Mississippi River Lake Pepin

Watershed Restoration and Protection Strategy Report

March 2015

CLEAN WATER LAND & LEGACY AMENDMENT

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Authors

Beau Kennedy, Goodhue County Soil and Water Conservation District

Justin Watkins, MPCA

Contributors / acknowledgements

Wabasha County Soil and Water Conservation District

Ashley Ignatius, MPCA

Tiffany Schauls, MPCA

Josh Stock, MPCA

Greg Johnson, MPCA

Editing and Graphic Design

Administrative staff: Cindy Penny, MPCA

Cover Photos

Justin Watkins, MPCA

Note Regarding Legislative Charge

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

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Key Terms

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

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

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

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

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

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

Mississippi River Lake Pepin (MRLP) Watershed: the land area that drains the small streams that are tributary to Lake Pepin and the Mississippi River from approximately Red Wing southeast to Lake City. MRLP is the name of the 8-digit HUC. In this case it includes neither Lake Pepin nor the Vermillion River watershed; both are being addressed via other watershed planning efforts.

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

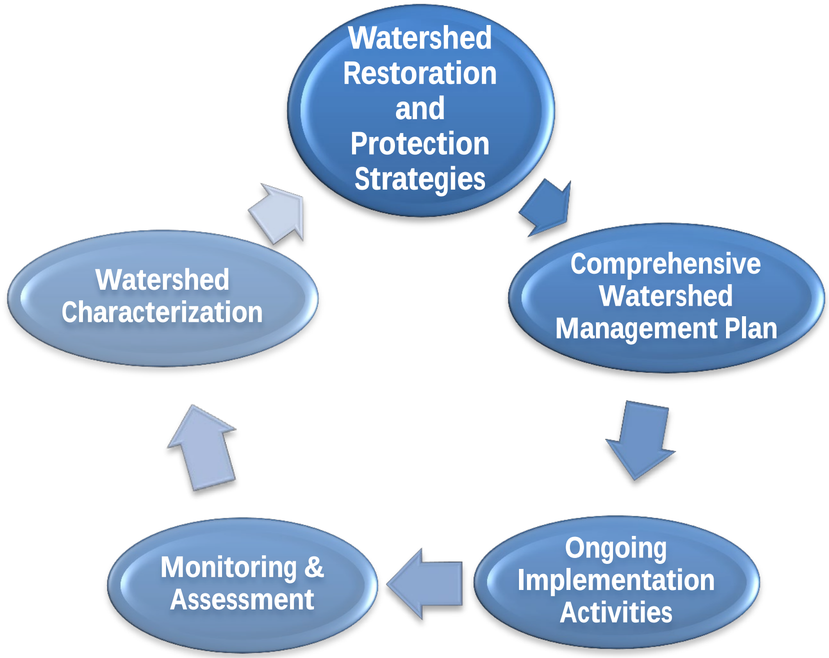
Restoration: This term is used to characterize actions taken in watersheds of impaired waters to improve conditions, eventually to meet water quality standards and achieve beneficial uses of the water bodies.

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

Stressor (or Biological Stressor): This is a broad term that includes both pollutant sources and non-pollutant sources or factors (e.g., altered hydrology, dams preventing fish passage) that adversely impact aquatic life.

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

What is the WRAPS Report?



The State of Minnesota has adopted a "watershed approach" to address the state's 81 "major" watersheds (denoted by 8-digit hydrologic unit code or HUC). This watershed approach incorporates **water quality assessment, watershed analysis, civic engagement, planning**, **implementation**, and **measurement of results** into a 10-year cycle that addresses both restoration and protection.

As part of the watershed approach, waters not meeting state standards are still listed as impaired and Total Maximum Daily Load (TMDL) studies are completed, as they have been in the past, but in addition the watershed approach process facilitates a more cost-effective and comprehensive characterization of multiple water bodies and overall watershed health. A key aspect of this effort is to summarize information and develop tools to help state agencies, local governments and other watershed stakeholders determine how to best proceed with restoring and protecting lakes and streams. This report summarizes past assessment and diagnostic work and outlines ways to prioritize actions and strategies for continued implementation.

Purpose

- Support local working groups and jointly develop scientifically-supported restoration and protection strategies to be used for subsequent implementation planning
- Summarize Watershed Approach work done to date including the following reports:
  - *Mississippi River Lake Pepin Watershed Monitoring and Assessment*
  - *Mississippi River Lake Pepin Watershed Biotic Stressor Identification*
  - *Mississippi River Lake Pepin Watershed Total Maximum Daily Loads*

Scope

- Impacts to aquatic recreation and impacts to aquatic life in streams
- Impacts to trout stream baseflow and associated aquifers
- Consideration of downstream goals: Lake Pepin and Gulf of Mexico

Audience

- Local working groups (local governments, SWCDs, watershed management groups, etc.)
- State agencies (MPCA, DNR, BWSR, etc.)

1. Watershed Background & Description

The Mississippi River-Lake Pepin Watershed includes 205,747 acres that drain several small, cold-water streams in bedrock-dominated bluff country. The largest of these streams is Wells Creek (45,954 acres), which winds through 18 miles of bluff lands and joins the Mississippi near Old Frontenac, southeast of Red Wing. Hay Creek is a popular trout stream (30,405 acres) that flows from south to north, joining the Cannon River bottoms at Red Wing. Most of the other streams in the watershed are also trout waters, and drain directly to the Mississippi River.

Figure 1: Photo of Mississippi River-Lake Pepin, Frontenac State Park (T. Schauls)

The Mississippi River-Lake Pepin watershed consists of forests, bluff lands, and cultivated lands. The top of the watershed is rolling cropland interspersed by many small tributaries that drop steeply through forested valleys with scattered goat prairies atop cliffs. The tributaries form the named streams, which drain directly into the Mississippi River.

1.1 Watershed land use.

Pasture/grassland (noted as rangeland in Figure 2) and cropland are the primary land uses in the watershed (approximately 63%). Corn and soybeans account for most of the tilled acreage of the area. Forage production is strong because of the large number of dairy cows in the region. Of the grassland, 90% is in pasture and a small percentage (<10%) is in a management intensive rotational grazing system. Most of the remaining acreage is deciduous forest. Frontenac State Park, Lake Pepin and the cold-water fisheries are significant natural resources that provide recreation and revenue in the region (Boody & Krinke). The character of the Mississippi River Lake Pepin (MRLP) watershed is described in detail in the assessment report, which discusses hydrology, land use and climate.

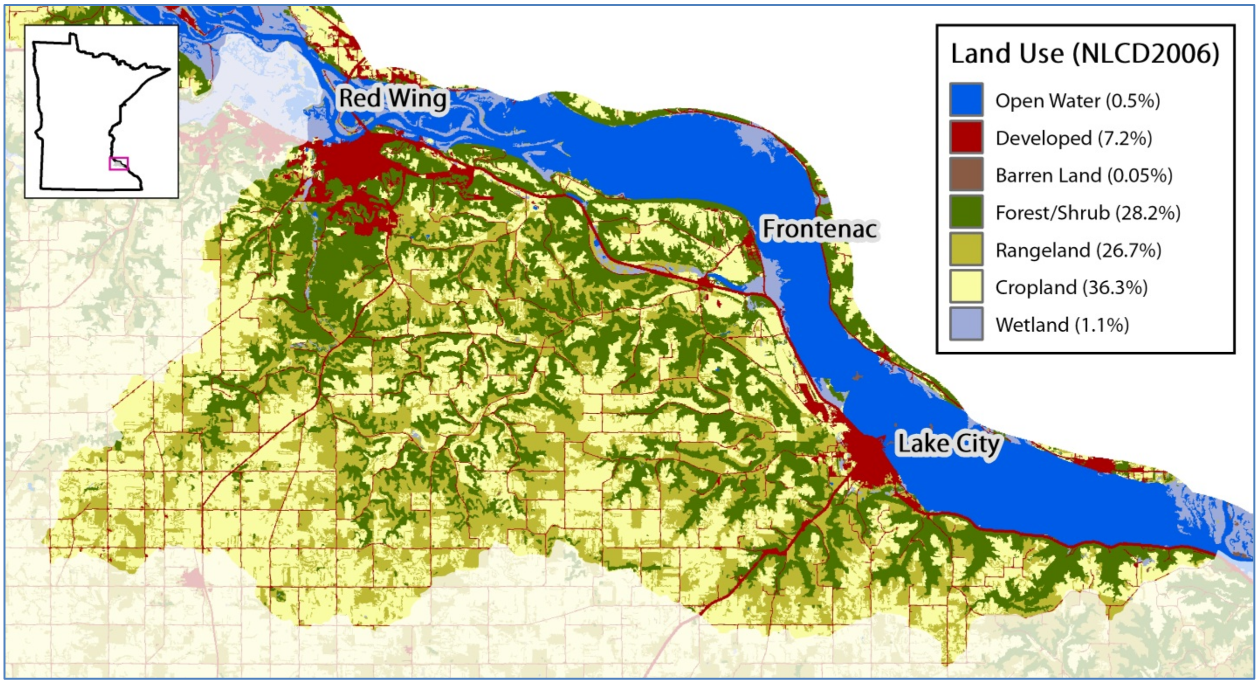


Figure 2. Land use map for the MLRP watershed

1.2 Additional Resources & Watershed Projects.

The MRLP Watershed has a long history of partnership, study and planning work. During the course of WRAPS construction, Goodhue Soil and Water Conservation District (SWCD) scanned and tabulated many documents and reports, and have made them available on their website: http://www.goodhueswcd.org/#!mississippi-river-lake-pepin-/caom.

Some organizations and reports are summarized below.

Wells Creek Watershed Partnership

Wells Creek Partnership was formed in 1993 to help manage the watershed's land and water resources for the long-term health of the resource. The Partnership is comprised of watershed citizens, the Minnesota Department of Natural Resources (DNR), the Minnesota Pollution Control Agency (MPCA), Natural Resource Conservation Service, Goodhue Soil and Water Conservation District, US Forest Service and the Board of Water and Soil Resources (BWSR). Each year the Wells Creek Watershed Partnership hosts a potluck picnic. All landowners within the watershed are invited to converse on water quality related topics, and hear from local/state agency staff. Beth Knudsen, DNR, assisted with development of a Watershed Plan in 1995/1996 which includes the goals and objectives, as well as coordination efforts that resulted in reports such as *The Multiple Benefits of Agriculture Project* (Boody & Krinke 2001) and

Hydrologic Modeling for a Subwatershed within Wells Creek Watershed (Packard). *The Multiple Benefits of Agriculture Project* utilized a watershed model to examine various land use scenarios. These scenarios included varying degrees/types of BMP implementation, such as adding 100' buffer to streams, using crop rotation effectively, and total perennial cover. The model estimated reductions of 37% for nitrogen, 31% for sediment and 57% for watershed phosphorus loading when simulating Scenario B (standard BMP implementation, Boody & Krinke). *Hydrologic Modeling for a Subwatershed within Wells Creek Watershed* (Packard) examined the effect of structural BMPs in reducing peak flows during runoff events. Utilizing the Geographic Information System (GIS) and HydroCAD software, various rainfall events were simulated and the effects of land use and impoundment structures in two subwatersheds were documented. The study concluded that if land use were to remain the same, the two structures identified within one subwatershed would reduce peak flows (cfs) by 13%.

Other contributors also offered valued research and background information regarding Wells Creek watershed. Scot Johnson, DNR, collected baseflow measurements at various sites and also completed a stream classification analysis on Wells Creek and many of its tributaries in 1996 and 1997 that examined the evolutionary stages and varying stability of different stream reaches. It was noted that one tributary includes channelized segments (D2) that exacerbate channel incision in the immediate area. Wells Creek main stem is generally classified as a B5c stream, which is fairly stable. Also worth mentioning, since the survey was completed, it is evident that the main stem is becoming more incised in various locations. It is also apparent that certain tributaries continue to be stable, regardless of flood events, and the use of agricultural BMPs seems to be effectively treating runoff. For more information on these documents, and more historic information on Wells Creek, visit the Goodhue SWCD website and click on the 'Watershed' tab. (www.goodhueswcd.org)

Hiawatha Valley Atlas

In 2006 the Hiawatha Valley Partnership developed an educational document specifically for land use planning efforts within the Bluffland Eco-Region of the MRLP Watershed. The atlas is designed to highlight specific environmental, geologic and recreational concerns to planners and the public so that sound and informed land use decisions can be made. Local ordinance recommendations that offer increased environmental protection of this area were also summarized in this document. The atlas can be found at the Goodhue SWCD Website or the Hiawatha Valley Partnership website: http://www.hiawathavalleypartnership.com/HiawathaValleyPartnership/Welcome.html.

