Grant

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Upper Hawk Creek and Willmar Chain of Lakes Section 319 Nine Key Element Plan

MINNESOTA POLLUTION CONTROL AGENCY

CLEAN WATER LAND & LEGACY AMENDMENT

Hawk Creek Watershed Project

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Executive summary

The Willmar Lakes and upper mainstem Hawk Creek Watershed is about 83,900 acres and encompasses three HUC-12 watersheds (070200040701, 070200040702, and 070200040705). This watershed includes the headwaters of Hawk Creek and was selected for priority implementation because of the impact the area can have to the stream. The three reaches of Hawk Creek in this watershed are listed as impaired for mercury in fish tissue. Willmar and Swan Lakes are listed for nutrient eutrophication and Eagle Lake is listed as impaired for mercury in fish.

In particular, the Hawk Creek Watershed Project (HCWP) has had strong success with their soil health programs, which reduces runoff and lessens the need for additional fertilizer inputs. By addressing this larger area, the partners increase their chances of successful landowner engagement. The downstream Hawk Creek is a significant contributor of sediment to the Minnesota River-Yellow Medicine system. It is logical to begin at the headwaters and work downstream. The continuity and the approach of the HCWP and partners will address the impairments in the watershed in an effective and systematic way.

"The Hawk Creek Watershed Project has been in existence since 1997 with a purpose of "improving the water quality/quantity issues in the watershed, while also promoting a healthy agricultural, industrial, and recreational-based economy for the region." In 2013, a joint powers agreement between the three counties of the watershed (Chippewa, Kandiyohi, and Renville) became the organizing structure of the HCWP." (https://www.hawkcreekwatershed.org/about_us). The HCWP and the county soil and water conservation districts (SWCDs) work closely together to achieve improved water quality in the watershed.

This plan outlines the implementation practices needed to reach water quality standards over the long term. If fully implemented, this plan should gain pollutant load reductions needed to meet water quality standards. The total suspended solids (TSS) is not a listed impairment for the specific reach in the HUC-12, but it is a known problem downstream. The watershed partners will continue to assess and evaluate the effectiveness of the practices at least every two years and will continue to add more implementation practices and milestones as time passes and the results are analyzed.

1. Introduction

The Upper Hawk Creek and Willmar Chain of Lakes Section 319 Nine Key Element Plan (NKE) Plan was developed by compiling and synthesizing information from previous studies and planning documents conducted in the watershed including:

- City of Willmar Comprehensive Plan, 2009
- Minnesota River – Granite Falls Watershed Monitoring and Assessment Report, 2013
- Hawk Creek Watershed Biotic Stressor Identification, 2013
- Hawk Creek Watershed and Surrounding Direct Minnesota River Tributaries: Restoration and Protection Strategies, 2017
- Hawk Creek Watershed Total Maximum Daily Load: *E. coli* Bacteria, Turbidity and Lake Nutrient Eutrophication, 2017
- Chippewa County Water Plan (2013-2023) with 2013-2018 Implementation Plan, 2013
- Kandiyohi County Comprehensive Plan (2013-2023) and Five Year Implementation Plan (2013-2018), 2013

This NKE Plan is a living, working document that serves as a guide and starting point for local stakeholders within the Upper Hawk Creek Watershed to achieve water quality goals through implementation of nonpoint source (NPS) pollution control measures. An adaptive management approach is taken to allow for change, reaction, and course correction throughout implementation. Milestones and progress check points are built into this plan on a minimum of a two-year interval. This process will give the partners the opportunity assess the effectiveness of the approach and adapt accordingly.

1.1 Document overview

The intent of this NKE Plan is to concisely address the nine elements identified in *EPA's Handbook for Developing Watershed Plans to Restore and Protect our Waters* (EPA 2008). The U.S. Environmental Protection Agency (EPA) emphasizes the use of watershed-based plans containing the nine elements in Section 319 watershed projects in its guidelines for the Clean Water Act Section 319 program and grants (EPA 2013). The nine elements are listed in Table 1 along with the section of this report in which each element can be found.

Table 1. Nine elements and report section

Section 319 Nine Element	Applicable Report Section
a. Identification of causes of impairment and pollutant sources or groups of similar sources that need to be controlled to achieve needed load reductions, and any other goals identified in the watershed plan.	Section 4
b. An estimate of the load reductions expected from management measures.	Section 6.2
c. A description of the NPS management measures that will need to be implemented to achieve load reductions in element b, and a description of the critical areas in which those measures will be needed to implement this plan.	Section 6
d. An estimate of the amounts of technical and financial assistance needed, associated costs, and/or the sources and authorities that will be relied upon to implement this plan.	Section 6 Section 9

Section 319 Nine Element	Applicable Report Section
e. An information and education component used to enhance public understanding of the project and encourage the public's early and continued participation in selecting, designing, and implementing the NPS management measures that will be implemented.	Section 7
f. Schedule for implementing the NPS management measures identified in this plan that is reasonably expeditious.	Section 6
g. A description of interim measurable milestones for determining whether NPS management measures or other control actions are being implemented.	Section 6
h. A set of criteria that can be used to determine whether loading reductions are being achieved over time and substantial progress is being made toward attaining water quality standards.	Section 6
i. A monitoring component to evaluate the effectiveness of the implementation efforts over time, measured against the criteria established under item h immediately above.	Section 8

1.2 Nonpoint source pollution management

Numerous nonpoint pollution management activities and planning efforts have been and are being conducted in the project area. These plans and studies, conducted at various levels, have provided the foundational work to create the NKE Plan. These studies and plans include the development of TMDLs, stressor identification, local plans, and other implementation plans.

Minnesota adopted a major watershed approach to address the state's major watersheds. The approach incorporates water quality assessment, watershed analysis, public participation, planning, implementation, and measurement of results into a 10-year cycle that addresses both restoration and protection needs. A key aspect of this effort is to develop and use watershed-scale models and other tools to identify strategies for addressing point and NPS pollution that will cumulatively achieve water quality targets. Several documents have been developed that are applicable to the Upper Hawk Creek Watershed as part of this process including the Minnesota River – Granite Falls Watershed Monitoring and Assessment Report[1] (MPCA 2013a), Hawk Creek Watershed Biotic Stressor Identification (MPCA 2013b), Hawk Creek Watershed Total Maximum Daily Load (MPCA 2017a), and the Hawk Creek Watershed and Surrounding Direct Minnesota River Tributaries Restoration and Protection Strategies Report (MPCA 2017b). The process used to develop these reports included significant stakeholder involvement; these reports provide much of the background information and inform selection of management activities. These documents will inform this plan for needed reductions and implementation strategies to apply in this area.

Kandiyohi and Chippewa County have developed comprehensive county water plans for 2013-2023 that outline major water quality and quantity concerns (Chippewa County Land & Resource Management 2014, Kandiyohi County and the Mid-Minnesota Development Commission 2013). Plan development included significant stakeholder involvement and informed selection of management activities. In addition, a new comprehensive watershed planning process recently began in support of a One

[1] The Minnesota River-Granite Falls Watershed and Minnesota River-Yellow Medicine/Hawk Creek Watershed are the same HUC-8 07020004.

Watershed, One Plan for the Hawk Creek Middle Minnesota Watershed. Additional information can be found at
https://www.kcmn.us/departments/environmental_services/onewatershedoneplan/index.php.

The HCWP was formed in 1997 with a purpose of "improving the water quality/quantity issues in the watershed, while also promoting a healthy agricultural, industrial, and recreational-based economy for the region." In 2013, a joint powers agreement between the three counties of the watershed (Chippewa, Kandiyohi, and Renville) became the organizing structure of the HCWP.

2. Watershed description

The Willmar Chain of Lakes and upper mainstem Hawk Creek Watershed is about 83,900 acres and encompasses three HUC-12 watersheds (070200040701, 070200040702, and 070200040705), with a number of large lakes located in the headwaters which are referred to as the Willmar Chain of Lakes due to their proximity to the City of Willmar, Minnesota (Figure 1). The Upper Hawk Creek Watershed lies within the larger Minnesota River-Yellow Medicine HUC-8 watershed (07020004) in west-central Minnesota. Hawk Creek flows from the headwater lakes to the confluence of Chetomba Creek near Clara City, Minnesota. Cities located within the watershed are Willmar, Clara City, and Raymond.

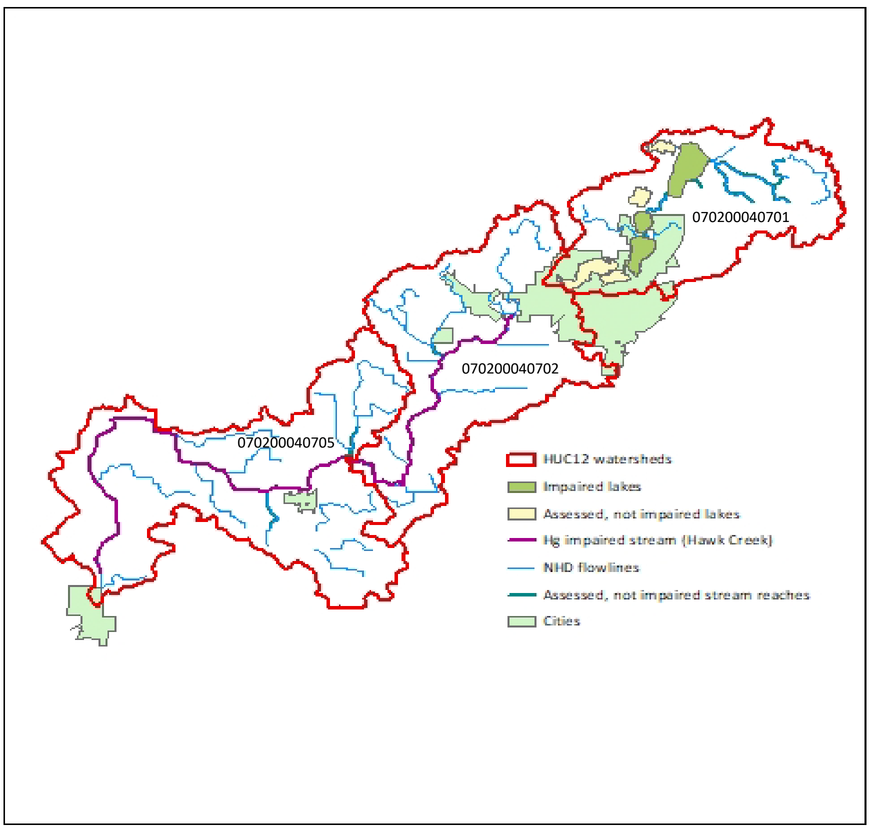
Table 2. Hawk Creek HUC-12 watersheds and waterbodies

HUC-12	Name	Waterbodies
070200040701	Willmar Lake	Point Lake, Eagle Lake *, Swan Lake *, Skataas Lake, Willmar Lake *
070200040702	Town of Priam-Hawk Creek	Hawk Creek *
070200040705	City of Raymond-Hawk Creek	Hawk Creek *

* Waterbodies that were assessed for impairment

The uppermost portion of the watershed is located in the North Central Hardwoods ecoregion (Eagle Lake and northwards) with the vast majority of the watershed located within the Western Corn Belt Plains ecoregion (MPCA 2017a).

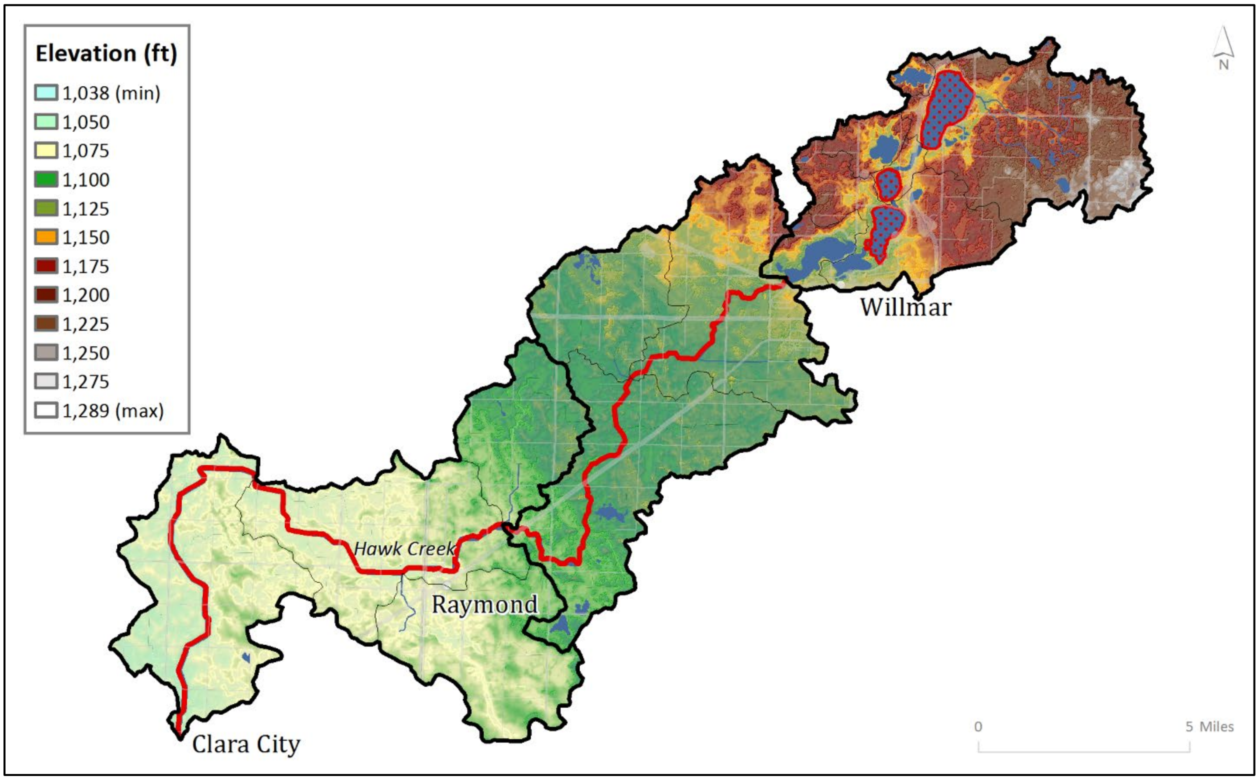
Figure 1. Willmar Chain of Lakes and upper mainstem Hawk Creek Watershed



2.1 Topography and drainage

The Upper Hawk Creek Watershed is characterized by numerous lakes in the headwaters which form the headwaters of Hawk Creek. This portion of Hawk Creek is highly channelized. Elevations are generally flat across the entire larger Hawk Creek Watershed, and within the Upper Hawk Watershed elevation ranges from 316 – 395 meters (1,037 – 1,296 feet) (Figure 2).

Figure 2. Upper Hawk Creek Watershed with elevation



2.2 Geology and soils

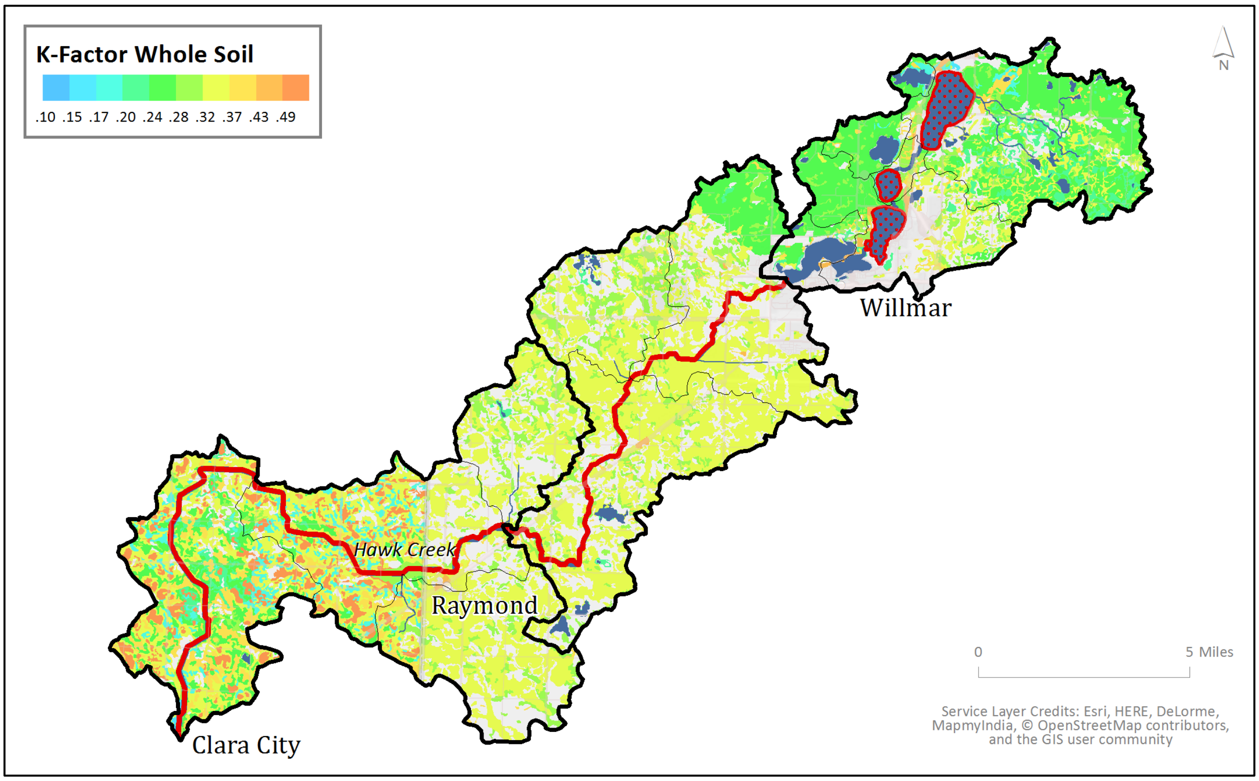
The Upper Hawk Creek Watershed is characterized by a gently twisting till plain formed during the advance of the Des Moines Lobe during the Wisconsin Glaciation. The major soil type present in the headwaters of Upper Hawk Creek is Wadenill-Sunburg-Delft soils which are a mixture of erosive and productive soils. These soils are formed in moderately coarse-textured glacial till, with terrain that is generally poorly drained and subject to erosion. The lower half of the watershed is largely Harps-Okoboji-Seaforth soils, which are loam and silt loam soils, characterized by flat and moderate rolling landscape of moraines and till plains. The area around Raymond, Minnesota (southwestern downstream end of the watershed) is Normania-Canisteo-Harps soils dominated by medium-textured glacial tills, and is prime farmland with the area heavily cultivated with soybeans and corn.

The vast majority of hydrologic soils groups across the Upper Hawk Creek Watershed are Group B (24.1%) or Group B/D (42.2%) (Table 3 and Figure 3). Group B soils are characterized as silt loam or loam with a moderate infiltration rate. Dual classified soils (e.g., A/D, B/D) reflect the behavior of the soil in a natural condition as Group D with high runoff potential and low infiltration. This is often due the presence of a high water table. The first letter of the dual classification reflects the soil's behavior in a drained condition. In this watershed, many of the dual classified soils have been drained through ditching or drain tiles.

Table 3. Upper Hawk Creek Watershed hydrologic soil groups

Hydrologic soil group	Percent of watershed
Null/Water	8.4%
A	2.1%
A/D	0.9%
B	24.1%
B/D	42.2%
C	8.9%
C/D	13.5%

Figure 3. Upper Hawk Creek Watershed K-Factor whole soil



2.3 Streams

Hawk Creek is the only major waterway located within the Upper Hawk Creek Watershed. The creek flows from Foot Lake near U.S. Highway 10 to the outlet of the watershed near Clara City, Minnesota. Hawk Creek in the Upper Hawk Creek Watershed is 30.8 miles long; however, Hawk Creek continues flowing southward for an additional 31.2 miles (Lower Hawk Creek) before receiving additional flow from Chetomba Creek and eventually flowing into the Minnesota River near the confluence of the Yellow Medicine River from the southwest.

There is an extensive ditch system throughout Kandiyohi County which carries runoff from agricultural lands and collects water from field tile systems (City of Willmar and the Mid-Minnesota Development Commission 2009). Nearly 60% of the entire Hawk Creek Watershed has been identified as "altered" due to the presence of tile drains and stream channelization (Figure 4).

Figure 4. Examples of channelized streams in the Hawk Creek Watershed- (left) East Creek Beaver Fork, and (right) Hawk Creek (MPCA 2013b)

2.4 Lakes

Upper Hawk Creek Watershed contains many small waterbodies, many of which are unnamed. Lakes that have been assessed as part of Minnesota's Watershed Approach (Table 4). The Willmar Chain of Lakes are located in the headwaters and include the following lakes: Skataas, Swan, Willmar, and Foot.

Table 4. Lakes in the Upper Hawk Creek Watershed

Lake name	Lake ID	Watershed area (ha)	Surface area (ac)	Average depth (ft)	Max depth (ft)	Littoral area (%)
Eagle	34-0171-00	4,613	892	24	65	33.3
Willmar	34-0180-00	7,988	640	6	14	100
Foot	34-0181-00	8,649	544	6	24	95.6
Swan	34-0186-00	5,426	205	3	5	100
Point	34-0193-00	190	74	10	32	75
Skataas	34-0196-00	529	200	8	10	100

Willmar Chain of Lakes

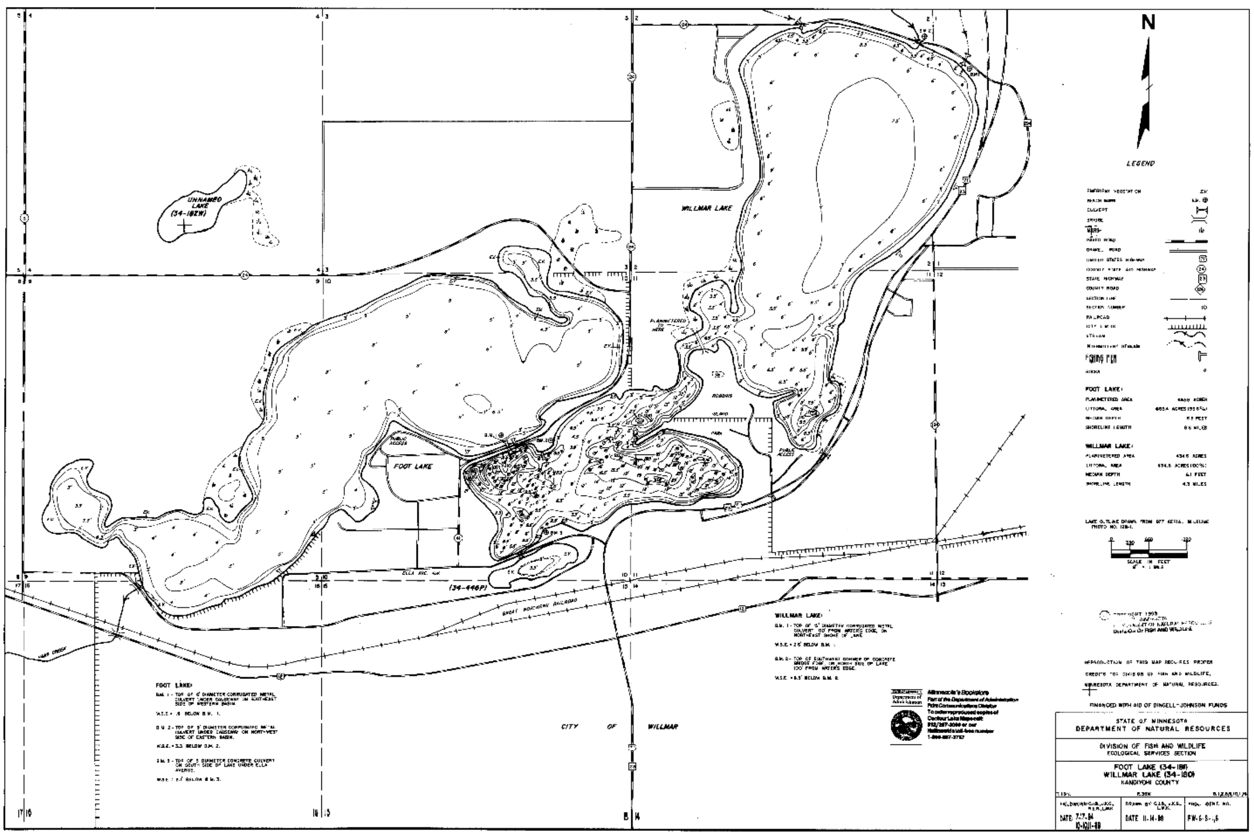
The Willmar Chain of Lakes include (from upstream to downstream) Skataas Lake, Swan Lake, Willmar Lake, and Foot Lake. The City of Willmar surrounds much of these lakes. The Willmar Area Lakes Association identified the following key issues facing the Chain of Lakes in their May 2019 newsletter: curly leaf pondweed, common carp, and stormwater. Point Lake and Eagle Lake discharges into Swan Lake from the north.

