengineering techniques are preferred approaches to address the streambank instability
Grade Stabilization (410)	grade control structures	A grade control structure is used to control the grade and head cutting in natural or artificial channels. Grade control structures can improve water quality by reducing erosion and sediment bound pollutants. Structural options may include road structures, embankment dams, and drop, chute, or box inlet drop spillways.
Livestock Management	Rotational Grazing (528), Livestock Exclusion (382, 472), Waste Storage Facility (313), Feedlot Runoff Control(362, 635)	This suite of practices is available to address livestock related management. Well managed livestock operations are a benefit to the watershed. These practices can help to mitigate the potential nutrient and bacteria loading related to manure resources as well as address in-stream and bank erosion that can be present in pasture systems.
Riparian and/or Ditch System Buffers/Filter Strips (390, 393)	Filter strips and/or riparian vegetation	Filter strips and/or riparian vegetation effectively reduce runoff volume and sediments while increasing bank stability.
Urban Practices	Rain gardens, rain barrels, Street Sweeping, Retention Ponds, Stormwater Management, Impervious Surface Management, Construction Site Erosion Controls	This suite of practices will help to mitigate the sediment and pollutant loading contributions made by residents and homeowners in the watershed's towns and cities.
Septic System Compliance		Individual Septic Treatment Systems are vital for those residences not connected to municipal wastewater treatment. Non-compliant systems are at risk of contributing bacteria and nutrients to surface waters.
In-Lake Practices	Shallow Lake Management, Aquatic Invasive Species Control , Commercial Netting	These practices may be part of the strategy of specific lakes especially those situations where the upland and external sources of phosphorus and sediment have already been minimized.
Lakeshore Practices	Shoreline Buffers, Shoreline Naturalizations, Rain Gardens, Rain Barrels, Fertilizer Management, Impervious Surface Management	This suite of practices can be implemented directly by lakeshore residents for the reduction of erosion and nutrient runoff.
Aquatic Connectivity	Dam Removal, Culvert Replacement	These practices when used appropriately aid in fish passage and the movement of other aquatic species that are critical for biotic integrity.
Other	1. Development of a Watershed Management Plan 2. Partial diversion of Little Chippewa River flow back to original channel	1. Development of a Watershed Management Plan 2. Partial diversion of Little Chippewa River flow back to original channel
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

Table 13: Estimated Watershed Restoration and Protection Strategies

Land use/Source Type	**Watershed Restoration and Protection Strategies** estimated to meet 10-year target at specified adoption rates	Adoption Rate: % watershed to newly adopt (treated area)	Adoption Rate: Acres to newly adopt (treated acres)	Adoption Rate: 10 year Target	Pollutant/Stressor — Relative effect of strategy on water quality goal per treated acre: TSS	Phosphorus	Nitrogen	Bacteria	Low DO	Flow	Habitat
Cultivated Crops	Nutrient management (for P & N)	10%	91,100	22,775		S	X				
	Cover crops	5%	45,600	11,400	X	S	X	X	X	V	
	Conservation tillage/residue management	10%	91,100	22,775	V	S	V	S	V	V	
	Buffers, prairie strips*, border filter strips*	5.5%	50,100	12,525	S	S		S	V	V	V
	WASCOBS, terraces, flow-through basins (for surface runoff)*	1%	9,100	2,275	V	S	-	M	S	M	
	Grassed waterway*	2%	18,200	4,550	X	M	M			M	M
	Treatment wetland (for tile drainage system)*	1%	9,100	2,275	S	M	X			M	M
	Crop rotation (including small grain)	10%	91,100	22,775	S	M	S	M	S	S	M
	Alternative tile intakes*	1%	9,100	2,275	X	S		S	M		
	Wood chip bioreactor*	1%	9,100	2,275		M	V				
	Saturated buffers*	1%	9,100	2,275		M	V			M	M
	Controlled drainage, drainage design*	1%	9,100	2,275		M	V			M	M
	Restored wetlands	0.5%	4,600	1,150	X	V	X	X	M	X	V
	Contour strip cropping (50% crop in grass)	0.5%	4,600	1,150	X	V	X	V	V	V	M
	Improved manure application, better setbacks & training	0.5%	4,600	1,150		S	V	X	S		M
	Conservation cover	0.1%	900	225	X	X	X	X	X	X	V
	Productive grassland conversion	3.0%	27,300	6,825	V	V	V	V	V	V	V
	Side inlet control to ditch (w serious erosion)*	0.5%	4,600	1,150	V	S					
Pas-trues	Rotational grazing	10.0%	10,500	2,625		X		X			S
	Livestock exclusion	2.0%	2,100	525		X		X			V
* = Strategy footprint is greater than treated area					X=Extremely, V= very, S=somewhat, M=minimal, <blank>=negligible						

Land use/Source Type	**Watershed Restoration and Protection Strategies** estimated to meet 10-year target at specified adoption rates	**Adoption Rate**	**Pollutant/Stressor** Relative effect of strategy on water quality goal per treated acre						
			TSS	Phosphorus	Nitrogen	Bacteria	Low DO	Flow	Habitat
City & Residential	Urban and residential stormwater practices: Street sweeping Construction site erosion control Smart snow pile management Impervious disconnections Municipal good house keepers Waterway buffers Rain gardens Golf course management Innovative technologies Pave gravel surfaces Pervious pavements	sufficient to reduce current city and residential contributions by 10%	Y	Y	Y	Y	Y	Y	Y
Failing SSTS	Maintenance and replacement/upgrades Enact ordinance to require compliant system sales	sufficient to reduce current SSTS contributions by 10%		Y		Y	Y		
Feed lots	Feedlot runoff controls including: buffer strips, clean water diversions, etc.	sufficient to reduce current feedlot contributions by 20%		Y	Y	Y	Y		
Stream banks, Ravines	Streambank and ravine stabilization where needed to protect high value property, use bioengineered methods when possible, address hydrology first	as needed to protect high-value property	Y	Y					Y
Lakes	Additional strategies specifically for lakes: Lakeshore Restoration/Stabilization In lake management and species control	sufficient to reduce/consume 2% of P load to lakes		Y		Y	Y		Y
Social Infrastructure	Ordinance & policy review/update General messaging and education Collaboration with ag professionals Community events Peer leader and peer to peer networking	sufficient to address barriers to adopting strategies at specified adoption rates	Y	Y	Y	Y	Y	Y	Y

Table 14 Ag BMP strategy NRCS project code and Additional Notes

See the NRCS design guidance and/or the Ag BMP handbook for additional information. The Ag BMP practices and NRCS codes listed in the table may not be the only available practices in which to select from.

Ag BMP	NRCS code(s)	Additional Notes
Conservation cover	327, 643	Native vegetation including grasses, trees, shrubs
Conservation tillage	329, 345, 346	No till or strip till with very high residue to protect surface soil
Construction site erosion control	570	Silt fence, etc. to prevent sediment runoff, turf reinforcement
Cover crops	340	A key soil health principle. Can be hard to be successful. Work with experienced users/professionals to implement.
Crop rotation	328	Consider in conjunction with cover crops and conservation tillage
Extended retention		See Ag BMP handbook (no NRCS code). Intended to slow discharge. Design must consider fish passage needs.
Feedlot runoff control	635, 362	Vegetated treatment area provides a controlled release of nutrient rich wastewater. Diverting runoff water.
Field buffers, borders, filter strips	393, 386, 332	Edge-of-field or within field
Grassed waterways	412, 342	Establishes permanent vegetation on flow pathways on erodible soils, slopes
In/near ditch retention and treatment	410, 587	Includes any practice where the ditch itself is incorporated in to practice: 2-state ditch, side inlet control, weirs and berms, etc.
In-lake management and species control		Prevention of invasive species, restore diverse fish populations to control rough fish, increase habitat diversity
Livestock exclusion	382, 472, 614	Exclusion from water bodies, can help to create watering station
Manure application setbacks	590	One specific component of nutrient management
Near-lake vegetative management		Leaving natural buffer zone at shoreline, using natural materials as wave breaks, restore/maintain emergent veg, woody debris
Nutrient (including manure) management	590	Considers amount, source, form, timing, etc..
Ravine (grade) stabilization	410	First address hydrology before costly stabilization
Restored wetlands	657, 643, 644	Restoring wetland (where one historically was located)
Rotational grazing	528	Managing for improved vegetation improves water quality
Saturated buffers	739	Vegetated subsurface drain outlet for nutrient removal
SSTS (Septic systems)	313	Maintenance and replacement when needed to ensure clean effluent
Streambank stabilization	580	Using bioengineering techniques as much as possible
Strip cropping	332, 585	Alternating erosion susceptible crops with erosion resident crops perpendicular to water flows
Tile system design; controlled drainage	554	Managing for less total runoff; includes alternative tile intakes
Treatment wetlands	656, 658	Specifically designed to treat tile drainage and/or surface runoff
Water and sediment basins, terraces	638, 600	Managing for extended retention and settling
Woodchip bioreactors	747	Reducing the level of nitrogen in drainage systems

Prioritizing and Targeting

The objective in "prioritizing" and "targeting" is to identify locations to cost effectively implement practices to achieve the greatest improvement in water quality. A third concept, particularly related to funding, is "measuring", which means that implementation activities should produce measurable results. Figure 45 (BWSR 2014a) visually represents these concepts. "Prioritized, targeted, and measurable" strategies and plans are more likely to improve water quality and have a better chance to be funded compared to those that are less strategic.

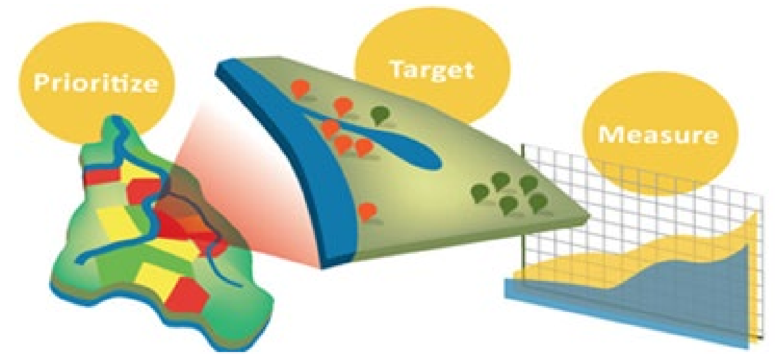

Figure 45: "Prioritized, targeted, and measurable"

"Prioritizing" refers to the process of selecting priority areas or issues based on a justified water quality, environmental, or other concern. Within the Chippewa River Watershed priority area selection criteria may include: water quality, environmental, or conservation practice effectiveness models or concerns; ordinances and rules; areas to create habitat corridors; areas of high public interest/value; and many more that can be selected to meet local needs.

Prioritization work is done by local partners and state agencies as part of the Watershed Approach work. Priorities can be selected after reviewing the known impairments and stressors. Rather than prioritizing one region over another, this work selects prioritized strategies within regions of the watershed. This information can help customize the watershed-wide adoption rates for each subwatershed. For instance, strategies that are high priority in a region may be implemented at two to three times the selected watershed adoption rate, while those that have low or no priority may be implemented at one quarter to one half of the watershed adoption rate. Adoption rate customizations should also consider the pollutant/stressor reduction goals per region and any additional prioritizing and targeting work done.

"Targeting" refers to the process of strategically selecting locations on the land (within a priority area) to implement strategies to meet water quality, environmental, or other concerns (that were identified in the prioritization process). The WRAPS report is intended to describe what it will take to restore and protect water quality. It is not intended to prescribe site specific actions; rather, the work done as part of the larger Watershed Approach should empower local partners in the One Watershed, One Plan (BWSR 2014a) process to target practices that satisfy local needs.

4 Monitoring Plan

This monitoring plan contains various types of monitoring. The data from all types of water quality and quantity monitoring will be analyzed to measure progress and effectiveness of implementation strategies, identify data gaps, and determine changing conditions. Progress toward meeting TMDL goals will be measured by regularly monitoring water quality and tracking total BMPs completed.

4.1 Intensive Watershed Monitoring

IWM was designed to assess the aquatic health of an entire major watershed through intensive biological and water chemistry sampling. The goal of the intensive approach is to allow assessment of the watershed for aquatic life, aquatic recreation, and aquatic consumption use support of the state's streams and lakes in each of the state's 80 major watersheds on a rotating 10-year cycle. These uses are assessed to make sure that the goals of the Clean Water Act are being met; having "fishable, swimmable" waters.

IWM does not sample enough sites for chemistry data to allow for chemical assessments based on the MPCA's Guidance Manual for Assessing the Quality of Minnesota Surface Waters for Determination of Impairment: 305(b) Report and 303(d) List (MPCA 2014d). In order to assist the IWM achieve its goal of assessing the aquatic health of an entire major watershed planning and communication between the MPCA bio-monitoring staff and local water monitoring staff is paramount. It is only through joint monitoring of the chosen sites that they will be able to be assessed.

4.2 Watershed Pollutant Load Monitoring Network

The CRWP has been an active partner in the MPCA's WPLMN since 2013 gathering water quality at four important sites in the Chippewa River Watershed. Site specific stream flow data from the USGS and the DNR is combined with the water quality data to compute annual pollutant loads. With sufficient funding, long term plans are to continue this WPLMN monitoring over the next 10 to 20 years. At the major river monitoring site 35 samples per year are collected year round and the other 3 sites have 25 samples collected from April through September and/or October [beginning and ending date determined by weather patterns].

Field parameter measurements include: pH, temperature, conductivity, DO, transparency tube. Laboratory measurements at a state certified lab include: TSS, TSVS turbidity, dissolved orthophosphate (DOP), TP, nitrate plus nitrite nitrogen (NO3 + NO2), total kjeldahl nitrogen (TKN)

4.3 Problem investigation monitoring

Problem investigation monitoring involves investigating problems or threats to determine specific causes of impairments and to quantify inputs of pollution from various sources. It is also used to help determine the actions needed to protect or improve a water body so water quality standards are met. Special sources of funding would be needed to conduct this type of monitoring.

4.4 Longitudinal surveys

The CRWP developed longitudinal surveys in 1999. Transparency tube readings were taken during June, July and August along the main stem and several tributaries of the Chippewa River. Readings were taken at each road crossing (242 sites) following a stream from its headwaters to its outlet. In 2009 and 2010, the data collected was expanded to include DO, temperature, conductivity, and pH, along with transparency tube readings. The CRWP established the 242 sites in STORET, now EQuIS, for the data. The data reveals geographically relevant water quality trends that are now being used to identify priority areas for effective use of project efforts. Plans are to continue the longitudinal surveys in the future. The survey methods are reliable, cost effective, simple to use and can be easily transferred to other watersheds.

4.5 Biological Monitoring

The MPCA staff monitors the health of rivers and wetlands using fish, macroinvertebrates, and plants. By measuring and evaluating the health of this aquatic life, the goal is to distinguish between naturally occurring variation and changes caused by human activities.

Once assessments of basic water quality have been made, the monitoring data gathered during intensive monitoring serves as a starting point in determining the sources and magnitude of pollution for polluted waters, or as a baseline to set protection measures for waters meeting standards.

A biological assessment was conducted by the MPCA in 2009 and that information was utilized in completing the SID for this report. The next scheduled biological assessment for the watershed is in 2019, however, conducting this assessment every five years, rather than ten, would better serve the watershed.

The DNR in 2012 established a site on the lower main stem of the Chippewa River for a yearly native mussel survey. Freshwater mussels are great indicators of healthy streams and ecosystems. Freshwater mussels are some of the most endangered invertebrates in North America.

4.6 Tile Line Monitoring

In conjunction with the Chippewa 10% project, a partnership between LSP and CRWP, tile line monitoring was started in 2014 and was continued into 2015. Funding for this type of monitoring has come from private foundation grants but has been hard to secure. A new source of funding is needed to continue this monitoring. There are three sites where equipment was placed in tile line outlets: a field with open tile intakes, a field with pattern tiling, and a field with manure application. Data from this monitoring contributes to aiding land owners/managers with nutrient reduction and management strategies. In those areas that use tile drainage this kind of monitoring is a powerful way to reach land managers and impact their management choices. Future funding of this kind of local on-farm research should be prioritized.

4.7 Pesticide Monitoring

The CRWP has a contract with the MDA to conduct pesticide monitoring in the Chippewa River Watershed to determine the impact of pesticides on surface water. The scope of work requires sampling between May 1 and August 31 in 15 day intervals, with additional storm event sampling. There are three sites in the watershed, one Tier 1 and two Tier 2 sites. The current contract is for years 2016 and 2017 and with sufficient funding pesticide monitoring should continue beyond 2017.

4.8 Citizen Volunteering Monitoring

Volunteers measure the clarity of lakes and streams. The MPCA uses this data to make decisions on assessment and watershed protection and restoration. In some lake and stream locations, data collected by volunteers (43 volunteers in 2014) are the only data available, making this work indispensable.

4.9 Buffer Surveys

Monitoring of buffer strips along the main stem and tributaries of the Chippewa River is conducted during the Longitudinal Surveys cited above. The presence or absence and width of the buffers are documented along approximately 775 miles of the Chippewa and its tributaries. Plans are to continue the buffer surveys as a component of the Longitudinal Surveys.