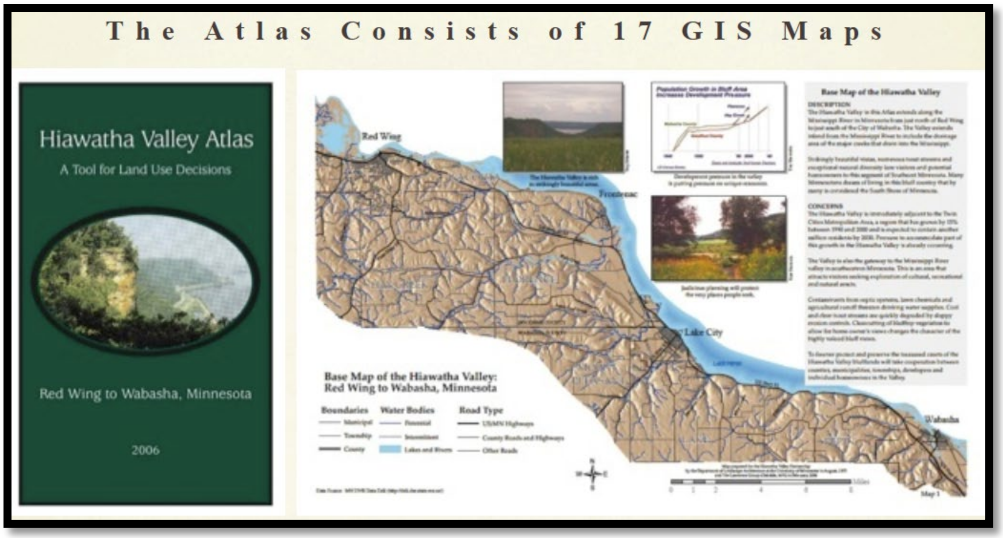


Figure 3. Hiawatha Valley Partnership Atlas

Edge of Field Monitoring

Within the MRLP Watershed, the Minnesota Agricultural Water Resources Center (MAWRC) is sponsoring an edge of field monitoring site known as a Discovery Farm. The edge of field site monitors surface runoff of a 6 acre drainage, 24 hours a day, year round. The monitoring station records field measurements such as soil temps, rainfall, surface runoff volume, temperature etc. Water samples are also collected from the station during rain events to evaluate water chemistry. Total Suspended Soils, Phosphorous and Nitrogen are all assessed and quantified on a water year cycle. The Goodhue SWCD has partnered with MAWRC to help maintain the monitoring site and collect runoff samples. The participating landowner was asked to not change the operation in order to establish a baseline of data for the drainage acres. The 6 acre watershed is in an active silage/alfalfa rotation which receives swine manure. This landowner follows silage harvest with drilling winter rye each year. Results from 2011 and 2012 have shown that sediment loss from the small watershed is relatively low @ just 47 lb/ac in 2011 and 22 lb/ac in 2012. Also worth noting is that the majority of runoff events occur during times of frozen soil; thus the low TSS values during spring runoff. In June of 2012, a large rain event accounted for nearly all of the 2012 sediment loss. This monitoring station provides land use managers, agronomists, agency staff and local landowners' useful information regarding pollutant loads leaving their fields via surface runoff. Similar efforts are being made by various agencies within the MRLP watershed to install more of these edge-of-field stations in an effort to gather a better understanding of flow/nutrients leaving cropland.

Figure 4. Monitoring Station GO1 (Discovery Farms Photo)

Additional Mississippi River Lake Pepin Watershed Resources

USDA Natural Resources Conservation Service (NRCS) Rapid Watershed Assessment for the Mississippi River Lake Pepin (also known as Rush-Vermillion) Watershed:
http://www.nrcs.usda.gov/wps/portal/nrcs/detail/mn/technical/?cid=nrcs142p2_023613

Minnesota Department of Natural Resources (DNR) Watershed Assessment Mapbook for the Mississippi River Lake Pepin Watershed:
http://files.dnr.state.mn.us/natural_resources/water/watersheds/tool/watersheds/wsmb38.pdf

2. Watershed Conditions

Summary

The MRLP watershed includes a small number of streams, most of which are cold-water trout streams that in general are supporting good aquatic communities. Habitat for fish and aquatic macro invertebrates is fair to good per the current resolution of assessment. Analysis of the fish flesh at Hay and Wells Creeks confirms that they meet criteria for safe consumption by humans. Nitrate-nitrite concentrations range from 2-8 mg/l and correspond well at the subwatershed scale to row crop land use, which is typically approximately 36 percent. None of the trout streams (protected as drinking water sources) exceed the 10 mg/l human health standard. There are 34 public water supplies in the watershed, all of which rely on groundwater sources; of these, 27 have wells that are considered vulnerable to contamination from the surface of the land. Further, three of the 25 volunteer nitrate network wells (private drinking water) are elevated (two in Goodhue, one in Wabasha); all three are located in the upper most reaches of the watershed and vary between 9mg/l - 22mg/l; each is ~100 years old and ~100-300 feet deep).

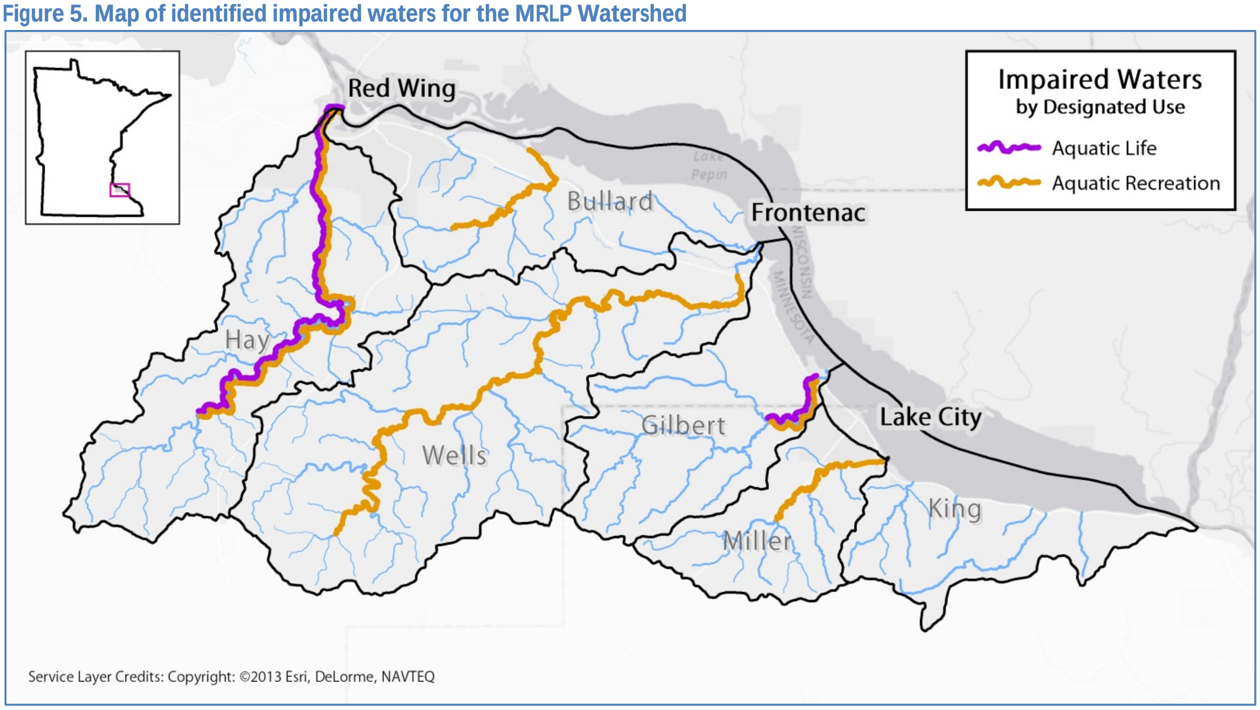
The presence of fecal pathogens in surface water is a regional problem in southeast Minnesota; *E.coli* is the only water quality standard that is exceeded in the surface waters of the MRLP watershed. The issue was well-described in a stakeholder driven process that culminated in approval of 39 approved fecal coliform TMDLs for streams and rivers in the region. The *Revised Regional Total Maximum Daily Load Evaluation of Fecal Coliform Bacteria Impairments in the Lower Mississippi River Basin in Minnesota*, approved in 2006, can be reviewed at the MPCA web site: http://www.pca.state.mn.us/index.php/view-document.html?gid=8006. Subsequent to TMDL approval, stakeholders completed an implementation plan: http://www.pca.state.mn.us/index.php/view-document.html?gid=8013. According to the findings and strategies summarized in these documents, numerous projects have been executed in efforts to reduce pathogen loading to the region's surface waters. Feedlot runoff, unsewered communities and over-grazed pastures (among others) have all been addressed via grant funding. The five *E.coli* TMDLs in the MRLP should be considered (for planning purposes) an addendum to the Regional TMDL work. Restoration strategies described in Table 8 will be founded on existing general strategies. For more information regarding *E.coli* and related research, see the *Mississippi River-Lake Pepin Tributaries Total Maximum Daily Loads*.

Given that most of the designated uses in the MRLP are currently supported, management strategies are largely aimed at protecting the current quality and working to restore as indicated by available data and professional judgment.

It should be noted that a Hay Creek aquatic life impairment (depicted in Figure 5), based on turbidity and transparency tube data is recommended for delisting in the 2014 reporting cycle. A comprehensive assessment of biological data and high resolution time-series turbidity data confirmed aquatic life use support for Hay Creek (AUID 07040001-518). Therefore that impairment is not addressed in this document.

The following sections provide more detail regarding the condition of the watershed's streams, pollutant sources and other stressors of aquatic life.

Figure 5. Map of identified impaired waters for the MRLP Watershed



2.1 Condition Status

Streams

Streams reaches in the MRLP Watershed were assessed for aquatic life, aquatic recreation, and aquatic consumption during the 2011 assessment cycle. Twenty-one (21) sites were sampled for biology at the outlets of variable sized sub-watersheds within the MRLP Watershed and tributaries during the 10 year assessment window. Eleven stream reaches were sampled for fish, and ten stream reaches were sampled for macro invertebrates in the MRLP Watershed during the 2008 intensive watershed monitoring year. Nine (9) streams that were assessed for aquatic life support were also assessed for aquatic recreation in this effort (Table 1). Two stream reaches were not assessed due to insufficient data, modified channel condition. Eight stream reaches were fully supporting of aquatic life use. Only one biota impairment was identified on lower Gilbert Creek due to a moderately low fish index of biotic integrity (IBI) (close to threshold).

Five new aquatic recreation impairments based on *E.coli* were identified in the MLRP Watershed (Figure 5).

Nitrate-nitrite concentrations range from 2-8 mg/l in the watershed's streams. Aquatic consumption assessments indicate that there are no impairments regarding contaminants in fish tissue (Figure 5, Table 1). Field assessments also indicate mostly fair to good habitat conditions throughout the watershed.

Lakes

The MPCA conducts and supports lake monitoring for a variety of objectives. Lake condition monitoring activities are focused on assessing the recreational use support of lakes and identifying trends over time. The MPCA also assesses lakes for aquatic consumption use support, based on fish-tissue and water-column concentrations of toxic pollutants. The only lake in the MLRP Watershed is Lake Pepin. Due to the size and complexity of this basin and the ongoing work developing a TMDL, Lake Pepin is outside of the scope of this document. More information can be found at: http://www.pca.state.mn.us/mvri97f.

More Information

Condition status is summarized is table 1. For more information regarding designated use support and assessment results for the MRLP watershed, see the *Mississippi River Lake Pepin Watershed Monitoring and Assessment Report* http://www.pca.state.mn.us/index.php/view-document.html?gid=18230.