Lakes within this headwater area have been altered due to past development. For example, the upper and lower sections of Foot Lake, Willmar Lake, and a slough along Ella Avenue were originally one body of water with two islands. This body of water was split into four distinct basins when the need for improved transportation routes resulted in the construction of streets and highways that separate them today. Despite past alterations, future development along shorelines will be "strictly regulated to insure compatibility with the water resource" (City of Willmar and the Mid-Minnesota Development Commission 2009).

The following descriptions of Foot Lake and Willmar Lake are from the City of Willmar Comprehensive Plan (City of Willmar and the Mid-Minnesota Development Commission 2009). Descriptions for both Swan Lake and Skataas Lake were developed based on best available information from the Minnesota LakeFinder and Minnesota LakeBrowser.

Foot Lake (AUID 34-0181-00) is moderately sized at 694 acres (Figure 5). There are two distinct basins (northwest and southeast) bisected by a road but connected via several culverts. Foot Lake is also connected to Willmar Lake via an upstream shallow channel. Foot Lake has two public access sites with one site on each basin. In addition, Robbins Island Park is located along the east side of the lake. The northwest basin is 6 feet deep maximum with abundant submergent vegetation (coontail, northern milfoil) and moderate water clarity. Curly leaf pondweed, a nonnative invasive species, is present in this lake and has led to dense algal mats. The southeast basin has a maximum depth of 24 feet with sparse submergent vegetation (sago pondweed) and poor water clarity (Secchi disk clarity at 3 feet). The Foot Lake outlet is considered the headwaters of Hawk Creek, although there are several lakes upstream connected via ditches and inlets. Foot Lake has been a popular fishing lake for black crappie, walleye, northern pike, bluegill, and largemouth bass in recent years. The lake is aerated in the winter months. Land use and land cover within 1,000 feet of the lake is 57% developed, 26% planted/cultivated, 14% wetland, 3% forest, less than 1% herbaceous (NLCD 2016).

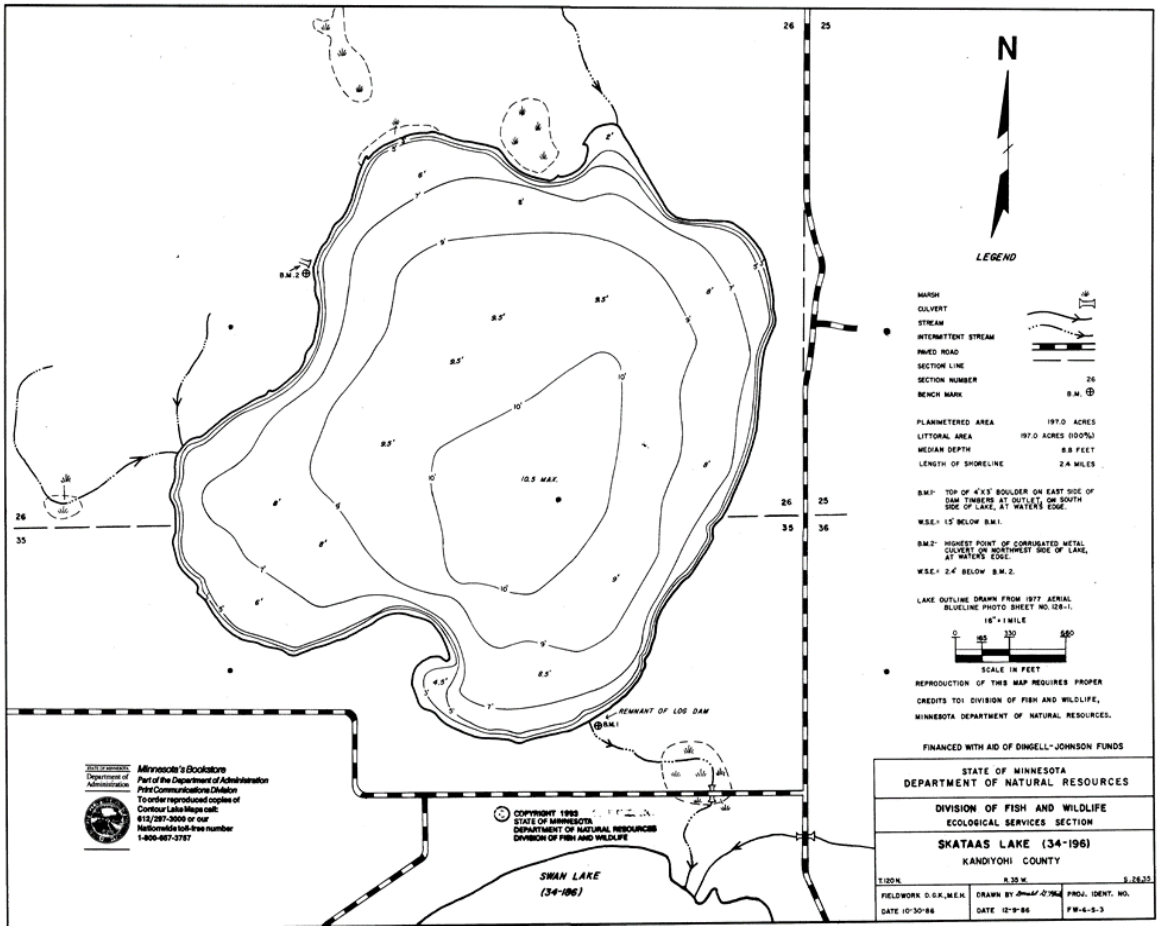
Figure 5. Foot and Willmar Lake bathymetry (MN LakeFinder)



Willmar Lake (AUID 34-0180-00) is moderate sized at 435 acres and has a maximum depth of 14 feet (Figure 5). A large golf course borders the north shore area and Robbins Island Park is located along the south shore. Residential development occurs primarily along the west shore. Willmar Lake is connected to Foot Lake via an outlet channel along the southwest portion adjacent to the City park. Willmar Lake is also connected to several shallow lakes and Eagle Lake via inlets along the north shore. Water clarity is often stained (coffee colored) throughout the summer months. Blue-green algae blooms are common on Willmar Lake. Aquatic vegetation is limited to primarily sago pondweed in the lake proper and cattails along the south portion of the lake. Willmar Lake is managed primarily for walleye, channel catfish, and black crappie. Walleye fry are generally stocked every other year. Land use and land cover within 1,000 feet of the lake is 87% developed, 6% planted/cultivated, 4% forest, 3% wetland, and less than 1% herbaceous (NLCD 2016).

Skataas Lake (AUID 34-0196-00) is located near the City of Willmar and is the most upstream lake in the so-called Willmar Chain of Lakes (Figure 6). The lake is approximately 200 acres in size with a maximum depth of 10.5 feet. It is a shallow lake with limited water quality data. Land use and land cover within 1,000 feet of the lake is 71% planted/cultivated, 16% forest, 10% developed, 2% wetland, and less than 1% shrubland/herbaceous (NLCD 2016).

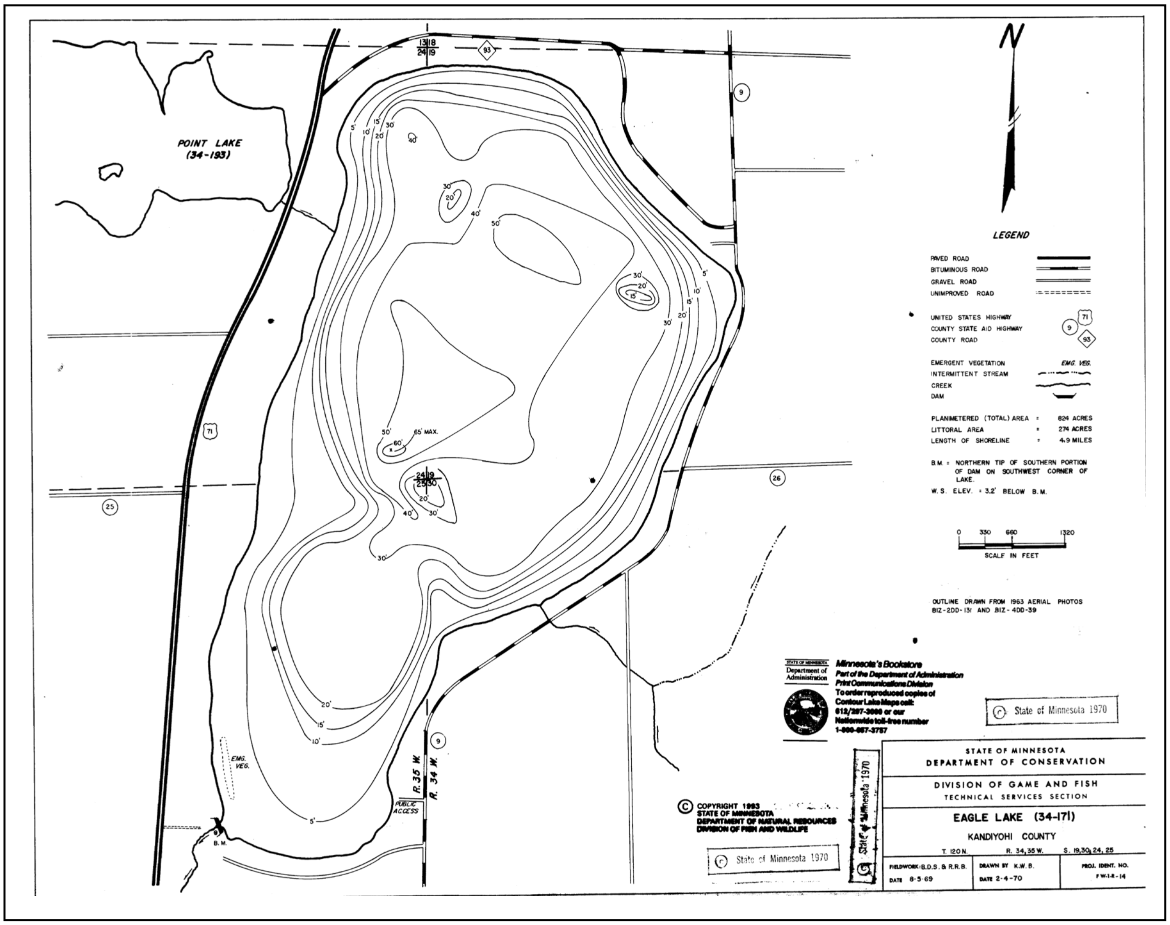
Figure 6. Skataas Lake bathymetry (MN LakeFinder)



Swan Lake (AUID 34-0186-00) is a shallow lake, 229 acres in size, located between Skataas Lake and Willmar Lake. Land use and land cover within 1,000 feet of the lake is 70% developed, 15% forest, 13% planted/cultivated, 1% wetland, and less than 1% herbaceous/barren (NLCD 2016). There are no bathymetry data available for Swan Lake.

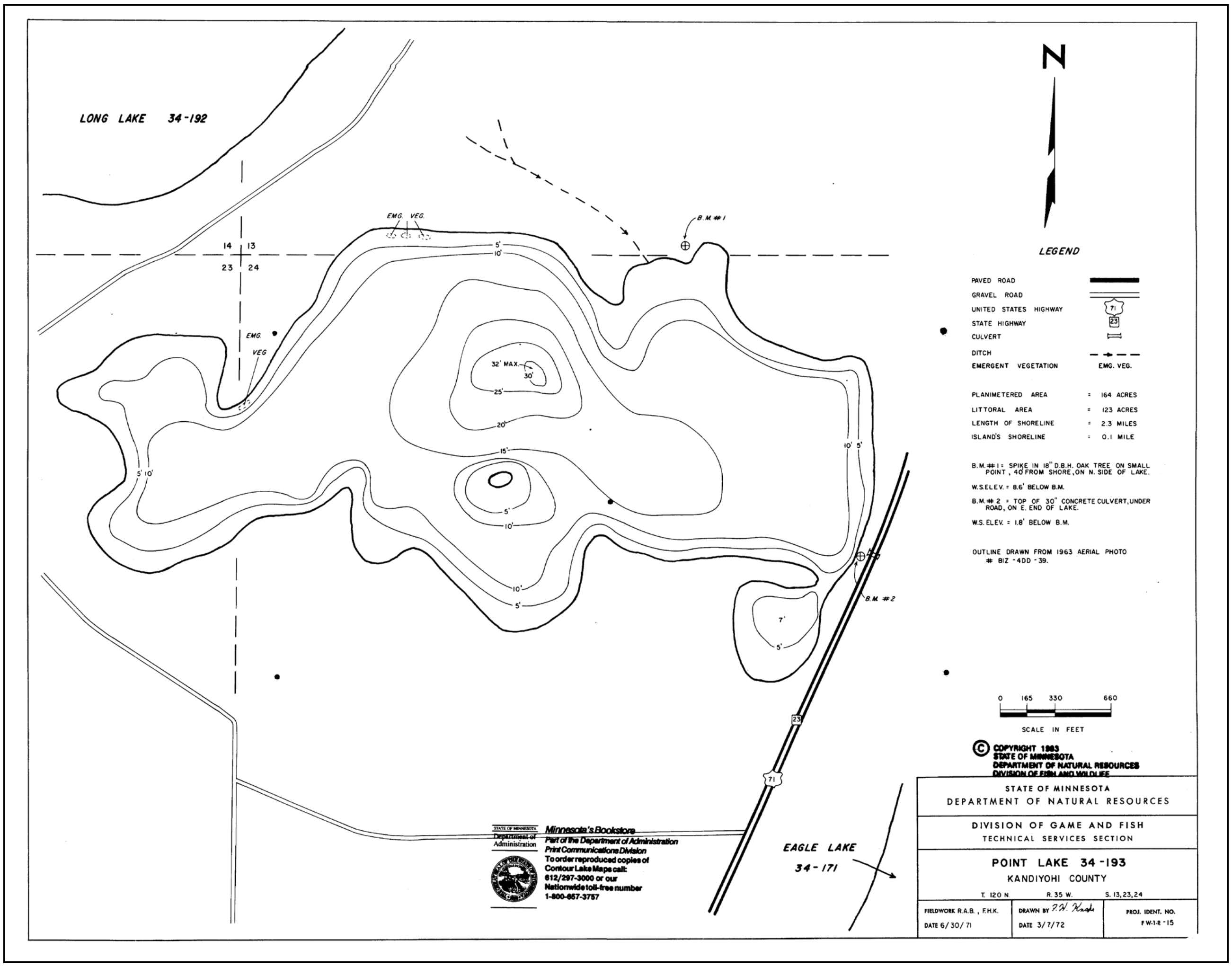
Eagle Lake (AUID 34-0171-00) is located near the town of Willmar, approximately 849 acres in size, with a littoral area of 274 acres, and maximum depth of 67 feet (Figure 12). Eagle Lake is located across Minnesota Highway 23 from Skataas Lake. There are three primary inlets to Eagle Lake and only one outlet, which is the start of Hawk Creek. Land use and land cover within 1,000 feet of the lake is 44% developed, 37% planted/cultivated, 10% forest, 5% wetland, 3% shrubland, and less than 1% herbaceous/barren (NLCD 2016). Zebra mussels were found in the lake in August 2018.

Figure 7. Eagle Lake bathymetry (MN LakeFinder)



Point Lake (AUID 34-0193-00) is located near the town of Spicer. Point Lake is approximately 174 acres with 123 acres of littoral area, and a maximum depth of 32 feet (Figure 8). The lake is located east of Long Lake, west of Eagle Lake, and north of Skataas Lake. Land use and land cover within 1,000 feet of the lake is 50 forest, 29% planted/cultivated, 12.5% developed, 7% wetland, 1% shrubland, and 0.5% herbaceous (NLCD 2016).

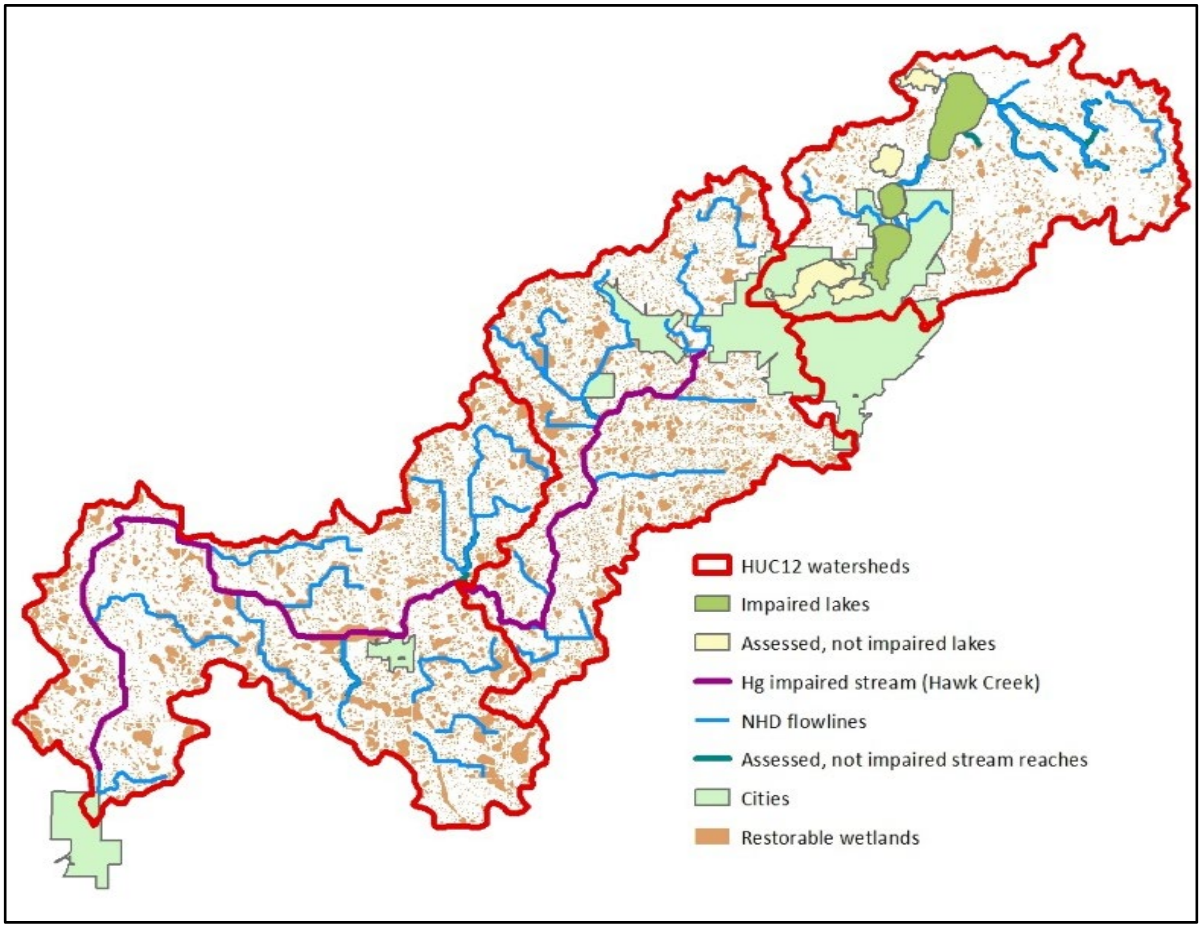
Figure 8. Point Lake bathymetry (MN LakeFinder)



2.5 Wetlands

Based on the National Land Cover Database (NLCD) 2016 land use raster for the Upper Hawk Creek Watershed, there are approximately 3,760 acres of wetland in the watershed, which is 4.5% of the total area. MPCA (2013a) estimated historic wetland loss within this watershed between 60 and 70%. Potential restorable wetlands were identified within the watershed by Ducks Unlimited, as shown in Figure 9. The City of Willmar has recognized the value of wetlands, and notes that both the environmental benefit and aesthetic value should be considered when developing land in or near these wetland areas (City of Willmar and the Mid-Minnesota Development Commission 2009). Restorable wetlands will prioritized by targeting wetlands that have the most contiguous areas to optimize the habitat restoration along with water quality benefits.

Figure 9. Ducks Unlimited restorable wetlands in the planning area



2.6 Groundwater

Groundwater generally flows southwestward across the Hawk Creek Watershed. Cretaceous sandstone aquifers are present over most of the area, generally less than 10-feet thick, however yields in many places are minimal (City of Willmar and the Mid-Minnesota Development Commission 2009).

The main supply of drinking water to the residents and businesses in the Hawk Creek Watershed is groundwater – either from private wells, community wells, or a rural water supplier. There are two community water suppliers providing drinking water in the Upper Hawk Creek Watershed: Willmar provides drinking water for a population of approximately 20,000 and Raymond serves a population of 764.

The communities of Raymond and Willmar have vulnerable drinking water systems, as determined by the Minnesota Department of Health (MDH). 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. In addition, Willmar provides nitrogen removal, indicating a potential excess of nitrogen in the groundwater (MDH 2019).

Source water protection plans have been developed for Willmar in 2016 and for Raymond in 2014. With current source water protection plans, the cities are eligible for MDH plan implementation grants to fund documented plan activities. The source water protection plans will also guide local planning partners by documenting other potential complementary watershed-level activities to protect drinking water on a larger scale. The wellhead protection plans will be added to this plan as Appendix D and E. Projects from these protection plans will be added to this plan as appropriate.

2.7 Land use

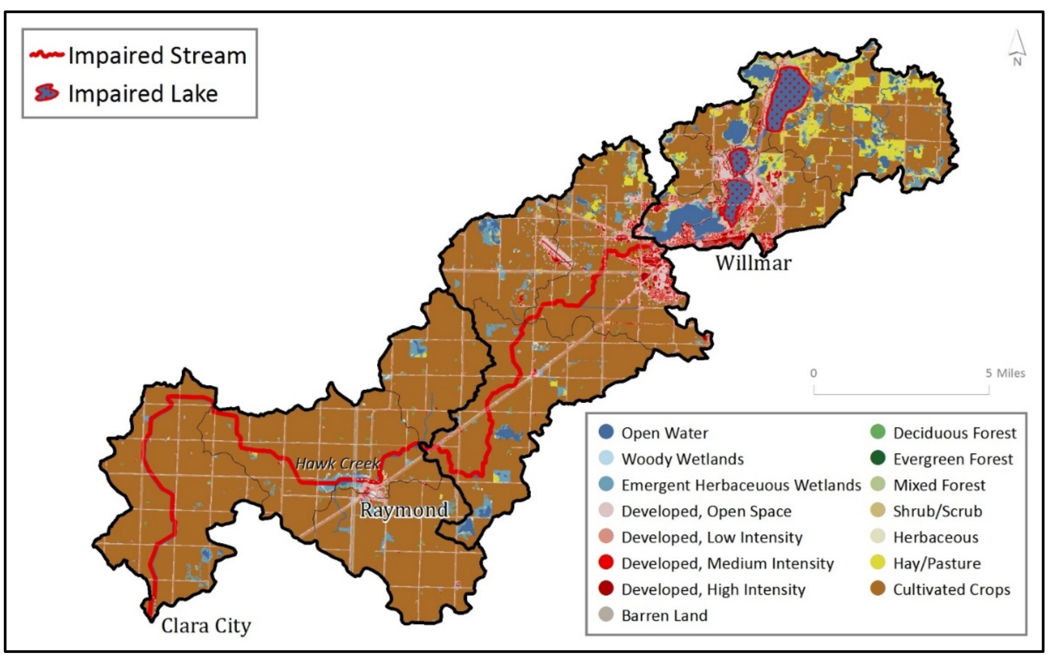
Within the 83,900-acre Willmar Chain of Lakes and Upper Mainstem Hawk Creek Watershed, 62,925 acres (75%) consist of cultivated crops dominated by corn and soybean (88%) and a small amount of sugar beets (8%) and hay/forage crops (4%). Table 5 displays the 2016 NLCD classification cover acreage and percent within the watershed as displayed in Figure 10.

The upper part of the watershed may be referred to as the “lakes zone” which transitions southward to the “farmed zone” which is intensively farmed for the vast majority of the lower watershed (MPCA 2017b). The shorelines of Foot Lake and Willmar Lakes are substantially developed. Future development is anticipated near Swan Lake, north of the City of Willmar, where residential development is occurring (City of Willmar and the Mid-Minnesota Development Commission 2009).

Table 5. Land use breakdown for the Upper Hawk Creek Watershed by lakeshed and streamshed (NLCD 2016)

	Watershed					
Land use classification	**Swan**	**Point/ Eagle**	**Skaatas**	**Willmar**	**Foot**	**Upper Hawk**
Urban	218	650	135	2,051	558	5,588
Cropland	177	6,072	782	2,987	379	52,503
Pastureland	35	2,037	106	349	64	759
Open water, shrub/herbaceous, and wetlands	235	2,090	230	825	609	2,961
Total	701	11,398	1,308	6,328	1,633	62,282

Figure 10. Land use and land cover for Upper Hawk Creek Watershed (NLCD 2016)



2.8 Wastewater

The City of Willmar (population of nearly 20,000) built a new wastewater treatment facility that began treating wastewater in 2010. The facility is a Class A Facility with an average wet weather design flow of 7.52 million gallons per day. The Willmar wastewater treatment facility discharges effluent into County Ditch #46 which flows into Upper Hawk Creek, and also uses land application methods of biosolids on about 2,200 acres of farmland. The City of Raymond is also located in the Upper Hawk Creek Watershed with a population of approximately 800. Raymond has a small wastewater treatment facility. While the Willmar wastewater plant is a “continuous discharge” facility, the Raymond facility is a controlled discharge system.