4.10 Bank Erosion Surveys

Bank Erosion Surveys were established by the CRWP in 2009. Sixty-two locations have bank pins established. At each site 600 feet of stream or ditch bank are surveyed. Two scientific methods for assessing the potential for bank erosion are utilized: The BEHI and the Wisconsin Bank Condition Severity Rating Method.

4.11 Best Management Practice Inventory

The CRWP and project partners listed above will track BMP installation in the watershed through inventories, BWSR e-Link, and NRCS reporting at watershed scale.

4.12 Monitoring and Research Needs

Adequate funding for staff to conduct these monitoring efforts is a monumental need for the CRWP.

Additional DO data is needed as many biological monitoring sites are showing DO stressors and there are gaps in DO data. An annual DO assessment is needed. Specifically, at each site an annual DO assessment is needed, which collects DO data every 15 minutes for 7 days or more.

Bacterial monitoring will be needed to address and work on delisting for the Chippewa River TMDL - Fecal Coliform. There is a funding need for the bacterial monitoring.

Further pollutant monitoring is needed at many sites that were listed as having insufficient data to assess. Too few samples were taken at these sites to allow for an assessment. Either the MPCA needs to conduct sufficient sampling at these sites to meet their minimum data requirements or they need to support local partners to sample these locations and inform them of the need.

4.13 Lake Monitoring

Lakes of the Chippewa River Watershed have been periodically monitored by volunteers and staff over the years. This monitoring is planned to continue to keep a record of the changing water quality as funding allows. Lakes are generally monitored for chlorophyll-a, TP, and Secchi disk transparency.

In-lake monitoring will continue as implementation activities are installed across the watersheds. These monitoring activities should continue until water quality goals are met. Some tributary monitoring has been completed on the inlets to the lakes and may be important to continue as implementation activities take place throughout the subwatersheds.

The DNR will continue to conduct macrophyte and fish surveys as allowed by their regular schedule. Currently fish surveys are conducted every five years and macrophyte surveys are conducted as staffing and funding allow on a 10-year rotation, unless there are special situations. Lake IBI surveys will be conducted in Cycle 2 of IWM, for both fish and aquatic plants. This will help to assess the condition of the lake biological communities.

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Chippewa River Reports

All Chippewa River reports referenced in this watershed report are available at the Chippewa River Watershed webpage: http://www.pca.state.mn.us/index.php/water/water-types-and-programs/watersheds/chippewa-river.html

6 Appendix

6.1 Assessments by Stream Reach

Table 15: Assessment status of stream reaches in the Chippewa River Watershed, presented (mostly) from north to south

HUC 10	AUID 07020005- (last three digits)	Stream	Reach Description	(Aquatic Life)				(Aquatic Recreation)
				Fish IBI	Macro-invertebrate IBI	Turbidity	Dissolved Oxygen	Bacteria
Chippewa River Headwaters	503	Chippewa River	Stowe Lk to Little Chippewa R		Imp	Imp		Imp
	539	County Ditch 60 (Chippewa River)	T130 R39W S14, east line to Upper Hunt Lk	NA	NA	Sup	IF	
	633	Unnamed creek	Holleque Lk to Lk Venus			Sup		
	581	Hoplin Creek	Little Chippewa Lk to Stowe Lk	NA	NA	Sup		
	634	Unnamed creek	Quam Lk to Lk Venus			Sup		
	536	Unnamed creek	Unnamed lk through Devils Lk to Little Chippewa Lk			IF		
	903	Unnamed creek	Little Freeborn Lk to Freeborn Lk			Imp		
	638	Unnamed creek	Unnamed lk to Unnamed lk	Imp	Imp			
	901	Unnamed creek (Freeborn Lake Inlet)	Headwaters to Freeborn Lk	NA		Imp		
Little Chippewa River	713	Little Chippewa River	Unnamed cr to CD 2	Imp	IF	Imp	IF	Imp
Lake Minnewaska	521	Unnamed creek	Lk Emily to Chippewa R			IF	IF	
	528	Signalness Creek	Headwaters to Outlet Cr	Sup	IF			
	523	Outlet Creek	Lk Minnewaska to Lk Emily	Imp	Imp	IF	IF	Imp
	630	Trapper Run Creek	Pelican Lk to Shallow Pond			Sup		
	628	Trapper Run Creek	Strandness Lk to Pelican Lk	Imp	Imp	Sup		IF
County Ditch 3	586	County Ditch 3	JD 9 to JD 8			Sup		
	694	Unnamed creek	Headwaters to JD 9				IF	
	504	Chippewa River	Little Chippewa R to Unnamed cr			Imp	IF	
	585	Judicial Ditch 9	Unnamed cr to CD 3			IF	IF	
	505	Chippewa River	Unnamed cr to E Br Chippewa R	Imp	IF	Imp	IF	Imp
	695	Judicial Ditch 9	Unnamed cr to Unnamed cr			Sup		
	506	Chippewa River	E Br Chippewa R to Shakopee Cr			Imp	IF	Imp
	579	County Ditch 3	CD 7 to Chippewa R	NA	NA	IF	IF	Imp
	714	Little Chippewa River	Unnamed wetland (61-0527-00) to Chippewa R	Imp	Imp	Sup		
East Branch Chippewa	580	County Ditch 15	Unnamed cr to E Br Chippewa R	NA	NA	Sup	IF	

HUC 10	AUID 07020005- (last three digits)	Stream	Reach Description	(Aquatic Life)				(Aquatic Recreation)
				Fish IBI	Macro-invertebrate IBI	Turbidity	Dissolved Oxygen	Bacteria
	623	Unnamed creek	Headwaters to Lk Ben	Imp			IF	
	627	Unnamed creek	Lk Hanson to CD 15			Sup	IF	
	514	Chippewa River, East Branch	Mud Cr to Chippewa R	Sup	Sup	Imp	IF	Imp
	625	Unnamed creek	Lk Ben to Lk Hanson			Sup	IF	
	672	Unnamed creek	Ellen Lk to Leven Lk			Sup		
	921	Unnamed creek (Gilchrist Lake Inlet)	Unnamed lk (61-0079-00) to Gilchrist Lk			Sup		
	712	Unnamed creek	Unnamed cr to E Br Chippewa R	NA	NA			
	515	Chippewa River, East Branch	Headwaters (Amelia Lk 61-0064-00) to Mud Cr	Sup	Sup	Sup	IF	Imp
	673	Unnamed creek	Villard Lk to Amelia Lk			Sup		
Mud Creek	554	Mud Creek	CD 15 to E Br Chippewa R	Imp	Imp	Sup	Imp	IF
	583	Unnamed creek	Headwaters to Mud Cr	IF	Sup			
	690	County Ditch 15	Unnamed cr to Unnamed cr	Imp	IF	Sup		
	563	Mud Creek	Unnamed lk (61-0012-00) to T123 R36W S27, west line			Sup	IF	
	551	Mud Creek	T123 R36W S28, east line to T123 R36W S29, west line		Imp	Sup		
	621	Spring Creek	Headwaters to Mud Cr			Sup	IF	
	691	County Ditch 15	Headwaters to Unnamed cr			Sup	IF	
	699	Unnamed creek	Headwaters to Spring Cr			Sup		
	564	Mud Creek	Unnamed cr to Unnamed cr			Sup		
	564	Mud Creek	T123 R36W S30, east line to Unnamed cr			Sup	IF	
Judicial Ditch 19	518	Mud Creek	T121 R39W S2, south line to E Br Chippewa R			Sup	IF	Imp
	516	Mud Creek	Headwaters to T120 R38W S1, north line	NA	NA	Sup	IF	
Shakopee Creek	559	Shakopee Creek	Shakopee Lk to Chippewa R	NA	NA	Imp	IF	Imp
	570	County Ditch 27	Unnamed ditch to Unnamed ditch	NA	NA	IF	IF	Imp
	574	Unnamed creek	Unnamed cr to Unnamed ditch			Imp		
	917	Unnamed creek (Huse Creek)	Headwaters to Norway Lk			Sup	IF	Imp
	904	Unnamed creek	Henschien Lk to Lk Andrew			Sup		IF
	916	Unnamed creek (Norway Lake Inlet)	to Norway Lk			Sup	IF	Imp
	566	Unnamed ditch (Judicial Ditch 29)	Headwaters to CD 29	Sup	IF	Sup	IF	IF

HUC 10	AUID 07020005- (last three digits)	Stream	Reach Description	(Aquatic Life)				(Aquatic Recreation)
				Fish IBI	Macro-invertebrate IBI	Turbidity	Dissolved Oxygen	Bacteria
	512	Shakopee Creek	Headwaters to T121 R36W S36, south line			Sup		
	911	Unnamed creek	Games Lk to Swan Lk			Sup	IF	Imp
	555	Shakopee Creek	T120 R36W S1, north line to Swan Lk	NA	NA	Imp	Imp	Imp
	567	County Ditch 29	Headwaters to Unnamed ditch	NA	NA	IF		
	557	Shakopee Creek	Swan Lk to Shakopee Lk	NA	NA	Sup	IF	Imp
Cottonwood Creek	510	Cottonwood Creek	Unnamed cr to T120 R41W S20, east line	NA	NA	Sup	IF	
	511	Cottonwood Creek	T120 R41W S21, west line to Chippewa R			IF	IF	
	546	Judicial Ditch 8	Unnamed cr to Unnamed ditch				IF	
	577	Unnamed creek (Cottonwood Creek)	Unnamed cr to Unnamed cr	NA	NA	Sup	IF	
	616	Unnamed creek (Cottonwood Creek)	Unnamed cr to Unnamed cr					IF
	705	Unnamed ditch	Unnamed ditch to JD 8			IF		
	578	Unnamed creek	Headwaters to Unnamed cr (Cottonwood Cr)	NA	NA	Imp	IF	Imp
	547	Judicial Ditch 8	Unnamed ditch to Cottonwood Cr			IF		
Chippewa River	501	Chippewa River	Watson Sag to Minnesota R	Imp	Sup	Imp		
	594	Spring Creek (County Ditch 10A)	T117 R40W S5, north line to Minnesota R	Sup	Imp	Sup	Imp	Imp
	576	Unnamed creek	Unnamed cr to Chippewa R	Imp	Imp			
	584	Unnamed creek	Unnamed cr to Chippewa R			Sup	IF	
	502	Chippewa River	Dry Weather Cr to Watson Sag	Sup	Imp	Imp	IF	
	708	Unnamed creek	Headwaters to Unnamed cr	IF	Imp	Imp	IF	Imp
	507	Chippewa River	Shakopee Cr to Cottonwood Cr			IF		
	508	Chippewa River	Cottonwood Cr to Dry Weather Cr			Imp	IF	
Dry Weather Creek	661	Unnamed creek	Unnamed cr to Unnamed cr	NA	NA	IF		
	709	Unnamed creek	Headwaters to Unnamed cr	NA	NA	Imp	If	Imp
	660	Unnamed creek	Unnamed cr to Dry Weather Cr		Imp	Imp		Imp
	509	Dry Weather Creek	Headwaters to Chippewa R	NA	NA			

Table Key	Assessment
Sup =	Support/not a stressor
Imp =	Impaired/ stressor
IF =	Inconclusive (need more data)

6.2 Lake assessments

Table 16: Assessment status of Chippewa River Watershed lakes, presented alphabetically by HUC 10

HUC 10	Lake	Lake ID	Assessment for Aquatic Recreation
Headwaters Chippewa River	Aaron	21-0242-00	Sup
	Block	56-0079-00	Imp
	Chippewa	21-0145-00	Sup
	Devils	21-0213-00	IF
	Fanny	21-0336-00	IF
	Freeborn	21-0162-00	Sup
	Gilbert	21-0189-00	Imp
	Indian (Kelly)	21-0136-00	IF
	Jennie	21-0323-00	Imp
	Little Chippewa	21-0212-00	Sup
	Little Oscar (Main)	21-0156-01	Sup
	Long	21-0343-00	Imp
	Lower Elk	26-0046-00	IF
	Moses	21-0245-00	Sup
	Pike	61-0183-00	IF
	Private	21-0125-00	IF
	Red Rock	21-0291-00	Imp
	South Oscar	21-0257-02	Sup
	Stowe	21-0264-00	IF
	Thompson	26-0020-00	Imp
	Venus	21-0305-00	IF
	Whiskey	21-0216-00	Sup
	Wicklund (Abrahamson)	61-0204-00	Imp
Little Chippewa River	Irgens (Irgen)	61-0211-00	Imp

HUC 10	Lake	Lake ID	Assessment for Aquatic Recreation
	Jorgenson	61-0164-00	Imp
	Maple	21-0079-00	Sup
	McIver	61-0199-00	Imp
	Rachel	21-0160-00	Sup
	Reno	61-0078-00	Imp
	Turtle	21-0090-00	Sup
Lake Minnewaska	Ann	61-0122-00	Imp
	Emily	61-0180-00	Imp
	John	61-0123-00	Imp
	Malmedal	61-0162-00	Imp
	Minnewaska	61-0130-00	Sup
	Pelican	61-0111-00	Imp
	Signalness (Mountain)	61-0149-00	Sup
	Strandness	61-0128-00	Imp
	Wallin (Wollan)	61-0156-00	IF
County Ditch (CD)3	Danielson Slough (Cyrus)	61-0194-00	Imp
	Long	75-0024-00	Imp
East Branch Chippewa River	Amelia	61-0064-00	Sup
	Benson	61-0139-00	IF
	Benson (Ben)	61-0097-00	Sup
	Edwards	61-0106-00	Imp
	Gilchrist	61-0072-00	Imp
	Hanson (Woodpecker)	61-0080-00	Imp
	Hassel	76-0086-00	Imp
	Hoff	61-0092-00	Sup

HUC 10	Lake	Lake ID	Assessment for Aquatic Recreation
	Leven	61-0066-00	Imp
	Linka	61-0037-00	Sup
	Marlu	61-0060-00	Sup
	Mary	61-0099-00	Imp
	Moore	76-0088-00	IF
	Nelson (Main Lake)	61-0101-01	Sup
	Rasmuson	61-0086-00	Imp
	Round	61-0048-00	Sup
	Scandinavian	61-0041-00	Sup
	State	61-0062-00	Sup
	Steenerson	61-0095-00	Imp
	Swenoda	61-0051-00	Imp
	Terrace Mill Pond	61-0055-00	IF
	Unnamed	61-0274-00	IF
	Villard	61-0067-00	Sup
Mud Creek	Camp	76-0072-00	Sup
	East Sunburg	34-0336-00	IF
	Goose	61-0043-00	IF
	Hefta	34-0347-00	IF
	Johanna	61-0006-00	Imp
	Johnson (Kittelson)	61-0010-00	Sup
	Monson	76-0033-00	Imp
	Simon	61-0034-00	Imp
	Sunburg	34-0359-00	IF
	Unnamed	61-0013-00	Sup

HUC 10	Lake	Lake ID	Assessment for Aquatic Recreation
	West Sunberg	76-0032-00	IF
Judicial Ditch (JD)19	Hollerberg	76-0057-00	Imp
Shakopee Creek	Andrew	34-0206-00	Sup
	Church	34-0292-00	IF
	Florida	34-0217-00	Sup
	Florida Slough	34-0204-00	Sup
	Games	34-0224-00	Sup
	Mary	34-0249-00	IF
	Middle	34-0208-00	Imp
	Norway	34-0251-00	Imp
	Swenson	34-0321-00	IF
	Unnamed	34-0327-00	IF

IF = insufficient data to make an assessment

Imp = impaired for impacts to aquatic recreation,

Sup = fully supporting aquatic recreation,

6.3 Stressors of Stream Biology

Table 17: Primary stressors to aquatic life in bio-impaired reaches in the Chippewa River Watershed

HUC-10	HUC-12 Subwatershed	AUID (Last 3 digits)	Stream	Reach Description	Biological Impairment	Primary Stressor						
						Low Dissolved Oxygen	High Nitrates	High Phosphorus	High Turbidity	Loss of Connectivity (dams, culverts)	Altered Hydrology	Poor Habitat
702000501	070200050104 070200050105 070200050107 070200050110	503	Chippewa River	Stowe Lk to Little Chippewa R	Macroinvertebrate	X		X	X		X	X
	70200050106	638	Quam and Venus Lake Drainage	Unnamed lk to Unnamed lk	Macroinvertebrate			X	X		X	
					Fish			X	X	X		
702000502	70200050203	713	Little Chippewa River	Unnamed cr to CD 2	Fish	X		X	X			X
702000503	70200050303	523	Outlet Creek	Lk Minnewaska to Lk Emily	Fish			X	X		X	
					Macroinvertebrate			X	X		X	
702000503	70200050301	628	Trappers Run	Strandness Lk to Pelican Lk	Macroinvertebrate	X		X			X	X
					Fish	X		X		X	X	X
702000504	70200050401	551	Mud Creek	T123 R36W S28, east line to T123 R36W S29, west line	Macroinvertebrate	X						
	70200050403	554	Mud Creek	CD 15 to E Br Chippewa R	Macroinvertebrate	X						
					Fish	X				X		X
702000506	70200050604	623	County Ditch 15	Headwaters to Lk Ben	Fish	X		X		X		
702000507	70200050702	714	Disconnected downstream section of the Little Chippewa River	Unnamed wetland (61-0527-00) to Chippewa R	Macroinvertebrate	X		X			X	
				Unnamed wetland (61-0527-00) to Chippewa R	Fish	X		X		X	X	
	70200050703	505	Chippewa River	Unnamed cr to E Br Chippewa R	Fish	X		X	X		X	X

HUC-10	HUC-12 Subwatershed	AUID (Last 3 digits)	Stream	Reach Description	Biological Impairment	Primary Stressor						
						Low Dissolved Oxygen	High Nitrates	High Phosphorus	High Turbidity	Loss of Connectivity (dams, culverts)	Altered Hydrology	Poor Habitat
0702000508	070200050806 070200050807	559	Shakopee Creek	Shakopee Lk to Chippewa R	Fish		X	X	X	X	X	X
702000509	70200050901	546	Cottonwood Creek	Unnamed cr to Unnamed ditch	Fish						X	X
702000511	70200051105	502	Chippewa River	Dry Weather Cr to Watson Sag	Macroinvertebrate	X		X	X		X	X
					Fish	X		X	X	X	X	X
	70200051101	507	Chippewa River	Shakopee Cr to Cottonwood Cr	Macroinvertebrate			X	X		X	X
	70200051102	508	Chippewa River	Cottonwood Cr to Dry Weather Cr	Macroinvertebrate			X	X		X	
	70200051103	584	Lines Creek	Unnamed cr to Chippewa R	Macroinvertebrate	X		X				

6.4 Point Sources in the Chippewa River Watershed

Table 18: Point Sources in the Chippewa River Watershed.