Table 1. Stream AUID assessment results for the MRLP Watershed

Mississippi River Lake Pepin	Area (acres)	# AUIDs Sampled	# Assessed AUIDs	Supporting*			Non-support*			Insufficient Data
				# Aquatic Life	# Aquatic Recreation	# Drinking Water	# Aquatic Life	# Aquatic Recreation	# Drinking Water	
HUC 8 Totals	172,215	**11**	**9**	**8**	**0**	**0**	**1**	**5**	**0**	**8**
Hay Creek	30,483	2	2	2	0	0	0	1	0	2
Wells Creek	44,855	3	2	2	0	0	0	1	0	1
Bullard Creek	34,498	1	1	1	0	0	0	1	0	2
Miller Creek	11,377	1	1	1	0	0	0	1	0	1
King Creek	27,061	1	1	1	0	0	0	0	0	0
Gilbert Creek	23,938	3	2	1	0	0	1	1	0	2

*Supporting means the stream supports a given designated use; non-support means it does not.

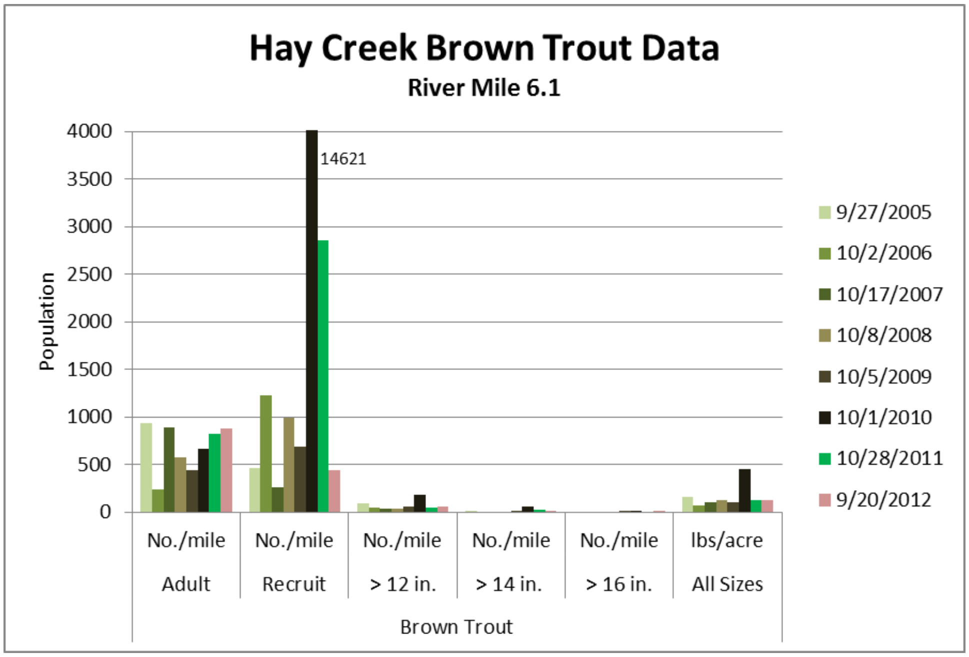
2.2 Water Quality Trends

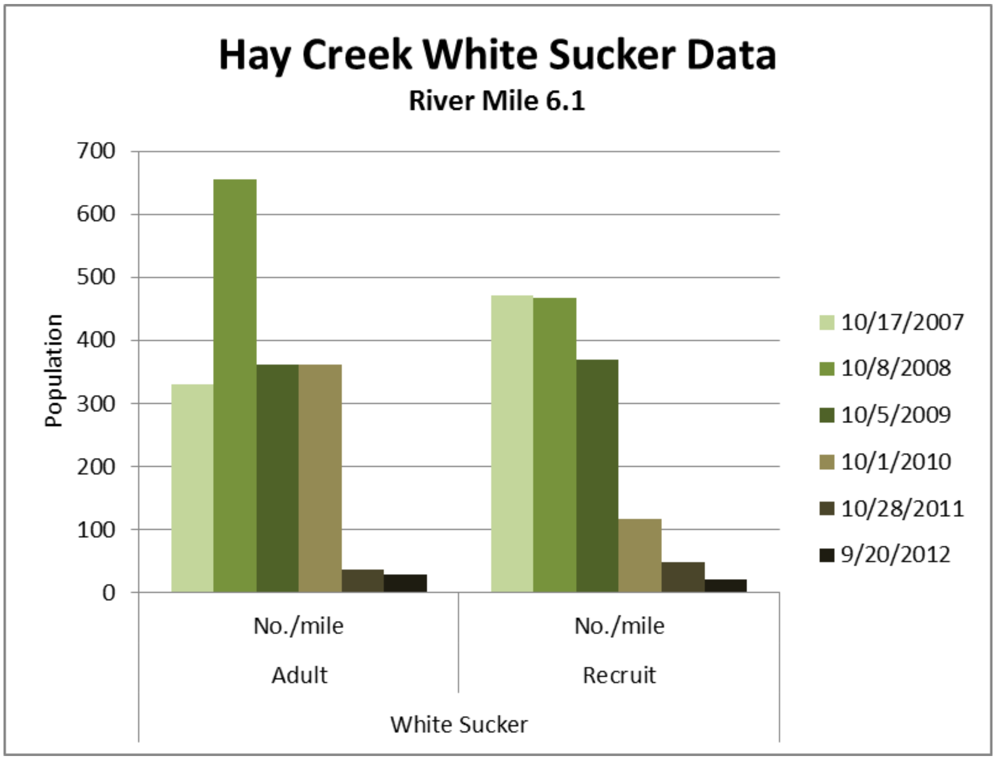
The MRLP watershed does not include long records of water quality data at surface water monitoring locations. Going forward, the load monitoring site at the mouth of Wells Creek will provide trends regarding pollutant export, and successive iterations of intensive watershed monitoring will allow for examination of biota data over time.

The DNR Fisheries data provide valuable information regarding trout and white sucker populations in Hay Creek (2005-2012) and Wells Creek (2010-2012). A Mann-Kendall Trend Test indicates that there is a significant downward trend for White Sucker adults at the Hay Creek station ($\alpha = 0.05$ level, $p = 0.001$). The trend for White Sucker recruits is not significant at the $\alpha = 0.05$ level, but it is significant at the $\alpha = 0.10$ level ($p = 0.096$). (The $\alpha = 0.05$ level tests for significance with 95% confidence and the $\alpha = 0.10$ tests for significance at the 90% confidence level.) These trends generally align with a regional trend at long-term fish monitoring stations in southeast Minnesota that suggests decreases in non-game fish populations; they are valuable in the long-term but do not readily translate to qualitative assessment, because the role of non-game fish species in food chain dynamics could vary from stream to stream. Possible causes include changes in water quality and/or habitat quality, changes in water temperature and/or groundwater flow and increased predation by piscivorous fishes. Further examination is required to establish causal linkages.

The Mann-Kendall Trend Test shows that there is no significant trend in the Brown Trout data, although the 'greater than 16 inches' data comes close to being significant at the 90% confidence level ($p = 0.108$). Wells Creek was not considered in the trend analysis given the short period of record.

Figure 6. Hay Creek fisheries data (DNR)





2.3 Stressors and Sources

Biological stressor identification is focused on streams that exhibit either fish or macro invertebrate biota impairments; it encompasses both evaluation of pollutants and non-pollutant-related factors (e.g., altered hydrology, fish passage, habitat) as potential stressors. Pollutant source and loading examinations are completed in cases in which a biological stressor links to a pollutant (e.g., suspended sediment, nitrates). In the case of the MRLP watershed, only Gilbert Creek was subjected to the stressor identification process, because no other biota impairments were documented.

Stressors of Biologically-Impaired Stream Reaches

The MPCA surveyed three biological stations in the Gilbert Creek Watershed; Upper Gilbert Creek, Lower Gilbert Creek, and Sugarloaf Creek. No invertebrate impairments were documented in the watershed, but the fish IBI at one station (08LM130, Lower Gilbert Creek) was 42, just below the threshold of 45 for streams of the southern cold-water fish class. This site also showed a poor habitat score and lacked quality habitat (deep pools) and coarse substrates. During the assessment process, the IBI score, as well as other factors, were used to determine impairment.

Station 08LM138, in the upper part of the Gilbert Creek Watershed, was not assessed due to channelization. However, the fish community and invertebrate community at station 08LM138 appear to be healthy. This site is near a Minnesota Department of Natural Resources (DNR) easement and monitoring station, which has shown consistent populations of trout, including natural reproduction. Therefore, stressor identification was focused on the lower stream segment, near 08LM130.

The results of the process suggest that physical habitat and bedded sediment are candidate stressors to the fish community of Gilbert Creek. Because these are not pollutant stressors, no TMDL is useful in examining restoration strategies. Rather, the reach should be considered within the greater context of the Gilbert Creek watershed, and fisheries managers should examine the potential need for habitat work in the impaired reach and/or in adjacent reaches. The bottom-most assessment unit (on which 08LM130 is located) is likely not a high priority for habitat improvement, given its location in the system (i.e., near the Mississippi River, well downstream of Gilbert Creek's managed trout waters). The biota impairment should be reclassified to category 4c during the next reporting cycle.

For more information see *Minnesota Pollution Control Agency (MPCA). 2013. Mississippi River-Lake Pepin Tributaries Biotic Stressor Identification*. http://www.pca.state.mn.us/index.php/view-document.html?gid=19681

Table 2: Candidate Stressors for Gilbert Creek

Candidate Stressors Found	Other Candidate Stressors Examined (found to not be affecting aquatic life at this time)
· Physical Habitat · Bedded Sediment	· Temperature · Pesticides · Flow Alteration · Dissolved Oxygen · Nitrate and Nitrite · Connectivity

Pollutant sources

The MRLP Watershed is a rural landscape. There are no significant discharges of municipal or industrial wastewater, and only 12.5% is encompassed by municipalities permitted to discharge stormwater (and all of that land area is at the "bottom" of the watershed – near the mouths of the streams as they empty to Lake Pepin). It follows that the vast majority of the pollutants loaded to surface and groundwaters come via nonpoint pathways, and the following discussion is focused on nonpoint sources of pollution.

Table 3: Point Sources in the MRLP Watershed

HUC-10 Subwatershed	Point Source			Pollutant reduction needed beyond current permit conditions/limits?	Notes
	Name	Permit #	Type		
Hay Creek – Mississippi River 0704000104	Hay Creek 070400010401	Red Wing MS400235	Municipal stormwater		4.89 square miles (10.2%)
	Bullard Creek 070400010402	Red Wing MS400235	Municipal stormwater		0.37 square miles (2.3%)

The only documented impairments in the MRLP watershed that are linked to a conventional pollutant are the *E.coli* impairments addressed in the *Mississippi River-Lake Pepin Tributaries Total Maximum*

Daily Loads. Pollutant sources are discussed and tabulated in that document, and summarized below. As described in the *Revised Regional Total Maximum Daily Load Evaluation of Fecal Coliform Bacteria Impairments in the Lower Mississippi River Basin in Minnesota Implementation Plan*, the most significant sources of pathogen loading to surface waters in southeast Minnesota are residential wastewater, feedlots and manure applied to fields. Because pathogens are not well-addressed via surface water quality models, the best means of focus is examination of geographic data that describe human and livestock waste presence and subsequent prioritization by local government units.

In addition to the local pollutant-driven impairments (*E.coli*), the MRLP watershed exports pollutants of concern that exacerbate downstream impairments. Sediment and nutrients from the MRLP watershed impact Lake Pepin and beyond (i.e., Mississippi River and Gulf of Mexico). Thus, strategies for sediment and nutrient reduction, drawn from studies and plans of greater scale, are included in the MRLP WRAPS. These considerations are summarized in Table 4.

Table 4: Scale considerations for pollutants

Pollutant	Local Considerations	Downstream Considerations
Pathogens (various, indicated by *E.coli* bacteria)	All streams assessed show impairment; this is consistent with greater southeast Minnesota regional assessment.	Not measured in downstream waters (i.e., Lake Pepin).
Sediment (measured as total suspended solids (TSS))	No aquatic life impairments directly attributed to suspended sediment, but sediment dynamics interplay with stream habitat quality and also impact infrastructure and local land uses.	Lake Pepin sedimentation.
Phosphorus (measured as total phosphorus (TP))	No inland lakes or major river reaches in which accelerated eutrophication is an issue.	Lake Pepin nutrient loading and Gulf Hypoxia.
Nitrogen (measured as nitrate-nitrite (NOx))	Drinking water impacts in shallower unprotected aquifers that are vulnerable to surface contamination. Potential for aquatic life toxicity, especially when 5-10 mg/l.	Gulf Hypoxia.