Outside of the service area, residents and businesses use onsite wastewater treatment (septic systems). Individual county estimates from the subsurface sewage treatment system (SSTS) county annual reports for the Hawk Creek Watershed range from 35% to 75% non-compliant. Some of these systems discharge inadequately treated wastewater into waterways and are a pollutant source during low flow conditions (MPCA 2017a).

2.9 Climate and precipitation

The climate of the Upper Hawk Creek Watershed is typical of southwestern Minnesota. The long-term average annual precipitation is 25 inches per year based on records from the Minnesota State Climatology Office for the larger HUC-8 watershed. Most of the precipitation (88%) occurs between March and October with the remainder (12%) falling between November and February as mostly snow. The average annual snowfall is about 40 inches. The normal average annual temperature in the watershed is 43 degrees Fahrenheit (F) with the winter and summer normal average temperatures being 15 degrees and 70 degrees F, respectively. The average minimum and maximum temperatures are 2 degrees and 81 degrees F, respectively.

Detailed weather data for the HUC-8 watershed along with other weather stations and volunteer observation sites are available at http://climate.umn.edu.

3. Water quality and quantity

3.1 Water quality standards

The federal Clean Water Act requires states to designate beneficial uses for all waters and develop water quality criteria to protect each use. Water quality standards consist of several parts:

- Beneficial uses — Identify how people, aquatic communities, and wildlife use our waters
- Numeric criteria — Amounts of specific pollutants allowed in a body of water and still protects it for the beneficial uses
- Narrative criteria — Statements of unacceptable conditions in and on the water
- Antidegradation protections — Extra protection for high-quality or unique waters and existing uses

Together, the beneficial uses, numeric and narrative criteria, and antidegradation protections provide the framework for achieving Clean Water Act goals.

Minnesota's water quality standards are provided in Minn. R. ch. 7050. All current state water rules administered by the MPCA are available on the Minnesota water rules page (https://www.pca.state.mn.us/water/water-quality-rules).

Beneficial uses

The beneficial uses for public waters in Minnesota are grouped into one or more classes as defined in Minn. R. ch. 7050.0140. The classes and beneficial uses are:

- Class 1 – domestic consumption
- Class 2 – aquatic life and recreation
- Class 3 – industrial consumption
- Class 4 – agriculture and wildlife
- Class 5 – aesthetic enjoyment and navigation
- Class 6 – other uses and protection of border waters
- Class 7 – limited resource value waters

The aquatic life use class now includes a tiered aquatic life uses (TALU) framework for rivers and streams. The framework contains three tiers—exceptional, general, and modified uses. All surface waters are protected for multiple beneficial uses.

Numeric criteria and state standards

Narrative and numeric water quality criteria for all uses are listed for four common categories of surface waters in Minn. R. ch. 7050.0220. The four categories are:

- Cold water aquatic life and habitat, also protected for drinking water: classes 1B; 2A, 2Ae, or 2Ag; 3A or 3B; 4A and 4B; and 5
- Cool and warm water aquatic life and habitat, also protected for drinking water: classes 1B or 1C; 2Bd, 2Bde, 2Bdg, or 2Bdm; 3A or 3B; 4A and 4B; and 5
- Cool and warm water aquatic life and habitat and wetlands: classes 2B, 2Be, 2Bg, 2Bm, or 2D; 3A, 3B, 3C, or 3D; 4A and 4B or 4C; and 5
- Limited resource value waters: classes 3C; 4A and 4B; 5; and 7

The narrative and numeric water quality criteria for the individual use classes are listed in Minn. R. ch. 7050.0221 through 7050.0227. The procedures for evaluating the narrative criteria are presented in Minn. R. ch. 7050.0150.

The MPCA assesses individual waterbodies for impairment for class 2 uses—aquatic life and recreation. Class 2A waters are protected for the propagation and maintenance of a healthy community of cold water sport or commercial fish and associated aquatic life and their habitats. Class 2B waters are protected for the propagation and maintenance of a healthy community of cool or warm water sport or commercial fish, and associated aquatic life and their habitats. Both class 2A and 2B waters are also protected for aquatic recreation activities including bathing and swimming.

Protection for aquatic recreation entails the maintenance of conditions safe and suitable for swimming and other forms of water recreation. In streams, aquatic recreation is assessed by measuring the concentration of *E. coli* in the water, which is used as an indicator species of potential waterborne pathogens. To determine if a lake supports aquatic recreational activities, its trophic status is evaluated using total phosphorus (TP), Secchi depth, and chlorophyll-a as indicators. Lakes that are enriched with nutrients and have abundant algal growth are eutrophic and do not support aquatic recreation.

Protection of aquatic life entails the maintenance of a healthy aquatic community as measured by fish and macroinvertebrate indices of biological integrity (IBI). Fish and invertebrate IBI scores are evaluated against criteria established for individual monitoring sites by waterbody type and use subclass (exceptional, general, and modified).

The ecoregion standard for aquatic recreation protects lake users from nuisance algal bloom conditions fueled by elevated phosphorus (P) concentrations that degrade recreational use potential.

The ecoregion standard for aquatic recreation protects lake users from nuisance algal bloom conditions fueled by elevated P concentrations that degrade recreational use potential.

Antidegradation policies and procedures

The purpose of the antidegradation provisions in Minn. R. ch. 7050.0250 through 7050.0335 is to achieve and maintain the highest possible quality in surface waters of the state. To accomplish this purpose:

1. Existing uses and the level of water quality necessary to protect existing uses shall be maintained and protected.
2. Degradation of high water quality shall be minimized and allowed only to the extent necessary to accommodate important economic or social development.
3. Water quality necessary to preserve the exceptional characteristics of outstanding resource value waters shall be maintained and protected.
4. Proposed activities with the potential for water quality impairments associated with thermal discharges shall be consistent with Section 316 of the Clean Water Act, United States Code, title 33, Section 1326.

Standards and criteria in the Upper Hawk Creek Watershed

The streams in the Upper Hawk Creek Watershed are primarily designated as class 2B and seven waters. The water quality standards and criteria used in assessing the streams (class 2B only) and lakes include the following parameters:

- Escherichia (E.) coli – not to exceed 126 organisms per 100 milliliters as a geometric mean of not less than five samples representative of conditions within any calendar month, nor shall more than 10% of all samples taken during any calendar month individually exceed 1,260 organisms per 100 milliliters. The standard applies between April 1 and October 31.
- Dissolved oxygen (DO) – daily minimum of 5 mg/L.
- pH – to be between 6.5 and 9.0 pH units.
- Total suspended solids (TSS) – 65 mg/L not to be exceeded more than 10% of the time between April 1 and October 31.
- Lakes – based on summer average concentrations in the Western Corn Belt Plains ecoregion (applied to Willmar Lakes):
  - Deep lakes: TP less than 65 µg/L and chl-a less than 22 µg/L or transparency not less than 0.9 meters
  - Shallow lakes: TP less than 90 µg/L and chl-a less than 30 µg/L or transparency not less than 0.7 meters
- Lakes – based on summer average concentrations in the North Central Hardwoods Ecoregion (applied to Eagle and Point Lakes):
  - Deep lakes: TP less than 40 µg/L and chl-a less than 14 µg/L or transparency not less than 1.4 meters
  - Shallow lakes: TP less than 60 µg/L and chl-a less than 20 µg/L or transparency not less than 1.0 meters
- Stream eutrophication – based on summer average concentrations for the South River Nutrient Region
  - Total phosphorus concentration less than or equal to 150 µg/L and
  - Chl-a (seston) concentration less than or equal to 35* µg/L or
  - Diel DO flux less than or equal to 4.5* mg/L or
  - Five-day biochemical oxygen demand concentration less than or equal to 3.0* mg/L.
  - If the TP criterion is exceeded and no other variable is exceeded, the eutrophication standard is met.
- Biological indicators – The basis for assessing the biological community are the narrative water quality standards and assessment factors in Minn. R. 7050.0150. Attainment of these standards is measured through sampling of the aquatic biota and is based on impairment thresholds for IBI) that vary by use class.
- Mercury: The standard for class 2 waters is based on the mercury concentration in edible fish tissue: 0.2 mg/kg fish mercury concentration.

Class 7 waters (limited use waters) have the following water quality standards as described in Minn. R. 7050.0227:

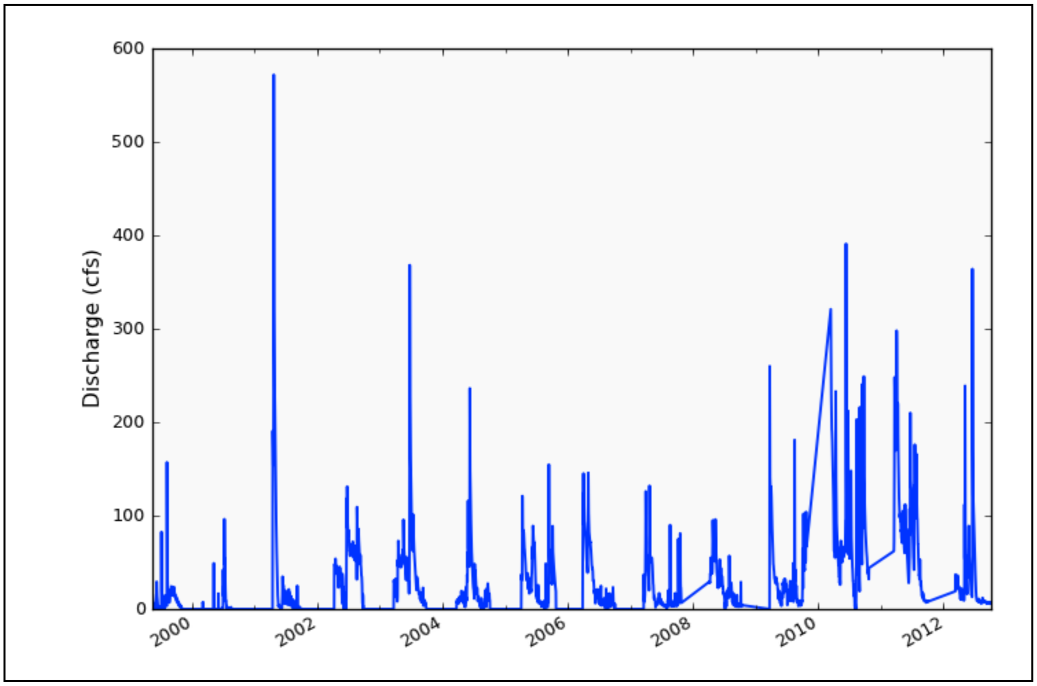
- *E. coli* – not to exceed 630 organisms per 100 milliliters as a geometric mean of not less than five samples representative of conditions within any calendar month, nor shall more than 10% of all samples taken during any calendar month individually exceed 1,260 organisms per 100 milliliters. The standard applies between May 1 and October 31.
- Dissolved oxygen – The level of DO must be maintained at concentrations:
  - That will avoid odors or putrid conditions in the receiving water
  - At not less than 1 mg/L (daily average)
  - Above 0 mg/L at all times

- pH – to be between 6.0 and 9.0 pH units
- Toxic pollutants: shall not be allowed in such quantities or concentrations that will impair the specified uses

3.2 Streamflow

There are no active U.S. Geological Survey flow monitoring stations within the Upper Hawk Creek Watershed, however flow data were collected from 1999-2012 at a Minnesota Department of Natural Resources (DNR) Hydstra gage 25007001 (Figure 23). This site is located southwest of the City of Willmar on Hawk Creek where the creek is crossed by 75th Street SW. This gage is located near the unincorporated town of Priam, Minnesota.

Figure 11. Flow data for DNR Hydstra gage 25007001, Hawk Creek near Priam, CR 116



3.3 Water quality data summaries

Total phosphorus (TP), chl-a, and Secchi depth transparency data have been collected from several lakes. However, few samples were collected at most sample stations. Table 7 presents average TP and chl-a concentrations and average Secchi depth for the six lakes that have a sample station with more than 10 samples.

Data collected from June through September 2010 and 2011 at Swan Lake were included in the Hawk Creek Watershed TMDL (MPCA 2017a).

Of the all the lake sites, site 34-071-00-204 on Eagle Lake has the most data collected since the year 2000. TP and chl-a concentrations and Secchi disc depth vary over a fairly consistent range from 2000 through 2018. In recent years, fewer, isolated high TP concentrations were observed.

Table 6. Average TP, chl-a, and Secchi transparency at select stations

Lake name	Lake ID	Station ID	Sample Counts [a]	Average TP (ug/L)	Average chl-*a* (ug/L)	Average Secchi (m)
Eagle	34-0171-00	34-0171-00-204	88/88/238	38	12	2.2
Willmar	34-0180-00	34-0180-01-203	18/18/16	131	37	0.4
Foot	34-0181-00	34-0181-00-204	24/24/33	64	15	0.9
Swan	34-0186-00	34-0186-00-201	19/18/26	113	29	0.4
Point	34-0193-00	34-0193-00-201	35/18/31	36	6	3.0
Skataas	34-0196-00	34-0196-00-201	18/17/71	104	27	0.7

a. Sample counts are report for TP, then chl-a, and then Secchi disc depth.

3.4 Water quality impairment assessments

The MPCA assesses the use support of individual waterbodies in Minnesota. A waterbody is defined as an individual stream reach, lake, or wetland and is identified as an assessment unit. Each assessment unit is assigned an assessment unit identification (AUID). Stream AUIDs are delineated using the 1:24,000 scale National Hydrography Dataset. Streams and rivers often contain more than one stream reach based on the presence of tributaries, lakes and wetlands, and other landscape changes. Lake and wetland AUIDs are based on the DNR's Protected Waters Inventory.

Assessment of aquatic life in streams is derived from the analysis of fish and macroinvertebrate assemblages, DO, TSS, chloride, pH, TP, chl-*a*, biochemical oxygen demand, and un-ionized ammonia data, while the assessment of aquatic recreation in streams is based solely on fecal indicator bacteria (*E. coli*) data. The assessment of aquatic recreation in lakes is based on TP, chl-*a*, and Secchi depth, and the assessment of aquatic life in lakes is based on chloride and fish data, where available. Where applicable and where sufficient data exist, other designated uses (e.g., limited resource value water, drinking water, and aquatic consumption) are assessed.

Hawk Creek (-508) was identified as impaired for Hg in 2006 and included in the statewide Mercury TMDL. The reach was later divided into three reaches (-508, -510, and -627). There were no stream assessments in the project area due to extensive channelization and Class 7 designation.

Six lakes were assessed for aquatic recreation; Swan and Willmar were identified as impaired (Table 7). The remaining four are fully supporting aquatic recreation.

Table 7. Assessment status of lakes

Lake ID	Lake name	Aquatic recreation use support
34-0171-00	Eagle	FS
34-0180-00	Willmar	NS
34-0181-00	Foot	FS
34-0186-00	Swan	NS
34-0193-00	Point	FS
34-0196-00	Skataas	FS

3.5 Impairments 303(d) listings

Water quality impairments are identified on Minnesota's 303(d) list. The most recent approved updates of the 303(d) list occurred in 2018; however, there are listed impairments dating back to 1998. Figure 1 shows the impairments, and Table 13 and Table 14 describe the criteria, date of listing and the status of TMDL development for these impairments based on their status in 2018.

Table 8. Impaired streams in the Willmar Chain of Lakes Watershed (2018)

Reach name	Reach description	Classification	Year listed	AUID (07020004-xxx)	Affected designated use	Pollutant or stressor	Status of TMDL
Hawk Creek	Headwaters (Foot Lk 34-0181-00) to T119 R35W S18, south line	2B, 3C	2006	627	Aquatic Consumption	Mercury in fish tissue	Approved 2007
Hawk Creek	T119 R35W S19, north line to T118 R37W S31, south line	7	2006	508	Limited Resource Value	Mercury in fish tissue	Approved 2007
Hawk Creek	T117 R37W S6, north line to Chetomba Cr	2B, 3C	2006	510	Aquatic Consumption	Mercury in fish tissue	Added to statewide mercury TMDL in 2007

Table 9. Impaired lakes in the Upper Hawk Creek Watershed (2018)

Lake name	Lake AUID	Use class	Year listed	Affected Designated Use	Pollutant or stressor	Status of TMDL
Eagle	34-0171-00	2B, 3C	1998	Aquatic Consumption	Mercury in fish tissue	Added to Statewide Mercury TMDL in 2008
Willmar	34-0180-01	2B, 3C	2018	Aquatic Recreation	Nutrient/ eutrophication biological indicators	2024 Target Completion
Swan	34-0186-00	2B, 3C	2014	Aquatic Recreation	Nutrient/ eutrophication biological indicators	Approved 2017

3.6 Watershed TMDLs

Various TMDLs address multiple impairments in the Upper Hawk Creek Watershed:

- The Hawk Creek Watershed TMDL (MPCA 2017a) addresses impairments due to excess nutrients/eutrophication in the Swan Lakes. A summary of the P TMDL is provided in Table 13.
- The Statewide Mercury TMDL and Implementation Plan addresses the Eagle Lake mercury impairment.

Willmar Lake was listed in 2018 and the TMDL has not been developed.

Table 10. TMDL summary for Swan Lake (34-0181-00) in lb/day

Waste load allocation	0.043
Load allocation	4.24
Margin of Safety	0.476
Total load capacity	4.76

4. Pollutant source assessments

Pollutant source assessments are conducted for typical pollutant impairment listings and where a biological stressor identification report process identifies a pollutant as a stressor. Sources of pollutants to lakes and streams include point sources and NPSs. Lake impairments in the Upper Hawk Creek Watershed include P and mercury. The stream itself is listed as impaired by mercury in fish tissue. Streams in this watershed have not been listed as impaired for other pollutants; however, downstream waterbodies (e.g., lower Hawk Creek reaches and Minnesota River) are listed as impaired for TSS and *E. coli*. With the downstream impairments, activities to decrease loading in the Upper Hawk Creek are included in this plan.

In addition to the NPS pollutant sources, there are two wastewater treatment facilities (Willmar and Raymond) and one MS4 permit (Willmar) in the watershed.

4.1 Phosphorus

The average annual TP loads in the three HUC-12 watersheds were estimated using the HSPF model for each of the HUC-12s (Table 11). The estimated loads for the two HSPF model segments in the Willmar Lake HUC-12 watersheds are shown in Figures 12 - 14 and Table 12. The estimated load contribution by nonpoint and point sources as a percentage of the total for each is also included in the tables. The estimated loads only represent the watershed and atmospheric contributions, not the internal loading of the lakes.

Table 11. Average annual TP load for the HUC-12 watersheds estimated by HSPF model

HUC-12 watershed	Load (lb/yr)	Grassland	Cropland	Developed	Bed/Bank	SSTS	Atmos. Dep.	Point source	Misc.
Willmar Lake	6,400	4%	63%	19%	2%	0.9%	8.5%	0%	11%
Town of Priam - Hawk Creek	66,200	< 1%	12%	2%	0%	< 1%	< 1%	86%	< 1%
City of Raymond - Hawk Creek	16,400	< 1%	89%	6%	< 1%	1.4%	< 1%	2%	2%

Figure 12. Total phosphorus load to Town of Priam Hawk Creek

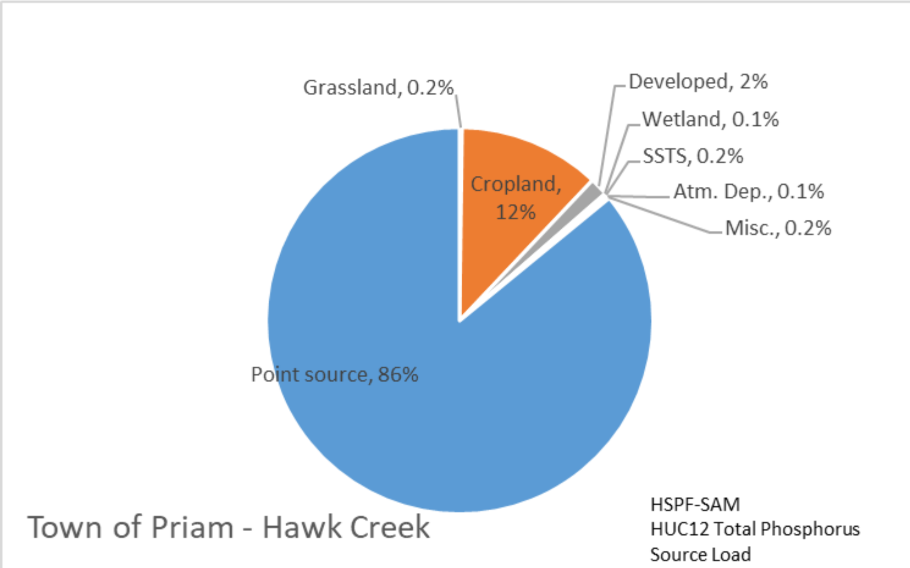


Figure 13. Total phosphorus load to Willmar Lake

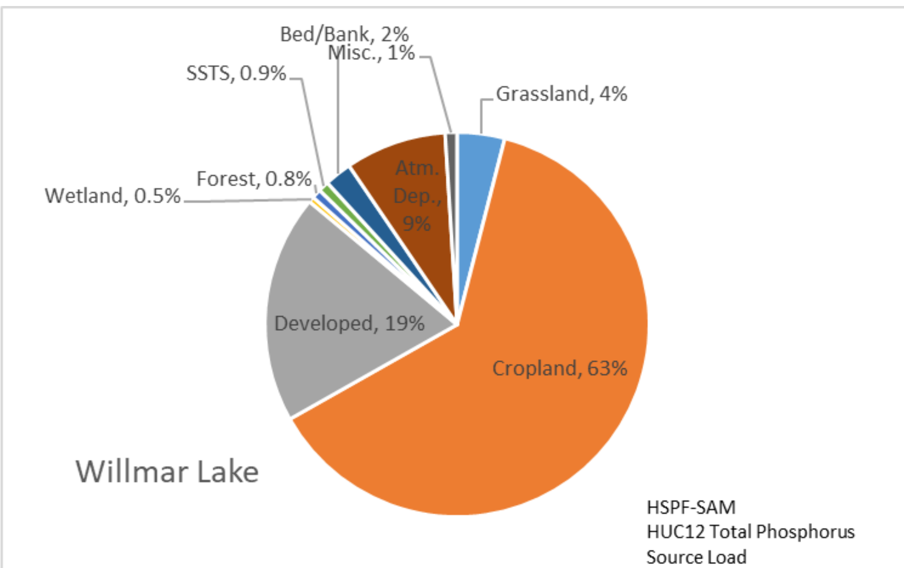


Figure 14. Total phosphorus load to City of Raymond-Hawk Creek

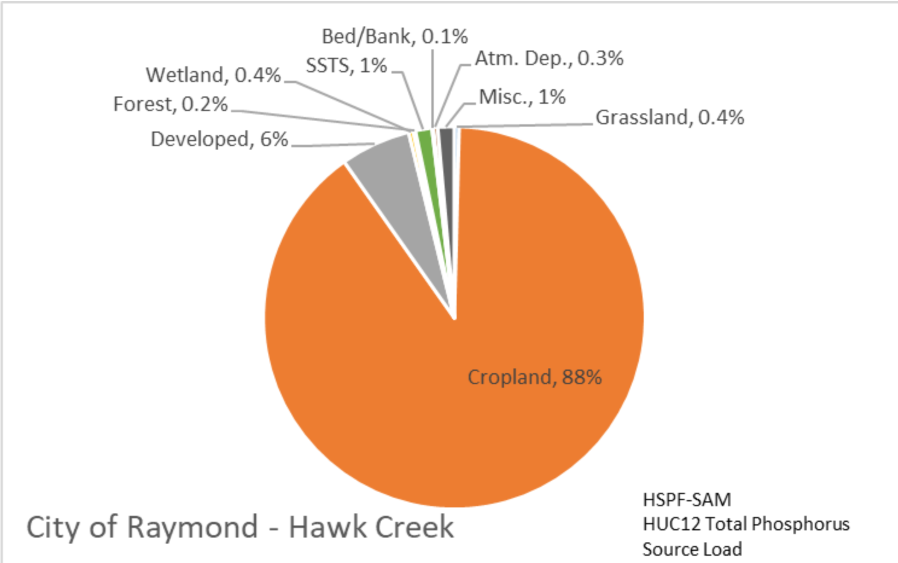


Table 12. Average annual TP load for the HSPF model segments in the Willmar Lake HUC-12 watershed

Combined sources (%)

HUC-12 watershed	Cropland	Developed	Wetland	Grassland	Point source	Atm. Dep.	Bed/ Bank	SSTS	Forest	Misc.
Willmar Lake	63%	19%	0.5%	4%	0%	9%	2%	0.9%	0.8%	1%
Town of Priam - Hawk Creek	12%	2%	0.1%	0.2%	86%	0.1%	0%	0.2%	0%	0.2%
City of Raymond - Hawk Creek	88%	6%	0.4%	0.4%	2%	0.3%	0.1%	1%	0.2%	1%
All	24%	3%	0.1%	0.5%	71%	0.8%	0.2%	0.4%	0.1%	0.4%

Combined sources (lb/yr)

HUC-12 watershed	Cropland	Developed	Wetland	Grassland	Point source	Atm. Dep.	Bed/ Bank	SSTS	Forest	Misc.
Willmar Lake	4,026	1,232	30	256	0	546	146	57	51	64
Town of Priam - Hawk Creek	7,851	1,003	44	133	56,946	33	3	118	16	118
City of Raymond - Hawk Creek	7,288	482	32	33	181	29	10	113	15	113
All	19,166	2,717	106	422	57,127	608	160	288	81	295

The average annual P load for Swan Lake was estimated to be 2,240 lb/yr in the BATHTUB lake eutrophication model (Table 13). The external watershed loading was estimated to be 62.7% with 2.5% from atmospheric deposition and 32.8% from internal loading. Internal sources were identified as Curly leaf pondweed growth and senescence, carp stirring up the bottom, and anoxic sediment release. External sources include atmospheric deposition, SSTS, nutrients in cropland runoff including manure and fertilizer application, streambank erosion, and urban stormwater runoff.