Major Subwatershed	Point Source			Pollutant reduction needed beyond current permit conditions/limits?	Notes
	Name	Permit #	Type		
Upper Chippewa	Brandon WWTP	MN0055841	Municipal wastewater	No	No discharge to surface water
Upper Chippewa	Evansville WWT[	MNG580074	Municipal wastewater	No	
Upper Chippewa	Farwell Kensington Sanitary District WWTP	MN0065293	Municipal wastewater	No	
Upper Chippewa	Hoffman WWTP	MNG580134	Municipal wastewater	No	
Upper Chippewa	Millerville WWTP	MN0054305	Municipal wastewater	No	No discharge to surface water

Major Subwatershed	Point Source			Pollutant reduction needed beyond current permit conditions/limits?	Notes
	Name	Permit #	Type		
Upper Chippewa	Urbank WWTP	MN0068446	Municipal wastewater	No	
Middle Chippewa	Cyrus WWTP	MN0052396	Municipal wastewater	No	No discharge to surface water
Middle Chippewa	Glenwood WWTP	MN0052710	Municipal wastewater	No	No discharge to surface water
Middle Chippewa	Lowry WWTP	MNG580123	Municipal wastewater	No	
Middle Chippewa	Starbuck WWTP	MN0021415	Municipal wastewater	No	
East Branch Chippewa River	Sunburg WWTP	MN0063894	Municipal wastewater	No	
Shakopee Creek	Kerkhoven WWTP	MN0020583	Municipal wastewater	No	
Shakopee Creek	Murdock WWTP	MN0052990	Municipal wastewater	No	
Lower Chippewa	Benson WWTP	MN0020036	Municipal wastewater	No	
Lower Chippeaw	Chippewa Valley Ethanol Co	MN0062898	Industrial Wastewater	No	
Lower Chippewa	Clontarf WWTP	MNG580108	Municipal wastewater	No	
Lower Chippewa	Danvers WWTP	MN0025593	Municipal wastewater	No	
Lower Chippewa	Hancock WWTP	MN0023582	Municipal wastewater	No	
Lower Chippewa	Holloway WWTP	MN0023728	Municipal wastewater	No	No discharge to surface water
Lower Chippewa	Montevideo WWTP	MN0020133	Municipal wastewater	No	City of Watson municipal wastewater is pumped to Montevideo for treatment.

Major Subwatershed	Point Source			Pollutant reduction needed beyond current permit conditions/limits?	Notes
	Name	Permit #	Type		
Upper Chippewa	Nadgwick Dairy	MNG441201	CAFO	No	
Middle Chippewa	Blair West Site	MN0066273	CAFO	No	
East Branch Chippewa River	Jennie-O Turkey Store - Rolling Forks	MNG441158	CAFO	No	
East Branch Chippewa River	Johnson Dairy Inc	MN0070033	CAFO	No	
Shakopee Creek	Willmar Poultry Farms Inc - Kerkhoven	MNG440742	CAFO	No	
Shakopee Creek	East Dublin Dairy LLP	MNG440797	CAFO	No	
Shakopee Creek	East Dublin Dairy LLP - Chippewa Calves	MNG441023	CAFO	No	
Shakopee Creek	East Dublin Dairy LLP - Dublin Dairy	MNG440472	CAFO	No	
Lower Chippewa	Hancock Pro Pork Inc - Sec 14	MNG440855	CAFO	No	
Lower Chippewa	Jennie-O Turkey Store - AJ Farm	MNG440108	CAFO	No	
Lower Chippewa	Jennie-O Turkey Store - Commerford Brood	MNG440107	CAFO	No	
Lower Chippewa	Jennie-O Turkey Store - CommerfordGrower	MNG440107	CAFO	No	
Lower Chippewa	Jennie-O Turkey Store - Swenson Farm	MNG440107	CAFO	No	
Lower Chippewa	Canadian Connection - Sec 14	MNG440305	CAFO	No	
Lower Chippewa	Michael O'Leary Farms Inc	MNG440737	CAFO	No	
Lower Chippewa	Hancock Pro Pork Inc	MNG440856	CAFO	No	
Lower Chippewa	Riverview LLP - Moore Calves	MNG440748	CAFO	No	

Major Subwatershed	Point Source			Pollutant reduction needed beyond current permit conditions/limits?	Notes
	Name	Permit #	Type		
Lower Chippewa	Stan Schaefer Inc	MNG440747	CAFO	No	
Dryweather Creek	Eric Meyer Farm	MNG441050	CAFO	No	
Upper Chippewa	Jack's Family Recycling Center LLC - Evans - ISW	MNRNE33GT	Industrial Stormwater	No	
Middle Chippewa	Canadian Pacific Railway - Glenwood Yard - SW	MNR053528	Industrial Stormwater	No	
Middle Chippewa	Lowry Manufacturing Co Inc - ISW	MNR0535ZW	Industrial Stormwater	No	
Middle Chippewa	MHC Fabrication Division - Glenwood - SW	MNR0535XW	Industrial Stormwater	No	
Middle Chippewa	Northern Metals LLC - ISW	MNR05348C	Industrial Stormwater	No	
Middle Chippewa	WASP Inc - Conveyor Division - SW	MNR0533WM	Industrial Stormwater	No	
Middle Chippewa	WASP Inc - GSE Division - SW	MNR0533WN	Industrial Stormwater	No	
Shakopee Creek	Kandiyohi County Sanitary Landfill - SW	MNR0536VT	Industrial Stormwater	No	
Lower Chippewa	Lorenz Manufacturing Co - SW	MNR0535TK	Industrial Stormwater	No	
Lower Chippewa	CNH America LLC - Benson LA Mfg Facility - ISW	MNR0536K5	Industrial Stormwater	No	
Lower Chippewa	CNH America LLC - Benson Main Facility - ISW	MNR0536K4	Industrial Stormwater	No	
Lower Chippewa	CNH America LLC - Benson Northstar Facility - ISW	MNR0536K6	Industrial Stormwater	No	

6.5 Septic Compliance by County

Table 19: Septic Compliance by County

Jurisdiction Information			Compliance						
Jurisdiction	SSTS Compliance Inspections for Property Transfer?	Total # Individual SSTS	Est % all systems Failing (FTPGW) Enter Number only, do not include percent sign or a decimal number	Calculated # of Failing (FTPGW)	Est % all Systems ITPHS	Calculated # of ITPHS	Est % all Compliant SSTS	Calculated # of Compliant	Total % SSTS=100%
Chippewa County	No	2,177	6	131	47	1,023	47	1,023	100
Douglas County	yes	5,335	14	747	3	160	85	4,535	102
Grant County	Yes	1,134	16	181	9	102	60	680	85
Kandiyohi County	Yes	6,114	27	1,651	2	122	71	4,341	100
Otter Tail County	Yes	21,731	25	5,433	5	1,087	70	15,212	100
Pope County	Yes	6,048	15	907	1	60	84	5,080	100
Stevens County	No	1,201	2	24	23	276	72	865	97
Swift County	Yes	3,975	50	1,988	22	875	24	954	96
TOTALS		47,715		11,062		3,705		32,690	

SSTS= Subsurface Sewage Treatment Systems, ITPHS =Imminent Threat to Public Health or Safety, FTPGW = Failing To Protect Groundwater

6.6 Animal Units in the Chippewa River Watershed

Table 20: Animal Units of the Chippewa River Watershed by number of Animal Units per farm and by Primary Stock Type

Farm size by Animal Unit	Number of farms	Animal Units
0-50	261	6,675
51-100	252	18,707
101-250	281	45,885
251-500	112	37,057
501-999	55	40,170
>999	22	47,518
Total	**983**	**196,013**

Primary Stock	Percent of all livestock in Chippewa River Watershed	Total Animal Units
BOVINES	66.43%	125,996
PIGS	20.41%	38,716
BIRDS	12.23%	23,205
GOAT/SHEEP	0.53%	1,012
DEERELK	0.24%	447
HORSES	0.12%	235
OTHER	0.03%	52

6.7 Nutrient BMP Summary Info from Minnesota and Iowa State Reduction Strategy Reports

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

IA: http://www.nutrientstrategy.iastate.edu/sites/default/files/documents/NRS2-141001.pdf

Table 1. Effectiveness of hydrological management practices to reduce nitrate (NO_3-N) concentrations under tile drainage management.

Type of study	Reference	Site	% Reduction in NO_3-N loss
Drainage	Sands et al. (2006)	Minnesota	15%
	Nangia et al. (2010)	Minnesota	59 to 78%
	Kalita and Kanwar (1993)	Iowa	39%
	Lalonde et al. (1996)	Quebec, Canada	62 to 96%
	Drury et al. (1996)	Ontario, Canada	49%
	Drury et al. (2009)	Ontario, Canada	31 to 44%
	Thorp et al. (2009)	Midwestern U.S.	31%
	Tan et al. (1998)	Ontario, Canada	14 to 26%
	Fausey (2005)	Ohio	46%
	Feser 2012	Minnesota	25%
	Ng et al. (2002)	Ontario, Canada	36%
	Woli et al. (2010)	Illinois	70%
	Range of % reduction		**14 to 96%**
Bioreactors	Blowes et al. (1994)	Ontario (field)	99%
	Roberson and Cherry (1995)	Canada (septic systems)	58 to 96%
	Schipper and Vojvodić-Vuković (1998)	New Zealand (field)	60 to 88%
	Schipper and Vojvodić-Vuković (2001)	New Zealand (field)	>95%
	Greenan et al. (2009)	Laboratory experiment	30 to 100%
	Greenan et al. (2006)	Laboratory experiment	80 to 96%
	Chun et al. (2009)	Laboratory experiment	10-40 to 100%
	Chun et al. (2010)	Illinois (field)	47%
	Christianson et al. (2011)	Iowa (field)	30-70%
	Verma et al. (2010)	Illinois (field)	42 to 98%
	Woli et al. (2010)	Illinois (field)	33%
	van Driel et al. (2006)	Ontario (field)	33 to 53%
	Jaynes et al. (2008)	Iowa (field)	55%
	Robertson et al. (2000)	Ontario (field)	58%
	Ranaivoson et al. (2012)	Minnesota (snowmelt+ rainfall-field)	31 to 74%
	Ranaivoson et al. (2012)	Minnesota (field)	47%
	Range of % reduction		**10 to 99%**

Table 2. Effectiveness of N management practices to reduce nitrate (NO_3-N) concentrations under tile drainage management.

Type of study	Reference	Site	% of Reduction in NO_3-N loss
N rates	Buzicky et al. (1983)	Minnesota	28%
	Nangia et al. (2005a)	Minnesota (model)	12 to 15%
	Gowda et al. (2006)	Minnesota (model)	11 to 14%
	Jaynes et al. (2004a)‡	Iowa	30%
	Baksh et al. (2004)	Iowa	17%
	Nangia et al. (2010)	Minnesota (model)	23%
	Kladivko et al. (2004)†	Indiana	70%
	Range of % reduction		**11 to 70%**
N application time and Inhibitors			
	Smiciklas and Moore (1999)	Illinois	58%
	Randall and Mulla (2001)	Minnesota	36%
	Gowda et al (2006)	Minnesota	34%
	Nangia et al. (2005b)	Minnesota	6%
	Randall et al (2003)	Minnesota	17 to 18%
	Randall and Vetsch (2005)	Minnesota	10 to 14%
	Range of % reduction		**10 to 58%**
Split applications	Randall et al. (2003)	Minnesota	13%
	Jaynes et al. (2004)	Iowa	30%
	Range of % reduction		**13 to 30%**

† This reduction also includes the effect of changing crop rotation and adding cover crops plus changing N rate over time.
‡ This reduction is also related to changing time of application.

Table 3. Effectiveness of landscape diversification management practices to reduce nitrate (NO_3-N) concentrations.

Type of study	Reference	Site	% Reduction NO_3-N
Riparian Buffers*	Barfield et al. (1998)	Kentucky	95 to 98%
	Blanco-Canqui et al (2004a)	Missouri	94%
	Blanco-Canqui et al (2004b)	Missouri	47 to 69%
	Dillaha et al (1989)	Virginia	54 to 77%
	Magette et al. (1989)	Maryland	17 to 72%
	Schmitt et al. (1999)	Nebraska	57 to 91%
	Lowrance and Sheridan (2005)	Georgia	59 to 78 %
	Duff et al (2007)	Minnesota	67 to 99%
	Range of % reduction		**17 to 99%**
Wetlands	Appelboom and Fouss (2006)		37 to 83%
	Kovacic et al. (2000)	Illinois	33 to 55%
	Crumpton et al. (2006)	Iowa	25 to 78%
	Hunt et al. (1999)	North Carolina	70%
	Xue et al. (1999)	Illinois	19 to 59%
	Iovanna et al. (2008)	Iowa	40 to 90%
	Range of % reduction		**19 to 90%**

*Note: none of the riparian buffer studies referenced here were at sites with subsurface tile drainage.

Table 4. Effectiveness of landscape diversification management practices to reduce nitrate (NO_3-N) concentrations under tile drainage management.

Type of study	Reference	Site	% Reduction in NO_3-N loss
Alternative cropping systems	Randall et al. (1997)	Minnesota	7 to 98%
	Boody et al. (2005)	Minnesota	51 to 74%
	Simpkins et al. (2002)	Iowa	5 to 15%
	Range of % reduction		**5 to 98%**
Cover crops			
	Kladivko et al. (2004)	Indiana	<60%
	Feyereisen et al. (2006)	Minnesota	11 to 30%
	Strock et al. (2004)	Minnesota	13%
	Jaynes et al. (2004b)	Iowa	60%
	Kaspar et al. (2007)	Iowa	61%
	Range of % reduction		**11 to 60%**

Table 2. Nitrogen reduction practices – potential impact on nitrate-N reduction and corn yield based on literature review.

	Practice	Comments	% Nitrate-N Reduction[+]	% Corn Yield Change++
			Average (SD*)	Average (SD*)
Nitrogen Management	Timing	Moving from Fall to Spring Pre-plant Application	6 (25)	4 (16)
		Spring pre-plant/sidedress 40-60 split Compared to Fall Applied	5 (28)	10 (7)
		Sidedress - Compared to Pre-plant Application	7 (37)	0 (3)
		Sidedress – Soil Test Based Compared to Pre-plant	4 (20)	13 (22)
	Source	Liquid Swine Manure Compared to Spring Applied Fertilizer	4 (11)	0 (13)
		Poultry Manure Compared to Spring Applied Fertilizer	-3 (20)	-2 (14)
	Nitrogen Application Rate	Reduce to Maximum Return to Nitrogen value 149 kg N/ha (133 lb N/ac) for CS and 213 kg N/ha (190 lb N/ac) for CC	10‡	-1‡‡
	Nitrification Inhibitor	Nitrapyrin – Fall - Compared to Fall-Applied without Nitrapyrin	9 (19)	6 (22)
	Cover Crops	Rye	31 (29)	-6 (7)
		Oat	28 (2)**	-5 (1)
	Living Mulches	e.g. Kura clover - Nitrate-N reduction from one site	41 (16)	-9 (32)
Land Use	Perennial	Energy Crops Compared to Spring- Applied Fertilizer	72 (23)	-100[ɣ]
		Land Retirement (CRP) Compared to Spring- Applied Fertilizer	85 (9)	-100[ɣ]
	Extended Rotations	At least 2 years of alfalfa in a 4 or 5 year rotation	42 (12)	7 (7)
	Grazed Pastures	No pertinent information from Iowa - Assume similar to CRP	85***	NA
Edge-of-Field	Drainage Water Mgmt.	No impact on concentration	33 (32)^	
	Shallow Drainage	No impact on concentration	32 (15)^	
	Wetlands	Targeted Water Quality	52†	
	Bioreactors		43 (21)	
	Buffers	Only for water that interacts with active zone below the buffer - a small fraction of all water that makes it to a stream.	91 (20)	

+ A positive number is nitrate concentration or load reduction and a negative number is increased nitrate.