The State of Minnesota has invested significant time and resources into major investigations of each of the pollutants of concern in the MRLP watershed. Nonpoint pollutant sources are summarized in this section (via major study conclusions and tables).

Sediment & Phosphorus Sources

Several investigations related to sediment source apportionment have been conducted within the past five to 15 years for watershed areas in southeast Minnesota and for Lake Pepin. These studies have generally involved sediment "fingerprinting" through the geochemical analysis of sediments and the representation of distinct sediment sources within HSPF models developed for the MPCA (LimnoTech 2013). Because phosphorus, given the nature of the MRLP watershed, shares general sources and pathways with those of sediment, these investigations are useful in considering both pollutants. In a literature review conducted in 2013, LimnoTech examined the following:

- Sediment fingerprinting for Lake Pepin and its tributary systems (Kelly and Nater 2000, Schottler et al. 2010);
- Minnesota River HSPF model development and calibration (TetraTech 2009);
- Sediment fingerprinting for the LeSueur watershed (Belmont 2012);
- Sediment fingerprinting for source and transport pathways in the Root River (Belmont 2011, Stout 2012); and
- Root River HSPF model development and calibration (TetraTech 2013).

A summary of general findings of the literature review:

- Overall sediment delivery from tributaries to the Upper Mississippi River in southeast Minnesota has increased substantially since European settlement and the onset of agricultural activities in the tributary watersheds;
- The contribution of sediments derived from "field" sheet and rill erosion is typically less than half of the total sediment delivery, and may be as low as ~20% in watersheds where bluff, ravine, and/or stream bank erosion are particularly significant; and
- The relative contributions of "non-field" sources of sediment to the overall watershed sediment yield appears to be increasing over time, with a likely link to the "flashier" hydrology (i.e., rapidly increasing and decreasing flow volumes) resulting from agricultural land use and associated drainage and urban development (LimnoTech 2013).

Other resources useful in examining sediment sources in the MRLP watershed include the Lower Mississippi River Basin Regional Sediment Data Evaluation Project (Barr Engineering 2004, http://www.pca.state.mn.us/index.php/view-document.html?gid=5983), The Multiple Benefits of

Agriculture (Boody & Krinke 2001), and Wells Creek Watershed Floodplain Geomorphology Transects (DNR 1999).

Local resource managers use the following tools to scale these general conclusions down to the MRLP watershed and projects therein:

- Hydrologic Assessment of Watersheds map for citing BMPs in select sub-watersheds.
- Streambank and habitat surveys using Minnesota Stream Habitat Assessment (MSHA), light detection and ranging (LiDAR), inventories and existing DNR and Goodhue & Wabasha SWCD priorities.
- Stream Power Index, using LiDAR.
- Examination of highly erodible land (HEL).

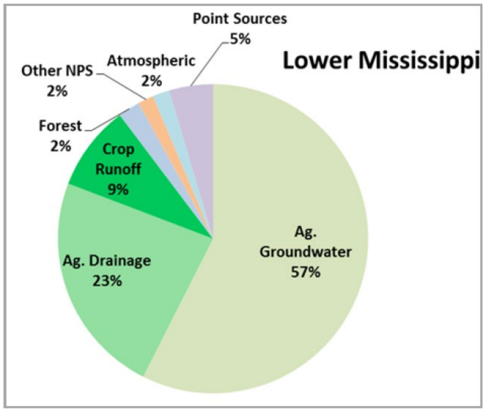
Nitrogen Sources

Minnesota recently initiated two state-level efforts related to N in surface waters. The MPCA is developing water quality standards to protect aquatic life from the toxic effects of high nitrate concentrations. The standards development effort, which is required under a 2010 Legislative directive, draws upon recent scientific studies that identify the concentrations of nitrate harmful to fish and other aquatic life (MPCA 2013).

Also in development is a state-level Nutrient Reduction Strategy (NRS), as called for in the 2008 Gulf of Mexico Hypoxia Action Plan. Minnesota contributes the sixth highest N load to the Gulf and is one of 12 member states serving on the Mississippi River/Gulf of Mexico Watershed Nutrient Task Force. The cumulative N and phosphorus (P) contributions from several states are largely the cause of a hypoxic (low oxygen) zone in the Gulf of Mexico. This hypoxic zone affects commercial and recreational fishing and the overall health of the Gulf, since fish and other aquatic life cannot survive with low oxygen levels. Minnesota is developing a strategy which will identify how further progress can be made to reduce N and P entering both in-state and downstream waters (MPCA 2013).

The scientific foundation of information for these efforts is represented in the 2013 report, *Nitrogen in Minnesota Surface Waters* (MPCA 2013, http://www.pca.state.mn.us/index.php/view-document.html?gid=19622). This document will be useful as the MPCA and other state and federal organizations further their nitrogen-related work, and also as local governments consider how high N levels might be reduced in their watersheds.

Figure 7. Estimated nitrogen sources to surface waters from the Minnesota contributing areas of the Lower Mississippi River Basin (average precipitation year) (MPCA 2013b)



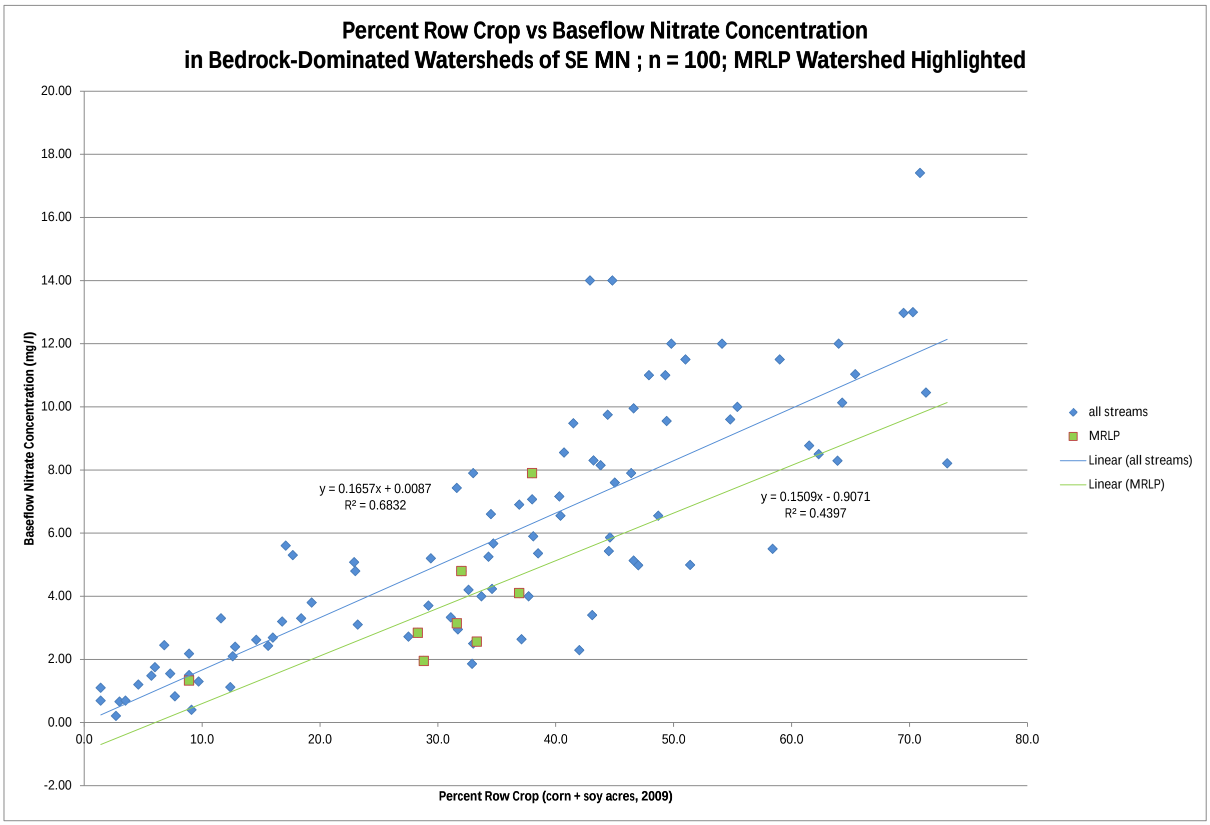
An analysis of the relationship between base flow nitrate concentrations in southeast Minnesota trout streams and percentage of row crop land in the watersheds of these streams produced a statistically significantly regression. The one hundred trout stream sites examined included eight in the MRLP (see Figure 8). Specific conclusions of this work include:

- Potential Source Linkage: Nitrate concentrations in Southeast Minnesota's trout streams show a strong linear relationship to row crop land use. A linear regression showed a slope of 0.16, suggesting that the average base flow nitrate concentration in the trout stream watersheds of Southeast Minnesota can be approximated by multiplying a watershed's row crop percentage by 0.16. This regression analysis indicates that a watershed of approximately 60% corn and soybean acres corresponds to exceedances of Minnesota's drinking water nitrate-nitrogen standard of 10 mg/L at the point of sample in the stream (trout streams in Minnesota are protected as drinking water sources). This conclusion is supported by the findings of Nitrogen in Minnesota Surface Waters, which describe similar relationships between nitrogen in surface waters and "leaky soils below row crops," which include areas of shallow depth to bedrock such as the trout stream region of Southeast Minnesota (MPCA 2013).
- Potential Natural Background: The natural background level of nitrate in streams appears to be very low given that the base flow concentrations of streams with undisturbed (very little row crop land use and little or no other human impact) watersheds were less than 1 mg/L. Statistical analysis also suggested that in the absence of human disturbance in a watershed, the base flow nitrate concentration at the point of sample in the stream could approach 0 mg/L. This is in

general agreement with recent work by the USGS that concluded that human impacts are the primary reason for elevated nitrogen in United States surface waters; background concentrations of nitrate were 0.24 mg/L in watersheds dominated by non-urban and non-agricultural land uses (Dubrovsky, et al. 2010) (Watkins, Rasmussen, Streitz et al. 2013).

In Figure 8 below the eight MRLP points include three in Wells Creek watershed, two in Gilbert Creek watershed and one in each of Miller, Bullard and Hay Creek watersheds.

Figure 8. Baseflow nitrate and row crop acres regression (Watkins, Rasmussen, Streitz et al. 2013)



Given that the primary transport mechanism for loading nitrate to the trout streams of the MRLP watershed is "ag groundwater" (i.e., leaching loss from agricultural lands to groundwater, which comprises the majority of trout stream base flow; see Figure 7), it follows that the response time of nitrate concentrations to changes in land use practices will likely vary in different hydrogeological settings (MGS 2013). Studies outside of southeastern Minnesota have concluded that some hydrogeological systems function in a manner whereby changes in base flow nitrate concentrations lag changes in land use practices by decades (e.g., Tesoriero et al. 2013). The most significantly lagged response in southeastern Minnesota should be expected in the deep valleys incised into the Prairie du Chien Plateau, where significant baseflow is derived from deep, siliciclastic-dominated bedrock sources with one or more overlying aquitards (MGS 2013).

MRLP Watershed Nitrogen Summary	
	• Geographic source: cultivated acres. • There are many complicating agronomic variables (e.g., soils, manure and fertilizer management). • While phosphorus is typically bound to soil and transported via runoff, nitrates are water soluble. • Main transport mechanism: leaching to groundwater, subsequent discharge to trout streams. Lag time between land surface and point of measure in trout stream can be significant.

Pathogen Sources

The following text, which provides an overview of nonpoint sources of fecal coliform and *E.coli* bacteria and associated pathogens, is excerpted and adapted from the *Revised Regional Total Maximum Daily Load Evaluation of Fecal Coliform Bacteria Impairments in the Lower Mississippi River Basin in Minnesota* (MPCA 2006). At the time, Minnesota's water quality standard was described in terms of fecal coliform colonies as indicators of fecal pathogens; it has since changed to make use of *E.coli* counts (the water quality standard used in these TMDLs) for the same purpose. While the specific indicator has changed, the discussion of likely pathogen sources at a southeast Minnesota regional scale applies well to the MRLP watershed.