Phosphorus sources and loads were also estimated for Willmar Lake. Table 14 provides the summary of an initial BATHTUB model for Willmar Lake. The internal load was increased to achieve a predicted P concentrations similar to the observed lake concentration. The difference in estimated loads between the models represents differences in the models. HSPF provides the total estimated loading for the watershed segments, while BATHTUB provides estimated loading based on the lakes P processing. It is assumed that the percentage values can be used relatively in both.

Table 13. BATHTUB summary for Swan Lake

	Current condition		**Standard achieved**	
Average concentration (µg/L)	111		90	
Source	**TP Load (lb/yr)**	**(%)**	**TP Load (lb/yr)**	**(%)**
Precipitation	55	2.5%	55	3.2%
Trib. from Eagle Lake	908*	40.5%	908	52.2%
Direct lakeshed	538	24%	299	17.2%
SSTS	4	0.2%	0	0%
Internal load	735	32.8%	478	27.5%
Total	**2,240**		**1,740**	
Outflow	1,387	61.9%	1,124	64.6%
Retention	853	38.1%	615	35.4%

*Derived from HSPF, assumes no reduction from Eagle Lake. For the purposes of this NKE plan, we assume that achieving reductions in Eagle Lake will result in reductions for Swan Lake.

Table 14. BATHTUB summary for Willmar Lake

	Current condition		Standard achieved	
Average concentration (µg/L)	118		90	
Source	**TP Load (lb/yr)**	**(%)**	**TP Load (lb/yr)**	**(%)**
Precipitation	53	2.2%	53	3.2%
Trib. from Swan Lake	633	26.4%	513	30.7%
Direct lakeshed	877	36.6%	689	41.2%
SSTS	n/a	0.0%	0	0%
Internal load	832	34.7%	416	24.9%
Total	**2,395**		**1,672**	
Outflow	1,126	47%	854	51%
Retention	1,270	53%	817	49%

A sanitary sewer operated by the City of Willmar is present around each of the lakes, so there is no P load to the lakes from wastewater from the lakeshore residences.

4.2 TSS

The average annual TSS loads in the three HUC-12 watersheds were estimated using the HSPF model for the three HUC-12s (

Table 15). The estimated load contribution by nonpoint and point sources as a percentage of the total for each is also included in the table.

Table 15. Average annual total suspended solids load for the HUC-12 watersheds estimated by HSPF model

HUC-12 watershed	Grassland	Cropland	Developed	Forest	Point source	Bed/Bank	Misc.	Barren	Wetland	Water
Willmar Lake	14	350	472	1.42	0.00	20	2	0.23	0.26	0.28
Town of Priam - Hawk Creek	8	830	392	0.42	53	605	0	0.69	0.38	0.05
City of Raymond - Hawk Creek	2	724	144	1.03	1.4	604	0	0.71	0.28	0.04
Total	25	1,904	1,008	3	54	1,228	2	2	1	0
Willmar Lake	1.7%	41.3%	55.8%	0.2%	0.0%	2.4%	0.2%	0.0%	0.0%	0.0%
Town of Priam - Hawk Creek	0.4%	44.1%	20.8%	0.0%	2.8%	32.2%	0.0%	0.0%	0.0%	0.0%
City of Raymond - Hawk Creek	0.2%	49.1%	9.8%	0.1%	0.1%	40.9%	0.0%	0.0%	0.0%	0.0%
All	0.6%	45.3%	24.0%	0.1%	1.3%	29.2%	0.0%	0.0%	0.0%	0.0%

The breakdown of contribution of sediment loading to each of the HUC-12s is illustrated in Figure 15, Figure 16, and Figure 17.

Figure 15.Sediment loading to Willmar Lake by land use

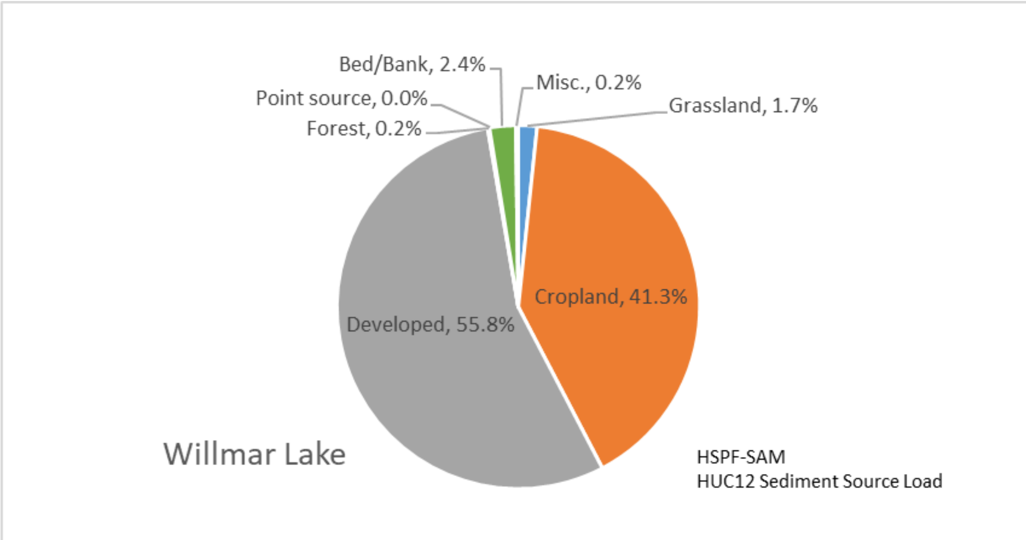


Figure 16. Sediment loading to City of Raymond-Hawk Creek by land use

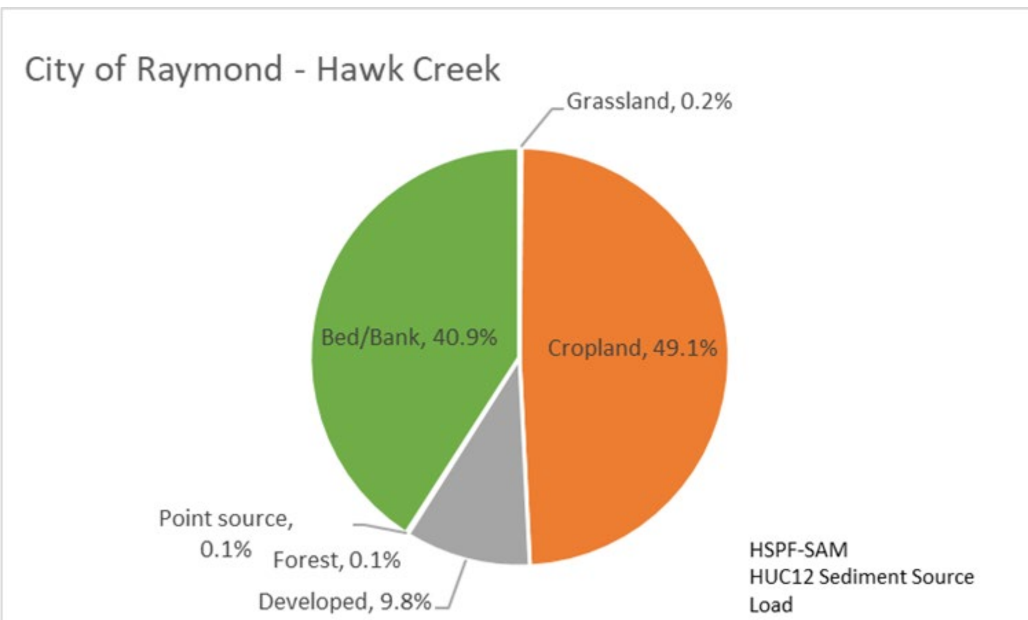
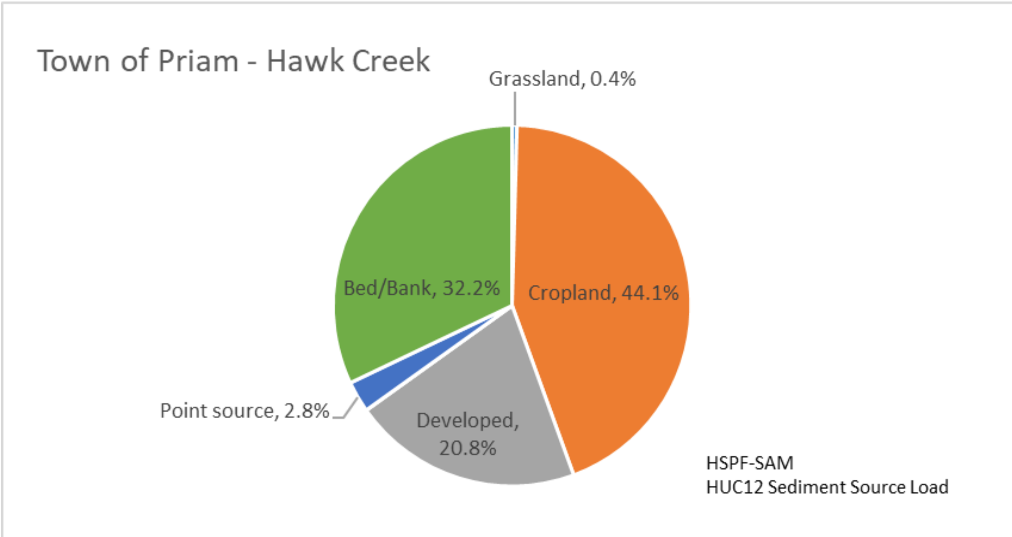


Figure 17. Sediment loading to Town of Priam-Hawk Creek by land use

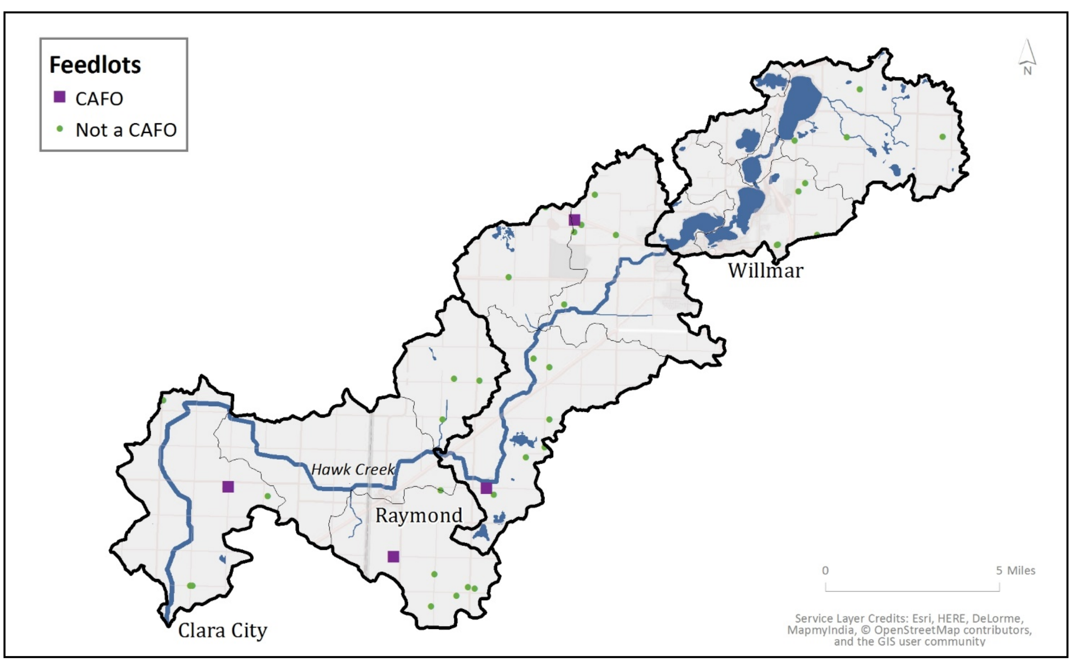


4.3 *E. coli*

The primary sources of *E. coli* include runoff from surface application of manure without incorporation and noncompliant and failing SSTS. It is estimated that unincorporated surface application of manure contributes half of the *E. coli* load.

There are approximately 40 feedlots in the watersheds, seven of which are National Pollutant Discharge Elimination System/State Disposal System (NPDES/SDS) permitted or gap site feedlots. These are displayed in Figure 18. Feedlots that are considered NPDES and SDS permitted meet specified criteria for permitting, the gap sites meet one or more criteria for the NPDES permit; however, do not meet the minimum threshold of animal units to require a permit. The NPDES/SDS permitted and gap site feedlots are represented by a square in Figure 18. All other feedlots are represented by a green dot.

Figure 18. Feedlots in the Upper Mainstem Hawk Creek Watershed



Feedlots in the Upper Mainstem Hawk Creek Watershed are primarily turkey operations, with some swine and beef (Table 16). It is assumed that the feedlots that are NPDES/SDS permitted or sites registered with the county are complying with the Minnesota Feedlot Rules and are not significant contributors of pollutants. Generally, the land application of manure to cropland tends to be the highest contributor of *E. coli*.

Table 16. Animal types and numbers in HUC12 watersheds

Animal type	Town of Priam-Hawk Creek	City of Raymond-Hawk Creek	Willmar Lakes
Beef cattle	933	3,554	731
Bison	149		
Dairy cattle	151	1,389	263
Goats	150		
Sheep	462		
Swine	9,455	20,025	
Turkeys	452,000	20,000	
Horses		2	267

The City of Willmar is approximated 9,500 acres, with approximately 3,800 acres categorized as developed (MRLC 2011). Stormwater runoff has been identified by the watershed partners as a concern for P and *E. coli* pollutant loading.

There are 1,066 SSTS in the watershed, with an estimated noncompliance rate of 75%. The watershed partners have made SSTS upgrades and replacements a priority by funding these through the Clean Water Partnership Loan funding program. A sanitary sewer operated by the City of Willmar is present around each of the lakes, so there is no *E. coli* load to the lakes from wastewater from the lakeshore residences.

4.3 Mercury

Almost all the mercury in Minnesota's lakes and rivers is delivered by the atmosphere. Mercury can be carried great distances on wind currents before it is brought down to earth in rain and snow. About 90% of the mercury deposited on Minnesota comes from other states and countries. Similarly, the vast majority of Minnesota's mercury emissions are carried by wind to other states and countries. It is impossible for Minnesota to solve this problem alone; the United States and other countries must greatly reduce mercury releases from all sources.

Atmospheric deposition of mercury is uniform across the state and supplies more than 99.5% of the mercury getting into fish. Agency research has demonstrated that 70% of current mercury deposition in Minnesota comes from human sources and 30% from natural sources, such as volcanic activity. There are no known natural sources in the state that emit mercury directly to the atmosphere.

5. Watershed goals

The goals of the watershed partners are to address the existing impairments in the watershed, as well as to decrease the pollutant loading to downstream reaches. The means to achieve these goals will be described in Section 6.

The Hawk Creek Watershed has lakes and streams that are priorities in central Minnesota. Several lakes and stream reaches are listed as impaired and in need of restoration (MPCA 2017a and MPCA 2017b). TMDLs have been completed for the impaired waterbodies or are scheduled for future completion. This plan focuses on the lakes in the headwaters of the watershed. The headwaters were prioritized for work by the watershed partners, given the citizens' interest in their local lakes. The Willmar Lakes Watershed is also the headwaters of Hawk Creek and provides an opportunity to address downstream concerns. It is a contributor of pollutant loading to the lower reaches of Hawk Creek that are impaired and Minnesota River.

Goals are:

- Achieve the water quality standard for Swan Lake by reducing P loading by 22%, as based on the TMDL
- Achieve the water quality standard for Willmar Lake by reducing P loading by 30% based on the BATHTUB model, until the TMDL is completed
- Contribute to achieving the TSS water quality standard in the lower reaches of Hawk Creek by reducing TSS loading by 31%, based on the TMDL for Hawk Creek
- Achieve *E. coli* water quality standards in the lower reaches of Hawk Creek by reducing *E. coli* loading by 83%, based on the TMDL for Hawk Creek.
- Protect Point, Eagle, Skataas, and Foot Lakes from future eutrophication impairment by reducing P loading by 5%, as following Minnesota's *Incorporating Lake Protection Strategies into WRAPS Reports* (https://www.pca.state.mn.us/sites/default/files/wq-ws4-03c.pdf)
- Achieve the goals by addressing identified critical areas with targeted implementation of management activities and practices
- To measure the progress of these activities and adapt this NKE Plan accordingly

5.1 Priority watersheds

Priority watershed areas are identified for this NKE Plan. For the purposes of this NKE Plan, priority areas include the following:

- Priority Area #1 – Willmar lakes. These lakes are a high priority for local stakeholders and serve as important recreation areas. Swan and Willmar lakes are identified as impaired for nutrients/eutrophication. Eagle Lake is impaired for mercury in fish tissue.
- Priority Area #2 – Upper Hawk Creek mainstem. Willmar lakes flow directly into the upper reach of Hawk Creek. The stream has been identified as nearly impaired for TSS and contributing to the downstream reaches.

5.2 Critical areas

Willmar Lakes receive high amounts of nutrient (phosphorus) loading from the developed areas. Swan, Foot, and Willmar Lakes are surrounded by developed areas. The critical loading area to the lake is the shoreline; these loads will be reduced with shoreline restoration projects.

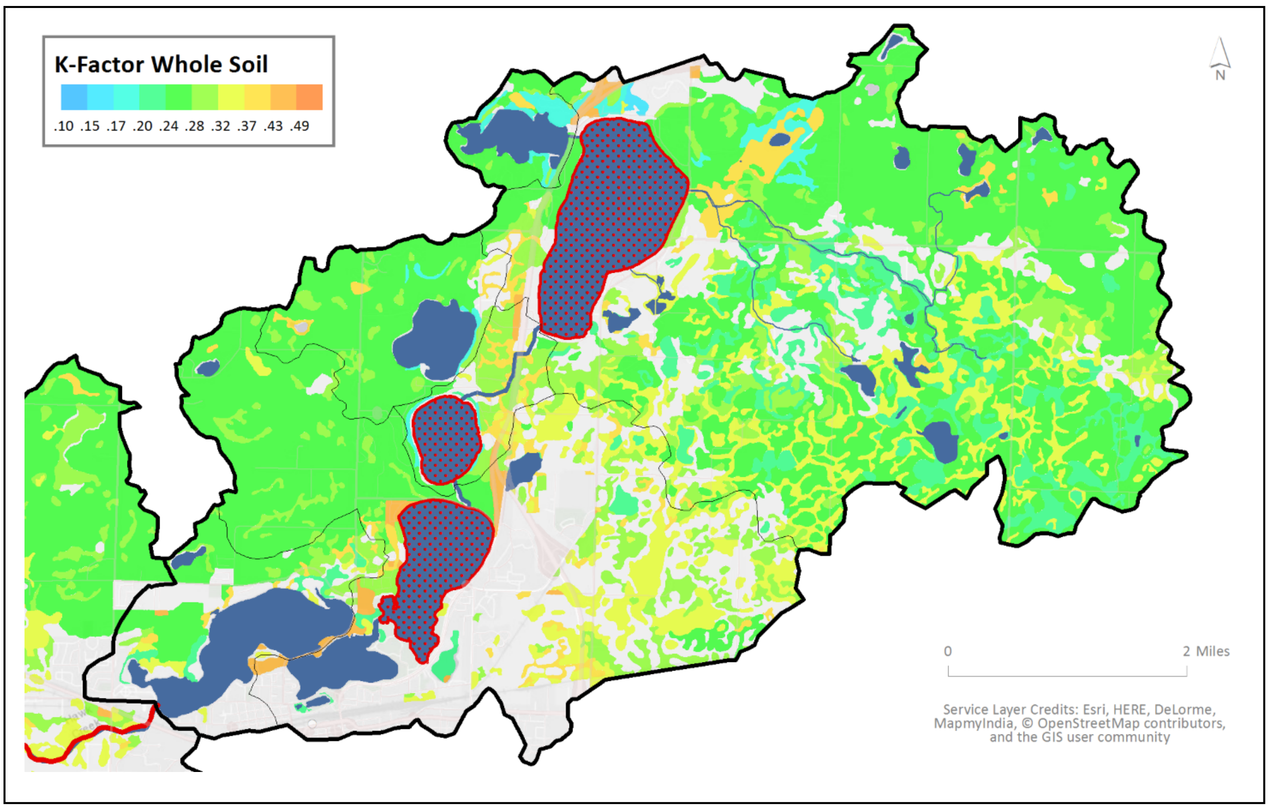
A critical streambank restoration between Swan and Eagle Lakes, including the Eagle Lake outlet, has been identified as critical loading points for Swan Lake.

Internal loading in Swan Lake and Willmar Lake will be critical to address. Curly leaf pondweed poses significant loading, along with managing carp populations. At this time, no carp studies have been identified. However, planned annual removal of curly leaf pondweed is expected to provide a significant impact on the internal loading in both lakes.

The watershed partners have identified stormwater as a major concern for loading to the lakes. Practices, such as rain gardens and bioretention basins, will be used to address the critical stormwater loading areas and will be focused on residential developed areas in the City of Willmar. The soils of the Willmar Lakes HUC-12 are characterized as having mid- to high-erosiveness (Figure 19).

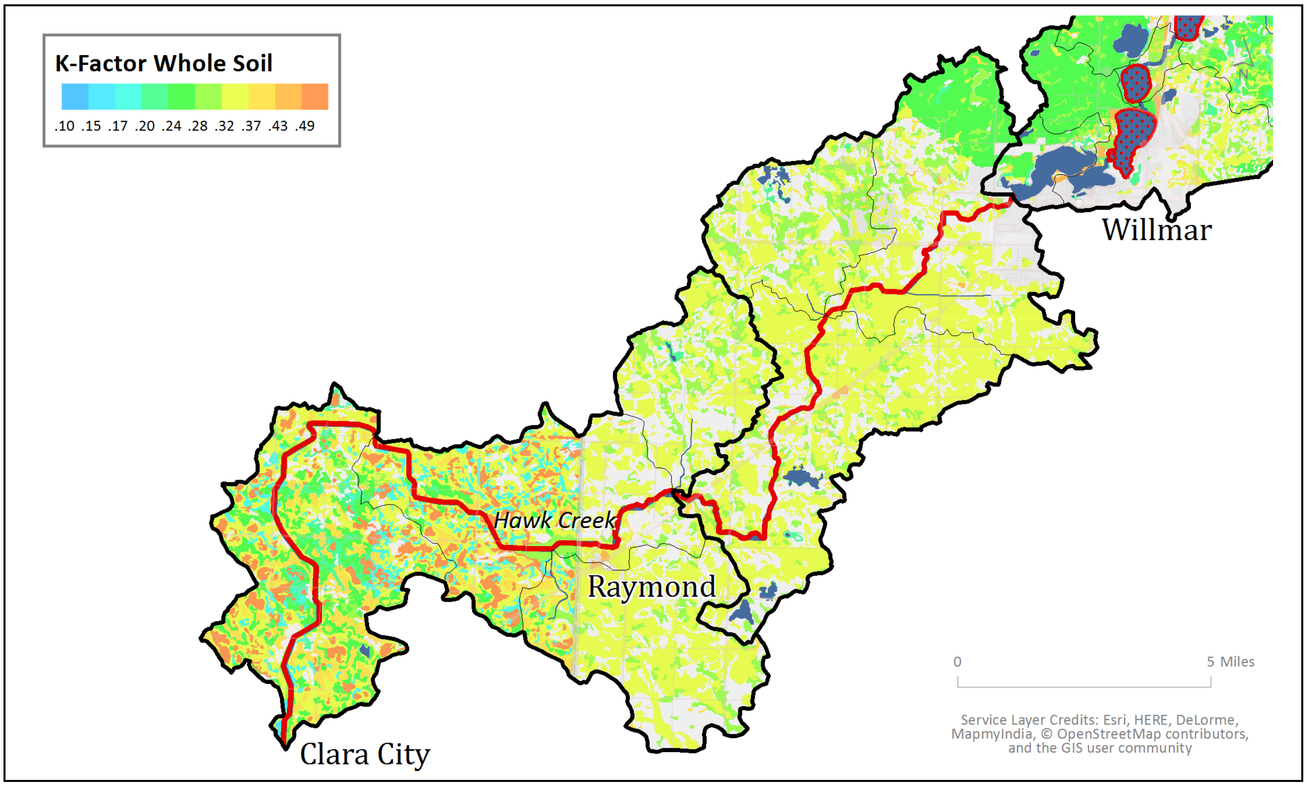
Although the immediate areas of these lakes are developed, there are still some significant contributions from agricultural land. These critical areas (K-factors greater than .32) will be addressed by targeted outreach to improve soil health and other BMP implementation.