++ A positive corn yield change is increased yield and a negative number is decreased yield. Soybean yield is not included as the practices are not expected to affect soybean yield.

* SD = standard deviation.

‡ Reduction calculated based on initial application rate for each Major Land Resource Area (MLRA).

‡‡ Calculated based on the Maximum Return to Nitrogen (MRTN) relative yield at the given rates.

** Based on 1 study with 3 years of corn and 2 years of soybean.

*** This number is based on the Land Retirement number – there are no observations to develop a SD.

^ These numbers are based on load reduction since there is no impact on concentration with these practices

† Based on one report looking at multiple wetlands in Iowa (Helmers et al., 2008a).

Table 3. Practices with the largest potential impact on phosphorus load reduction.
Notes: Corn yield impacts associated with each practice also are shown as some practices may be increase or decrease corn production. See text for information on value calculations.

	Practice	Comments	% Phosphorus Load Reduction[a]	% Corn Yield Change[b]
			Average (SD[c])	Average (SD[c])
Phosphorus Management Practices	Phosphorus Application	Applying P based on crop removal - Assuming optimal soil-test P level and P incorporation	0.6[d] [70[e]]	0[f]
		Soil-Test P – Producer does not apply P until soil-test P drops to the optimal level	17[g] [40[h]]	0[f]
		Site-specific P management		0[f]
	Source of Phosphorus	Liquid swine, dairy, and poultry manure compared to commercial fertilizer – Runoff shortly after application	46 (45)	-1 (13)
		Beef manure compared to commercial fertilizer – Runoff shortly after application	46 (96)	
	Placement of Phosphorus	Broadcast incorporated within one week compared to no incorporation – Same tillage	36 (27)	0[f]
		With Seed or knifed bands compared to surface application without incorporation	24 (46) [35[i]]	0[f]
Erosion Control and Land Use Change Practices	Tillage	Conservation till – chisel plowing compared to moldboard plowing	33 (49)	0 (6)
		No till compared to chisel plowing	90 (17)	-6 (8)
	Crop Choice	Extended rotation	[j]	7 (7)[k]
	Perennial	Energy crops	34 (34)	NA
		Land retirement (CRP)	75	NA
		Grazed pastures	59 (42)	NA
	Terraces		77 (19)	
Edge-of-Field Practices	Wetlands	Targeted water quality	[l]	
	Buffers		58 (32)	
	Sediment Control	Sedimentation basins	85	

a - A positive number is phosphorus reduction and a negative number is increased phosphorus.
b - A positive corn yield change is increased yield and a negative number is decreased yield. Practices are not expected to affect soybean yield.
c - SD = standard deviation.
d - Maximum and average estimated by comparing application of 200 and 125 kg P_2O_5/ha, respectively, to 58 kg P_2O_5/ha (corn-soybean rotation requirements) (Mallarino et al., 2002).
e - This represents the worst case scenario as data is based on runoff events 24 hours after P application. Maximum and average were estimated as application of 200 and 125 kg P_2O_5/ha, respectively, compared to 58 kg P_2O_5/ha (corn-soybean rotation requirements), considering results of two Iowa P rate studies (Allen and Mallarino, 2008; Tabbara, 2003).
f - Indicates no impact on yield should be observed.
g - Maximum and average estimates based on reducing the average STP (Bray-1) of the two highest counties in Iowa and the statewide average STP (Mallarino et al., 2011a), respectively to an optimum level of 20 ppm (Mallarino et al., 2002). Minimum value assumes soil is at the optimum level.
h - Estimates made from unpublished work by Mallarino (2011) in conjunction with the Iowa P Index and Mallarino and Prater (2007). These studies were conducted at several locations and over several years but may, or may not, represent conditions in all Iowa fields.
i - Numbers are from a report by (Dinnes, 2004) and are the author's professional judgment.
j - There is scarce water quality data for P loss on extended rotations in Iowa compared to a corn-soybean rotation.
k - This increase is only seen in the corn year of the rotation – one of five years.
l - Specific conditions are important in wetlands with regards to P as with changing inflow loads.

Table 28. Example Statewide Combination Scenarios that Achieve the Targeted Nitrate-N Reductions, Associated Phosphorous Reductions and Estimated Equal Annualized Costs based on 21.009 Million Acres of Corn-Corn and Corn-Soybean Rotation.

Notes: Research indicates large variation in reductions from practices that is not reflected in this table. Additional costs could be incurred for some of these scenarios due to industry costs or market impacts.

Name	Practice/Scenario**	Nitrate-N % Reduction from baseline	Phosphorus % Reduction from baseline	Cost of N Reduction from baseline ($/lb)	Initial Investment (million $)	Total EAC* Cost (million $/year)	Statewide Average EAC Costs ($/acre)
NCS1	Combined Scenario (MRTN Rate, 60% Acreage with Cover Crop, 27% of ag land treated with wetland and 60% of drained land has bioreactor)	42	30	2.95	3,218	756	36
NCS2	Combined Scenario (MRTN Rate, 100% Acreage with Cover Crop in all MLRAs but 103 and 104, 45% of ag land in MLRA 103 and 104 treated with wetland, and 100% of tile drained land in MLRA 103 and 104 treated with bioreactor)	39	40	2.61	2,357	631	30
NCS3	Combined Scenario (MRTN Rate, 95% of acreage in all MLRAs with Cover Crops, 34% of ag land in MLRA 103 and 104 treated with wetland, and 5% land retirement in all MLRAs)	42	50	4.67	1,222	1,214	58
NCS4	Combined Scenario (MRTN Rate, Inhibitor with all Fall Commercial N, Sidedress All Spring N, 85% of all tile drained acres treated with bioreactor, 85% of all applicable land has controlled drainage, 38.25% of ag land treated with a wetland)	42	0	0.88	4,810	225	11
NCS5	Combined Scenario (MRTN Rate, Inhibitor with all Fall Commercial N, Sidedress All Spring N, 65% of all tile drained acres treated with bioreactor, 65% of all applicable land has controlled drainage, 29.25% of ag land treated with a wetland, and 15% of corn-soybean and continuous corn acres converted to perennial-based energy crop production)	41	11	5.58	3,678	1,418	67
NCS6	Combined Scenario (MRTN Rate, 25% Acreage with Cover Crop, 25% of acreage with Extended Rotations, 27% of ag land treated with wetland, and 60% of drained land has bioreactor)	41	19	2.13	3,218	542	26
NCS7	Combined Scenario (MRTN Rate, Inhibitor with all Fall Commercial N, Sidedress All Spring N, 70% of all tile drained acres treated with bioreactor, 70% of all applicable land has controlled drainage, 31.5% of ag land treated with wetland, and 70% of all agricultural streams have a buffer)	42	20	0.95	4,041	240	11

NCS8	Combined Scenario (MRTN Rate, Inhibitor with all Fall Commercial N, Sidedress All Spring N, 70% of all tile drained acres treated with bioreactor, 70% of all applicable land has controlled drainage, 31.5% of ag land treated with a wetland, and 70% of all agricultural streams have a buffer) - Phosphorus reduction practices (phosphorus rate reduction on all ag land, Convert 90% of Conventional Tillage CS & CC acres to Conservation till and Convert 10% of Non-No-till CS & CC ground to No-Till)	42	29	***	4,041	77	4

Table 26. Example Statewide Combination Scenarios that Achieve Targeted P Reductions and Associated Nitrate-N Reductions

Notes: Estimated EAC based on 21.009 Million Acres of Corn-Corn and Corn-Soybean Rotation.
Research indicates large variation in reductions. Some practices interact such that the reductions are not additive.
Additional costs could be incurred for some of these scenarios due to industry costs or market impacts.

		Phosphorus	Nitrate-N	Cost of P Reduction $/lb (from baseline)	Total EAC Cost* (million $/year)	Average EAC Costs ($/acre)
Name	**Practice/Scenario****	**% Reduction (from baseline)**				
BS	Baseline					
PCS1	Phosphorus rate reduction on all ag acres (CS, CC, EXT, and pasture); Conservation tillage on all CS and CC acres; Buffers on all CS and CC acres	30	7	-18.03	-182.7	-$8
PCS2	Phosphorus rate reduction on 56% of all ag acres (CS, CC, EXT, and pasture); Convert 56% of tilled CS and CC acres to No-Till; Buffers on 56% CS and CC acres	29	4	-4.41	-43.0	-$2
PCS3	Phosphorus rate reduction on 53% of all ag acres (CS, CC, EXT, and pasture); Convert 53% of tilled CS and CC acres to No-Till; Cover crops on No-till CS and CC acres	29	14	45.76	449.9	$20
PCS4	Phosphorus rate reduction on 63% of ag acres (CS, CC, EXT, and pasture); Convert 63% of tilled CS & CC acres to No-till and cover crops on No-till crop acres except for MLRAs 103 and 104	29	9	19.55	189.5	$8
PCS5	Phosphorus rate reduction on 48% of ag acres (CS, CC, EXT, and pasture); Convert 48% of tilled CS and CC acres to No-till with Cover Crop on No-till acres; Buffers on 48% CS and CC acres	29	16	-3.41	-33.2	-$1

***EAC stands for Equal Annualized Cost (50-year life and 4% discount rate) and factors in the cost of any corn yield impact as well as the cost of physically implementing the practice. Average cost based on 21.009 million acres, costs will differ by region, farm and field.**

****These practices include substantial initial investment costs.**

6.8 Agricultural BMP Summary Table

Table 21: Agricultural BMP Summary Table

Conservation Practice: Practice "group"		Individual Practices (Ag BMP Handbook page#)	Sediment (from upland/field)	Phosphorus (Total, dissolved, or particulate)	Nitrogen (Total, nitrate, or dissolved)	Pesticides (one or more)	Bacteria (fecal and/or e. coli)	Hydrology	Habitat	Sediment (from bank, bluff, channel or ravine)
Restore to natural/ minimal management		Conservation Cover (22) land out of production, into vegetation	*	*	10mg/L in streams with 3% of watershed in practice **					
		Restored Wetland (151) (previously drained; typically larger)	>75% reduction *	0-50% TP reduction *	68- >85% TN reduction *					
Improve soil health and/or vegetation	General (can do anywhere)	Cover Crops (36)	32-92% reduction	54-94% TP reduction 7-63% dP reduction	13-64% TN reduction 66% TN reduction**	40% reduction		11% reduction in volume of tile drainage		
		Conservation Tillage (94) (no-till or high residue)	90% reduction 6-99% reduction **	57% dP reduction 59-91% TP reduction **	-3-91% TN reduction **			56%-99% reduction in surface runoff		
		Nutrient Management (48)	15-65% reduction after adding manure**	50% dP reduction 14-91% TP reduction**	10-40% TN reduction**			2-62% reduction in runoff volume after adding manure		
		Crop Rotation (26) including perennial or small grains	32-92% reduction	53-67% TP reduction	59-62% TN reduction 66-68% TN reduction *					
		Pest Management (60)				17-43% reduction 40-50% (5 years) 70-80% (10 years)*				
	Site-specific	Contour Buffer Strips (28) applies only to steep fields	83-91% reduction 30-94% reduction*	49-80% TP reduction 20-50% dP reduction	27-50% TN reduction 18-49% dN reduction	53-77% reduction*	43-74% reduction			
		Grassed Waterway (84) for concentrated surface flows/gullies	94-98% reduction 77-97% reduction **			70-96% reduction **		2-20% reduction in surface runoff (modeled)		
		Contour Stripcropping (72) 50% or more of field in grass, etc..	43-95% reduction	70-85% TP reduction 8-93% TP reduction	20-55% TN reduction					
		Terrace (113) applies only to steep fields	80-95% reduction	70-85% TP reduction	20-55% TN reduction					
		Contour Farming (33) applies only to steep fields	28-67% reduction	10-62% TP reduction	25-68% TN reduction					
Improve water manage-ment (retention and filtration)	Tile drainage /subsurface water	Alternative Tile Intakes (67) replacing open intakes	70-100% reduction*	*						
		Tile System Design (63) shallower and wider pattern			40-47% NO_3 reduction					
		Saturated Buffers (not in handbook) intercepting tile drainage water								
		Controlled Drainage (75)		50% TP reduction 63% dP reduction *	20-61% NO_3 reduction *			15-50% reduction in volume of tile drainage		
		Woodchip Bioreactor (156) (for tile drainage water)		*	30-50% NO_3 reduction *	*	*			
	Surface water	Treatment Wetland (146) (constructed; typically smaller)	75% reduction in urban settings *	59% TP reduction * 49-56% dP reduction 71-74% TP	40-43% TN reduction 64% TN reduction					
		Filter Strips, Field Borders (125)	76-91% reduction 0-99% reduction **	38-96% TP reduction 50% dP reduction 2-93% TP	27% TN reduction 1-93% NO_3 reduction **	45-78% reduction *	*			
		Sediment Basin (134)	60-90% reduction 77% reduction	34-73% TP reduction 72% TP reduction	30% TN reduction 82% NO_3 reduction		70% reduction			
		Side Inlet Control to Ditch (137) for grade stabilization and retention								
		Extended Retention (80) created by culvert/road design						11-41% reduction in 10-yr peak flow for drainage area		
		Water & Sediment Basin (143)	64 (modeled) - 99% reduction	74% organic P 80% sediment-bound P (modeled)						
Improve riparian areas		Riparian and Channel Veg (99) intercepting surface runoff	53-99.7% reduction 55-95% reduction	41-93% TP reduction 63% pP reduction	58-92% TN reduction 37-57% TN reduction					
		Streambank Stabilization (109) using bioengineering techniques								
		Two Stage Ditch (115) replacing trapezoidal ditch			5-15% TN reduction*					*
		Grade Stabilization (40) of headcut in ravine or small channel								75-90% reduction
Improve livestock and/or manure management		Rotational Grazing (103) replacing row crops/continuous graze	49% reduction compared to row crop	75% reduction compared to row crop	62% reduction compared to row crop		consistently lower than continuous graze			
		Livestock Exclusion (45) applies only to livestock operations		75% TP reduction	62% TN reduction 32% NO_3 reduction					49% reduction 82-84% reduction
		Waste Storage Facility (91) improved from leaky structure		25-90% TP reduction	29-80% TN reduction*					
		Feedlot Runoff Control (121) improvements to system with runoff	79% reduction 35-95% reduction *	83% TP reduction * 30-85% TP reduction	84% TN reduction 10-45% TN reduction *		Up to 99% removal *	67% reduction in surface runoff		

Notes: Numeric effectiveness and level of study from the MN Ag BMP Handbook (Miller et al., 2012). Relative effectiveness (shades) estimated by local conservation professionals. Refer to the handbook for additional details and before selecting a BMP to ensure its applicability, siting and design criteria. Rev date: 4/29/14 JB

Relative Effectiveness
- very effective BMP
- somewhat effective BMP
- minimally effective BMP
- not effective BMP

Level of Study in Upper Midwest
- ** well studied
- * some study

6.9 Chippewa 10 Percent Scenario Model

RESPEC

RSI(MPO)-2435/2-15/34

External Memorandum

To: Mr. George Boody
Land Stewardship Project
821 East 35th Street, Suite 200
Minneapolis, MN 55407

cc: Mr. Jason Love, RESPEC
Project Central File 2435 — Category A

From: Ms. Emily Javens
Ms. Cindie McCutcheon
RESPEC
1935 West County Road B2, Suite 320
Roseville, MN 55113

Date: June 19, 2015 (Revised Memo – Original Date: February 20, 2015)

Subject: Chippewa 10 Percent Scenario Model

The Land Stewardship Project (LSP) and Chippewa River Watershed Project (CRWP) co-coordinate the Chippewa 10% Project (C10). This C10 engages farmers, landowners, scientists and conservationists to advance solutions including more continuous living cover in agriculture that can protect and restore our waters and for fishing hunting, swimming, and recreation, provide good wildlife habitat and be profitable for farmers. CRWP has conducted water quality monitoring in the Chippewa River Watershed. Other partners who worked on modeling include: the Agricultural Research Service's North Central Soil Conservation Research Lab (ARS), University of Minnesota Extension Service and University of Minnesota's West Central Research and Outreach Center. LSP convened and directed modeling efforts of the C10 partners as well as providing the GIS analysis and files to RESPEC for baseline crop rotations in the focal areas and identifying areas to apply "what if" scenarios for modeling changes to water quality. In this document, when LSP is used it means LSP on behalf of the Chippewa 10% Project partners.

The CRWP recently analyzed 15 years of monitoring data and discovered a correlation between land cover and in-stream pollutant concentrations. This correlation suggested water quality goals could be met if perennial cover in the watershed was increased to 34 percent. The current perennial cover is estimated to be 24 percent, which indicates that 10 percent more permanent cover on the landscape is needed. The Agricultural Production Systems sIMulator (APSIM) software was also used to complete the modeling. ARS led modeling on the APSIM allows the user to simulate how a variety of different crops, soils, weather, and management actions interact. It generated ecosystem services output coefficients for crop rotations that were also mapped [Jaradat and Boody, 2011]. LSP selected relevant ecosystem services output coefficients, generated from APSIM and statistically analyzed by ARS, to use in HSPF modeling.