The relationship between land use and fecal coliform concentrations found in streams is complex, involving both pollutant transport and rate of survival in different types of aquatic environments. Intensive sampling at numerous sites in southeastern Minnesota shows a strong positive correlation between stream flow, precipitation, and fecal coliform bacteria concentrations. In the Vermillion River watershed, storm-event samples often showed concentrations in the thousands of organisms per 100 milliliters, far above non-storm-event samples. A study of the Straight River watershed divided sources into continuous (failing individual sewage treatment systems, unsewered communities, industrial and institutional sources, wastewater treatment facilities) and weather-driven (feedlot runoff, manured fields, urban stormwater categories). The study hypothesized that when precipitation and stream flows are high; the influence of continuous sources is overshadowed by weather-driven sources, which generate extremely high fecal coliform concentrations. However, during drought, low-flow conditions continuous sources can generate high concentrations of fecal coliform, the study indicated. Besides precipitation and flow, factors such as temperature, livestock management practices, wildlife activity, fecal deposit age, and channel and bank storage also affect bacterial concentrations in runoff (Baxter-Potter and Gilliland 1988). Fine sediment particles in the streambed can serve as a substrate harboring fecal coliform bacteria. "Extended survival of fecal bacteria in sediment can obscure the source and extent of fecal contamination in agricultural settings," (Howell et al. 1996). Sadowsky et al. studied growth and survival of *E.coli* in ditch sediments and water in the Seven Mile Creek watershed; their work concluded that while cattle are likely major contributors to fecal pollution in the sediments of Seven Mile Creek, it is also likely that some *E.coli* strains grow in the sediments and thus some sites probably contain a mixture of newly acquired and resident strains (Sadowsky et al. 2008-2010).

Hydrogeological features in southeastern Minnesota may favor the survival of fecal coliform bacteria. Cold groundwater, shaded streams, and sinkholes may protect fecal coliform from light, heat, drying, and predation (MPCA 1999). Sampling in the South Branch of the Root River watershed showed concentrations of up to 2,000 organisms/100 ml coming from springs, pointing to a strong connection between surface water and ground water (Fillmore County 1999 & 2000). The presence of fecal coliform bacteria has been detected in private well water in southeastern Minnesota. However, many such detections have been traced to problems of well construction, wellhead management, or flooding, not from widespread contamination of the deeper aquifers used for drinking water. One study from Kentucky showed that rainfall on well-structured soil with a sod surface could generate fecal coliform contamination of the shallow ground water through preferential flow (McMurry et al. 1998). Finally, fecal coliform survival appears to be shortened through exposure to sunlight. This is purported to be the reason why, at several sampling sites downstream of reservoirs, fecal coliform concentrations were markedly lower than at monitoring sites upstream of the reservoirs. This has been demonstrated at Lake Byllesby on the Cannon River and the Silver Creek Reservoir on the South Branch of the Zumbro River in

Rochester. Despite the complexity of the relationship between sources and in-stream concentrations of fecal coliform, the following can be considered major source categories:

Urban and Rural Stormwater

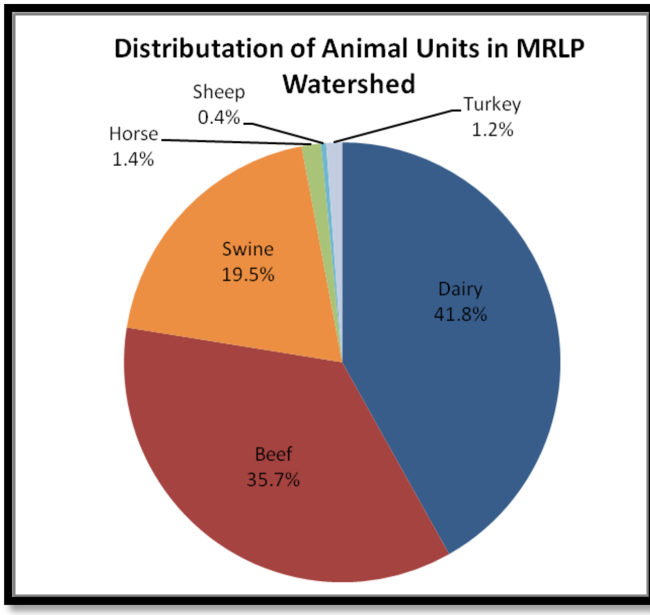
Untreated stormwater from cities, small towns, and rural residential or commercial areas can be a source for many pollutants including fecal coliform bacteria and associated pathogens. Fecal coliform concentrations in urban runoff can be as great as or greater than those found in cropland runoff, and feedlot runoff (USEPA 2001). Sources of fecal coliform in urban and residential stormwater include pet and wildlife waste that can be directly conveyed to streams and rivers via impervious surfaces and storm sewer systems. Newer urban development often includes stormwater treatment in the form of such practices as sedimentation basins, infiltration areas, and vegetated filter strips. Smaller communities or even rural residences not covered by MS4 permits may be sources of stormwater and associated pollutants. Regarding the MRLP streams, the City of Red Wing MS4 has only a small intersection with the impaired reach watersheds for Hay and Bullard Creeks; it presents limited possibilities regarding pathogen sources.

Livestock Facilities and Manure Application

The MPCA currently uses the federal definition of a Concentrated Animal Feeding Operations (CAFO) in its regulation of animal feedlots. In Minnesota, the following types of livestock facilities are issued, and must operate under, a National Pollutant Discharge Elimination System (NPDES) permit: a) all federally defined (CAFOs), some of which are under 1000 animal units in size; and b) all CAFOs and non-CAFOs which have 1000 or more animal units.

The vast majority of livestock facilities in the Lower Mississippi River Basin in Minnesota are not CAFOs subject to NPDES permit requirements. Nevertheless, they are subject to state feedlot rules which include provisions for registration, inspection, permitting, and upgrading. Much of this work is accomplished through delegation of authority from the state to county government.

Figure 9. MRLP watershed animal units



There are approximately 37,000 animal units in the MRLP watershed (29,236 AU in Goodhue County as of 2009 registration and 7,766 AU in Wabasha as of 2005 registration).

The majority of livestock waste applied in the MRLP watershed is from cattle and swine. Swine accounts for 19% of the overall animal units within the MRLP. The large majority of swine feedlots are large confined facilities (under a roof), with a pit for liquid manure beneath a slated floor. Thus, feedlot runoff is not a common occurrence with most confined facilities. Dairy and beef cattle are prevalent throughout the MRLP, together accounting for 77% of the animal units in the watershed. The majority of cattle operations are relatively small, with open feedlots near streams and along bluff land areas. Where over-grazing occurs, serious erosion and manure runoff can result.

Land application of manure can be a major source of nonpoint pollution. Liquid swine manure is commonly incorporated into the soil during or shortly after land application, which greatly reduces the pollution potential. The steep landscape lends itself to smaller, segmented fields and provides opportunities for contour farming with hay in rotation and pastureland. Where properly managed, pasture land can increase infiltration rates, improve forage productivity, improve soil health and offer a form of habitat for wildlife. See Appendix B: Feedlots of the MRLP Watershed.

Individual Sewage Treatment Systems

Nonconforming septic systems are an important source of fecal coliform bacteria, particularly during periods of low precipitation and runoff when this continuous source may dominate fecal coliform loads. Unsewered or under sewered communities include older individual systems that are generally failing, and/or collection systems that discharge directly to surface water. This may result in locally high concentrations of wastewater contaminants in surface water, including fecal coliform bacteria, in locations close to population centers where risk of exposure is relatively high.

Approximately 1,910 septic systems were identified within the MRLP watershed by Goodhue County Environmental Health inspection/installation records and a GIS review of homestead sites in Wabasha County. Appendix B (Septic System Overview MRLP Watershed) depicts the MRLP watershed septic systems and applies subwatershed coloring to denote the number of septic systems per square mile. In general septic systems are an important potential source of pathogens; however the majority of the areas with the greatest density of septic systems per square mile are located along HWY 61 and Lake Pepin. There is very little concentrated flow from these subwatersheds, and thus collecting water quality samples would be difficult (none have been collected to date). Further, these land areas do not drain to the impaired reaches addressed in this TMDL.

Summary

The City of Red Wing MS4 has only a small intersection with the impaired reach watersheds for Hay and Bullard Creeks; it presents limited possibilities regarding pathogen sources and the current permit includes BMPs to address pet waste. Urban and rural stormwater accounts for very little of the MRLP watershed. The sources of greatest presence are livestock manure (feedlots and land applied manure as discussed) and septic systems, neither of which demonstrate good correlations between their respective subwatershed densities and the corresponding downstream *E.coli* concentrations. However, existing programs designed to address these sources provide a foundation for implementation. Partners in the MRLP watershed can draw on both the Regional TMDL and the MRLP *E.coli* TMDLs to describe focus areas and implementation strategies. Further, conservation work designed to address other pollutant loads (e.g., phosphorus, nitrogen) will in many cases also serve to reduce pathogen loading.

<u>Means of scaling these general works down to MRLP subwatersheds for focus and prioritization:</u>

- GIS inventories of septic systems and feedlots (see TMDLs document);
- Heightened Nutrient Management Planning within select subwatersheds
- MNFarm modeling on feedlots with a direct conveyance to surface water
- Further examination of *E.coli* persistence and direct measurements of pathogens in surface waters.

The table below generalizes the level of potential pollutant sources for each watershed in the MRLP. The ratings were developed using a comprehensive assessment of the MRLP at a sub-watershed scale (see appendix), Goodhue SWCD staff professional judgment and local stakeholder input.

Table 5: Nonpoint Sources in the MRLP Watershed. Relative magnitudes of contributing sources are indicated

HUC-10 Subwater-shed	Stream/Reach (AUID) or Lake (ID)	Pollutant	Pollutant Sources													
			Fertilizer & manure run-off	Fertilizer & manure leaching loss	Livestock overgrazing in riparian	Failing septic systems	Wildlife	Poor riparian vegetation cover	Upland soil erosion	Urban Runoff						
Hay Creek – Mississippi River 0704000104	Hay Creek 070400010401	Bacteria	˜		›	™	™			™						
		TSS			™			›	˜	™						
		TP			™			›	›	™						
		N	™	˜	™	™	™									
	Bullard Creek 070400010402	Bacteria	›		™	™	™			™						
		TSS			™			›	™	™						
		TP			™			›	™	™						
		N	™	˜	™	™	™									
Wells Creek 0704000106	Upper Wells Creek 070400010601	Bacteria	˜		›	™	™									
		TSS			›			›	˜							
		TP			›			›	˜							
		N	™	˜	™	™	™									
	Lower Wells Creek 070400010602	Bacteria	›		™	™	™									
		TSS			™			›	›							
		TP			™			›	›							
		N	™	˜	™	™	™									
Lake Pepin 0704000107	Gilbert Creek 070400010703	Bacteria	›		™	›	™			™						
		TSS			™			›	˜	™						
		TP			™			›	˜	™						
		N	™	˜	™		™									
	Miller Creek 070400010704	Bacteria	˜		˜	›	™			™						
		TSS			›			›	›	™						
		TP			›			›	›	™						
		N	™	˜	™	™	™									

Key: ˜ = High › = Moderate ™ = Low

2.4 TMDL Summary

The *Mississippi River-Lake Pepin Tributaries Total Maximum Daily Loads* (MPCA 2014) document includes *E.coli* TMDL components (i.e., loading capacities, margins of safety, wasteload allocations and load allocations) for five impairments listed in Table 6 below. The TMDL document also describes the existing scientific and planning context within which these pathogen impairments are cast. The general strategies described in the stakeholder-driven process that culminated in approval of 39 approved fecal coliform TMDLs for streams and rivers in the region (*Revised Regional Total Maximum Daily Load Evaluation of Fecal Coliform Bacteria Impairments In the Lower Mississippi River Basin in Minnesota*, approved in 2006 http://www.pca.state.mn.us/index.php/view-document.html?gid=8006) constitute the approach for reducing pathogen loading to surface waters. Source assessment specific to the MRLP watershed will guide local implementation. Many strategies and corresponding BMPs designed to address phosphorus and sediment loading will also reduce loading of fecal pathogens to surface waters. The TMDL also notes the need for focused monitoring and research regarding fecal pathogens and their indicators, including methods to evaluate pollutant migration pathways and delivery mechanisms from pathogen sources to surface waters and DNA "fingerprinting" to identify pathogen sources. Local partners in MRLP have already begun this work.