Figure 19. K-Factor whole soil map of the Willmar Lake HUC-12



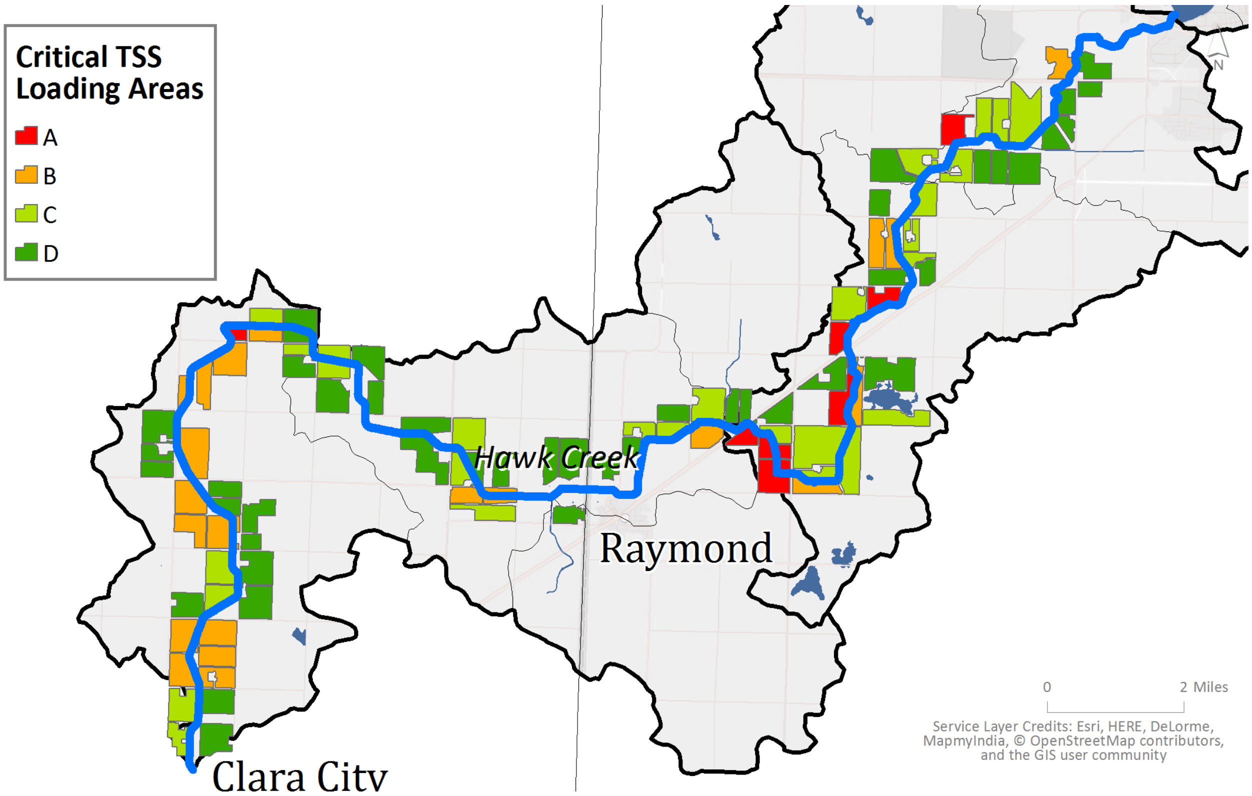
The K-factor whole soil map for the Upper Mainstem Hawk Creek (Figure 20) also shows a high level of erosivity in the soils. Although this stream reach is not impaired for TSS, nutrients, or *E. coli* managing these highly erosive soils will help reduce loading to the impaired reaches downstream.

Figure 20. K-Factor whole soil map of the City of Raymond-Hawk Creek and Town of Priam-Hawk Creek HUC-12s



The erosivity of the soils and intensive corn/soy crop rotation is being targeted for agricultural practices that increase soil health. Specifically, areas with higher K-factor soils (.32 and greater) will receive priority and targeted outreach.

Figure 21. TSS critical areas along the Upper Mainstem Hawk Creek



Critical areas along the Upper Mainstem Hawk Creek Watershed were further narrowed by a 40-acre parcel, based on the sediment runoff risk (Figure 21). Targeting the A- and B- level critical areas for BMP implementation (particularly soil health practices and streambank restoration) will have the greatest impact on TSS and P loading to the creek. Using this information, the partners will do field level inspections to find the highest loading critical areas to prioritize targeting.

In future years, additional priority areas may be added to address Hawk Creek.

6. Management strategies and activities

Management strategies and activities to meet watershed goals have been described in many existing documents. This section summarizes those strategies and activities and expands upon them based on local input and priorities. Milestones and activities, including costs and assessment criteria are described in Table 17. Internal loading will be addressed as watershed BMPs are implemented.

Reductions have been calculated using the Spreadsheet Tool for Estimating Pollutant Load (STEPL) (Table 18). It is expected that practices described in this plan (Table 17) will achieve water quality standards when fully implemented. Every two years, the progress of the plan will be checked against the milestones to determine any necessary course corrections and milestones will be added.

Each type of treatment BMP will be described in Sections 7.1 through 7.13. Education and outreach milestones are included in Table 20 in Section 7.

6.1 Implementation, milestone, goals, and assessment table

The management activities for this watershed are described in Table 17 and will combined as described in the following sections (e.g., basin-wide management, urban and residential BMPs, etc.). For the purposes of meeting the nine elements, these goals have been further broken down to the lakesheds and mainstem of the Hawk to calculate reductions using the STEPL tool. The process of running STEPL is described fully in Appendix A.

The Point and Eagle Lakes lakesheds are combined for the purposes of this NKE plan. Point Lake drains into Eagle Lake and 40% of the land cover is open water. These lakesheds are combined for the purposes of calculating the reductions. All other lakesheds were run individually through the STEPL combined efficiencies tool to calculate estimated pollutant reductions by lakeshed. The upper mainstem Hawk Creek does not include the lakesheds.

Table 17. Management BMPs and activities, including milestones, goals, assessment criteria and costs

Treatment type	Milestones					Long-Term Goals	Assessment	Costs
	2-year (2023)	4-year (2025)	6-year (2027)	8-year (2029)	10 year (2031)			
Develop nutrient management plans (cost share program) (about 50% of farms have a plan)	4 plans developed	4 plans developed	4 plans developed	4 plans developed	4 plans developed	Nutrient management plans of 5% of acres currently unmanaged (4,500 acres) 20 new plans	# of plans developed	$100,000
Implement nutrient management plan (50% of farms are)	Add 9,435 of acres under nutrient management plan (3,200 new acres)	Add 9,435 of acres under nutrient management plan (3,200 new acres)	Add 9,435 of acres under nutrient management plan (3,200 new acres)	Add 9,435 of acres under nutrient management plan (3,200 new acres)	Add 9,435 of acres under nutrient management plan (3,200 new acres)	47,175 acres (75%) total using the nutrient management plan (16,000 in new acres)	# of acres	$6,000
Cover Crops (about 25% of farms planting cover crops)	Add 9,435 acres of cover crops (6,400 new acres)	Add 9,435 acres of cover crops (6,400 new acres)	Add 9,435 acres of cover crops (6,400 new acres)	Add 9,435 acres of cover crops (6,400 new acres)	Add 9,435 acres of cover crops (6,400 new acres)	47,175 acres in cover crops; (32,000 new acres)	# of acres	$450,000
Pilot reduced tillage (FFY 2018 Section 319 grant) (1 adoptee, demonstration, 80 acres)	Analyze results of Section 319 grant Pilot Program and adapt approach	Use adapted approaches to continue outreach for the reduced tillage (grant expired) for this planning area	See other outreach activities			To utilize the information from the pilot program to better inform outreach		$1,000
Acres using strip till or no-till (reduced) tillage	Add 9,435 of new acres	Add 9,435 of new acres	Add 9,435 of new acres	Add 9,435 of new acres	Add 9,435 of new acres	47,175 acres of reduced tillage with at least 20% residue	# of acres	$250,000

Treatment type	Milestones					Long-Term Goals	Assessment	Costs
	2-year (2023)	4-year (2025)	6-year (2027)	8-year (2029)	10 year (2031)			
Crop rotation (including small grains) encourage diversity within crop rotation	1,000 acres in crop rotation	1,000 acres in crop rotation	1,000 acres in crop rotation	1,000 acres in crop rotation	1,000 acres in crop rotation	5,000 acres in crop rotation (including small grains)	# of acres	$300,000
Maintain 100% compliance to MN Buffer Law	Local SWCDs inspect/assist to ensure compliance	Local SWCDs inspect/assist to ensure compliance	Local SWCDs inspect/assist to ensure compliance	Local SWCDs inspect/assist to ensure compliance	Local SWCDs inspect/assist to ensure compliance	Continue to comply to the MN Buffer Law	% of compliance	
Alternative tile intakes	11 alternative tile intakes installed	11 alternative tile intakes installed	11 alternative tile intakes installed	11 alternative tile intakes installed	11 alternative tile intakes installed	55 alternative tile intakes installed	# of intakes	$35,000
Wetland restoration	49 acres of wetland restoration	50 acres of wetland restoration	50 acres of wetland restoration	50 acres of wetland restoration	50 acres of wetland restoration	250 acres of wetlands restored to increase water storage and sequester phosphorus	# of acres	$2,000,000
Retention pond	50 acres of retention pond storage	49 acres of retention pond storage	50 acres of retention pond storage	50 acres of retention pond storage	50 acres of retention pond storage	250 acres of retention ponds to increase water storage		$1,200,000
Field erosion stabilization	12 stabilizations	12 stabilizations	12 stabilizations	12 stabilizations	12 stabilizations	Install 60 field erosion stabilizations	# of acres treated	$400,000
WASCOBs	13 WASCOBs installed	13 WASCOBs installed	13 WASCOBs installed	13 WASCOBs installed	13 WASCOBs installed	65 WASCOBs installed	# of WASCOBs	$400,000
Saturated buffers	Work with landowners to generate interest in	Work with landowners to generate interest in	6 saturated buffers (approximatel y 2,500 ft)	Work with landowners to generate interest in	Work with landowners to generate interest in	Introduce and develop saturated buffers in this watershed, treat	# of acres treated by saturated buffers	$25,000

Treatment type	Milestones					Long-Term Goals	Assessment	Costs
	2-year (2023)	4-year (2025)	6-year (2027)	8-year (2029)	10 year (2031)			
	saturated buffers	saturated buffers		saturated buffers	saturated buffers	a total of 180 acres of land with saturated buffers		
Grassed waterway	1,200 lin ft of grassed waterway (avg)	1,200 lin ft of grassed waterway (avg)	1,200 lin ft of grassed waterway (avg)	1,200 lin ft of grassed waterway (avg)	1,200 lin ft of grassed waterway (avg)	7,000 lin ft of grassed waterways	# of lin ft	$70,000
Wood chip bioreactor	1 bioreactor installed	1 bioreactor installed	1 bioreactor installed	1 bioreactor installed	1 bioreactor installed	5 bioreactor installed	# of bioreactors	$225,000
Conservation covers (CRP, filter, harvestable buffers, perennial planting, wellhead buffers, clean water diversions etc.)	1 project, avg 10 acres	1 project, avg 10 acres	1 project, avg 10 acres	1 project, avg 10 acres	1 project, avg 10 acres	5 projects, 50 acres total	# of acres	$15,000
Grade stabilizations	4 grade stabilizations installed	4 grade stabilizations installed	4 grade stabilizations installed	4 grade stabilizations installed	4 grade stabilizations installed	20 grade stabilizations	# of grade stabilization	$450,000
Side inlets	86 side inlets installed	86 side inlets installed	86 side inlets installed	86 side inlets installed	86 side inlets installed	Install 430 side inlets	# of inlets	$100,000
Contour strip cropping (50% crop in grass)	Outreach to critical landowners	10 acres of farmland using contour strip farming	Develop demonstration project with successful landowner	10 acres of farmland using contour strip farming	Continue demonstrations and outreach-5 relationships developed	20 acres in contour strip cropping	# of acres	$10,000
In-channel storage (two-stage ditches, check dams)	Promote and educate landowners	One-on-one with target landowners	1 two-stage ditch	1 check dam	Analyze effectiveness of BMP	Increase in-channel storage opportunities	# of projects	$500,000

Treatment type	Milestones					Long-Term Goals	Assessment	Costs
	2-year (2023)	4-year (2025)	6-year (2027)	8-year (2029)	10 year (2031)			
Critical area seeding	5 project, avg 5 acres	5 project, avg 5 acres	5 project, avg 5 acres	5 project, avg 5 acres	5 project, avg 5 acres	25 projects, 158 acres total	# of acres	$15,000
Grazing Land Management (rotational grazing with fenced areas)	Outreach to critical landowners	150 acres pasture operating with rotational grazing protocol	Outreach to critical landowners, including demonstration	150 acres pasture operating with rotational grazing protocol	Outreach to critical landowners, including demonstration	Grazing acres used appropriately, without overgrazing (approx. 300 acres)	# of acres	$5,000
Livestock exclusion w/ alternative water source	2,500 lin-feet of fencing		2,500 lin-feet of fencing		2,500 lin-feet of fencing	All cattle/animals excluded from streams	# lin feet fenced	$14,175
Perimeter fencing	2,500 lin-feet of fencing		2,500 lin-feet of fencing		2,500 lin-feet of fencing	All cattle/animals excluded from streams	# lin feet fenced	$14,175
Control structure			Design control structure project	Control structure at the source of Hawk Creek at Eagle Lake's outlet		Replace the control structure at Eagle Lake Outlet (450 ft of bank restoration)	# of feet of bank restoration # of outlets replaced	$150,000
Streambank stabilization (no natural stream in this planning area)	Address and stabilize critical areas in 1,000 lin ft	Address and stabilize critical areas in 1,000 lin ft	Address and stabilize critical areas in 1,000 lin ft	Address and stabilize critical areas in 1,000 lin ft	Address and stabilize critical areas in 1,000 lin ft	Restore natural stream at the headwaters (Eagle to Swan Lake), approx 5,280 lin ft	# of feet of streambank restoration	$528,000

Treatment type	Milestones					Long-Term Goals	Assessment	Costs
	2-year (2023)	4-year (2025)	6-year (2027)	8-year (2029)	10 year (2031)			
Streambank stabilization (no natural stream in this planning area)	Address and stabilize critical areas in 2,000 lin ft	Address and stabilize critical areas in 2,000 lin ft	Address and stabilize critical areas in 2,000 lin ft	Address and stabilize critical areas in 2,000 lin ft	Address and stabilize critical areas in 2,000 lin ft	Restore streambanks in the Town of Priam and City of Raymond Hawk Creek HUC-12s, approx 10,560 lin ft	# of feet of streambank restoration	$1,200,000
Lake shore restoration	2 lakeshore restorations of avg 50 lin ft each in Eagle, Willmar, and Swan Lakes (total of 6)	2 lakeshore restorations of avg 50 lin ft each	2 lakeshore restorations of avg 50 lin ft each	2 lakeshore restorations of avg 50 lin ft each	2 lakeshore restorations of avg 50 lin ft each	Complete 10 lakeshore restorations (avg 50 lin ft)	# of lin ft restored	$65,000
Rain gardens	1 raingardens installed	1 raingardens installed	1 raingardens installed	1 raingardens installed	1 raingardens installed	Install 5 raingardens in Willmar Lakes Area		$30,000
	Demo raingarden for the City of Willmar	Continue to help promote the City's raingarden (tour, demonstrations, news releases)	Evaluate the effectiveness of program	Adapt program				$10,000
1 already completed (add redux)	Demo 2 raingardens for WALA Lake Association	Use for continued promotion of rain gardens, stormwater treatment	Evaluate the effectiveness of program	Adapt program				$12,000

Treatment type	Milestones					Long-Term Goals	Assessment	Costs
	2-year (2023)	4-year (2025)	6-year (2027)	8-year (2029)	10 year (2031)			
Rain barrels	Work with WAL, Eagle Lake, and Long Lake Associations to implement rain barrel cost share/incentive to increase membership	Continue rain barrel distribution	Continue rain barrel distribution	Continue rain barrel distribution	Continue rain barrel distribution	All lakeshore land owners have rain barrels	# of rain barrels	$20,000
Lake association meetings, events	4 meetings/ events	4 meetings/ events	4 meetings/ events	4 meetings/ events	4 meetings/ events	Engage lake residents	# of events/ meetings	$10,000
Leaf/grass cleanups annual lake associations	Annual fall clean-up events	Annual fall clean-up events	Annual fall clean-up events	Annual fall clean-up events	Annual fall clean-up events	Engage lake landowners in fall cleanup activities	# of events	
	Promote ideas to landowners to compost, cleanup leaf/grass/organic litter with Willmar	Promote ideas to landowners to compost, cleanup leaf/grass/organic litter and expand to other cities	Expand program to lake associations	Evaluate effectiveness of the program	Adapt program/outreach	To provide information to landowners to properly utilize organic litter	# of participants	$10,000
Controlling carp population (Long Lake completed, Willmar wants)	Carp seining on Willmar Lakes	Analyze effectiveness of Long Lake seine	Carp seining on Long Lake, if supported by analysis					
Controlling AIS	Clean, drain, dry, county inspections, promotion,	Clean, drain, dry, county inspections, promotion,	Clean, drain, dry, county inspections, promotion,	Clean, drain, dry, county inspections, promotion,	Clean, drain, dry, county inspections, promotion,	Educate and promote good practices for AIS	# of educational opportunities	$2,000

Treatment type	Milestones					Long-Term Goals	Assessment	Costs
	2-year (2023)	4-year (2025)	6-year (2027)	8-year (2029)	10 year (2031)			
	education activities	education activities	education activities	education activities	education activities			
Control invasive weeds (e.g., milfoil, curly leaf pondweed etc.)	Lake associations, county AIS and state AIS funding manage invasive weeds (i.e. harvesting, etc.)	Lake associations, county AIS and state AIS funding manage invasive weeds (i.e. harvesting, etc.)	Lake associations, county AIS and state AIS funding manage invasive weeds (i.e. harvesting, etc.)	Lake associations, county AIS and state AIS funding manage invasive weeds (i.e. harvesting, etc.)	Lake associations, county AIS and state AIS funding manage invasive weeds (i.e. harvesting, etc.)	Educate and promote good practices for AIS	# of educational opportunitie s	$2,000
Ag waste project	2 ag waste project	2 ag waste project	2 ag waste project	2 ag waste project	2 ag waste project	10 ag waste projects	# of projects	$500,000

6.2 Estimated load reductions

Reductions have been calculated using the Spreadsheet Tool for Estimating Pollutant Load (STEPL) for the practices planned (Table 17). It is expected that practices described in this plan, along with the estimated reductions from recent watershed work, will achieve load reductions needed to meet water quality standards when fully implemented. The estimated current loads using STEPL for P, TSS, and *E. coli* loads are 68,729 lbs/yr, 16,304 t/yr, and 1.4E+06 billion MPN/yr. The table also describes the loads for the individual lakesheds within the Willmar Lakes HUC-12 and the two Hawk Creek HUC-12 watersheds. Full details for STEPL, including combined BMPs and assumptions, are included in Appendix A. The STEPL reductions were calculated using the combined BMP efficiency tool.

Table 18. Estimated load reductions

Watershed	P load (no BMP) lbs/yr	TSS load (no BMP) t/yr	*E. coli* load (no BMP) billion MPN/yr	P reduction lbs/yr	TSS reduction t/yr	*E. coli* reduction billion MPN/yr	% P reduction	% TSS reduction	% *E. coli* reduction
Swan	1240.6	737.5	4.2E+04	418.4	495.0	4.1E+01	33.7	67.1	0.1
Point/Eagle	15420.4	2497.4	5.6E+05	2488.2	382.5	1.6E+03	16.1	15.3	0.3
Skaatas	2281.6	487.7	9.3E+04	334.1	72.3	1.5E+02	14.6	14.8	0.2
Willmar	7097.7	1451.7	1.5E+04	1215.4	201.5	5.6E+02	17.1	13.9	3.7
Foot	1475.0	500.5	4.5E+02	163.4	33.9	7.8E+01	11.1	6.8	17.4
Upper Hawk	41213.9	10629.9	6.4E+05	7212.9	1913.4	2.8E+03	17.5	18.0	0.4
Total	68729.2	16304.8	1.4E+06	11832.5	3098.7	5.2E+03	17.2	19.0	0.4

Load reductions from the removal of curly leaf pondweed is estimated to have between a 36% and 48% efficiency for reducing P (Table 19). Reductions for this plan were estimated using the lower end of the reduction rang. The efficiencies in the literature assume 100% weed removal. The partners assumed that 100% weed removal was high; therefore, reductions are based on a 75% removal success rate. The full description of the practice and benefits for in-lake treatment can be found in Section 6.6.

Table 19. In lake P reductions for Swan and Willmar Lakes curly leaf pondweed removal

			Assuming 100% weed removal		Assuming 75% weed removal	
	P lbs/yr	Reduction efficiencies (low)	Internal P load reduction lbs/yr	Internal P load reduction %	Internal P load reduction lbs/yr	Internal P load reduction %
Swan Lake						
Total load	2,240					
Internal P load	735	0.36	264.6	12	198.45	27
Willmar Lake						
TP load	2,395					
Internal P load	832	0.36	299.52	13	224.64	27

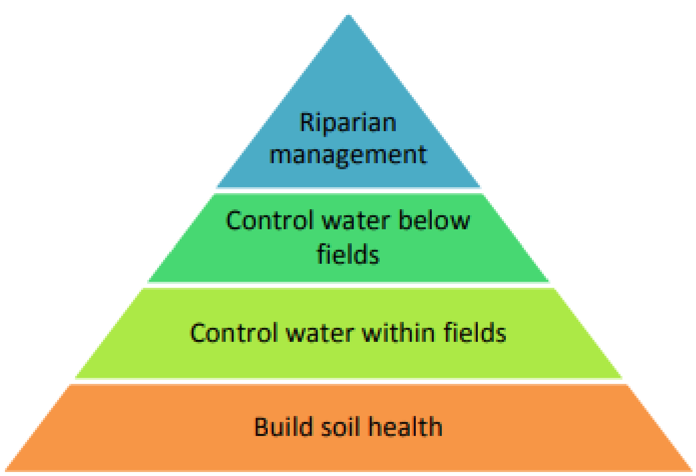
Every two years, the progress of the plan will be checked against the milestones to determine any necessary course corrections and milestones will be amended or new ones added. STEPL estimated reductions for P planned exceed the 33% reduction required by the Hawk Creek TMDL. The reductions for Willmar Lake will achieve the 30% needed reduction as estimated using the BATHTUB model (Table 14). Therefore, we expect the water quality standard and the goals of this plan to be met if this plan is fully implemented as described.

6.3 Basin-wide management strategy considerations

The Upper Hawk Creek Watershed is part of the larger Hawk Creek HUC-8 watershed, which is impacted by altered hydrology, sediment/turbidity, bacteria, nitrogen, phosphorus (P), poor instream and riparian habitat, and low dissolved oxygen. Successful implementation of management strategies in the Upper Hawk Creek relies in some part on the cohesive management of resources and staff time across the entire Hawk Creek HUC-8 watershed. The Hawk Creek Watershed and Surrounding Direct Minnesota River Tributaries: Restoration and Protection Strategies report provide a conceptual model to address water quality in the Hawk Creek Watershed. Soil health principals such as nutrient management, reduced tillage, and crop rotation, make up the base of the model followed by in-filed water control, which includes practices such as greased waterways, controlled drainage, and filter strips. This is then followed by below-field practices such as wetlands impoundments, and lastly riparian management such as buffers, stabilization, and stream restoration (Figure 33).