An HSPF model application existed in the Chippewa River Watershed with a modeling period of 1995–2012. Further information on developing and calibrating the Chippewa model application is available in external memoranda [Kenner, 2014a; 2014b]. Multiple scenarios were run in HSPF to determine results of specified land-use changes that the LSP has been working on with landowners. Before the scenarios were run, the watershed boundaries of the original model were updated to match three LSP-specified focal areas—the East Branch Chippewa, the Middle Main Chippewa, and the Shakopee Creek (Figure 1). Setup included acquiring the model application, Geographic Information System (GIS) files, and model documentation to ensure that the application executed properly. HSPF subwatersheds and reaches are illustrated in Figure 2. In addition, the baseline model predictions were analyzed to quantify the baseline loadings and loading rates for total phosphorus (TP), total nitrogen (TN), and total suspended solids (TSS). TP includes orthophosphate and organic phosphorus, and TN includes nitrate, nitrite, ammonia, and organic nitrogen. The following four scenarios were run, some of which used efficiency factors derived by LSP from ARS APSIM modeling:

- Scenario A—Decrease conservation reserve program grasses
- Scenario B—Reduce nitrogen application on corn fields
- Scenario C—Increase perennial cover
- Scenario D—Diversify crop rotations on good farmland.

SCENARIO A—DECREASE CONSERVATION RESERVE PROGRAM GRASSES

The LSP realizes that their goal of improving water quality by increasing perennial cover by 10 percent means that no losses of land currently in perennial cover can occur. Unfortunately, land enrolled in conservation programs, such as the Conservation Reserve Program (CRP), is being threatened by high crop prices. For Scenario A, the impacts of land anticipated to exit the CRP program in focal areas of the Chippewa River Watershed were modeled. Lands to exit CRP were predicted by an economic model used by researchers at the University Of Minnesota Department Of Applied Economics. The economic model uses CRP parcels enrolled in 2007 and predicts their likelihood of exit from 2014-2019 based on 2010 crop prices. The schematic in an HSPF model application tells the model the total area of each land use that contributes to each subwatershed. For Scenario A, the areas that represented CRP exit areas in the East Branch, Middle Main, and Shakopee focal areas were adjusted in the base schematic from their base land use to cropland. Occasionally CRP exit areas slightly overlapped with base land uses that were not grassland or pasture in the National Land Cover Dataset. For this scenario, the overlapping urban areas were not converted to cropland. The Scenario A areas that represented CRP exit areas are illustrated in Figure 3.

Load and concentration changes resulting from Scenario A are provided in Tables 1 and 2, respectively. Scenario A average loads of TN, TP, and TSS in the focal areas increased from the base scenario by 0.8 percent, 0.7 percent, and 0.6 percent, respectively. Scenario A average concentrations of TN, TP, and TSS in the focal areas changed from the base scenario by 0.2 percent, 0.2 percent, and 0.2 percent, respectively.

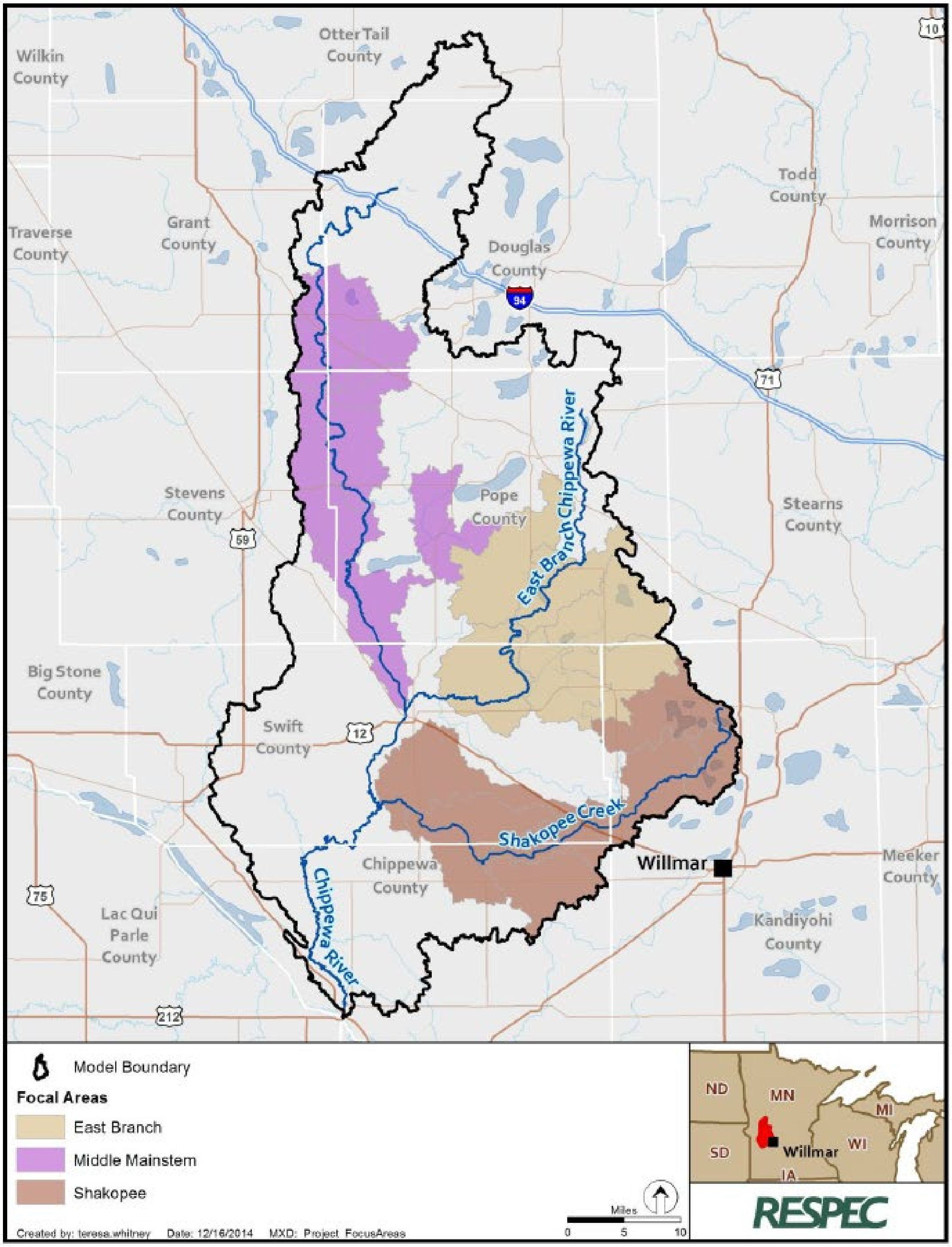

Figure 1. HSPF Model Boundary and Focal Areas.

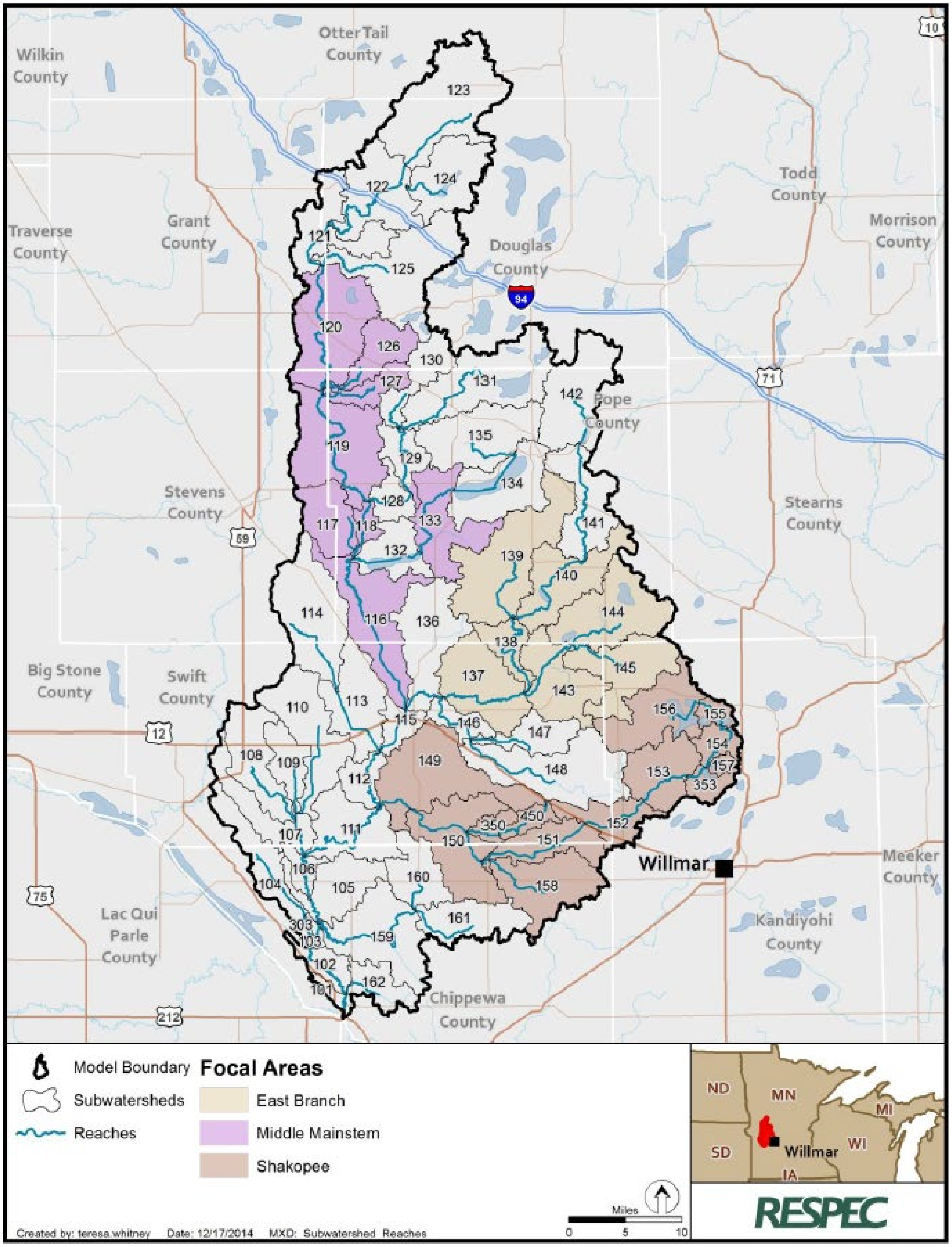

Figure 2. HSPF Subwatersheds and Reaches.

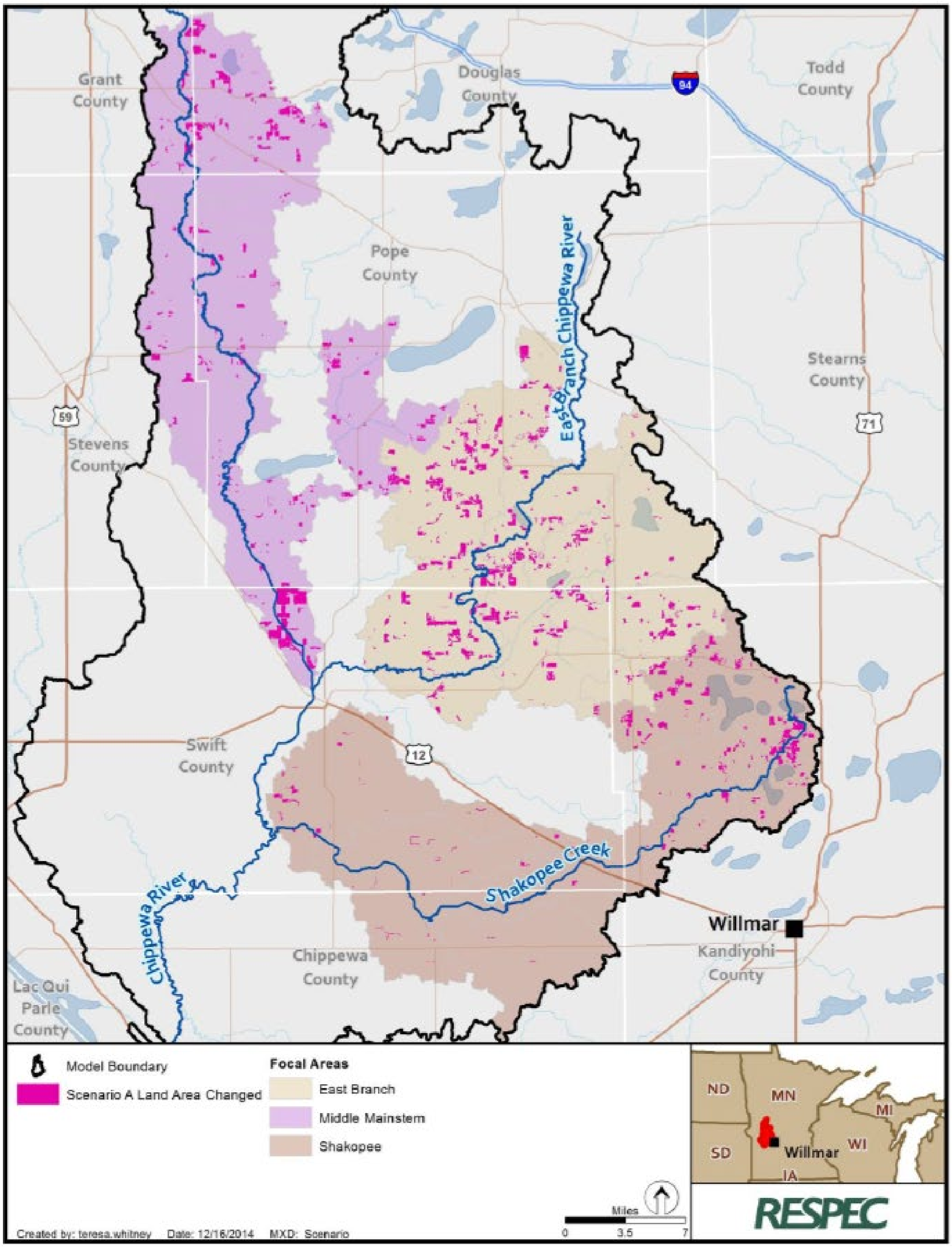

Figure 3. Land Predicted to Exit the Conservation Reserve Program Scenario A.

Table 1. Scenario A: Change in Load from Base Condition

Location	Variable	Base Load (lb/year)	Scenario A Load (lb/year)	Percent Change
East Branch (HSPF Reach 137)	Total Nitrogen	764,720	774,947	1.3
	Total Phosphorus	53,207	53,786	1.1
	Total Suspended Solids	31,861,278	32,116,654	0.8
Middle Main (HSPF Reach 116)	Total Nitrogen	891,630	896,379	0.5
	Total Phosphorus	117,919	118,660	0.6
	Total Suspended Solids	87,903,141	88,325,623	0.5
Shakopee (HSPF Reach 149)	Total Nitrogen	1,505,064	1,513,443	0.6
	Total Phosphorus	72,506	72,867	0.5
	Total Suspended Solids	31,695,735	31,886,450	0.6
Chippewa Outlet (HSPF Reach 106)	Total Nitrogen	4,242,047	4,264,816	0.5
	Total Phosphorus	314,598	316,235	0.5
	Total Suspended Solids	182,584,216	183,477,272	0.5

lb/year = pounds per year.

Table 2. Scenario A: Change in Concentration from Base Condition

Location	Variable	Base Concentration (mg/L)	Scenario A Concentration (mg/L)	Percent Change
East Branch (HSPF Reach 137)	Total Nitrogen	1.87	1.88	0.4
	Total Phosphorus	0.122	0.122	0.3
	Total Suspended Solids	31.85	31.92	0.2
Middle Main (HSPF Reach 116)	Total Nitrogen	1.59	1.59	0.1
	Total Phosphorus	0.141	0.141	0.2
	Total Suspended Solids	30.63	30.64	0.0
Shakopee (HSPF Reach 149)	Total Nitrogen	3.49	3.50	0.2
	Total Phosphorus	0.186	0.186	0.1
	Total Suspended Solids	46.44	46.60	0.4
Chippewa Outlet (HSPF Reach 106)	Total Nitrogen	2.18	2.18	0.1
	Total Phosphorus	0.16	0.16	0.1
	Total Suspended Solids	37.78	37.84	0.2

mg/L = milligrams per liter.

SCENARIO B—REDUCE NITROGEN APPLICATION ON CORN FIELDS

In HSPF, loads from different land uses can be adjusted based on efficiencies. The APSIM nitrate (NO3-N) efficiency factor represented NO3-N leaching in the watershed. Therefore, for Scenario B, the APSIM efficiency factor supplied by LSP was used, which represented a 13 percent reduction to NO3-N in subsurface and groundwater outflow in the model application. To acquire an efficiency factor for the nitrates in surface water, RESPEC ran the model application with a 20 percent reduction of the HSPF Monthly Varying Parameters ACCUM and SQOLIM parameters for nitrate to reflect the reduced application. The difference between these results and the base results were used to calculate a percent reduction (16 percent), which was applied to the surface water. Additionally, because LSP determined that 62 percent of the corn/soybean rotation was corn in 2013, the efficiency factors were multiplied by 0.62 to avoid nitrogen application representation on soybeans. The efficiency factors were applied to the East Branch, Middle Main, and Shakopee focal area watersheds.