Table 6. Impairments addressed with TMDLs

Listed Water body Name	AUID#	Listed Pollutant	Impaired Use	Year Placed in Impairment Inventory	303(d) List Scheduled Start & Completion Dates
Hay Creek	07040001-518	*Escherichia coli*	Aquatic Recreation	2012	2011-2014
Bullard Creek	07040001-526	*Escherichia coli*	Aquatic Recreation	2012	2011-2014
Gilbert Creek	07040001-530	*Escherichia coli*	Aquatic Recreation	2012	2011-2014
Miller Creek	07040001-534	*Escherichia coli*	Aquatic Recreation	2012	2011-2014
Wells Creek	07040001-708	*Escherichia coli*	Aquatic Recreation	2012	2011-2014

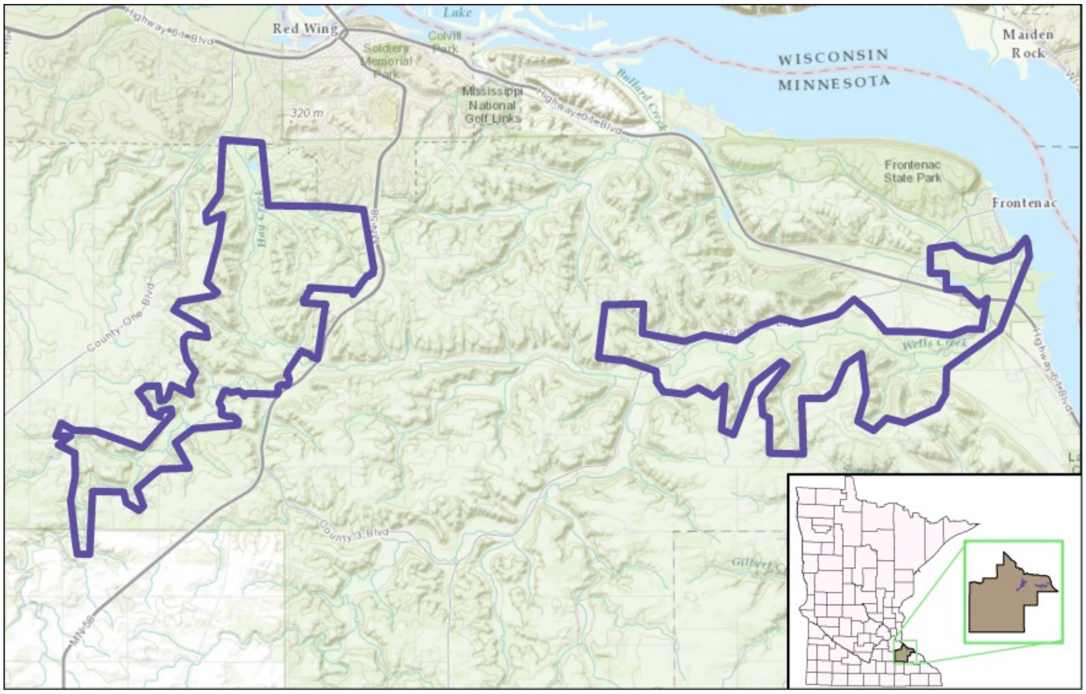
2.5 Protection Considerations

Protection of Existing Use Support

With the exception of the bottom reach of Gilbert Creek, all of the assessed stream reaches in the MRLP watershed demonstrated aquatic life use support (i.e., good aquatic ecosystems as measured by fish and macro invertebrate indices). These waters should be protected from degradation that could occur via increased pollutant loading, flow alterations and habitat impacts. Efforts to reduce pollutant loads in pursuit of downstream water quality goals (i.e., Lake Pepin and Mississippi River, Gulf of Mexico) will serve to benefit and further protect aquatic life in the MRLP watershed. Protection strategies are discussed further in Section 3.

Protection of Outstanding Resource Areas

In addition to consideration of existing use support, protection planning is focused on outstanding value natural resources in the MRLP watershed. These land and water areas are priorities described by The Nature Conservancy, a local stakeholder and partner in conservation planning. Figure 10 depicts protection priority polygons, which are generally based on proximity to existing protected lands and/or falling within an area of high or outstanding biodiversity as identified by the Minnesota Biological Survey. Other areas are along riparian/floodplain corridors connecting conservation lands. These land areas are focus points for protection via acquisition and easement and also via technical assistance that would maintain and manage perennial cover (e.g., forest stewardship planning) on private lands.



Protection via Mining Ordinance

In 2013 Goodhue County Land Use Management Department conducted extensive background study on aggregate and sand mining in Goodhue County. The primary focus of the undertaking was to address the concerns surrounding silica sand mining operations and corresponding local impacts of the land use. Sand and gravel resources are prevalent throughout the MRLP watershed, and extraction of the resources must be carefully approached. The Goodhue County Mining Ordinance update recognizes the sensitivity of the water resources in the Bluffland Ecoregion and thus prohibits the use of flocculants in washing sands and placed stringent setbacks on all perennial streams, floodplains, bluffs and even the Mississippi River for all mining activities.

3. Prioritizing and Implementing Restoration and Protection

A primary focus of this planning effort is to summarize priority areas for targeting actions to protect and improve water quality. This section of the report summarizes the tools used to prioritize and target; it also tabulates the restoration and protection strategies for the MRLP watershed. Rural/agricultural stormwater retention is listed as a priority within the sub-watersheds that have a low percentage of land treatment. This practice is both a protection and restoration strategy. By reducing peak flows, retention efforts assist with restoring the immediate, sub-watershed hydrologic characteristics due to the lack of perennial cover (row crop) while also providing continued protection to the overall stream system (stream health/habitat). It is understood that some efforts are appropriate for detailed targeting and prioritization (e.g., volume treatment in subwatersheds with few existing BMPs, stream corridors with poor riparian cover, outstanding resource value lands and waters) and others are greater landscape issues that are best approached as "saturation efforts" (e.g., nutrient management, nonpoint *E.coli* reduction).

Example 1: targeting volume control and phosphorus reduction using upland structural BMPs. Figure 14 highlights the subwatersheds that include few BMPs. Targeting these areas will provide capture of sediment and phosphorus from the upstream drainage areas and also treat peak flows downstream thereby reducing impacts on stream channels and accordingly reducing downstream sediment and phosphorus loss.

Example 2: targeting riparian corridor and habitat work. Figure 14 highlights the subwatersheds in which a great percentage of the upland area is treated by existing BMPs. In these areas, in-channel habitat work and/or stream restoration work can be targeted, given that the uplands are addressed. Further, the stream buffer inventory (existing GIS data) can be used to target those areas that do not meet the perennial cover requirement in the local zoning ordinance.

Example 3: nitrogen reduction via saturation effort. The primary means of reducing nitrogen loading to surface waters in southeast Minnesota are optimization of rate and timing of fertilizer application, and vegetation changes (MPCA 2014). Targeting riparian BMPs as described in example 2 will thus support nitrogen loading reductions. However, nutrient management and cover crop application cannot be well-targeted using GIS data. Rather, in pursuit of the nitrogen reduction goals, local partners will undertake an effort to implement these BMPs in the MRLP watershed, using detailed agronomic data and professional judgment to determine viable project areas.

3.1 Targeting of Geographic Areas

The primary means of targeting geographic areas for restoration and protection work are provided by GIS work executed by local partners. The greatest of these efforts, described in detail below, was an in-depth examination (using LiDAR and BMP inventories) of upland land treatment in the MRLP watershed; the resultant maps and tables describe subwatersheds in which more upland BMPs are needed, and subwatersheds that are sufficiently treated in the uplands and thus more viable candidates for in-stream restoration and habitat work as needed. In addition to this primary analysis, other important inventories will further guide strategy execution: GIS data that detail riparian land use will be used to prioritize stream buffer targets; detailed land use data will support a protection strategy of no net loss of perennial cover in the MRLP watershed.

Upland BMP Inventory

All structural BMPs in the MRLP watershed were identified (for both Goodhue and Wabasha County land areas). This desktop task was accomplished by using the LiDAR Hillshade feature, aerial imagery, and the local SWCD knowledge of recently installed structures. Earthen BMPs such as water and sediment control basins, terraces and grade stabilization structures were identified and the drainage acres were delineated for each. The drainage acres above each structure are herein described as 'treated acres'; these practices by design mitigate flow peaks and reduce transport of surface loaded pollutants such as sediment and phosphorus.

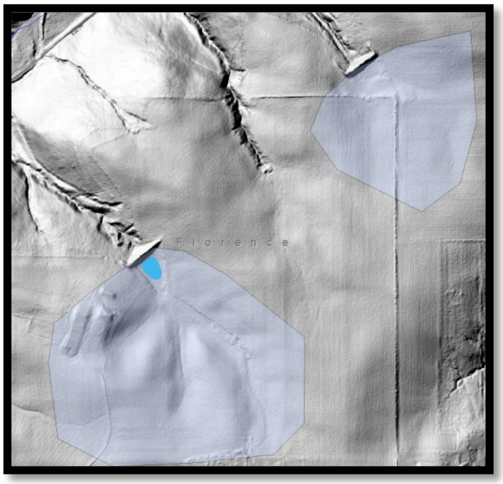


Figure 11. Identifying BMPs and respective treated areas using LiDAR. The shaded blue polygons delineate the areas that drain to the treatment structures (which are the linear features evident in the topography).

A MRLP watershed map that summarizes of the BMP inventory is depicted in Figure 14. The map describes the percent of land treated by structural BMPs in each sub-watershed.

The subwatersheds highlighted in red and yellow in Figure 14 are priorities for upland treatment focusing on volume (which in turn addresses surface pollutants, e.g., sediment, phosphorus and in some cases, pathogens). Protection efforts include but are not limited to increasing the amount of storage on the landscape in the form of structural BMPs as well as increasing perennial cover.

Watersheds highlighted in blue indicate a high percentage of land currently treated by BMPs. Protection strategies should include maintaining the amount of perennial cover on the landscape and proper maintenance of the existing BMP structures. Riparian habitat and streambank improvements in these watersheds is a focus, given that upland treatment is installed (see highlighted blue watersheds of Bullard Creek, Trout Brook, Sugarloaf Creek, Cold Creek (C. R. 45), Wells Crk Trib (C. R. 5)).

This analysis constitutes the primary means for targeting strategies aimed at volume control and reduction of surface-runoff drive pollutant loads (e.g., sediment, phosphorus, and in some cases, pathogens)

Within the priority areas described in Figure 14, the precise location of the appropriate BMPs will be determined by various inputs, but are largely subject to landowner interest and the professional judgment of the parties involved with the WRAPS process.

In addition to the upland treatment analysis and mapping, the following GIS data and inventory work will be used to prioritize strategy implementation:

(1) Riparian inventory, including pastures (e.g., managed grazing land is a protection priority), vegetated (use existing inventory to apply zoning ordinance), stream segments that are ideal candidates for larger restoration efforts (use stream classification work, LiDAR), edges of fields that drop off steeply to wooded valleys and frequently flooded lands are all readily identifiable focus areas.

(2) Land use coverages (to describe existing perennial lands); NLCD data useful in this context.

(3) LiDAR and land use coverages in combination to target frequently flooded lands and highly erodible lands.

These data are available to local partners; maps are not included in this document.