The goals and values of the basin-wide management strategies are reflected in the focused Upper Mainstem Hawk Creek Watershed in this NKE plan.

Figure 22. Conceptual model to address water quality in the Hawk Creek HUC-8 watershed (MPCA 2017b)



6.4 Urban and residential BMPs opportunities

Runoff from impervious, urban areas is identified as a contributor to P in the Upper Hawk Creek Watershed. Several BMPs were recommended in the Upper Hawk Creek Watershed to address urban and residential sources of P. Residential green infrastructure including rain gardens, pervious pavement and rain barrels. Demonstration projects for these types of BMPs can increase residential awareness and understanding and increase implementation.

- Lawn care BMPs such as and proper fertilizer use, leaf management, and disposal of lawn clippings.

- Erosion and sediment control practices such as filter blankets, sediment basins, and vegetative cover seeding can reduce soil loss from construction sites and other disturbed areas. These may be conducted as part of the City's MS4 and construction stormwater permit requirements.
- Lakeshore restoration is an important component to improving the water quality in the Willmar Lakes.

6.5 In-lake restoration (internal load management)

With the internal load of P in the lakes being a large portion of the excess P in the lakes, in-lake management activities are an important part of the lake restoration efforts. A focus solely on in-lake treatments, however, will not provide long-term restoration of the lakes without significant watershed BMP implementation. In-lake restoration activities that will be used to reduce internal P loading include aquatic invasive species vegetation management, carp management, biomanipulation of fish species, and alum treatments.

The Kandiyohi County Comprehensive Local Water Plan (2013-2023) also recommends working with DNR and other stakeholders to resolve any lake level conflicts that may arise on an annual basis (Kandiyohi County and the Mid-Minnesota Development Commission 2013). If any game fish impacts are expected, education and public outreach on the process and benefits of more natural lake function may be necessary.

Aquatic vegetation management

Controlling aquatic invasive plant species, especially curly leaf pondweed, has been demonstrated to improve Secchi disk clarity significantly. Control has been identified as a means of reducing the internal load by preventing the associated loading with the mid-June dieback (James et al. 2007). Modeling completed by James et al. suggested a 36 to 48% reduction by eliminating 100% of the curly leaf pondweed. Management can include water level manipulation and planting of aquatic vegetation that will uptake nutrients from the lake (HCWP 2012). Control can also include mechanical removal and herbicide treatment. Estimating an average removal rate of 75%, it is estimated that the reduction of internal P loading will be 27% for Swan Lake and 27% for Willmar Lake. Curly leaf pondweed controls will occur annually following a plan developed by the area lake association.

Carp management practices

High carp densities have been associated with significant P release due to high bioturbation of sediment by carp. The management of carp populations in lakes can be used to reduce the internal loading caused by carp stirring up the bottom sediments. Phosphorus reduction associated with carp management depend on many factors; however, population density of less than 100 kg/ha have been identified as a threshold for healthy shallow lake ecosystems.

The Willmar Area Lakes Association conducted a carp removal project in 2018.

Alum treatment

Alum treatments are very individualized to the specific lake conditions and typically provide quickly observable phosphorus reductions from sediment release in the short term. Because of the unique nature of alum treatments, a feasibility study will need to be conducted for each waterbody treated and will include specific number of treatments, areas, costs, and expected P reductions. Alum treatments may be considered for several of the waterbodies at a later time and the plan will be updated accordingly to reflect this new information.

6.6 Agricultural BMPs

Upland erosion and fertilizer and manure application were identified as sources of P in the Hawk Creek Watershed TMDL. The Hawk Creek Watershed partners have made improving soil health through activities and practices such as conservation tillage, nutrient and manure application, cover crops, and crop rotation (see Section 6.3) a priority to address the erosion issues. In addition to the soil health initiative, practices including wetland restorations, grade stabilizations, WASCOBs, and other agricultural BMPs will be implemented. In this plan, there is a proposed 5,000 acres to be put into small grain crop rotations. There are no reductions associated with this in the plan at this time; however, increasing crop diversity, reducing tillage and nutrient inputs, has been associated with water quality improvements. Upon further study and effectiveness monitoring, the watershed partners intend to add reductions at a later time.

Surface runoff and the reduction of nutrients will also reduce loading to the Willmar Lakes and contribute the protection of unimpaired lakes and the restoration of Swan and Willmar Lakes, which are impaired for nutrients/eutrophication.

Upper Hawk Creek is not impaired for TSS or nutrients, however, Lower Hawk Creek is impaired for TSS and nutrients. The implementation of agricultural BMPs will contribute to the goal of Hawk Creek Watershed partners to reduce loading of TSS, nutrient, and *E. coli* to the downstream reaches.

6.7 Feedlot BMPs

Livestock and manure management strategies such as waste storage facilities, meeting land application requirements, use of filter strips, riparian buffers and clean water diversions to collect, direct and contain manure laden runoff from agricultural fields are expected to reduce *E. coli* and nutrient pollutant loads from feedlots. The development of manure management plans will address the field application of manure. BMPs for grazing and pastureland, such as livestock access control including fencing and alternative water supplies and rotational grazing, are planned to address loading from pastured animals.

6.8 County ditch maintenance

The Kandiyohi County Comprehensive Water Plan identified several ditches that are critical areas for the installation of ditch BMPs: CD12, CD10, Willmar Lake, Foot Lake, CD46, CD47, Lat. 10, CD25A, Branch B3, Swan Lake, Branches B1, B2 (Kandiyohi County and the Mid-Minnesota Development Commission 2003). BMPs are identified in this plan.

6.9 SSTS compliance

SSTSs were identified as a source of P to impaired lakes. Annual inspections, in addition to regular maintenance, ensure that systems are functioning properly. The Hawk Creek Watershed partners have participated in the Clean Water Partnership Loan program to provide an affordable sources of funding for residents to upgrade or replace failing or nonconforming systems.

6.10 Wetland restoration, enhancement, and preservation

The Hawk Creek Watershed is a priority watershed within the Kandiyohi County Comprehensive Local Water Plan (2013-2023) for wetland restoration (Kandiyohi County and the Mid-Minnesota

Development Commission 2013). Wetland restoration can address altered hydrology in the watershed, which can impact the amount and movement of pollutants. In addition to slowing the flow of runoff, wetlands can act as a nutrient and sediment filter. Wetland restoration has been identified as practice to both reduce P and to increase water storage in the watershed. Wetland projects will be prioritized by targeting those projects with the greatest amount of contiguous area. The larger, contiguous wetlands will improve habitat and have the greatest impact on water quality improvement.

6.11 Streambank erosion control

Streambank erosion was identified as a potential source of P to impaired lakes. Various activities can be conducted to address stream bank erosion. A critical site of the outlet from Eagle Lake has been identified as a potential stream restoration site and is included in this plan. Additionally, the mile long stream from Eagle Lake to Swan Lake has been identified as a critical loading area for TSS and nutrients.

The Upper Mainstem Hawk Creek has several areas that are identified as potential areas for stream restoration. This plan includes two miles of stream restoration in the critical loading (most eroding) areas. Although the Upper Mainstem is not impaired for TSS or nutrients, the Hawk Creek Watershed partners would like to reduce loading to the downstream impaired reaches.

6.12 Mercury management

Atmospheric deposition of mercury is uniform across the state and supplies more than 99.5% of the mercury getting into fish. Agency research has demonstrated that 70% of current mercury deposition in Minnesota comes from human sources and 30% from natural sources, such as volcanoes. There are no known natural sources in the state that emit mercury directly to the atmosphere.

The long-term goal of the mercury TMDL is for the fish to meet water quality standards; the approach for Minnesota’s share is mass reductions from state mercury sources. This mercury TMDL establishes that there needs to be a 93% reduction in state emissions from 1990 for the state to meet its share. Water point sources will be required to stay below 1% of the total load to the state and all but the smallest dischargers will be required to develop mercury minimization plans. Air sources of mercury will have a 93% emission reduction goal.

Almost all the mercury in Minnesota’s lakes and rivers is delivered by the atmosphere. Mercury can be carried great distances on wind currents before it is brought down to earth in rain and snow. About 90% of the mercury deposited on Minnesota comes from other states and countries. Similarly, the vast majority of Minnesota’s mercury emissions are carried by wind to other states and countries. It is impossible for Minnesota to solve this problem alone; the United States and other countries must greatly reduce mercury releases from all sources.

Because mercury in runoff is derived from atmospheric deposition, mercury in stormwater is accounted for in the calculation of the atmospheric load. Separate strategies for reducing NPSs are not included in this plan because implementation of the strategies in Section 4 to reduce air deposition will ultimately reduce stormwater loading.

Any efforts to reduce soil erosion will tend to reduce mercury entering a lake or river from nonpoint water sources. Many of these practices are already employed for control of sediment and nutrient loading and will result in reducing mercury loading to surface waters.

7. Education and outreach

The Hawk Creek Watershed partners have conducted and planned a comprehensive education and outreach strategy. The partners understand that they only way to address NPS in their watershed is to educate and engage their citizens. NPS solutions require voluntary participation, which comes from trust. The Hawk Creek Watershed partners have cultivated relationships and trust over the past 20 plus years. Specific goals and milestones for civic engagement and outreach are detailed in Table 20.

Table 20. Education, outreach, and civic engagement milestones, goals, assessment criteria and costs

Education, outreach, and civic engagement	Milestones					Long-Term Goals	Assessment	Costs
	2-year (2023)	4-year (2025)	6-year (2027)	8-year (2029)	10 year (2031)			
Previous Section 319 grants (FFY 2015 to present) that utilize cover crops	Analyze data from previous Section 319 grants to improve and increase cover crop participation outreach and enrollment activities	Use adaptive management in all areas of outreach and enrollment				Utilize lessons learned from previous grants	# of improvements utilized	$1,000
Field Days	Annual Fall Field Day with min. 20 attendees; add 5 new/year	Annual Field Day with min. 30 attendees; add 5 new/year	Annual Field Day with min. 40 attendees; add 5 new/year	Annual Field Day with min. 50 attendees; add 5 new/year	Annual Field Day with min. 60 attendees; add 5 new/year	Conduct training/demonstrations for continuously growing attendance to engage producers in the benefit of using cover crops	# of new attendees	$50,000
Informational Meetings	Annual February Info Meeting with min. 20 attendees; add 5 new/year	Annual February Info Meeting with min. 20 attendees; add 5 new/year	Annual February Info Meeting with min. 20 attendees; add 5 new/year	Annual February Info Meeting with min. 20 attendees; add 5 new/year	Annual February Info Meeting with min. 20 attendees; add 5 new/year	Provide general cover crop information to continuously growing attendance to engage producers in the benefit of using cover crops	# of new attendees	$50,000
Radio promotions (adverts, interviews/shows, announcements, etc.)	4 unique radio broadcasts (will be repeated)	4 unique radio broadcasts (will be repeated)	4 unique radio broadcasts (will be repeated)	4 unique radio broadcasts (will be repeated)	4 unique radio broadcasts (will be repeated)	Reach target market during farm related productions to reach a large number of the target audience	# of unique radio broadcasts	$20,000

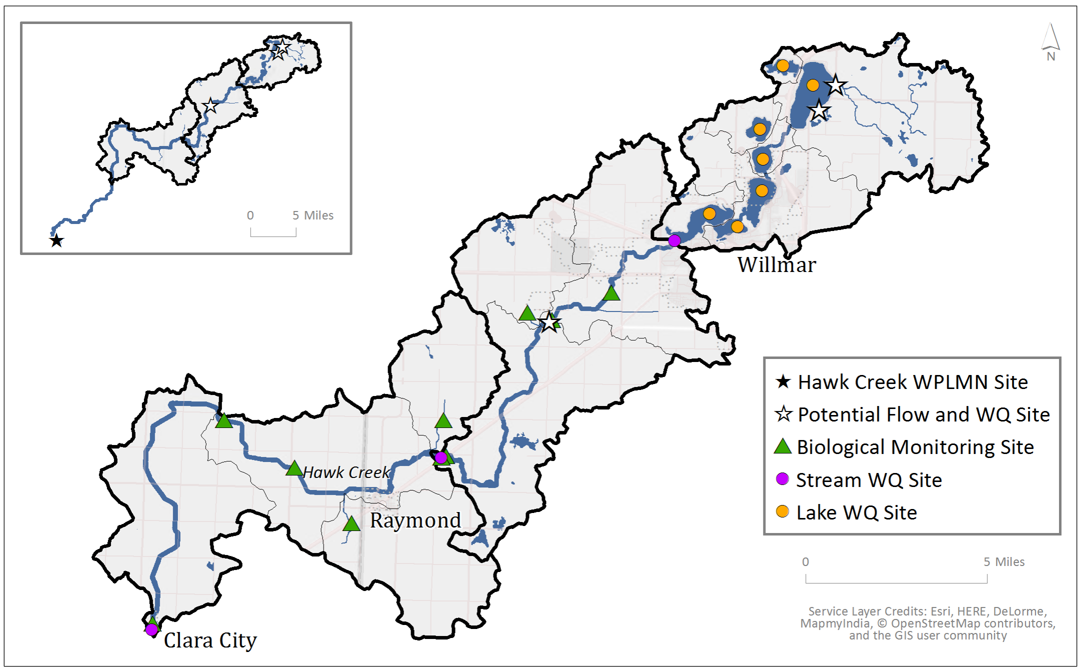
Education, outreach, and civic engagement	Milestones					Long-Term Goals	Assessment	Costs
	2-year (2023)	**4-year (2025)**	**6-year (2027)**	**8-year (2029)**	**10 year (2031)**			
Newsletters (6 page x1) circulation 3,000 and other (2 pages and circulation 30)	4 newsletters published and distributed	4 newsletters published and distributed	4 newsletters published and distributed	4 newsletters published and distributed	4 newsletters published and distributed	Inform residents and citizen scientists about the state of the watershed	# of newsletters	$45,000
Website	Analyze website traffic	Update website, maintain usage, to meet the informational needs of the stakeholders	Maintain website	Analyze website traffic	Update website, maintain usage, to meet the informational needs of the stakeholders	To have an informational website that is useful to the stakeholders	# of updates	$10,000
One-on-ones, shop talk groups	100 interactions with stakeholders	100 interactions with stakeholders	100 interactions with stakeholders	100 interactions with stakeholders	100 interactions with stakeholders	Develop/maintain strong relationships with stakeholders	# of interactions	$25,000
County fairs information booths (Renville, Kandiyohi, and Chippewa Counties)	6 events	6 events	6 events	6 events	6 events	Outreach to county residents about soil and water quality	# of events	$15,000
School activities (K-8), student activities (e.g., scouting, community, etc.)	4 events	4 events	4 events	4 events	4 events	Engage students in conservation	# of events	$10,000
Ridgewater College/UMN student outreach/activities	2 collegiate educational events	2 collegiate educational events	2 collegiate educational events	2 collegiate educational events	2 collegiate educational events	Work with college students to engage the future of conservation/agriculture	# of events	$10,000

Education, outreach, and civic engagement	Milestones					Long-Term Goals	Assessment	Costs
	2-year (2023)	**4-year (2025)**	**6-year (2027)**	**8-year (2029)**	**10 year (2031)**			
Crop consultants, free water quality CEUs, at meeting	6 events, with min of 5 consultants in attendance	6 events, with min of 5 consultants in attendance	6 events, with min of 5 consultants in attendance	6 events, with min of 5 consultants in attendance	6 events, with min of 5 consultants in attendance	To expose the crop consultants to soil health practices for water quality improvement AND money savings for producer	# of crop consultants	$5,000
Appeal to new dairy farms (e.g., contract for alfalfa, grains, etc.)	Added new dairies, invited to outreach, challenging to determine contacts	Analyze effectiveness	Use new/adapted approach					$1,000
Encourage the addition of livestock to make crop diversity more palatable	Promote the idea, include topic in appropriate one-on-one conversations	Analyze effectiveness and adapt approach						$1,000
	Work with landowners to generate interest in wetland restoration (newsletter, postcards, one-on-one)	Work with landowners to generate interest in wetland restoration (newsletter, postcards, one-on-one)	Work with landowners to generate interest in wetland restoration (newsletter, postcards, one-on-one)	Work with landowners to generate interest in wetland restoration (newsletter, postcards, one-on-one)	Work with landowners to generate interest in wetland restoration (newsletter, postcards, one-on-one)	Generate interest and participation in restoration of wetlands	# of postcards # of newsletters # of conversations	$5,000
Chloride management outreach	1 newsletter article	1 newsletter article	1 newsletter article	1 newsletter article	1 newsletter article	Build awareness of potential chloride pollution problems	# of articles	$1,000

8. Monitoring

A long-term stream flow and water quality monitoring site is located downstream of the Upper Hawk Creek Section 319 Focus Watershed (Figure 23). The site is part of the Minnesota Watershed Pollutant Load Monitoring Program (Hawk Creek near Maynard, MN23 (DNR flow gage ID 25024001 and EQuIS Site ID S002-148)). The site will provide data to determine progress toward and eventual achievement of the TSS water quality standard for the lower reaches of Hawk Creek (downstream of Focus Watershed). The site includes continuous water level, development and maintenance of a streamflow rating curve, routine field measurements, and discrete water sampling and laboratory analysis. Continuous turbidity and temperature sensors will be added when possible.

Figure 23. Identified monitoring sites in the Hawk Creek Watershed



A second stream flow and water quality monitoring site will be considered to further the performance evaluation monitoring for the watershed and available funding is considered. The monitoring site (EQuIS Site ID S008-396) on Hawk Creek midway between the Watershed Pollutant Load Monitoring Network (WPLMN) site and Willmar Chain of Lakes would be the initial candidate for the site. Discrete water samples would be collected on a storm event basis, targeting a minimum of 25 samples per year. Lab analysis will include TSS, *E. coli*, TP, and nitrate. Field measurements will include turbidity, Secchi tube transparency, temperature, DO, and specific conductivity.

Streamflow and water quality sampling will provide load calculations to evaluate for load reductions and the effectiveness of the practices implemented in the Hawk Creek Watershed.

The 10-year cycle intensive watershed monitoring conducted by MPCA and its partners is scheduled for the Hawk Creek Watershed in 2020. Biological monitoring was conducted at 10 sites in 2010 with many likely to be sampled again in 2020. Water quality monitoring is also conducted at several sites between 10 and 20 times in a two-year period. An outcome of this monitoring effort is the identification of waters that are impaired (i.e., do not meet standards and need restoration) and waters in need of protection to prevent impairment.

Additional annual stream biological monitoring will also be conducted, if resources are available. Stream habitat and geomorphology monitoring will be completed in conjunction with the flow, chemistry, and biology monitoring.

The Eagle Lake Improvement Association annually monitors the lake and small streams that drain the watershed into Eagle Lake. Phosphorus, algae (i.e., chl-a), clarity, temperature and recreational and aesthetic suitability are monitored routinely between May and September. Monitoring will also be conducted at sites on Swan Lake, Willmar Lake, and Foot Lake. Approximately five sites out of nine existing sites on the lakes will be sampled two times per month during the summer.

BMP implementation is tracked by the Board of Water and Soil Resources (BWSR) in its eLINK database for state-funded implementation and the United States Department of Agriculture for federally-funded implementation. Both agencies track the locations of BMP installations; however, reporting is generally limited to individual watersheds due to data privacy limits. Changes in land cover and land use not associated with BMP implementation will be tracked using visual observations, field measurements, and aerial imaging.

The estimated cost of conducting this monitoring for 10 years is $426,000 (Table 21).

Table 21. Monitoring costs in Hawk Creek Watershed

Monitoring type	Description	Unit cost (annual)	Total (10-years)
Streamflow and water quality sampling and analysis	0.1 FTE for 2 sites 0.1 FTE for data analysis Lab costs/site Equipment/2 sites	$10,000 $10,000 $2,000 $5,000/site	$230,000
Biological monitoring	0.1 FTE for 10 sites 2-4 person crew and data analysis	$10,000	$100,000
Habitat and stream geomorphology	0.2 FTE (2 times per 10-year period)	$20,000	$40,000
Lake monitoring	0.05 FTE for 5 sites Lab costs/site	$5,000 $600	$56,000
Total			**$426,000**

Citizen stream and lake monitoring data provides a record of waterbody transparency and relies on a network of volunteers who make weekly to monthly lake and river measurements. There are currently about a dozen lake and stream monitoring locations in the Upper Hawk Creek Watershed.

9. Financial and technical resources

Implementation of the Upper Hawk Creek NKE Plan will require additional financial and technical resources

A list of existing funding sources available to support implementation is provided in Table 21.

Table 21. Partial list of funding sources for restoration and protection strategies

Sponsor or information source	Program description
MPCA	**Section 319 Grants:** Federal grant funding from the EPA as part of the Clean Water Act, Section 319. Grants awarded by MPCA to local governmental units and other groups are to address NPS pollution through implementation projects. **Clean Water Partnership Loan**: The state funded Clean Water Partnership Program awards no-interest loans to local governmental units for work on projects that address NPS pollution. **Clean Water State Revolving Fund:** The state revolving fund provides loans to for both point source (wastewater and stormwater) and NPS water pollution control projects.
BWSR	**Clean Water Fund Competitive Grants:** These grants are to restore, protect, and enhance water quality. Eligible activities must be consistent with a comprehensive watershed management plan, county comprehensive local water management plan, soil and water conservation district comprehensive plan, metropolitan local water plan or metropolitan groundwater plan that has been State approved and locally adopted or an approved TMDL, Watershed Restoration and Protection Strategy document, surface water intake plan, or well head protection plan. **Targeted Watershed Demonstration Program:** This program awards grants to local governmental units organized for the management of water in a watershed or subwatershed where multiyear plans that will result in a significant reduction in water pollution in a selected subwatershed are in place. **The Erosion Control and Water Management Program**, commonly known as the State Cost-Share Program: This program provides funds to SWCDs to share the cost of systems or practices for erosion control, sedimentation control, or water quality improvements that are designed to protect and improve soil and water resources. Through this program, land occupiers can request financial and technical assistance from their local SWCD for the implementation of conservation practices.
Minnesota Department of Agriculture (MDA)	**AgBMP Loan Program:** This program encourages implementation of BMPs that prevent or reduce pollution problems, such as runoff from feedlots, erosion from farm fields and shoreline, and noncompliant septic systems and wells. MDA provides a wide array of other information from their agency as well as other state and federal agencies on conservation programs addressing agriculture and other land uses. In addition, Clean Water Research projects are available for funding.
Minnesota DNR	**DNR grants** are available for a variety of programs relating to land preservation, wildlife and habitat, native prairie, forestry and wetlands.
U.S. Department of Agriculture (USDA) Natural Resources Conservation Service	**Environmental Quality Incentives Program:** Voluntary program to implement conservation practices, or activities, such as conservation planning, that address natural resource concerns for agricultural producers. **Conservation Reserve Program – Continuous Signup:** This program is a USDA Farm Service Agency-funded voluntary program designed to help farmers restore and protect environmentally sensitive land—particularly wetlands, wildlife habitat and water quality buffers. **Conservation Stewardship Program:** Voluntary program to improve resource conditions such as soil quality, water quality, water quantity, air quality, habitat quality, and energy.

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11. Appendix A. STEPL output and assumptions

The STEPL was used to estimate P, TSS, and *E. coli* loads and reductions for the watershed. The loads estimated in STEPL were comparable with the loading that was estimated using HSPF-SAM for the development of the draft TMDLs in the watershed. STEPL output and reduction estimates in Section 6.2 include loading and streambank restoration reductions.

The reductions for BMPs identified in the 10-year milestone table were summed and entered as combined efficiency practices in STEPL. The reductions for BMPs implemented between 2013 and 2018 were estimated in the same way. Reduction efficiencies for *E. coli* were assumed from MPCA (2011) and Wright Water Engineers, Inc. (2010) and added to the “BMPList” worksheet in STEPL. The practices and assumed reduction efficiencies are shown in Table 22. The Combined Efficiencies of the BMPs with area of watershed treated for each lakeshed and the Upper Mainstem Hawk Creek are described in Table 23 through Table 28. The treatment efficiencies for the BMPs that are not in the original list of BMPs and reduction efficiencies (BMPList) in STEPL were assigned based on the similarity of the treatment processes with selected BMPList practices.