Load and concentration changes that resulted from Scenario B are provided in Tables 3 and 4, respectively. Scenario B average total nitrogen and nitrate loads in the focal areas decreased from the base scenario by 4 percent and 6 percent, respectively. Scenario B average total nitrogen and nitrate concentrations in the focal areas decreased from the base scenario by 3 percent and 6 percent, respectively.

Table 3. Scenario B Change in Load from Base Condition

Location	Variable	Base Load (lb/year)	Scenario B Load (lb/year)	Percent Change
East Branch (HSPF Reach 137)	Total Nitrogen	764,720	733,257	-4.1
	Total Nitrate	448,993	417,546	-7.0
Middle Main (HSPF Reach 116)	Total Nitrogen	891,630	884,760	-0.8
	Total Nitrate	244,869	238,034	-2.8
Shakopee (Reach 149)	Total Nitrogen	1,505,064	1,414,942	-6.0
	Total Nitrate	1,108,514	1,018,630	-8.1
Chippewa Outlet (HSPF Reach 106)	Total Nitrogen	4,242,047	4,117,322	-2.9
	Total Nitrate	2,534,959	2,410,556	-4.9

Table 4. Scenario B Change in Concentration from Base Condition

Location	Variable	Base Concentration (mg/L)	Scenario B Concentration (mg/L)	Percent Change
East Branch (HSPF Reach 137)	Total Nitrogen	1.87	1.81	-3.2
	Total Nitrate	0.97	0.91	-6.1
Middle Main (HSPF Reach 116)	Total Nitrogen	1.59	1.58	-0.8
	Total Nitrate	0.50	0.49	-2.4
Shakopee (HSPF Reach 149)	Total Nitrogen	3.49	3.31	-5.2
	Total Nitrate	2.24	2.06	-8.0
Chippewa Outlet (HSPF Reach 106)	Total Nitrogen	2.18	2.13	-2.3
	Total Nitrate	1.15	1.10	-4.4

SCENARIO C—INCREASE PERENNIAL COVER

Various scenarios were run in HSPF to reflect an increase in perennial cover. Scenarios C1 through C5 described in the following sections build on each other cumulatively. For example, Scenario C3 includes the changes made in Scenarios C1 and C2.

Scenario C1—Riparian Filter Strips

In the Chippewa River Watershed, farming to the edge of ditches and streams is common. For Scenario C1, 16-foot riparian buffers were represented along all corn and soybean fields in the Shakopee Basin, and 100-foot riparian buffers were represented along all corn and soybean fields in the East Branch and Middle Main Basins. The LSP determined acres on which buffers should be added in ArcGIS. The totals reflect the filter strips that are not currently in place. These areas were transferred from row crop to grassland. In addition, efficiency factors were incorporated on the loads originating from the cropland buffered by the filter strips to reflect the filtering that would occur before the water reaches local waterbodies in these watersheds. Efficiency factors were calculated for 16-foot and 100-foot riparian buffers based on a study that summarized two other literature reviews showing that TSS, TP, and TN removal can be calculated as a function of buffer width according to Equation 1 (TSS), Equation 2 (TP), and Equation 3 (TN), where y represents removal efficiency (%) and x represents buffer width (feet). Scenario C1 efficiency factors are provided in Table 5 [Miller et al., 2012].

Table 5. Scenario C1 Efficiency Factors [Miller et al., 2012] Before Decreasing by Effective Area Percentage

Constituent	16-Foot Buffer (%)	100-Foot Buffer (%)
Total Suspended Solids	75	90
Total Phosphorus	80	79
Total Nitrogen	43	80

$$y = 8.5Ln(x)+51.3 \tag{1}$$

$$y = 15.84Ln(x)+5.9 \tag{2}$$

$$y = 20.24Ln(x)-13.18 \tag{3}$$

Filter strips are typically assumed to only impact runoff from areas within a distance of the overland flow length, so an overland flow length of 300 feet was assumed. In addition, an effective area was calculated to account for lower delivery ratios further from the filter strips. Using an effective area results in delivery of higher loads from areas closer to filter strips. The filter strip effective area percentages (9 percent each in the East Branch and the Middle Main and 14 percent in the Shakopee) were estimated by using Equation 4 from the University of Minnesota [2006] where x equals the flow distance between the edge of a field to the nearest surface water and y equals the delivery ratio.

$$y = x^{-0.2069} \tag{4}$$

Load and concentration changes that resulted from Scenario C1 are provided in Tables 6 and 7, respectively. Scenario C1 average load reductions of TN, TP, and TSS in the focal areas were 5 percent, 5 percent, and 4 percent, respectively. Scenario C1 average concentration reductions of TN, TP, and TSS in the focal areas were 4 percent, 4 percent, and 4 percent, respectively.

Table 6. Scenario C1 Change in Load From Base Condition

Location	Variable	Base Load (lb/year)	Scenario C1 Load (lb/year)	Percent Change
East Branch (HSPF Reach 137)	Total Nitrogen	764,720	720,858	-5.7
	Total Phosphorus	53,207	50,518	-5.1
	Total Suspended Solids	31,861,278	30,589,002	-4.0
Middle Main (HSPF Reach 116)	Total Nitrogen	891,630	863,811	-3.1
	Total Phosphorus	117,919	113,499	-3.7
	Total Suspended Solids	87,903,141	84,767,427	-3.6
Shakopee (HSPF Reach 149)	Total Nitrogen	1,505,064	1,412,187	-6.2
	Total Phosphorus	72,506	67,838	-6.4
	Total Suspended Solids	31,695,735	30,034,209	-5.2
Chippewa Outlet (HSPF Reach 106)	Total Nitrogen	4,242,047	4,089,513	-3.6
	Total Phosphorus	314,598	303,932	-3.4
	Total Suspended Solids	182,584,216	176,570,652	-3.3

Table 7. Scenario C1 Change in Concentration from Base Condition

Location	Variable	Base Concentration (mg/L)	Scenario C1 Concentration (mg/L)	Percent Change
East Branch (HSPF Reach 137)	Total Nitrogen	1.87	1.78	-4.9
	Total Phosphorus	0.12	0.12	-4.6
	Total Suspended Solids	31.85	30.65	-3.8
Middle Main (HSPF Reach 116)	Total Nitrogen	1.59	1.55	-2.7
	Total Phosphorus	0.14	0.14	-2.8
	Total Suspended Solids	30.63	29.76	-2.8
Shakopee (HSPF Reach 149)	Total Nitrogen	3.49	3.29	-5.8
	Total Phosphorus	0.19	0.18	-5.9
	Total Suspended Solids	46.44	44.29	-4.6
Chippewa Outlet (HSPF Reach 106)	Total Nitrogen	2.18	2.12	-2.8
	Total Phosphorus	0.16	0.16	-2.2
	Total Suspended Solids	37.78	36.76	-2.7

Scenario C2—Marginal Row Crop to Management-Intensive Rotational Grazing Pasture

In Scenario C2, corn and soybean fields in the focal area watersheds with areas greater than 40 acres with Land Cover Classification (LCC) = 3 and a slope > 6 percent or with LCC = 4–8 were converted to grassland, which was used as a surrogate for Management Intensive Rotational Grazing (MIRG) pasture. The GIS layer representing areas to be converted was supplied by LSP. After the scenario was run, reductions were compared to efficiencies from APSIM supplied by LSP. The comparison showed that using grassland as a surrogate for MIRG pasture had efficiencies within 3 percent of the APSIM efficiencies for TSS and within 4 percent of the APSIM efficiencies for nitrates.

Load and concentration changes that resulted from Scenario C2 are provided in Tables 8 and 9, respectively. Tables 8 and 9 also show the percent change from Scenario C1 to C2. Scenario C2 average load reductions of TN, TP, and TSS in the focal areas from the base scenario were 6 percent, 6 percent, and 5 percent, respectively. Scenario C2 average concentration reductions of TN, TP, and TSS in the focal areas from the base scenario were 5 percent, 5 percent, and 5 percent, respectively.

Table 8. Cumulative Scenarios C1 and C2 Change in Load from Base Condition

Location	Variable	Base Load (lb/year)	Scenario C2 Load (lb/year)	Percent Change	Percent Change From Scenario C1
East Branch (HSPF Reach 137)	Total Nitrogen	764,720	703,604	-8.0	-2.4
	Total Phosphorus	53,207	49,459	-7.0	-2.1
	Total Suspended Solids	31,861,278	29,972,614	-5.9	-2.0
Middle Main (HSPF Reach 116)	Total Nitrogen	891,630	861,422	-3.4	-0.3
	Total Phosphorus	117,919	112,794	-4.3	-0.6
	Total Suspended Solids	87,903,141	84,340,026	-4.1	-0.5
Shakopee (HSPF Reach 149)	Total Nitrogen	1,505,064	1,406,551	-6.5	-0.4
	Total Phosphorus	72,506	67,613	-6.7	-0.3
	Total Suspended Solids	31,695,735	29,959,890	-5.5	-0.2
Chippewa Outlet (HSPF Reach 106)	Total Nitrogen	4,242,047	4,064,232	-4.2	-0.6
	Total Phosphorus	314,598	301,934	-4.0	-0.7
	Total Suspended Solids	182,584,216	175,424,509	-3.9	-0.6

Table 9. Cumulative Scenarios C1 and C2 Change in Concentration from Base Condition

Location	Variable	Base Concentration (mg/L)	Scenario C2 Concentration (mg/L)	Percent Change	Percent Change From Scenario C1
East Branch (HSPF Reach 137)	Total Nitrogen	1.87	1.78	-5.1	-0.2
	Total Phosphorus	0.12	0.12	-4.9	-0.4
	Total Suspended Solids	31.85	29.97	-5.9	-2.2
Middle Main (HSPF Reach 116)	Total Nitrogen	1.59	1.55	-2.7	-0.1
	Total Phosphorus	0.14	0.14	-3.1	-0.3
	Total Suspended Solids	30.63	29.65	-3.2	-0.4
Shakopee (HSPF Reach 149)	Total Nitrogen	3.49	3.28	-6.0	-0.2
	Total Phosphorus	0.19	0.17	-6.1	-0.1
	Total Suspended Solids	46.44	44.21	-4.8	-0.2
Chippewa Outlet (HSPF Reach 106)	Total Nitrogen	2.18	2.12	-2.9	-0.1
	Total Phosphorus	0.16	0.16	-2.4	-0.2
	Total Suspended Solids	37.78	36.56	-3.2	-0.5

Scenario C3—Prairie Strips

The LSP has been following a research project being performed by Iowa State called Science-Based Trials of Rowcrops Integrated with Prairie Strips (STRIPS). This research project is studying the overall farmland health of adding small areas of prairie into row-cropped fields along the contours and especially at the foot of a field. Scenario C3 evaluated implementing this practice on some of the smaller fields where crop productivity is determined to be marginal.

For Scenario C3, corn and soybean land with LCC = 3, a slope greater than 6 percent, and field size less than 40 acres were transitioned to prairie strips (grassland) in HSPF. Scenario C3 efficiency factors, provided in Table 10, were calculated by using Neiber's filter strip equations from Miller et al. [2012], which assumes that runoff would run through 50-foot-wide strips in Shakopee and 100-foot-wide strips in the East Branch and the Middle Main. Also, efficiency factors from two Iowa State University studies on the loads originating from the cropland buffered by these prairie strips were reviewed [Zhou et al., 2014; Helmers et al., 2012]. Load reductions from the Iowa State University papers were 96 percent for TSS, 90 percent for TP, and 84 percent for TN. For consistency with the filter strip scenario (C1) and to ensure the reduction estimates were conservative, efficiency factors calculated by using Neiber's filter strip equations were used. Similar to Scenario C1, prairie strip effective area percentages (44 percent in the East Branch and the Middle Main and 35 percent in the Shakopee) were also estimated by using Equation 4 from the University of Minnesota [2006].

Table 10. Scenario C3 Efficiency Factors Before Decreasing by Effective Area Percentage

Constituent	50-Foot Buffer (%)	100 Foot Buffer (%)
Total Suspended Solids	85	90
Total Phosphorus	68	79
Total Nitrogen	66	80

Load and concentration changes resulting from Scenario C3 are provided in Tables 11 and 12, respectively. Tables 11 and 12 also show the percent change from Scenario C2 to C3. Scenario C3 average load reductions of TN, TP, and TSS in the focal areas from the base scenario were 26 percent, 24 percent, and 20 percent, respectively. Scenario C3 average concentration reductions of TN, TP, and TSS in the focal areas from the base scenario were 22 percent, 20 percent, and 18 percent, respectively.

Table 11. Cumulative Scenario C1, C2, and C3 Change in Load from Base Condition

Location	Variable	Base Load (lb/ year)	Scenario C3 Load (lb/ year)	Percent Change	Percent Change From Scenario C2
East Branch (HSPF Reach 137)	Total Nitrogen	764,720	520,365	-32.0	-26.0
	Total Phosphorus	53,207	38,765	-27.1	-21.6
	Total Suspended Solids	31,861,278	24,775,010	-22.2	-17.3
Middle Main (HSPF Reach 116)	Total Nitrogen	891,630	746,758	-16.2	-13.3
	Total Phosphorus	117,919	95,741	-18.8	-15.1
	Total Suspended Solids	87,903,141	72,023,670	-18.1	-14.6
Shakopee (HSPF Reach 149)	Total Nitrogen	1,505,064	1,074,232	-28.6	-23.6
	Total Phosphorus	72,506	52,743	-27.3	-22.0
	Total Suspended Solids	31,695,735	25,502,164	-19.5	-14.9
Chippewa Outlet (HSPF Reach 106)	Total Nitrogen	4,242,047	3,479,667	-18.0	-14.4
	Total Phosphorus	314,598	263,325	-16.3	-12.8
	Total Suspended Solids	182,584,216	153,631,849	-15.9	-12.4

Table 12. Cumulative Scenario C1, C2, and C3 Change in Concentration from Base Condition

Location	Variable	Base Concentration (mg/L)	Scenario C3 Concentration (mg/L)	Percent Change	Percent Change From Scenario C2
East Branch (HSPF Reach 137)	Total Nitrogen	1.87	1.41	-25.0	-20.9
	Total Phosphorus	0.12	0.09	-22.7	-18.7
	Total Suspended Solids	31.85	24.84	-22.0	-17.1
Middle Main (HSPF Reach 116)	Total Nitrogen	1.59	1.38	-13.1	-10.6
	Total Phosphorus	0.14	0.12	-13.7	-10.9
	Total Suspended Solids	30.63	26.14	-14.7	-11.9
Shakopee (HSPF Reach 149)	Total Nitrogen	3.49	2.56	-26.6	-21.9
	Total Phosphorus	0.19	0.14	-24.2	-19.3
	Total Suspended Solids	46.44	38.25	-17.6	-13.5
Chippewa Outlet (HSPF Reach 106)	Total Nitrogen	2.18	1.88	-13.6	-11.0
	Total Phosphorus	0.16	0.15	-10.0	-7.9
	Total Suspended Solids	37.78	32.89	-13.0	-10.1

Scenario C4—Diversified Crop Rotations

Scenario C4 represents a diversification the of the corn soybean rotation to include 3 years of hay for land with LCC = 4–8 and field size less than 40 acres. Table 13 shows APSIM model efficiency factors that represented this rotation of 1 year of corn, 1 year of soybeans, and 3 years of hay were used as efficiency factors for the lands converted.

Table 13. Scenario C4 Efficiency Factors

Constituent	APSIM Efficiency
Total Suspended Solids	0.71
Total Phosphorus	0.54[a]
Nitrates	0.42

(a) From Literature, [Yoo et al., 1988]

Load and concentration changes resulting from Scenario C4 are provided in Tables 14 and 15, respectively. Tables 14 and 15 also show the percent change from Scenario C3 to C4. Scenario C4 average load reductions of TN, TP, and TSS in the focal areas from the base scenario were 26 percent, 25 percent, and 20 percent, respectively. Scenario C4 average concentration reductions of TN, TP, and TSS in the focal areas from the base scenario were 22 percent, 20 percent, and 18 percent, respectively.