Targeting for Nitrogen

Given that the primary transport mechanism for loading nitrate to the trout streams of the MRLP watershed is “ag groundwater” (i.e., leaching loss from agricultural lands to groundwater, which comprises the majority of trout stream base flow; see Figure 7), it follows that BMPs designed to address volume and surface runoff will in most cases not address nitrogen loading (most of the nitrate exported from the MRLP watershed is in the dissolved form nitrate; see Appendix A: Wells Creek load monitoring data). Nitrogen loading in the MRLP watershed is a groundwater issue. The means of reducing nitrogen loading to surface waters in southeast Minnesota are optimization of rate and timing of fertilizer application, and vegetation changes (MPCA 2014). Regarding nitrogen lost through groundwater paths, there is no desktop method for targeting geographic areas beyond the resolution of the watershed’s row crop acres; the agronomic variables are too many. Rather, such targeting will be managed by the local government units (mainly the SWCDs and NRCS) and interested landowner. Vegetation changes also encompasses application of cover crops; the Nutrient Reduction Strategy calls for prioritizing early –off fields now, while continuing research and development regarding cover crops for corn/soybean and corn/corn rotations (MPCA 2014). Inherent in this directive is geographic targeting: corn silage, canning crops and other early harvest fields are a focus for cover crops in the MRLP watershed. Such targeting can only be executed by local government units and partners; it cannot be well described using static maps or models. Increasing cover crop adoption is a saturation strategy more so than a targeting strategy. The organic/particulate component of the nitrogen load is addressed by way of the focus and BMPs described previously for treating sediment and phosphorus.

The Wellhead Protection Plan for St. John's Lutheran Church (located within the MRLP watershed) describes the need for nitrate reductions within their Drinking Water Source Management Area (DWSMA). Currently the Church's well shows a concentration of 9.8 mg/l. The Wellhead Protection Area (WHPA) is approximately 90% row-crop agriculture. Optimization of rate and timing of applied nitrogen and cover crop implementation are priorities within this target area. See Figure 12 and Figure 13 below. The Surface Water Contribution Area (SWCA) is the area that is topographically above and drains to an area of focused recharge.

Figure 12. St. John's Lutheran Church DWSMA

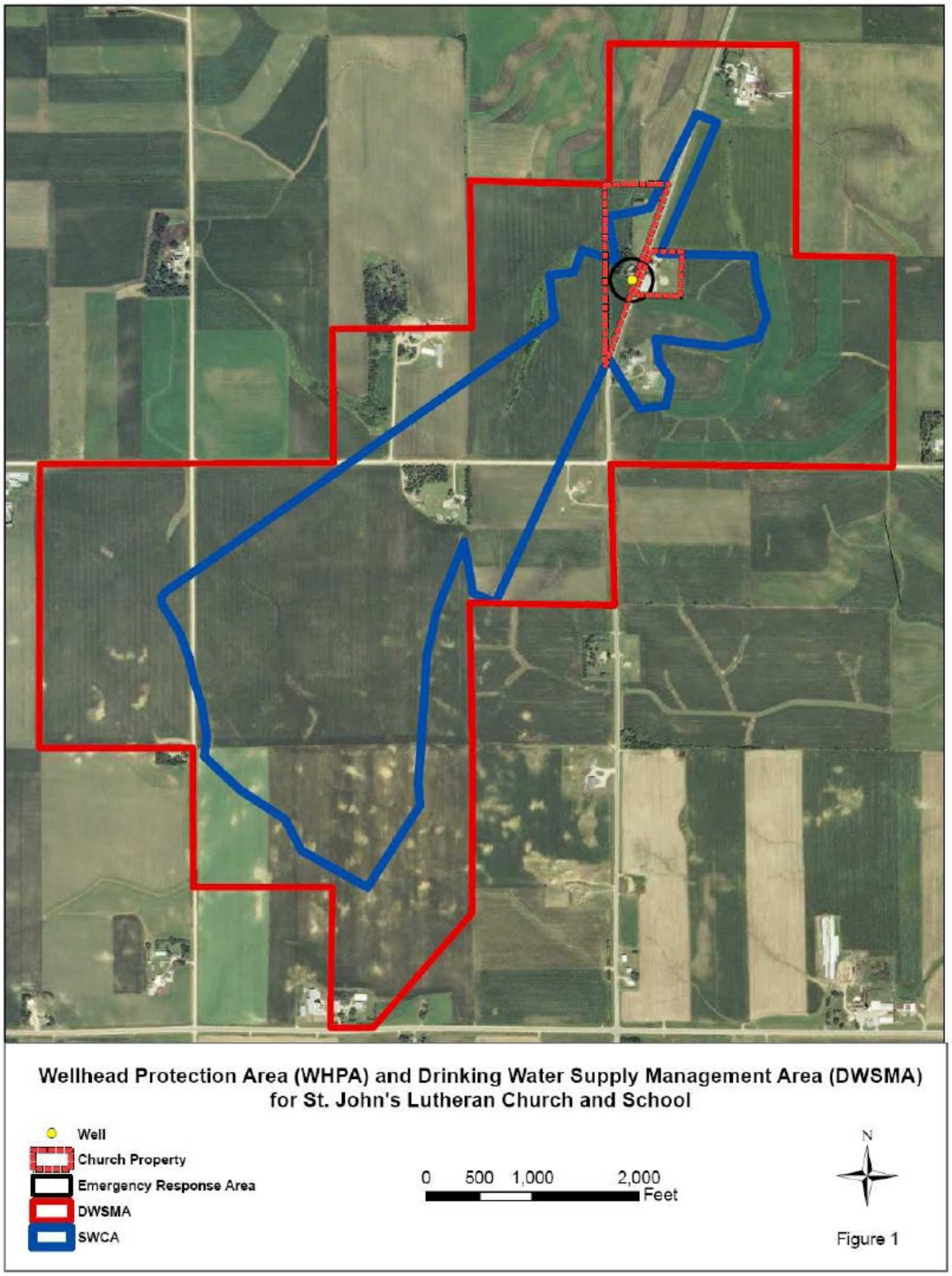


Figure 13. St. John's Lutheran Church nitrate data

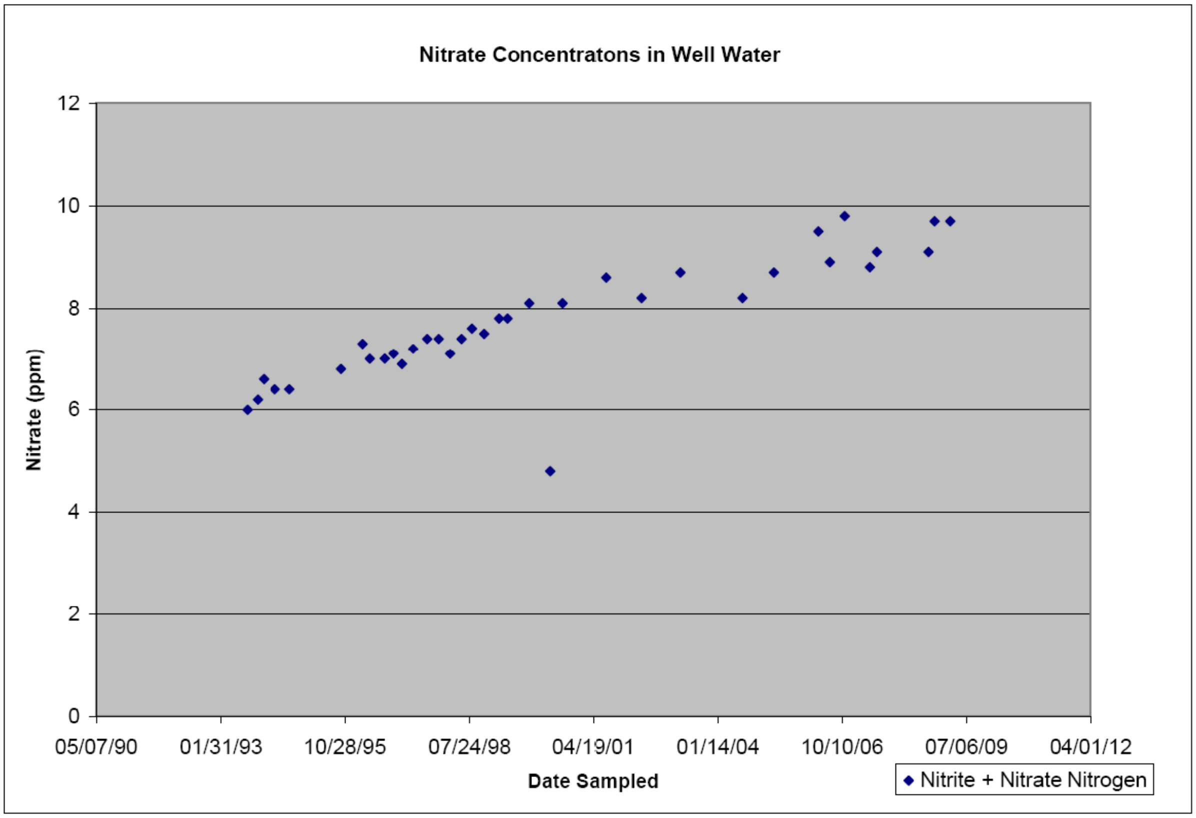
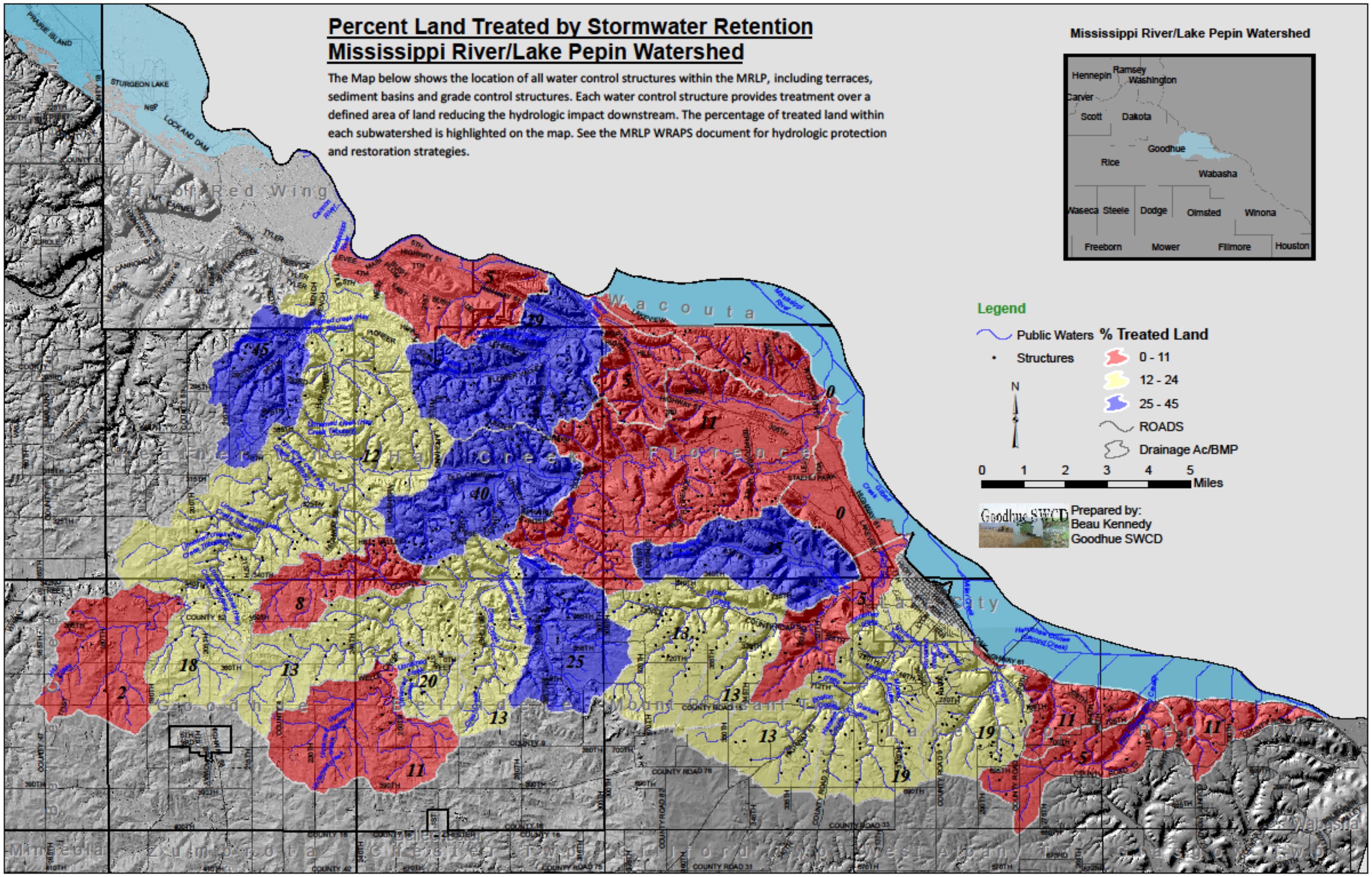


Figure 14. MRLP upland treatment map



3.2 Civic Engagement

Preceding Stakeholder and Public Processes

Because the MRLP WRAPS document is largely built on preceding efforts, the associated stakeholder processes should be summarized.