Table 22. Land use, BMPs, and efficiencies for STEPL (added all *E. coli* efficiencies)

Landuse	BMP & Efficiency	N	P	TSS	*E. coli*	Assumptions and Additions
Cropland	Alternative Tile Intake	0.253	0.308	0.4	0.3	Added Alternative Tile Intake, assuming same efficiencies as STEPL Practice Terrace, assume 20 acres treated per practice
Cropland	Bioreactor	0.453	ND	ND	0.9	Assume bioreactor treats 10 acres
Cropland	Buffer - Grass (35ft wide)	0.338	0.435	0.533	0.65	Assume 100% of cropland treated by buffer strips (MN Buffer Law)
Cropland	Combined BMPs-Calculated [1]	0	0	0	0	
Cropland	Conservation Cover	0.204	0.15	0.2	0.5	Added Conservation Cover, assuming same efficiencies as STEPL practice Cover Crop 3, assume that each practice is 10 acres
Cropland	Conservation Tillage 1 (30-59% Residue)	0.15	0.356	0.403	0.3	
Cropland	Contour Farming	0.279	0.398	0.341	ND	
Cropland	Cover Crop 3 (Group A Traditional Early Planting Time) (High Till only for TP and Sediment)	0.204	0.15	0.2	0.5	
Cropland	Field Erosion Stabilization	0.253	0.308	0.4	0.3	Added Field Erosion Stabilization, assuming same efficiencies as STEPL cropland practice Terrace. Assume each practice treats 20 acres.
Cropland	Grade Stabilization Structures	0.253	0.308	0.4	0.3	Added Grade Stabilization Structures, assuming same efficiencies as STEPL practice Terrace, assume 40 acres treated per practice.
Cropland	Grassed Waterways	0.253	0.308	0.4	0.3	Added Grassed Waterways, assume 1,000 ft of grassed waterways treats 50 acres, assume same efficiencies as STEPL practice Terrace
Cropland	Land Retirement	0.898	0.808	0.95	0.9	Added Nutrient/Manure Management, Assuming same efficiencies as STEPL practice Nutrient Management 1, increased e. coli efficiencies to .9
Cropland	Manure/Nutrient Management	0.154	0.45	ND	0.9	
Cropland	Nutrient Management 2 (Determined Rate Plus Additional Considerations)	0.247	0.56	ND	0.9	
Cropland	Retention Pond	0.898	0.808	0.95	0.9	Added Retention Pond, assuming same efficiencies as STEPL cropland practice Land Retirement
Cropland	Saturated Buffer	0.12	0.28	ND	0.3	Added Saturated Buffer, assuming same efficiencies as STEPL practice Two Stage Ditch; Assume 1,000 ft treats 30 acres.

Landuse	BMP & Efficiency	N	P	TSS	*E. coli*	Assumptions and Additions
Cropland	Side water inlets	0.253	0.308	0.4	0.3	Added Side Water inlets, assumed same efficiencies as Terrace, assume each treats 10 acres
Cropland	Terrace	0.253	0.308	0.4	0.3	
Cropland	Two-Stage Ditch	0.12	0.28	ND	0.3	
Cropland	WASCOB (Water and Sediment Control Basin	0.253	0.308	0.4	0.3	Added WASCOB, assuming the same efficiencies as Terrace, assuming 40 acres treated per WASCOB
Cropland	Wetland Restoration	0.898	0.808	0.95	0.9	Added Wetland Restoration, assuming same efficiencies as STEPL practice Land retirement assuming 40 acres treated per acre of wetland
Pastureland	Combined BMPs-Calculated [1]	0	0	0	0	
Pastureland	Critical Area Planting	0.175	0.2	0.42	ND	
Pastureland	Fencing and Watering Projects	0.203	0.304	0.62	0.65	Added pastureland Fencing and watering projects, assuming same efficiencies as STEPL practice Livestock Exclusion Fencing
Pastureland	Livestock Exclusion Fencing	0.203	0.304	0.62	0.65	
Pastureland	Prescribed Grazing	0.408	0.227	0.333	ND	
Pastureland	Rotational Grazing	0.43	0.263	0.333	0.65	Added pastureland Rotational Grazing, assuming same efficiencies as STEPL practice Grazing Land Management, and TSS reduction from Prescribed Grazing
Pastureland	Streambank Protection w/o Fencing	0.15	0.22	0.575	0.3	
Pastureland	Streambank Restoration	0.75	0.75	0.75	0.65	
Feedlots	Waste Storage Facility	0.65	0.6	ND	0.9	
Urban	Alum Treatment	0.6	0.9	0.95	ND	
Urban	Bioretention facility	0.63	0.8	ND	0.9	
Urban	Bioretention practices	0.63	0.8	0.85	0.95	Added Urban STEPL Bioretention practice, efficiencies for TSS and *E. coli* based on MN Stormwater manual (https://stormwater.pca.state.mn.us/index.php/Calculating_credits_for_bioretention)
Urban	LID/Bioretention	0.43	0.81	ND	ND	
Urban	Lake Shore Restoration	0.3	0.3	0.4	0.6	0.3
Urban	Raingardens	0.6	0.65	0.75	0.9	Added Urban STEPL raingardens, assuming same efficiencies as STEPL practice Infiltration basin (urban)

[1] Combined efficiencies are broken out by watershed/lakeshed in Table 23 through Table 28

Table 23. Combined efficiencies for BMPs and acres treated as STEPL inputs for Swan Lake Lakeshed

Area (ac)	Select a BMP Type	N	P	TSS	*E. coli*
88	Nutrient Management 2 (Determined Rate Plus Additional Considerations)	0.247	0.56	0	0
132.75	Cover Crop 3 (Group A Traditional Early Planting Time) (High Till only for TP and Sediment)	0.204	0.15	0.2	0.5
132.75	Conservation Tillage 2 (equal or more than 60% Residue)	0.25	0.687	0.77	0
177	Buffer - Grass (35ft wide)	0.338	0.435	0.533	0.65
20	Alternative Tile Intake	0.253	0.308	0.4	0.3
2	Wetland Restoration	0.898	0.808	0.95	0.9
2	Retention Pond	0.898	0.808	0.95	0.9
20	Field Erosion Stabilization	0.253	0.308	0.4	0.3
10	WASCOB	0.253	0.308	0.4	0.3
0	Saturated Buffer	0.12	0.28	0.75	0.3
50	Grassed Waterway	0.253	0.308	0.4	0.3
10	Bioreactor	0.453	0	0	0.9
10	Conservation Cover	0.204	0.15	0.2	0.5
20	Grade Stabilization	0.253	0.308	0.4	0.3
20	Side Inlets	0.253	0.308	0.4	0.3
0	Contour Farming	0.279	0.398	0.341	0.3
0	Two-Stage Ditch	0.12	0.28	0.75	0.3
654.5	Total acres and combined efficiencies	0.270	0.409	0.410	0.346
Pasture Land					
3	Critical Area Planting	0.175	0.2	0.42	0
50	Streambank Restoration	0.75	0.75	0.75	0.65
60	Streambank Protection w/o Fencing	0.15	0.22	0.575	0.3
10	Livestock Exclusion Fencing	0.203	0.304	0.62	0.65
10	Perimeter Fencing	0.203	0.304	0.62	0.65
40	Grazing Land Management (rotational grazing with fenced areas)	0.43	0.263	0	0.65
173	Total acres and combined efficiencies	0.395	0.392	0.495	0.517

Table 24. Combined efficiencies for BMPs and acres treated as STEPL inputs for Point and Eagle Lakes Lakesheds

Area (ac)	Select a BMP Type	N	P	TSS	*E. coli*
4,554	Nutrient Management 2 (Determined Rate Plus Additional Considerations)	0.247	0.560	0.000	0.000
4,554	Cover Crop 3 (Group A Traditional Early Planting Time) (High Till only for TP and Sediment)	0.204	0.150	0.200	0.500
4,554	Conservation Tillage 2 (equal or more than 60% Residue)	0.250	0.687	0.770	0.000
6,072	Buffer - Grass (35 ft wide)	0.338	0.435	0.533	0.650
300	Alternative Tile Intake	0.253	0.308	0.400	0.300
200	Wetland Restoration	0.898	0.808	0.950	0.900
200	Retention Pond	0.898	0.808	0.950	0.900
500	Field Erosion Stabilization	0.253	0.308	0.400	0.300
300	WASCOB	0.253	0.308	0.400	0.300

Area (ac)	Select a BMP Type	N	P	TSS	*E. coli*
60	Saturated Buffer	0.120	0.280	0.750	0.300
150	Grassed Waterway	0.253	0.308	0.400	0.300
10	Bioreactor	0.453	0.000	0.000	0.900
10	Conservation Cover	0.204	0.150	0.200	0.500
100	Grade Stabilization	0.253	0.308	0.400	0.300
720	Side Inlets	0.253	0.308	0.400	0.300
0	Contour Farming	0.279	0.398	0.341	0.300
0	Two-Stage Ditch	0.120	0.280	0.750	0.300
21,454	Total acres and combined efficiencies	0.276	0.448	0.400	0.325
Pastureland					
46	Critical Area Planting	0.175	0.200	0.420	0.000
751	Streambank Restoration	0.750	0.750	0.750	0.650
940	Streambank Protection w/o Fencing	0.150	0.220	0.575	0.300
20	Livestock Exclusion Fencing	0.203	0.304	0.620	0.650
20	Perimeter Fencing	0.203	0.304	0.620	0.650
40	Grazing Land Management (rotational grazing with fenced areas)	0.430	0.263	0.000	0.650
1,817	Total acres and combined efficiencies	0.406	0.441	0.632	0.452

Table 25. Combined efficiencies for BMPs and acres treated as STEPL inputs for Skataas Lake Lakesheds

Area (ac)	Select a BMP Type	N	P	TSS	*E. coli*
Cropland					
586.5	Nutrient Management 2 (Determined Rate Plus Additional Considerations)	0.247	0.560	0.000	0.000
586.5	Cover Crop 3 (Group A Traditional Early Planting Time) (High Till only for TP and Sediment)	0.204	0.150	0.200	0.500
586.5	Conservation Tillage 2 (equal or more than 60% Residue)	0.250	0.687	0.770	0.000
782	Buffer - Grass (35ft wide)	0.338	0.435	0.533	0.650
40	Alternative Tile Intake	0.253	0.308	0.400	0.300
2	Wetland Restoration	0.898	0.808	0.950	0.900
2	Retention Pond	0.898	0.808	0.950	0.900
40	Field Erosion Stabilization	0.253	0.308	0.400	0.300
10	WASCOB	0.253	0.308	0.400	0.300
0	Saturated Buffer	0.120	0.280	0.750	0.300
0	Grassed Waterway	0.253	0.308	0.400	0.300
10	Bioreactor	0.453	0.000	0.000	0.900
10	Conservation Cover	0.204	0.150	0.200	0.500
40	Grade Stabilization	0.253	0.308	0.400	0.300
60	Side Inlets	0.253	0.308	0.400	0.300
0	Contour Farming	0.279	0.398	0.341	0.300
0	Two-Stage Ditch	0.120	0.280	0.750	0.300
2,645.5	Total acres and combined efficiencies	0.266	0.444	0.387	0.318

Pastureland					
6	Critical Area Planting	0.175	0.200	0.420	0.000
86	Streambank Restoration	0.750	0.750	0.750	0.650
107	Streambank Protection w/o Fencing	0.150	0.220	0.575	0.300
10	Livestock Exclusion Fencing	0.203	0.304	0.620	0.650
10	Perimeter Fencing	0.203	0.304	0.620	0.650
40	Grazing Land Management (rotational grazing with fenced areas)	0.430	0.263	0.000	0.650
259	Total acres and combined efficiencies	0.397	0.409	0.544	0.490

Table 26. Combined efficiencies for BMPs and acres treated as STEPL inputs for Willmar Lake

Area (ac)	Select a BMP Type	N	P	TSS	*E. coli*
Cropland					
2,240.3	Nutrient Management 2 (Determined Rate Plus Additional Considerations)	0.247	0.560	0.000	0.000
2,240.3	Cover Crop 3 (Group A Traditional Early Planting Time) (High Till only for TP and Sediment)	0.204	0.150	0.200	0.500
2,240.3	Conservation Tillage 2 (equal or more than 60% Residue)	0.250	0.687	0.770	0.000
2,987.0	Buffer - Grass (35ft wide)	0.338	0.435	0.533	0.650
100	Alternative Tile Intake	0.253	0.308	0.400	0.300
5	Wetland Restoration	0.898	0.808	0.950	0.900
5	Retention Pond	0.898	0.808	0.950	0.900
40	Field Erosion Stabilization	0.253	0.308	0.400	0.300
30	WASCOB	0.253	0.308	0.400	0.300
30	Saturated Buffer	0.120	0.280	0.750	0.300
50	Grassed Waterway	0.253	0.308	0.400	0.300
10	Bioreactor	0.453	0.000	0.000	0.900
10	Conservation Cover	0.204	0.150	0.200	0.500
60	Grade Stabilization	0.253	0.308	0.400	0.300
200	Side Inlets	0.253	0.308	0.400	0.300
0	Contour Farming	0.279	0.398	0.341	0.300
0	Two-Stage Ditch	0.120	0.280	0.750	0.300
9,977.8	Total acres treated and combined efficiencies	0.265	0.448	0.389	0.316
Pastureland					
26	Critical Area Planting	0.175	0.200	0.420	0.000
417	Streambank Restoration	0.750	0.750	0.750	0.650
521	Streambank Protection w/o Fencing	0.150	0.220	0.575	0.300
10	Livestock Exclusion Fencing	0.203	0.304	0.620	0.650
10	Perimeter Fencing	0.203	0.304	0.620	0.650
40	Grazing Land Management (rotational grazing with fenced areas)	0.430	0.263	0.000	0.650
1,024.0	Total acres treated and combined efficiencies	0.407	0.439	0.621	0.455

Table 27. Combined efficiencies for BMPs and acres treated as STEPL inputs for Foot Lake

Area (ac)	BMP Type	N	P	TSS	*E. coli*
Cropland					
284.25	Nutrient Management 2 (Determined Rate Plus Additional Considerations)	0.247	0.560	0.000	0.000
284.25	Cover Crop 3 (Group A Traditional Early Planting Time) (High Till only for TP and Sediment)	0.204	0.150	0.200	0.500
284.25	Conservation Tillage 2 (equal or more than 60% Residue)	0.250	0.687	0.770	0.000
379	Buffer - Grass (35ft wide)	0.338	0.435	0.533	0.650
40	Alternative Tile Intake	0.253	0.308	0.400	0.300
0	Wetland Restoration	0.898	0.808	0.950	0.900
0	Retention Pond	0.898	0.808	0.950	0.900
0	Field Erosion Stabilization	0.253	0.308	0.400	0.300
0	WASCOB	0.253	0.308	0.400	0.300
0	Saturated Buffer	0.120	0.280	0.750	0.300
0	Grassed Waterway	0.253	0.308	0.400	0.300
0	Bioreactor	0.453	0.000	0.000	0.900
0	Conservation Cover	0.204	0.150	0.200	0.500
0	Grade Stabilization	0.253	0.308	0.400	0.300
0	Side Inlets	0.253	0.308	0.400	0.300
0	Contour Farming	0.279	0.398	0.341	0.300
0	Two-Stage Ditch	0.120	0.280	0.750	0.300
1271.75	Total acres treated and combined efficiencies	0.265	0.452	0.388	0.315
Pastureland					
7	Critical Area Planting	0.175	0.200	0.420	0.000
108	Streambank Restoration	0.750	0.750	0.750	0.650
135	Streambank Protection w/o Fencing	0.150	0.220	0.575	0.300
10	Livestock Exclusion Fencing	0.203	0.304	0.620	0.650
10	Perimeter Fencing	0.203	0.304	0.620	0.650
40	Grazing Land Management (rotational grazing with fenced areas)	0.430	0.263	0.000	0.650
310	Total acres treated and combined efficiencies	0.399	0.415	0.561	0.483

Table 28. Combined efficiencies for BMPs and acres treated as STEPL inputs for Upper Mainstem Hawk Creek

Area (ac)	Select a BMP Type	N	P	TSS	*E. coli*
Cropland					
39,377.25	Nutrient Management 2 (Determined Rate Plus Additional Considerations)	0.247	0.560	0.000	0.000
39,377.25	Cover Crop 3 (Group A Traditional Early Planting Time) (High Till only for TP and Sediment)	0.204	0.150	0.200	0.500
39,377.25	Conservation Tillage 2 (equal or more than 60% Residue)	0.250	0.687	0.770	0.000
52,503	Buffer - Grass (35ft wide)	0.338	0.435	0.533	0.650
600	Alternative Tile Intake	0.253	0.308	0.400	0.300
40	Wetland Restoration	0.898	0.808	0.950	0.900
40	Retention Pond	0.898	0.808	0.950	0.900

Area (ac)	Select a BMP Type	N	P	TSS	*E. coli*
600	Field Erosion Stabilization	0.253	0.308	0.400	0.300
300	WASCOB	0.253	0.308	0.400	0.300
90	Saturated Buffer	0.120	0.280	0.750	0.300
100	Grassed Waterway	0.253	0.308	0.400	0.300
20	Bioreactor	0.453	0.000	0.000	0.900
10	Conservation Cover	0.204	0.150	0.200	0.500
180	Grade Stabilization	0.253	0.308	0.400	0.300
3,300	Side Inlets	0.253	0.308	0.400	0.300
20	Contour Farming	0.279	0.398	0.341	0.300
50	Two-Stage Ditch	0.120	0.280	0.750	0.300
172,424.75	Total acres treated and combined efficiencies	0.266	0.452	0.389	0.315
Pastureland					
70	Critical Area Planting	0.175	0.200	0.420	0.000
1,137	Streambank Restoration	0.750	0.750	0.750	0.650
1,421	Streambank Protection w/o Fencing	0.150	0.220	0.575	0.300
20	Livestock Exclusion Fencing	0.203	0.304	0.620	0.650
20	Perimeter Fencing	0.203	0.304	0.620	0.650
100	Grazing Land Management (rotational grazing with fenced areas)	0.430	0.263	0.000	0.650
2,768	Total acres treated and combined efficiencies	0.408	0.440	0.623	0.454

The reductions for replacing and/or upgrading failing or non-conforming SSTS were estimated using the STEPL septic tab. Outputs from this worksheet are described in Table 29.

Table 29. STEPL output for SSTS *E. coli* load reductions for all HUC-12s and lakesheds

Watershed	# of SSTS	Pop per SSTS	SSTS failure rate %	Failing SSTS	Pop. on failing SSTS	Failing SSTS gal/day	Failing SSTS flow l/hr	N load lb/hr	P Load lb/hr	*E. coli* MPN/hr
Swan	25	2.43	75	19	46	3189	503	0.067	0.026	4.8E+09
Point/Eagle	331	2.43	75	248	603	42227	6660	0.881	0.345	6.3E+10
Skaatas	55	2.43	75	41	100	7017	1107	0.146	0.057	1.0E+10
Willmar	7	2.43	75	5	13	893	141	0.019	0.007	1.3E+09
Foot	0	2.43	75	0	0	0.000	0.000	0.000	0.000	0.0E+00
Hawk Creek	373	2.43	75	280	680	47585	7505	0.993	0.389	7.1E+10

2. Septic nutrient load in lb/yr except *E. coli* in MPN/yr)					Load after Reduction			
Watershed	**N Load, lb/yr**	**P Load, lb/yr**	**BOD, lb/yr**	***E. coli*, MPN/yr**	**N Load, lb/yr**	**P Load, lb/yr**	**BOD, lb/yr**	***E. coli*, MPN/yr**
Swan	583	228	2380	4.2E+13	0	0	0	0
Point/Eagle	7718	3023	31514	5.5E+14	0	0	0	0
Skaatas	1282	502	5236	9.2E+13	0	0	0	0
Willmar	163	64	667	1.2E+13	0	0	0	0
Foot	0.00	0.00	0.00	0.0E+00	0	0	0	0
Hawk Creek	8697	3406	35512	6.2E+14	0	0	0	0
Assumptions for SSTS								

The direct contribution of nutrients to a stream or lake is from failing SSTS		
Required input for calculating SSTS nutrient load are number of SSTS, failure rate, loading rate (lb/hr), and flow (cfs)		
Assumption: failing SSTS are distributed evenly across the watershed based on land area, with the exception of the Foot Lake Watershed, which has zero SSTS		
Assume the average concentrations reaching the stream (from SSTS overcharge) are:		
Total nitrogen:	60	mg/L (range of 20 to 100)
Total phosphorus:	23.5	mg/L (range of 18 to 29)
Organics (BOD):	245	mg/L (range of 200 to 290)
E. coli *	9.5E+05	MPN/100ml
Typical septic overcharge flow rate of:	70	gal/day/person(range of 45 to 100)
* *E. coli* effluent # assumed to be 948,000 as equivalent from the BWSR Septic System Improvement Estimator Tool (Heger 2017) assumption		

12. Appendix B. HSPF-SAM

4 Model Scenarios

This task order included a limited amount of budget and calendar time to support scenario analysis. Two specific scenarios were requested by the Hawk Creek Watershed Project. Scenario 1 evaluates the potential impacts of the recent upgrades to the Willmar wastewater treatment plant, which was a major source of pollutant load to Hawk Creek. Scenario 2 investigates the potential impact of widespread acceptance of stream buffers in agricultural lands.

4.1 Scenario 1: Willmar Treatment Plant Upgrades

The City of Willmar recently undertook a major upgrade to their wastewater treatment plant. This scenario is designed to evaluate the potential water quality benefits of the plant upgrade.

The upgrade included phosphorus removal and nitrification, resulting in order of magnitude decreases in total phosphorus and ammonia nitrogen load. Nitrogen is not removed, however; rather it is mostly converted to nitrate form. There has also been a significant decrease in biochemical oxygen demand (BOD).

As part of the upgrade, Willmar also moved its discharge point. However, the new discharge location still falls within the same model segment (213).

Specifications for post-upgrade water quality in the Willmar effluent were provided by the Hawk Creek Watershed Project after consultation with the wastewater treatment plant superintendent. The following assumptions are used:

Total Phosphorus	0.661 mg/L
Ammonia-N	0.20 mg/L
Nitrate-N	17 mg/L
Organic N	1.6 mg/L
TSS	5.857 mg/L
Fecal Coliform	59 #/100 ml
BOD5	2 mg/L

The projected average flow for the new plant is 4.73 MGD, whereas the average flow in the model for 1996-2009 is 3.55 MGD. Because effluent flow is correlated to weather conditions the scenario was constructed by using the historic weather and effluent flow time series, scaling up the effluent flow by a factor 1.214. Pollutant loads are then added based on the concentration assumptions provided above.

4.2 Scenario 2: Agricultural Buffer Implementation

This scenario is a bounding scenario, designed to investigate the maximum impact of applying 50-foot stream buffers to all cropland within the Hawk Creek watershed. Partial implementation would approximate a linear scaling between current conditions and full implementation.

The buffers are assumed to be applied to all NHD streamlines in the watershed. Further, the average stream density characteristics of the entire watershed are assumed to apply to croplands within each subbasin of the Hawk Creek watershed. A GIS analysis indicates that land area within 50 feet of NHD streamlines accounts for 1.57 percent of the total area in the watershed. (A cursory examination suggests that the NHD represents the majority, but not the entirety of public drainage ditches within the watershed.

Thus, the impact of instituting buffers based on the NHD may be slightly less than could be obtained by instituting buffers on all public drainage ditches.)

Buffers are assumed to be maintained as vegetative filter strips (VFSs) with perennial grass cover. Thus, the first effect of the scenario is a shift in land use with 1.57% of cropland converting to grass.

The representation of pollutant removal by buffers in HSPF presents challenges because HSPF is a lumped model. That is, land use areas within a subbasin do not have a specific position relative to streams, as would be the case in a gridded model, so it is difficult to assess how buffers affect total pollutant loading. Similar problems are present in SWAT, also a lumped model. In the recent release of SWAT2009 an approach was developed to address this issue, and the same approach is adopted for the HSPF representation of this scenario.

The SWAT2009 approach (M.J. White and J.G. Arnold, 2009, Development of a simplistic vegetative filter strip model for sediment and nutrient retention at the field scale, *Hydrological Processes*, 23: 1602-1616) develops a method based on empirical analyses of field studies and application of the vegetative filter strip model (VFSMOD) to create an approximation of treatment by buffers and filter strips that can be incorporated into lumped models. The approach contains two major components: a conceptualization of the flow paths and their impacts on BMP efficiency in an agricultural setting, and regression equations that estimate pollutant removal rates conditional on flow path. The approach also replaces the traditional reliance on buffer width with an alternate measure, the ratio of contributing area to buffer area, which is more appropriate to the varied and uncertain geometry of lumped models.

The best buffer pollutant removal performance is obtained when all flow is directed to the buffer as sheet flow and evenly distributed across the length of the buffer. In contrast, flow that becomes fully channelized is able to punch through the buffer with little or no pollutant removal. White and Arnold's approach recognizes that most real-world applications of buffers occur in situations where a majority of the field runoff is directed to a relatively small portion of the buffer. It thus divides the flow from the upland area into three categories: general loading to the buffer without concentrated flow, the fraction of (non-channelized) concentrated flow that is directed to the most heavily loaded 10 percent of the filter strip, and fully channelized flow that is subject to minimal pollutant removal.

Pollutant removal relationships depend on the magnitude of flow and the magnitude of sediment loading in the regression models developed by White and Arnold. This is inconvenient to implement in HSPF without changes to the underlying FORTRAN code; however, at the ranges of surface runoff flow and surface sediment loading expected in the Hawk Creek watershed, the impacts on removal rates are relatively small – and also well within the range of uncertainty in the regression models. It is thus appropriate to adopt a static representation of treatment efficiency for incorporation into HSPF.