Table 14. Cumulative Scenario C1, C2, C3, and C4 Change in Load from Base Condition

Location	Variable	Base Load (lb/ year)	Scenario C4 Load (lb/ year)	Percent Change	Percent Change From Scenario C3
East Branch (HSPF Reach 137)	Total Nitrogen	764,720	517,831	-32.3	-0.5
	Total Phosphorus	53,207	38,517	-27.6	-0.6
	Total Suspended Solids	31,861,278	24,646,705	-22.6	-0.5
Middle Main (HSPF Reach 116)	Total Nitrogen	891,630	745,966	-16.3	-0.1
	Total Phosphorus	117,919	95,338	-19.1	-0.4
	Total Suspended Solids	87,903,141	71,685,595	-18.4	-0.5
Shakopee (HSPF Reach 149)	Total Nitrogen	1,505,064	1,072,078	-28.8	-0.2
	Total Phosphorus	72,506	52,609	-27.4	-0.3
	Total Suspended Solids	31,695,735	25,458,904	-19.7	-0.2
Chippewa Outlet (HSPF Reach 106)	Total Nitrogen	4,242,047	3,474,460	-18.1	-0.1
	Total Phosphorus	314,598	262,614	-16.5	-0.3
	Total Suspended Solids	182,584,216	153,126,883	-16.1	-0.3

Table 15. Cumulative Scenario C1, C2, C3, and C4 Change in Concentration from Base Condition

Location	Variable	Base Concentration (mg/L)	Scenario C4 Concentration (mg/L)	Percent Change	Percent Change From Scenario C3
East Branch (HSPF Reach 137)	Total Nitrogen	1.87	1.40	-25.2	-0.3
	Total Phosphorus	0.12	0.09	-23.1	-0.5
	Total Suspended Solids	31.85	24.73	-22.4	-0.4
Middle Main (HSPF Reach 116)	Total Nitrogen	1.59	1.38	-13.2	-0.1
	Total Phosphorus	0.14	0.12	-13.9	-0.3
	Total Suspended Solids	30.63	26.04	-15.0	-0.4
Shakopee (HSPF Reach 149)	Total Nitrogen	3.49	2.56	-26.7	-0.2
	Total Phosphorus	0.19	0.14	-24.3	-0.2
	Total Suspended Solids	46.44	38.19	-17.8	-0.1
Chippewa Outlet (HSPF Reach 106)	Total Nitrogen	2.18	1.88	-13.7	-0.1
	Total Phosphorus	0.16	0.15	-10.2	-0.1
	Total Suspended Solids	37.78	32.81	-13.2	-0.2

Scenario C5—Management Intensive Rotational Grazing

Scenario C5 represented converting all land anticipated to exit the CRP program in the focal areas of the Chippewa River Watershed to grasslands, which were a surrogate for MIRG. Occasionally CRP exit areas slightly overlapped with base land uses that were not grassland or pasture in the National Land Cover Dataset. For this scenario, the overlapping forest and wetland areas were not converted to grassland. After the scenario was run, reductions were compared to efficiencies from APSIM supplied by LSP. The comparison showed that using grassland as a surrogate for MIRG pasture had efficiencies within 13 percent of the APSIM efficiencies for TSS and within 1 percent of the APSIM efficiencies for nitrates. The TSS APSIM efficiency factor was assumed to be zero, because it was calculated from a soil loss of 0.01 ton per acre per year on CRP to a soil loss of 0.06 tons per acre per year on MIRG.

Load and concentration changes resulting from Scenario C5 are provided in Tables 16 and 17, respectively. Tables 16 and 17 also show the percent change from Scenario C4 to C5. Scenario C5 average load reductions of TN, TP, and TSS in the focal areas from the base scenario were 26 percent, 25 percent, and 21 percent, respectively. Scenario C5 average concentration reductions of TN, TP, and TSS in the focal areas from the base scenario were 21 percent, 20 percent, and 19 percent, respectively. Figure 4 illustrates the land that was converted as described in Scenarios C1 through C5. Lands illustrated in Figure 4 make up approximately 12 percent of the total area in focal areas.

Table 16. Cumulative Scenario C1, C2, C3, C4, and C5 Change in Load from Base Condition

Location	Variable	Base Load (lb/ year)	Scenario C5 Load (lb/ year)	Percent Change	Percent Change From Scenario C4
East Branch (HSPF Reach 137)	Total Nitrogen	764,720	515,148	-32.6	-0.5
	Total Phosphorus	53,207	38,349	-27.9	-0.4
	Total Suspended Solids	31,861,278	24,409,029	-23.4	-1.0
Middle Main (HSPF Reach 116)	Total Nitrogen	891,630	747,283	-16.2	0.2
	Total Phosphorus	117,919	94,847	-19.6	-0.5
	Total Suspended Solids	87,903,141	71,446,886	-18.7	-0.3
Shakopee (HSPF Reach 149)	Total Nitrogen	1,505,064	1,063,521	-29.3	-0.8
	Total Phosphorus	72,506	52,264	-27.9	-0.7
	Total Suspended Solids	31,695,735	25,272,029	-20.3	-0.7
Chippewa Outlet (HSPF Reach 106)	Total Nitrogen	4,242,047	3,462,960	-18.4	-0.3
	Total Phosphorus	314,598	261,453	-16.9	-0.4
	Total Suspended Solids	182,584,216	152,430,776	-16.5	-0.5

Table 17. Cumulative Scenario C1, C2, C3, C4, and C5 Change in Concentration from Base Condition

Location	Variable	Base Concentration (mg/L)	Scenario C5 Concentration (mg/L)	Percent Change	Percent Change From Scenario C4
East Branch (HSPF Reach 137)	Total Nitrogen	1.87	1.43	-23.7%	1.9
	Total Phosphorus	0.12	0.10	-21.8%	1.7
	Total Suspended Solids	31.85	24.23	-23.9%	-2.0
Middle Main (HSPF Reach 116)	Total Nitrogen	1.59	1.39	-12.7%	0.5
	Total Phosphorus	0.14	0.12	-13.9%	0.0
	Total Suspended Solids	30.63	25.89	-15.5%	-0.6
Shakopee (HSPF Reach 149)	Total Nitrogen	3.49	2.55	-27.0%	-0.3
	Total Phosphorus	0.19	0.14	-24.5%	-0.1
	Total Suspended Solids	46.44	37.93	-18.3%	-0.7
Chippewa Outlet (HSPF Reach 106)	Total Nitrogen	2.18	1.89	-13.5%	0.3
	Total Phosphorus	0.16	0.15	-10.1%	0.1
	Total Suspended Solids	37.78	32.61	-13.7%	-0.6

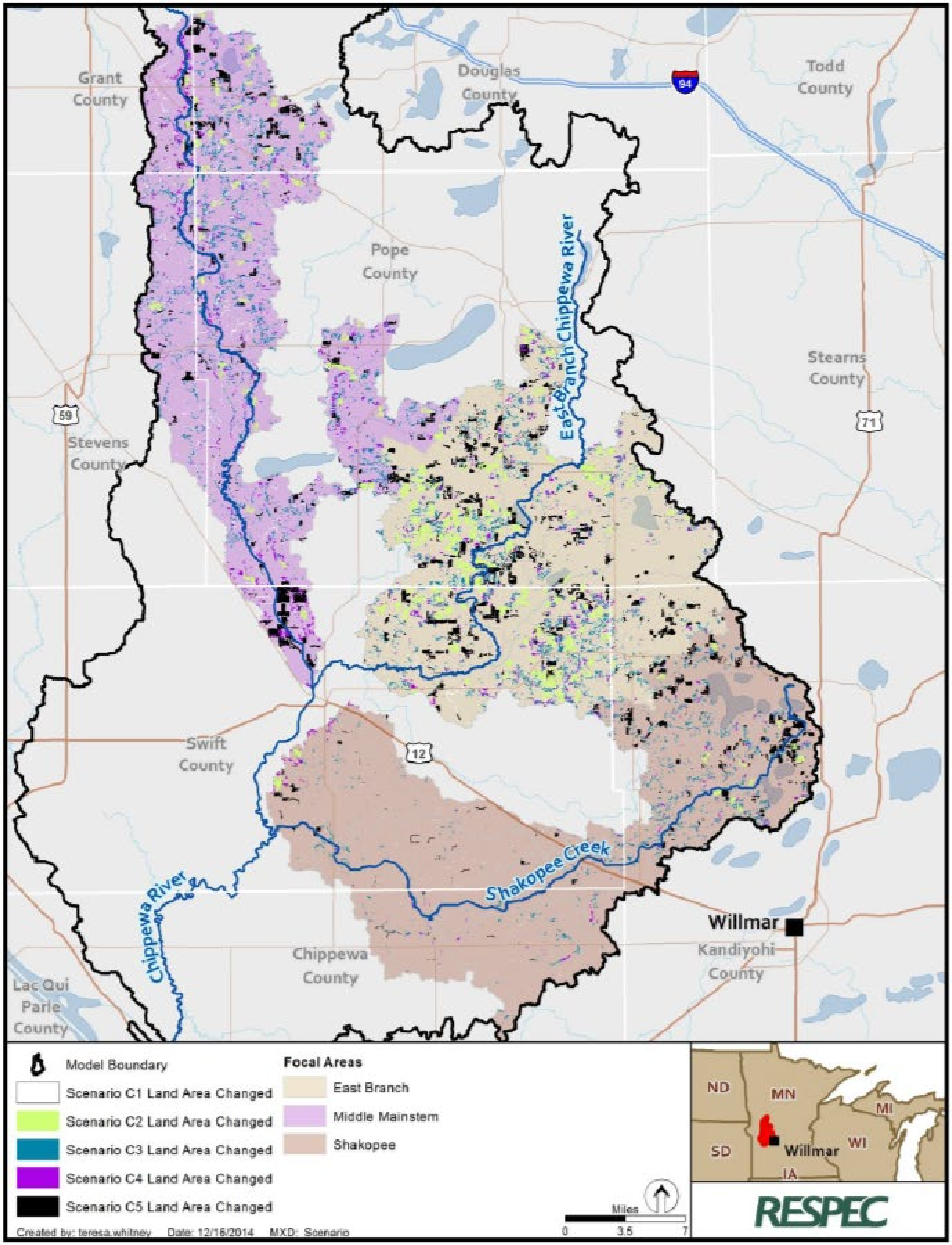

Figure 4. Areas Meeting Criteria for Scenarios C1 Through C5.

SCENARIO D—DIVERSIFY CROP ROTATIONS ON GOOD FARMLAND

The purpose of Scenario D was to analyze the impact of diversifying the crop rotation on 10 percent of the land in the targeted watersheds with LCC = 1, 2 and for land with LCC = 3 with a slope less than 6 percent. Typical crop rotations include corn and soybeans, and Scenario D adds in 1 year of wheat and 1 year of alfalfa after each corn/soybean (CS) rotation. Two versions of Scenario D were run. Scenario D1 used efficiency factors from APSIM where available and Scenario D2 used efficiency factors from literature. Table 18 shows the efficiency factors used for Scenario D1. Table 19 shows the literature efficiency factors used for Scenario D2. Areas that met the Scenario D criteria are illustrated in Figure 5.

Table 18. Scenario D1 Efficiency Factors

Constituent	APSIM Efficiency
Total Suspended Solids	0.34
Total Phosphorus	0.54[a]
Nitrates	0.13

(a) From literature [Yoo et al., 1988].

Table 19. Scenario D2 Efficiency Factors

Constituent	Literature Efficiency	Source
Total Suspended Solids	0.70	Merriman [2009]
Total Phosphorus	0.54	Yoo et al. [1988]
Nitrates	0.61	Kaspar et al. [2007]

Load and concentration changes that resulted from Scenario D1 are provided in Tables 20 and 21, respectively. Scenario D1 average load reductions of TN, TP, and TSS in the focal areas from the base scenario were 2 percent, 2 percent, and 4 percent, respectively. Scenario D1 average concentration reductions of TN, TP, and TSS in the focal areas from the base scenario were 2 percent, 1 percent, and 4 percent, respectively. Load and concentration changes that resulted from Scenario D2 are provided in Tables 22 and 23, respectively. Scenario D2 average load reductions of TN, TP, and TSS in the focal areas from the base scenario were 4 percent, 9 percent, and 4 percent, respectively. Scenario D2 average concentration reductions of TN, TP, and TSS in the focal areas from the base scenario were 4 percent, 8 percent, and 4 percent, respectively.

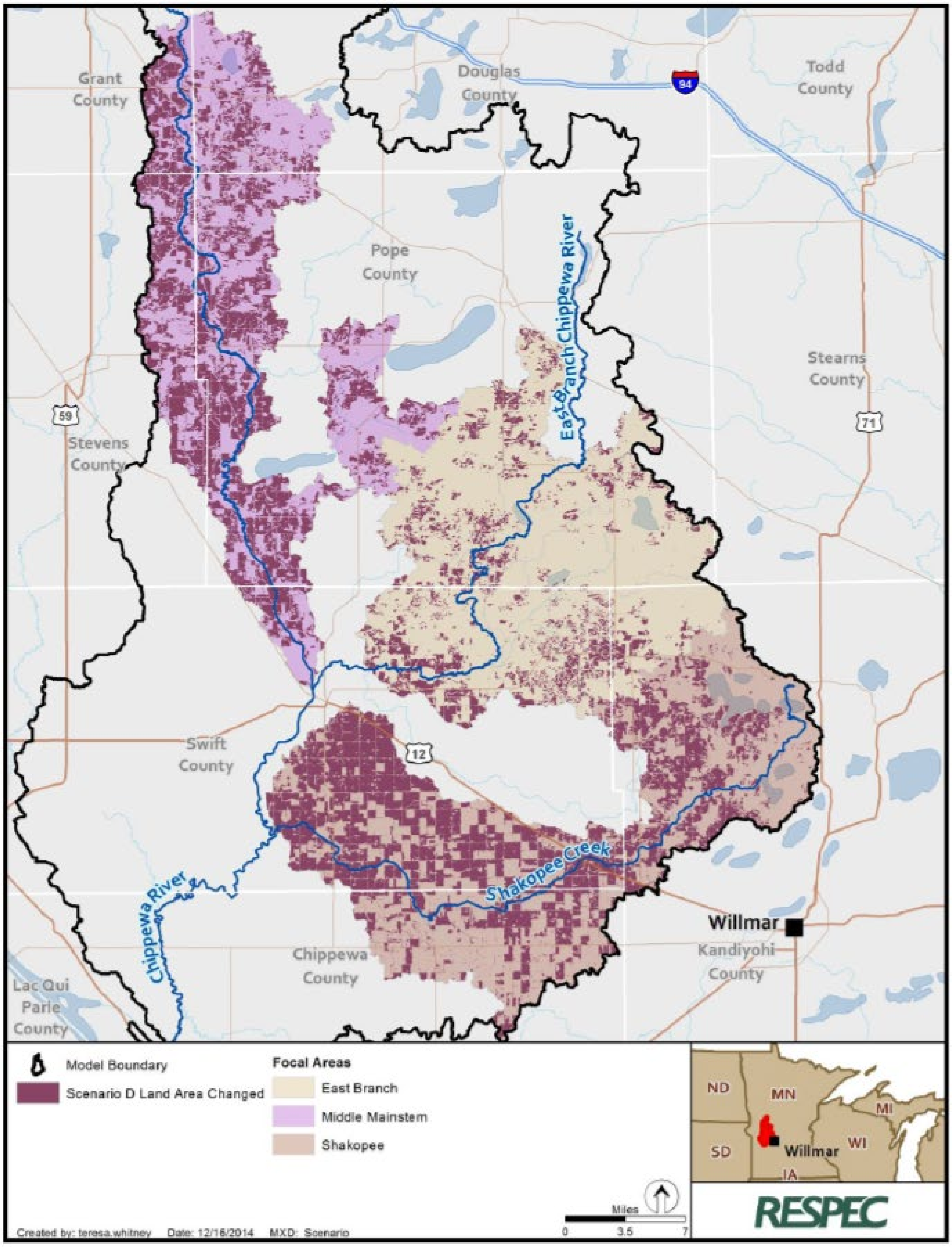

Figure 5. Areas Meeting Criteria for Scenario D.