A key factor in applying the White and Arnold approach is the determination of the different flow fractions – especially the fraction of surface runoff that is expected to be fully channelized. It is generally believed that it is difficult to maintain dispersed sheet flow over a distance of more than 300 feet from the buffer – which, with a buffer width of 50 feet, would result in a ratio of contributing area to buffer area of 6. The GIS analysis indicates that ratio of contributing area to buffer area is 62.6. This suggests that 90 percent of the flow reaching the buffer will be concentrated; however, this may fall within the 10 percent focus area and may not all be fully channelized. We assume that 50% of the flow directed to the concentrated area is fully channelized, and that the remaining 50% receives some treatment (although less effective than in the portion of the buffer that receives sheet flow).

As mentioned above, the treatment efficiency of buffers varies with flow loading rate. For small flows, most of the volume may be infiltrated in the buffer, stranding any particulate pollutants. However, these stranded pollutants may be remobilized and transported to the streams during subsequent events. Further, soils in streamside buffer areas are often saturated during wet weather events, reducing or eliminating infiltration. Therefore, it is reasonable to settle on fixed (rather than flow-dependent) removal rates.

In the relatively flat and permeable Hawk Creek watershed rates of generation of overland flow and overland sediment transport are quite low, with much of the flow proceeding through ground water and tile drainage, and much of the sediment being generated from scour associated with tile drain outlets and channel erosion during high flow events. We undertook a modeling analysis of the predicted pollutant removal rates using the equations of White and Arnold under a variety of flows ranging from the median overland surface flow to the 99th percentile overland surface flow. While removal rates are predicted to be greater at lower flow depths, the range is generally small (due in part to the assumptions regarding fully channelized or bypass flow). Further, the majority of pollutant loads move during a few large events. Therefore, the removal rates calculated at the 95th percentile overland surface flow appear appropriate for the analysis. The resulting removal rates relative to the total upland field load generation, calculated consistent with the approach employed in SWAT2009, are shown in Table 5.

Table 5. Pollutant Removal Rates for Agricultural Buffer Scenario

Constituent	Range of Net Removal Rates (50th to 99th percentile overland flow)	Selected Removal Rate (95th percentile overland flow)
Sediment	48 – 55 %	51 %
Organic N	38 – 47 %	42 %
Inorganic N	34 – 54 %	43 %
Sorbed and Organic P	43 – 50 %	46 %
Dissolved P	27 – 44 %	35 %

Note that these rates apply only to sheet and rill erosion; loads generated through ravine/gully erosion are assumed to not be treated by buffers.

In sum, the approach for implementing this scenario is as follows:

1. Shift 1.57 % of cropland to the grass land use category (in the corresponding slope and hydrologic soil group class.)
2. Modify the MASS-LINK table to incorporate the reduction rates for pollutant loads associated with surface runoff (excluding ravine sediment load) as shown in the table above.

This should provide a realistic first-cut estimate of the potential benefits associated with streamside buffers in reducing upland pollutant loads. It should be noted, however, that the analysis will not account for any additional benefits that might accrue from increasing streambank stability through the use of buffers.

4.3 Scenario Results

Results of the scenarios are analyzed by comparing pollutant loads and concentrations at the mouth of Hawk Creek. Scenario 2 results are also shown at the mouth of Beaver Creek (Scenario 1 does not affect Beaver Creek). Concentrations are compared on the basis of medians, as the averages are potentially biased by the model difficulties in simulating concentrations at very low flows.

Scenario results are summarized in Table 6 and Table 7. In general, the upgrade of the Willmar Wastewater Treatment Plant is predicted to result in large decreases in both median concentrations and loads of total P and total N – although the median concentration of nitrate-N is not predicted to change.

The buffer scenario results in a predicted 11 percent decrease in TSS load in Hawk Creek and a 15 percent decrease in Beaver Creek, with smaller fractional losses of N and P. The net effect of the buffers is reduced at the watershed scale due to the assumptions regarding the fraction of flow that can be effectively treated in non-concentrated form, as well as the fact that subsurface loads (including tile drainage) are not mitigated by the buffers. The buffers have little impact on median concentrations because they primarily address surface loading during high flow events.

Table 6. Scenario Results, Hawk Creek Mouth (1996-2009 Simulation)

	Baseline	Scenario 1	Scenario 2
TSS median concentration (mg/L)	10.80	10.10	10.10
TSS mass (tons/yr)	8927	8921	7901
NOx median concentration (mg/L)	6.30	6.30	6.20
Total N median concentration (mg/L)	13.40	7.20	13.10
Total N mass (tons/yr)	2025	1123	1965
Total P concentration (mg/L)	1.00	0.49	0.96
Total P Mass (tons/yr)	59.9	36.3	58.8

Table 7. Scenario Results, Beaver Creek Mouth (1996-2009 Simulation)

	Baseline	Scenario 2
TSS median concentration (mg/L)	9.40	8.70
TSS mass (tons/yr)	4203	3571
NOx median concentration (mg/L)	3.40	3.30
Total N median concentration (mg/L)	6.20	6.10
Total N mass (tons/yr)	413	385
Total P concentration (mg/L)	0.45	0.45
Total P Mass (tons/yr)	14.2	13.5

13. Appendix C. BATTHUB models for Swan and Willmar Lakes

Swan Lake BATHTUB Model Run – Modeled to Observed In-lake Phosphorus

Overall Water & Nutrient Balances

Overall Water Balance — Averaging Period = 1.00 years

Trb	Type	Seg	Name	Area km^2	Flow hm^3/yr	Variance (hm3/yr)^2	CV -	Runoff m/yr
1	1	1	SSTS		0.0	0.00E+00	0.00	
2	2	1	Swan Lake Shed		1.1	0.00E+00	0.00	
3	1	1	R:215	46.1	4.8	0.00E+00	0.00	0.10
PRECIPITATION				0.8	0.6	0.00E+00	0.00	0.74
TRIBUTARY INFLOW				46.1	4.8	0.00E+00	0.00	0.10
NONPOINT INFLOW					1.1	0.00E+00	0.00	
***TOTAL INFLOW				47.0	6.5	0.00E+00	0.00	0.14
ADVECTIVE OUTFLOW				47.0	5.7	0.00E+00	0.00	0.12
***TOTAL OUTFLOW				47.0	5.7	0.00E+00	0.00	0.12
***EVAPORATION					0.8	0.00E+00	0.00	

Overall Mass Balance Based Upon Predicted Outflow & Reservoir Concentrations

Component: TOTAL P

Trb	Type	Seg	Name	Load kg/yr	%Total	Load Variance (kg/yr)^2	%Total	CV	Conc mg/m^3	Export kg/km^2/yr
1	1	1	SSTS	1.9	0.2%	0.00E+00		0.00	189.0	
2	2	1	Swan Lake Shed	244.1	24.0%	0.00E+00		0.00	229.2	
3	1	1	R:215	411.7	40.5%	0.00E+00		0.00	86.3	8.9
PRECIPITATION				24.9	2.5%	1.55E+02	100.0%	0.50	40.8	30.0
INTERNAL LOAD				333.5	32.8%	0.00E+00		0.00		
TRIBUTARY INFLOW				413.6	40.7%	0.00E+00		0.00	86.5	9.0
NONPOINT INFLOW				244.1	24.0%	0.00E+00		0.00	229.2	
***TOTAL INFLOW				1016.1	100.0%	1.55E+02	100.0%	0.01	157.4	21.6
ADVECTIVE OUTFLOW				629.2	61.9%	1.14E+04		0.17	110.9	13.4
***TOTAL OUTFLOW				629.2	61.9%	1.14E+04		0.17	110.9	13.4
***RETENTION				386.9	38.1%	1.14E+04		0.28		

Overflow Rate (m/yr)	6.8	Nutrient Resid. Time (yrs)	0.0906
Hydraulic Resid. Time (yrs)	0.1463	Turnover Ratio	11.0
Reservoir Conc (mg/m3)	111	Retention Coef.	0.381

Swan Lake BATHTUB Model Run – Modeled to Phosphorus Standard

Overall Water & Nutrient Balances

Overall Water Balance — Averaging Period = 1.00 years

Trb	Type	Seg	Name	Area km^2	Flow hm^3/yr	Variance (hm3/yr)^2	CV -	Runoff m/yr
1	1	1	SSTS		0.0	0.00E+00	0.00	
2	2	1	Swan Lake Shed		1.1	0.00E+00	0.00	
3	1	1	R:215	46.1	4.8	0.00E+00	0.00	0.10
PRECIPITATION				0.8	0.6	0.00E+00	0.00	0.74
TRIBUTARY INFLOW				46.1	4.8	0.00E+00	0.00	0.10
NONPOINT INFLOW					1.1	0.00E+00	0.00	
***TOTAL INFLOW				47.0	6.5	0.00E+00	0.00	0.14
ADVECTIVE OUTFLOW				47.0	5.7	0.00E+00	0.00	0.12
***TOTAL OUTFLOW				47.0	5.7	0.00E+00	0.00	0.12
***EVAPORATION					0.8	0.00E+00	0.00	

Overall Mass Balance Based Upon Predicted Outflow & Reservoir Concentrations
Component: TOTAL P

Trb	Type	Seg	Name	Load kg/yr	%Total	Load Variance (kg/yr)^2	%Total	CV	Conc mg/m^3	Export kg/km^2/yr
2	2	1	Swan Lake Shed	135.5	17.2%	0.00E+00		0.00	127.3	
3	1	1	R:215	411.7	52.2%	0.00E+00		0.00	86.3	8.9
PRECIPITATION				24.9	3.2%	1.55E+02	100.0%	0.50	40.8	30.0
INTERNAL LOAD				216.6	27.5%	0.00E+00		0.00		
TRIBUTARY INFLOW				411.7	52.2%	0.00E+00		0.00	86.1	8.9
NONPOINT INFLOW				135.5	17.2%	0.00E+00		0.00	127.3	
***TOTAL INFLOW				788.8	100.0%	1.55E+02	100.0%	0.02	122.2	16.8
ADVECTIVE OUTFLOW				509.7	64.6%	6.49E+03		0.16	89.8	10.9
***TOTAL OUTFLOW				509.7	64.6%	6.49E+03		0.16	89.8	10.9
***RETENTION				279.1	35.4%	6.48E+03		0.29		

Overflow Rate (m/yr)	6.8	Nutrient Resid. Time (yrs)	0.0945
Hydraulic Resid. Time (yrs)	0.1463	Turnover Ratio	10.6
Reservoir Conc (mg/m3)	90	Retention Coef.	0.354

WillmarLake
File: **C:\Users\Aplevan\Desktop\WIllmar\WillmarLake.btb**
Description:

Global Variables	Mean	CV
Averaging Period (yrs)	1	0.0
Precipitation (m)	0.75	0.0
Evaporation (m)	0.75	0.0
Storage Increase (m)	0	0.0

Atmos. Loads (kg/km^2-yr)	Mean	CV
Conserv. Substance	0	0.00
Total P	30	0.50
Total N	1000	0.50
Ortho P	15	0.50
Inorganic N	500	0.50

Model Options	Code	Description
Conservative Substance	0	NOT COMPUTED
Phosphorus Balance	8	CANF & BACH, LAKES
Nitrogen Balance	0	NOT COMPUTED
Chlorophyll-a	2	P, LIGHT, T
Secchi Depth	1	VS. CHLA & TURBIDITY
Dispersion	1	FISCHER-NUMERIC
Phosphorus Calibration	1	DECAY RATES
Nitrogen Calibration	1	DECAY RATES
Error Analysis	1	MODEL & DATA
Availability Factors	0	IGNORE
Mass-Balance Tables	1	USE ESTIMATED CONCS
Output Destination	2	EXCEL WORKSHEET

Segment Morphometry

		Outflow		Area	Depth	Length	Mixed Depth (m)		Hypol Depth		Non-Algal Turb (m^{-1})		Internal Loads (mg/m2-day) Conserv.		Total P		Total N	
Seg	Name	Segment	Group	km^2	m	km	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV
1	WillmarLk	0	1	1.78	1.8	2	1.8	0	0	0	0.08	0.2	0	0	1.28	0	0	0

Segment Observed Water Quality

	Conserv		Total P (ppb)		Total N (ppb)		Chl-a (ppb)		Secchi (m)		Organic N (ppb)		TP - Ortho P (ppb)		HOD (ppb/day)		MOD (ppb/day)	
Seg	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV
1	0	0	118	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Segment Calibration Factors

	Dispersion Rate		Total P (ppb)		Total N (ppb)		Chl-a (ppb)		Secchi (m)		Organic N (ppb)		TP - Ortho P (ppb)		HOD (ppb/day)		MOD (ppb/day)	
Seg	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV
1	1	0	1	0	1	0	1	0	1	0	1	0	1	0	1	0	1	0

Tributary Data

				Dr Area	Flow (hm^3/yr)		Conserv.		Total P (ppb)		Total N (ppb)		Ortho P (ppb)		Inorganic N (ppb)	
Trib	Trib Name	Segment	Type	km^2	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV
1	Swan Lake outlet	1	1	54.3	5.7	0	0	0	111	0	0	0	0	0	0	0
2	Willmar direct drainage	1	1	22.9	3.83	0	0	0	229	0	0	0	0	0	0	0

Model Coefficients	Mean	CV
Dispersion Rate	1.000	0.70
Total Phosphorus	1.000	0.45
Total Nitrogen	1.000	0.55
Chl-a Model	1.000	0.26
Secchi Model	1.000	0.10
Organic N Model	1.000	0.12
TP-OP Model	1.000	0.15
HODv Model	1.000	0.15
MODv Model	1.000	0.22
Secchi/Chla Slope (m^2/mg)	0.025	0.00
Minimum Qs (m/yr)	0.100	0.00
Chl-a Flushing Term	1.000	0.00
Chl-a Temporal CV	0.620	0
Avail. Factor - Total P	0.330	0
Avail. Factor - Ortho P	1.930	0
Avail. Factor - Total N	0.590	0
Avail. Factor - Inorganic N	0.790	0

WillmarLake

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Segment & Tributary Network

--------Segment:	1	WillmarLk		
Outflow Segment:	0	Out of Reservoir		
Tributary:	1	Swan Lake outlet	Type:	Monitored Inflow
Tributary:	2	Willmar direct drainage	Type:	Monitored Inflow

WillmarLake

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Hydraulic & Dispersion Parameters

Seg	Name	Outflow Seg	Net Inflow hm^3/yr	Resid Time years	Overflow Rate m/yr	Velocity km/yr	Dispersion--------> Estimated km^2/yr	Numeric km^2/yr	Exchange hm^3/yr
1	WillmarLk	0	9.5	0.3362	5.4	5.9	287.6	5.9	0.0

Morphometry

Seg	Name	Area km^2	Zmean m	Zmix m	Length km	Volume hm^3	Width km	L/W -
1	WillmarLk	1.8	1.8	1.8	2.0	3.2	0.9	2.2
Totals		1.8	1.8			3.2		

WillmarLake
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Overall Water & Nutrient Balances

Overall Water Balance — **Averaging Period = 1.00 years**

Trb	Type	Seg	Name	Area km²	Flow hm³/yr	Variance (hm3/yr)²	CV -	Runoff m/yr
1	1	1	Swan Lake outlet	54.3	5.7	0.00E+00	0.00	0.10
2	1	1	Willmar direct drainage	22.9	3.8	0.00E+00	0.00	0.17
PRECIPITATION				1.8	1.3	0.00E+00	0.00	0.75
TRIBUTARY INFLOW				77.2	9.5	0.00E+00	0.00	0.12
***TOTAL INFLOW				79.0	10.9	0.00E+00	0.00	0.14
ADVECTIVE OUTFLOW				79.0	9.5	0.00E+00	0.00	0.12
***TOTAL OUTFLOW				79.0	9.5	0.00E+00	0.00	0.12
***EVAPORATION					1.3	0.00E+00	0.00	

Overall Mass Balance Based Upon **Predicted** **Outflow & Reservoir Concentrations**
Component: **TOTAL P**

Trb	Type	Seg	Name	Load kg/yr	%Total	Load Variance (kg/yr)²	%Total	CV	Conc mg/m³	Export kg/km²/yr
1	1	1	Swan Lake outlet	632.7	26.4%	0.00E+00		0.00	111.0	11.7
2	1	1	Willmar direct drainage	877.1	36.6%	0.00E+00		0.00	229.0	38.3
PRECIPITATION				53.4	2.2%	7.13E+02	100.0%	0.50	40.0	30.0
INTERNAL LOAD				832.2	34.7%	0.00E+00		0.00		
TRIBUTARY INFLOW				1509.8	63.0%	0.00E+00		0.00	158.4	19.6
***TOTAL INFLOW				2395.4	100.0%	7.13E+02	100.0%	0.01	220.5	30.3
ADVECTIVE OUTFLOW				1125.7	47.0%	6.99E+04		0.23	118.1	14.3
***TOTAL OUTFLOW				1125.7	47.0%	6.99E+04		0.23	118.1	14.3
***RETENTION				1269.6	53.0%	7.02E+04		0.21		

Overflow Rate (m/yr)	5.4	Nutrient Resid. Time (yrs)	0.1580
Hydraulic Resid. Time (yrs)	0.3362	Turnover Ratio	6.3
Reservoir Conc (mg/m3)	118	Retention Coef.	0.530

WillmarLake

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Segment Mass Balance Based Upon Predicted Concentrations

Component: TOTAL P **Segment: 1 WillmarLk**

Trib	Type	Location	Flow hm^3/yr	Flow %Total	Load kg/yr	Load %Total	Conc mg/m^3
1	1	Swan Lake outlet	5.7	52.5%	632.7	26.4%	111
2	1	Willmar direct drainage	3.8	35.3%	877.1	36.6%	229
PRECIPITATION			1.3	12.3%	53.4	2.2%	40
INTERNAL LOAD			0.0	0.0%	832.2	34.7%	
TRIBUTARY INFLOW			9.5	87.7%	1509.8	63.0%	158
***TOTAL INFLOW			10.9	100.0%	2395.4	100.0%	220
ADVECTIVE OUTFLOW			9.5	87.7%	1125.7	47.0%	118
***TOTAL OUTFLOW			9.5	87.7%	1125.7	47.0%	118
***EVAPORATION			1.3	12.3%	0.0	0.0%	
***RETENTION			0.0	0.0%	1269.6	53.0%	

Hyd. Residence Time =	0.3362	yrs
Overflow Rate =	5.4	m/yr
Mean Depth =	1.8	m

WillmarLake

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Water Balance Terms (hm3/yr) **Averaging Period = 1.00 Years**

			Inflows		Storage	Outflows------>		Downstr	
Seg	**Name**	**External**	**Precip**	**Advect**	**Increase**	**Advect**	**Disch.**	**Exchange**	**Evap**
1	WillmarLk	10	1	0	0	10	0	0	1
Net		10	1	0	0	10	0	0	1

Mass Balance Terms (kg/yr) Based Upon Predicted Reservoir & Outflow Concentrations Component: TOTAL P

		Inflows-->			Storage	Outflows----->		Net	Net
Seg	**Name**	**External**	**Atmos**	**Advect**	**Increase**	**Advect**	**Disch.**	**Exchange**	**Retention**
1	WillmarLk	1510	53	0	0	1126	0	0	437
Net		1510	53	0	0	1126	0	0	437

WillmarLake

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Predicted & Observed Values Ranked Against CE Model Development Dataset

Segment: **1** **WillmarLk**

	Predicted Values--->			Observed Values--->		
Variable	**Mean**	**CV**	**Rank**	**Mean**	**CV**	**Rank**
TOTAL P MG/M3	118.1	0.23	84.2%	118.0		84.2%
CHL-A MG/M3	60.1	0.30	99.2%			
SECCHI M	0.6	0.29	24.1%			
ORGANIC N MG/M3	1532.2	0.29	98.9%			
TP-ORTHO-P MG/M3	104.7	0.34	90.6%			
ANTILOG PC-1	2225.2	0.56	95.4%			
ANTILOG PC-2	15.0	0.08	94.6%			
TURBIDITY 1/M	0.1	0.20	1.1%	0.1	0.20	1.1%
ZMIX * TURBIDITY	0.1	0.20	0.0%	0.1	0.20	0.0%
ZMIX / SECCHI	2.8	0.30	18.7%			
CHL-A * SECCHI	38.0	0.10	96.8%			
CHL-A / TOTAL P	0.5	0.28	93.3%			
FREQ(CHL-a>10) %	99.5	0.01	99.2%			
FREQ(CHL-a>20) %	92.8	0.07	99.2%			
FREQ(CHL-a>30) %	79.1	0.17	99.2%			
FREQ(CHL-a>40) %	63.5	0.28	99.2%			
FREQ(CHL-a>50) %	49.4	0.38	99.2%			
FREQ(CHL-a>60) %	37.9	0.48	99.2%			
CARLSON TSI-P	73.0	0.05	84.2%	72.9		84.2%
CARLSON TSI-CHLA	70.8	0.04	99.2%			
CARLSON TSI-SEC	66.6	0.06	75.9%			

WillmarLake

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Segment	Name
1	WillmarLk

PREDICTED CONCENTRATIONS:

Variable Segment-->	1
TOTAL P MG/M3	118.1
CHL-A MG/M3	60.1
SECCHI M	0.6
ORGANIC N MG/M3	1532.2
TP-ORTHO-P MG/M3	104.7
ANTILOG PC-1	2225.2
ANTILOG PC-2	15.0
TURBIDITY 1/M	0.1
ZMIX * TURBIDITY	0.1
ZMIX / SECCHI	2.8
CHL-A * SECCHI	38.0
CHL-A / TOTAL P	0.5
FREQ(CHL-a>10) %	99.5
FREQ(CHL-a>20) %	92.8
FREQ(CHL-a>30) %	79.1
FREQ(CHL-a>40) %	63.5
FREQ(CHL-a>50) %	49.4
FREQ(CHL-a>60) %	37.9
CARLSON TSI-P	73.0
CARLSON TSI-CHLA	70.8
CARLSON TSI-SEC	66.6

OBSERVED CONCENTRATIONS:

Variable Segment-->	1
TOTAL P MG/M3	118.0
TURBIDITY 1/M	0.1
ZMIX * TURBIDITY	0.1
CARLSON TSI-P	72.9

OBSERVED/PREDICTED RATIOS:

Variable Segment-->	1
TOTAL P MG/M3	1.0
TURBIDITY 1/M	1.0
ZMIX * TURBIDITY	1.0
CARLSON TSI-P	1.0

OBSERVED STANDARD ERRORS

Variable Segment-->	1

TURBIDITY 1/M	0.0
ZMIX * TURBIDITY	0.0

PREDICTED STANDARD ERRORS

Variable Segment-->	1
TOTAL P MG/M3	27.8
CHL-A MG/M3	17.8
SECCHI M	0.2
ORGANIC N MG/M3	445.3
TP-ORTHO-P MG/M3	35.3
ANTILOG PC-1	1236.1
ANTILOG PC-2	1.2
TURBIDITY 1/M	0.0
ZMIX * TURBIDITY	0.0
ZMIX / SECCHI	0.8
CHL-A * SECCHI	3.9
CHL-A / TOTAL P	0.1
FREQ(CHL-a>10) %	0.6
FREQ(CHL-a>20) %	6.3
FREQ(CHL-a>30) %	13.4
FREQ(CHL-a>40) %	17.7
FREQ(CHL-a>50) %	19.0
FREQ(CHL-a>60) %	18.1
CARLSON TSI-P	3.4
CARLSON TSI-CHLA	2.9
CARLSON TSI-SEC	4.3

WillmarLake

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T Statistics Compare Observed and Predicted Means Using the Following Error Terms:

1 = Observed Water Quality Error Only

2 = Error Typical of Model Development Dataset

3 = Observed & Predicted Error

Segment:	**1**	**WillmarLk**						
	Observed		**Predicted**		**Obs/Pred**	**T-Statistics ---->**		
Variable	**Mean**	**CV**	**Mean**	**CV**	**Ratio**	**T1**	**T2**	**T3**
TOTAL P MG/M3	118.0	0.00	118.1	0.23	1.00		0.00	0.00

WillmarLake

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Variable = TOTAL P MG/M3 **R^2 = 1.00**

Global Calibration Factor = 1.00 CV = 0.45

			Calibration Factor		Predicted		Observed		Log (Obs/Pred)		
Seg	Group	Name	Mean	CV	Mean	CV	Mean	CV	Mean	SE	t
1	1	WillmarLk	1.00	0.00	118.1	0.23	118.0	0.00	0.00	0.23	0.00

Variable = CHL-A MG/M3 **R^2 = 1.00**

Global Calibration Factor = 1.00 CV = 0.26

			Calibration Factor		Predicted		Observed		Log (Obs/Pred)		
Seg	Group	Name	Mean	CV	Mean	CV	Mean	CV	Mean	SE	t