Table 20. Scenario D1 Change in Load from Base Condition

Location	Variable	Base Load (lb/ year)	Scenario D1 Load (lb/ year)	Percent Change
East Branch (HSPF Reach 137)	Total Nitrogen	764,720	756,500	-1.1
	Total Phosphorus	53,207	51,021	-4.1
	Total Suspended Solids	31,861,278	31,220,231	-2.0
Middle Main (HSPF Reach 116)	Total Nitrogen	891,630	887,720	-0.4
	Total Phosphorus	117,919	114,929	-2.5
	Total Suspended Solids	87,903,141	86,407,291	-1.7
Shakopee (HSPF Reach 149)	Total Nitrogen	1,505,064	1,483,018	-1.5
	Total Phosphorus	72,506	68,253	-5.9
	Total Suspended Solids	31,695,735	31,015,894	-2.1
Chippewa Outlet (HSPF Reach 106)	Total Nitrogen	4,242,047	4,209,977	-0.8
	Total Phosphorus	314,598	306,125	-2.7
	Total Suspended Solids	182,584,216	179,796,057	-1.5

Table 21. Scenario D1 Change in Concentration from Base Condition

Location	Variable	Base Concentration (mg/L)	Scenario D1 Concentration (mg/L)	Percent Change
East Branch (HSPF Reach 137)	Total Nitrogen	1.87	1.85	-1.0
	Total Phosphorus	0.12	0.12	-4.0
	Total Suspended Solids	31.85	31.29	-1.8
Middle Main (HSPF Reach 116)	Total Nitrogen	1.59	1.58	-0.4
	Total Phosphorus	0.14	0.14	-2.2
	Total Suspended Solids	30.63	30.24	-1.3
Shakopee (HSPF Reach 149)	Total Nitrogen	3.49	3.44	-1.4
	Total Phosphorus	0.19	0.18	-5.5
	Total Suspended Solids	46.44	45.59	-1.8
Chippewa Outlet (HSPF Reach 106)	Total Nitrogen	2.18	2.17	-0.6
	Total Phosphorus	0.16	0.16	-1.9
	Total Suspended Solids	37.78	37.33	-1.2

Table 22. Scenario D2 Change in Load from Base Condition

Location	Variable	Base Load (lb/ year)	Scenario D2 Load (lb/ year)	Percent Change
East Branch (HSPF Reach 137)	Total Nitrogen	764,720	727,438	-4.9
	Total Phosphorus	53,207	48,546	-8.8
	Total Suspended Solids	31,861,278	30,492,372	-4.3
Middle Main (HSPF Reach 116)	Total Nitrogen	891,630	875,604	-1.8
	Total Phosphorus	117,919	110,909	-5.9
	Total Suspended Solids	87,903,141	84,786,960	-3.5
Shakopee (HSPF Reach 149)	Total Nitrogen	1,505,064	1,403,525	-6.7
	Total Phosphorus	72,506	63,885	-11.9
	Total Suspended Solids	31,695,735	30,243,626	-4.6
Chippewa Outlet (HSPF Reach 106)	Total Nitrogen	4,242,047	4,095,409	-3.5
	Total Phosphorus	314,598	296,223	-5.8
	Total Suspended Solids	182,584,216	176,714,451	-3.2

Table 23. Scenario D2 Change in Concentration from Base Condition

Location	Variable	Base Concentration (mg/L)	Scenario D2 Concentration (mg/L)	Percent Change
East Branch (HSPF Reach 137)	Total Nitrogen	1.87	1.79	-4.2
	Total Phosphorus	0.12	0.11	-7.9
	Total Suspended Solids	31.85	30.49	-4.3
Middle Main (HSPF Reach 116)	Total Nitrogen	1.59	1.56	-1.7
	Total Phosphorus	0.14	0.13	-4.4
	Total Suspended Solids	30.63	29.71	-3.0
Shakopee (HSPF Reach 149)	Total Nitrogen	3.49	3.27	-6.3
	Total Phosphorus	0.19	0.17	-10.8
	Total Suspended Solids	46.44	44.45	-4.3
Chippewa Outlet (HSPF Reach 106)	Total Nitrogen	2.18	2.12	-2.8
	Total Phosphorus	0.16	0.16	-3.8
	Total Suspended Solids	37.78	36.73	-2.8

SUMMARY

In summary, the cumulative Scenario C was most effective in removing TN, TP, and TSS loads. Scenario A, which represented changing land that is likely to exit the CRP program given 2010 crop prices, resulted in a slight increase in loads. The maximum Scenario A percent load increase was 1.3 percent in total nitrogen. Scenario B was less effective than Scenario C in removing total nitrogen and total nitrate loads, with maximum total nitrogen load reductions of approximately 6 percent and maximum nitrate load reductions of approximately 5.2 percent in Shakopee Creek. The combination of Scenarios C1 through C5 resulted in the highest load reductions in all focal areas, with TN load reductions as high as 33 percent, TP load reductions as high as 28 percent, and TSS reductions as high as 23 percent. All of the highest Scenario C reductions occurred in the East Branch focal area. Of Scenarios C1 through C5, Scenario C3 resulted in the highest load and concentration reductions, with average load and concentration reductions from Scenario C2 to C3 over 20 percent. Scenario C5 resulted in minimal reductions, and sometimes slight increases, because of the similarities between CRP and MIRG. Scenarios D1 and D2 were less effective than Scenario C in removing TN, TP, and TSS with load reductions ranging from 0.4 to 6 percent for Scenario D1 and 2 to 12 percent for Scenario D2. Bar charts of TN, TP, and TSS load changes that resulted from all scenarios in each focal area are illustrated in Figures 6 through 8. Table 24 provides an average of the percent reductions (TN, TP, and TSS) in each focus area divided by the percent of the actual implementation area in each focus area. These percent changes per areas implemented upon are positive for Scenario A and negative for all of the other scenarios. The highest reduction per area occurs from Scenario C4 in the Shakopee focal area. In terms of the Chippewa River Watershed taking steps to meet water quality goals, Scenario C3 (Prairie Strips) would be an excellent starting point. A combination of Scenarios B, C, and D would make significant strides toward reducing nitrogen, phosphorus, and sediment loading to the Chippewa River.

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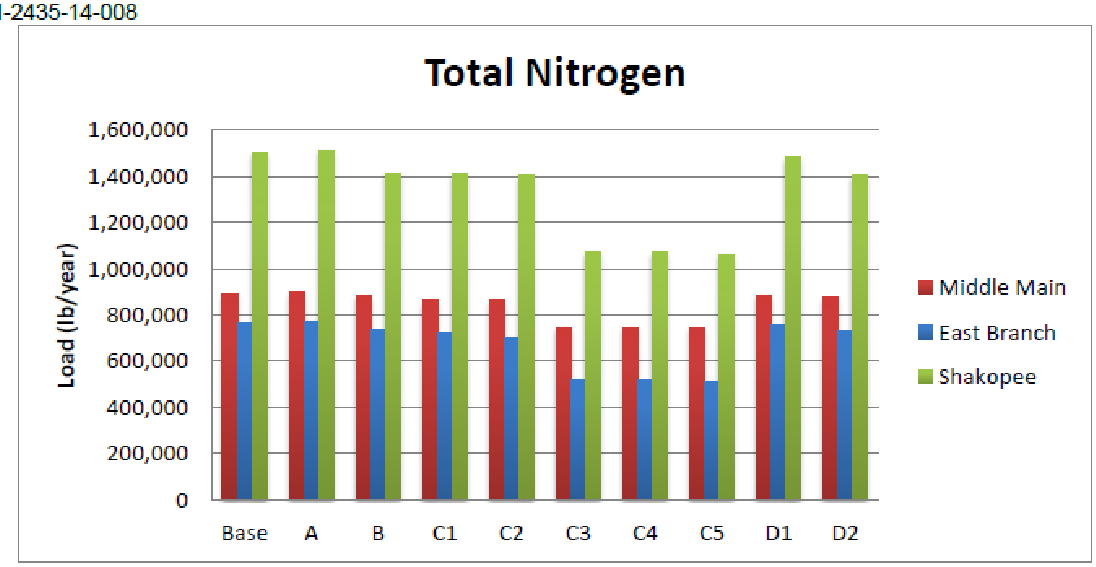

Figure 6. Total Average Annual Nitrogen Loads (1996–2012) for Each Scenario.

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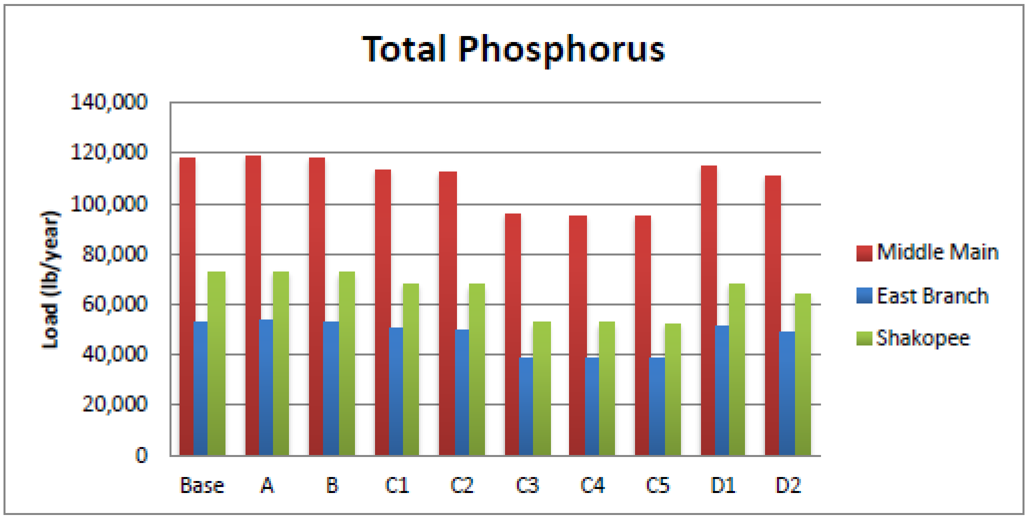

Figure 6. Total Average Annual Phosphorus Loads (1996–2012) for Each Scenario.

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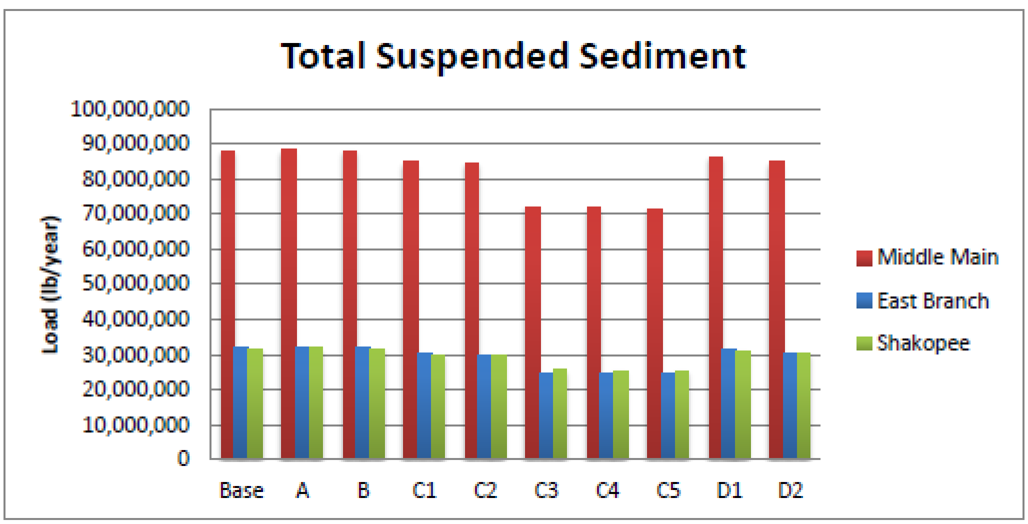

Figure 7. Total Average Annual Suspended Solids Loads (1996–2012) for Each Scenario.

Table 24. Water Quality Factors Representing Average Percent Load Reductions per Percent Area Implementation

Scenario	Focal Area	Water Quality Factor
A	East Branch	0.2
	Middle Main	0.1
	Shakopee	0.2
	Chippewa Outlet	0.3
C1	East Branch	-8.6
	Middle Main	-2.6
	Shakopee	-20.5
	Chippewa Outlet	-10.9
C2	East Branch	-1.4
	Middle Main	-2.3
	Shakopee	-12.7
	Chippewa Outlet	-4.0
C3	East Branch	-6.1
	Middle Main	-3.5
	Shakopee	-10.6
	Chippewa Outlet	-9.9
C4	East Branch	-14.8
	Middle Main	-7.5
	Shakopee	-40.2
	Chippewa Outlet	-24.5
C5	East Branch	-4.9
	Middle Main	-3.9
	Shakopee	-11.4
	Chippewa Outlet	-9.6
D1	East Branch	-1.6
	Middle Main	-0.4
	Shakopee	-0.7
	Chippewa Outlet	-1.2
D2	East Branch	-3.9
	Middle Main	-1.0
	Shakopee	-1.8
	Chippewa Outlet	-3.0

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6.10 Zonation analysis process

Description of Prioritization Approach and Methods

By Paul J. Radomski and Kristin Carlson

Prioritization Overview

As threats to Minnesota's watersheds continue to mount, it is becoming increasingly important to identify and conserve high-priority areas. There are multiple opportunities for protection or restoration in any watershed. Identifying which practices to implement and where in the landscape to implement them can help more effectively target efforts and more efficiently utilize limited resources. A number of information technology tools are available for prioritizing and targeting land for restoration and protection efforts within a watershed.

A systematic approach aimed at optimizing environmental benefits while reducing interference between competing land uses will be critical. Two of the most common approaches for conservation prioritization are system-based models and value-based models. One of the major strengths of system-based models is that they require us to think deeply about a system by writing down our mental models of how we believe the system functions. For many watersheds this has been done using the HSPF hydrologic system model, which simulates watershed hydrology and water quality at the catchment scale. However, we often do not have system models that can accurately identify where in the watershed specific good management practices should be applied or that have the ability to simulate alternative land management actions and predict consequences at specific locations in the watershed.

Values-based models use a compilation of individual criteria of valuable landscape features (heterogeneous content) and aggregated criteria (context and connections) with an objective function to prioritize places within the landscape for conservation. Although there are some shortcomings of using value models over system models (value models only allow exploration of tradeoffs and optimization, and they do not provide guidance on what practices should be implemented where), the use of value models is an efficient method for prioritizing places for protection or restoration.

The values-based model prioritization approach we used is based on fundamental conservation principles, including content, context, heterogeneity, and connectivity. We used the DNR's five-component healthy watershed conceptual model to facilitate an organized process to assess and review watershed problems and solutions. The five components are: biology, hydrology, water quality, geomorphology, and connectivity. This approach recognizes that attempts to solve our clean water needs are not separate from our other conservation needs; each conservation activity should provide multiple benefits. Value models help achieve this multiple benefits goal by identifying areas that optimize benefits by accounting for what the community values. The use of an additive benefits objective function in the value model allows for the retention of high quality occurrences of as many conservation features as possible while reducing interference between competing land uses (e.g., row crop areas). Value models also can be used in a public participation process, whereby participants can decide on what features are valued and the ranking of those valued features. Addressing conservation goals effectively necessitates a collaborative approach, and value-based models provide a structure for collaborative efforts. In addition, value models and the five-component conceptual model used to structure the content in the value models are simple concepts that are easy to explain and apply at the local government scale.

Methods:

The value models were developed using Zonation software (Moilanen et al. 2009). Zonation produces a nested hierarchy of conservation priorities. It begins with the full landscape and iteratively removes parcels (cells) that contribute least to conservation; therefore, the removal order is the reverse order of the priority ranking for conservation. Zonation assumes that the full watershed is available for conservation. In our models, the lakes were masked out prior to analysis. This focused the prioritization on the terrestrial parcels, in accordance with the conservation and restoration goals of our partners. Zonation's algorithms seek maximal retention of weighted normalized conservation features.

Weights are used to influence which features are valued more. Within the five-component healthy watershed framework, for example, water quality conservation features could be weighted higher than biological features. The feature-specific weights used in the value models reflect social valuation, and they were set using the analytic hierarchy process (AHP; Saaty and Peniwati 2007). A survey comprised of pairwise comparisons was used to solicit the preferences of individuals that were present at the Annual CRWP meeting on April 30, 2013. Features used in the comparison were based loosely on the DNR's five-component healthy watershed approach, with the addition of alternative land uses/economic features representing a social component. The pairwise survey was structured to gather value preferences for both a protection and a restoration scenario. Each individual taking the survey used his or her judgment about the relative importance of all elements at each level of the hierarchy. The relative importance values included "equal," "prefer," and "strongly prefer." The use of abbreviated pairwise importance values helped reduce the cognitive burdens associated with a large number of pairwise comparisons. Individual responses were aggregated with a geometric mean, and the pairwise comparison matrix was constructed to compute the feature-specific weights consistent with the AHP.

There are three commonly definable objective functions possible in Zonation: core area, target-based planning, and additive benefit functions. The core area objective function aims to retain high-quality occurrences of each feature. This function is most appropriate when there is a definite set of conservation features and all of them are to be conserved. The target-based planning objective function is a prescriptive approach where requirements are specified a priori for each feature. This function produces a minimum set coverage solution, and is most appropriate when a defined proportion of the watershed is assigned for conservation.

We used the additive benefit function variant of Zonation, which aggregates values by summation across features: $V(P) = \Sigma w_j N_j(P)^{z}{}_{j} - \Sigma w_k N_k(P)^{z}{}_{k}$ where the value of a parcel V(P) is equal to the summation of weighted w normalized conservation features of the parcel $N_j(P)$, squashed to the power of z, minus the summation of the weighted normalized alternative land use features of the parcel $N_k(P)$, squashed by z.

The conservation features used in the analysis each had a layer that was on the same grid scale with a resolution of 30 by 30m. We used high-resolution data to maximize conservation planning realism and for greater practicality in local government conservation planning and implementation.

We used z_j = 0.25 for conservation features and z_k = 4 for alternative land uses. The additive benefit function is appropriate when tradeoffs between conservation features are allowed and it is necessary to account for alternative land use features. In our analyses, we developed prioritizations that would minimize interference with important agricultural areas. Additionally, Zonation allows ranking to be influenced by neighboring parcels, so that highly valued areas can be aggregated. This minimizes fragmentation of conservation within the landscape. We utilized the distribution-smoothing algorithm in Zonation, which uses an aggregation kernel a parameter. Using this algorithm assumes that fragmentation (low connectivity) generally should be avoided for all conservation features. Initial analyses indicate that an aggregation kernel a of 0.01, which corresponds to a connectivity distance of 200m, may be appropriate for conservation efforts targeted at the watershed scale. We found that very small connectivity distances made no difference in parcel prioritization, since the connectivity effect did not extend very far into neighboring parcels, and very large connectivity distances aggregated parcels across unrealistically large areas. We also found that across a modest range of connectivity distances the results were minor. The connectivity distance can be conservation feature-specific, for a biological example, if a species dispersal capability or fragmentation vulnerability was known, then a species-specific parameter could be explicitly used. We did not use distribution-smoothing for alternative land uses/economic features.

The final step in identifying areas for potential protection and restoration included a mapping exercise. Participants used their knowledge and experiences within the watershed to revise the Zonation output maps to create a final map that may be used to provide guidance on which areas within the watershed may be priorities for potential future conservation investments. This synthesis step captured the wisdom of the group of people interested and knowledgeable about the stresses, risks, and vulnerability of water resources within the watershed.

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