(1) The Wells Creek Partnership was formed in 1993 to help manage the watershed's land and water resources for the long-term health of the resource. The Partnership is comprised of watershed citizens, the DNR, the MPCA, the Natural Resource Conservation Service, the Goodhue Soil and Water Conservation District, the US Forest Service and the BWSR. For 20+ years this group has worked to better understand their watershed, execute planning and demonstration projects and maintains partnerships. Their existing forum is a good platform for civic engagement going forward.

(2) A regional fecal coliform TMDL and implementation plan (and many implementation projects) have been executed in efforts to reduce pathogen loading to southeast Minnesota's surface waters. Feedlot runoff, unsewered communities and over-grazed pastures (among others) have all been addressed via grant funding. It is within this greater planning context, founded on a significant stakeholder process, that *E.coli* TMDLs for the MRLP watershed are executed.

(3) The Nutrient Reduction Strategy (currently draft), which outlines the primary means of addressing nitrogen and phosphorus in the MRLP watershed, was driven by a rigorous engagement process. An interagency coordination team (ICT) is supporting development of the Strategy and consists of representatives from various agencies and organizations that administer key nutrient reduction programs or implement programs that support decisions affecting nutrient loads. The ICT structure includes a high-level Steering Committee comprised of senior agency managers and a work group comprised of agency program managers. Two sector-specific focus groups were also formed to provide input and direction on Strategy development. The Agricultural Sector group includes representation from the MDA, Natural Resource Conservation Service (NRCS), the BWSR, and University of Minnesota. The Point Source Sector group includes representation from the MPCA and Metropolitan Council. Each of these groups met twice to identify potential strategies for nutrient reduction (MPCA 2014).

Stakeholder Process Specific to TMDLs and the WRAPS

Stakeholder interactions regarding the MRLP TMDLs and WRAPS were focused on Goodhue and Wabasha Counties, the City of Red Wing, Lake City and other partner agencies. On March 13, 2014, these partners met in Goodhue to discuss the TMDL, examine MS4 requirements and look ahead to the WRAPS completion. Information was exchanged via Wells Creek Partnership meetings (one per summer 2011-2013), Goodhue County Water Plan meetings, phone conversations and various meetings with agencies and local partners. The MRLP Professional Judgment Group meeting (at which assessment results are discussed and finalized) was held on August 22, 2011 and attended by the MPCA, the DNR Fisheries, Wabasha County, Goodhue County and City of Red Wing. The *E.coli* impairments addressed in this TMDL were subject to public notice as part of the 2012 impaired waters list. In June 2014 the Professional Judgment Group and a broader peer/partner review of the WRAPS report was conducted; comments were incorporated in the public notice draft. On June 26, 2014 the Goodhue County Water Plan Committee hosted a meeting of local partners and citizens at which the WRAPS were presented and discussed. This input was incorporated in the public notice draft.

Subsequent Stakeholder and Public Process

Public process and engagement will continue as the MRLP WRAPS moves forward. Primary components will include:

(1) Vetting the WRAPS documents with local water planning and watershed groups.
   a. Sharing the core strategies and inventory/maps that were created.
   b. Discussing means of integrating WRAPS content with local planning work.
   c. Demonstrations of execution of the strategies highlighted in the WRAPS.
      i. Some hosted by Wells Creek Partnership.

(2) Public notice from August 11 – September 10, 2014; minor changes were made according to public comments received.

(3) Collaboration by local partners in pursuit of project funding to support WRAPS implementation.

3.3 Restoration & Protection Strategies

The management strategies for the MRLP watershed are focused on protecting and improving local water and land resources and addressing a “fair share” obligation to reduce pollutant loading in pursuit of downstream goals (i.e., Lake Pepin and Gulf Hypoxia). The strategies are summarized below and detailed in Table 8. The strategies for nitrogen and phosphorus load reductions based on downstream needs (yellows rows in Table 8) make use of the goals and timeline described in the Nutrient Reduction Strategy (MPCA 2014); they also constitute local protection strategies (e.g., keeping stream nitrate concentrations low and maintaining no net loss of perennial vegetation). The stream habitat protection strategy is noted individually (green row) because it is not addressed in the scope of the NRS.

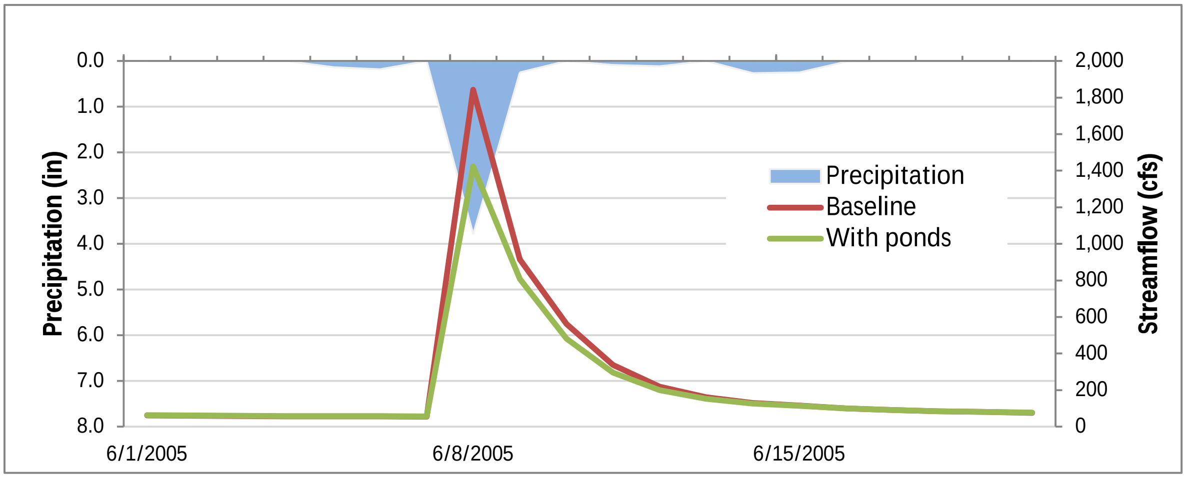
- Strategies for addressing volume, sediment, phosphorus and pathogens.
  - Installation of upland BMPs, per targeting in section 3.1.
  - Maintaining/rehabilitation of existing BMP structures.
  - Continued implementation of existing programs to address feedlots, manure management, unsewered communities, and septic systems.
  - Increase use of reduced and conservation tillage, especially on steep slopes; focus on reduced tillage following soybeans.
  - Stream restoration and channel work in watersheds that have been sufficiently treated in the uplands, per targeting in Section 3.1, to address legacy sediment issues, channel incision and habitat deficiencies.
- Strategies for addressing nitrogen.
  - Maintenance (or increase) of the current level of perennial cover (e.g.,grassland, pasture, forest, CRP) in the watershed, to prevent increased nitrogen loading to local aquifers and trout streams.
    - Encourage well managed pastures and rotational grazing as working land BMPs.
    - Encourage the re-enrollment of expiring CRP contract acres.
    - Enforce shoreland buffer ordinance, targeting using existing GIS data.
  - Optimization of rate and timing of nitrogen application, employing a “saturation approach” as opposed to targeting specific acres.
  - Increased adoption of cover crops on the watershed’s cultivated acres, focusing on early-off fields but in general employing a saturation approach.
  - Assist St. John's Lutheran Church implementing their Wellhead Protection Plan.
  - Nitrogen strategies and estimated scales of adoption examined via Nitrogen BMP (NBMP) tool; see Appendix B.
- Strategies for protecting outstanding resource value lands and waters.

- Use easements and fee title acquisition with focus in the areas delineated in Section 3.1, and also focus on acquiring state park and forest land near C. R. 2 and C. R. 5 intersection and the hills and floodplain of Hay Creek watershed near campground.
- Pursue the DNR Fisheries management easements as a protection measure and a means of focusing habitat improvement money.
- Use zoning ordinance to and newly defined mining setbacks to protect the MRLP watersheds from future bluff, floodplain, habitat corridors and water resource impacts.
- Enforce the Wetlands Conservation Act and work toward no net loss of wetlands in the watershed (i.e., mitigation of wetland impacts to be kept within the confines of the MRLP watershed).
- Protect the base flow of the MRLP trout streams; use stream monitoring and groundwater modeling/monitoring to confirm that new appropriations will not adversely impact base flow.

These strategies comport with both Minnesota's Nutrient Reduction Strategy (draft at time of WRAPS completion) and the findings of the Multiple Benefits of Agriculture modeling, which found that riparian buffers, conservation tillage and nutrient management (scenario B) would help meet Wells Creek's local goal regarding downstream gulf hypoxia (Boody & Krinke 2001). Further, SWAT modeling in the nearby Little Cannon River watershed (Goodhue County), documents the effectiveness of impoundment structures within an agricultural watershed setting. The model simulated a 23% reduction in peak streamflow (for an individual rain event) achieved using a scenario in which 40% of the watershed was treated through an impoundment structure (LimnoTech 2014). These strategies and their respective goals and timelines are detailed in Table 8, following.

Many strategies will address multiple pollutants and/or provide multiple benefits. For example, increasing perennial lands will address nutrient (both phosphorus and nitrogen) and sediment loads, decrease peak flows, improve habitat and in many cases reduce pathogen loading. To avoid redundancy only strategies most primary to each goal are included in Table 8.

Figure 15. Little Cannon River SWAT model simulation (LimnoTech 2014)



Information generated from the Little Cannon River SWAT model can be utilized as a peak discharge reduction effort in the MRLP sub-watersheds. An agricultural based watershed with 40% of its area being treated by an impoundment structure shows a reduction in total water runoff yield to the watershed by 0.5". This is consistent with the reduction in surface runoff under a "Natural Background" scenario. Thus, to restore the natural hydrology of a stream system during runoff events, a goal for BMP implementation in the MRLP would be to treat 40% of the surface runoff leaving agricultural watersheds.

Table 7. Little Cannon River SWAT model hydrology summary (LimnoTech 2014 DRAFT)

Scenario	Precipitation (in)	[2]ET (in)	Water Yield (in)					Seepage (in)	Relative change in Water Yield (in)
			Surface runoff	Lateral flow	Tile flow	[3]GW flow	Total		
Baseline	33.6	22.8	2.8	2.1	0.3	5.2	10.4	0.5	-
A. No-till Soybean	33.6	22.8	2.9	2.0	0.5	5.1	10.5	0.3	+1%
B. No-till on Slopes >2%	33.6	22.6	2.8	2.1	0.3	5.3	10.5	0.5	+1%
C. Cropland to Perennials	33.6	21.6	2.7	2.2	0.2	6.2	11.4	0.7	+10%
D. Conservation Easement	33.6	22.8	2.8	2.0	0.3	5.2	10.3	0.5	-1%
E. Natural Background	33.6	24.8	2.3	2.0	0.0	4.3	8.6	0.2	-17%
F. Detention Ponds	33.6	23.1	2.3	2.1	0.3	5.3	10.0	0.6	-4%
G. Cover Crop	33.6	23.0	2.8	2.0	0.3	5.1	10.2	0.4	-2%
H. Fertilizer Management	33.6	22.8	2.8	2.1	0.3	5.2	10.4	0.4	0%

[2]ET – actual evapotranspiration
[3]GW – groundwater

Table 8: Strategies and actions proposed for the MRLP Watershed

	HUC-10 Subwatershed	Waterbody and Location	Parameter (incl. non-pollutant stressors)	Water Quality		Strategies	Estimated Scale of Adoption Needed Focused Adoption vs Saturation Effort?	Entities with Primary Responsibility									Interim 10-year milestones	Timeline to achieve water quality target
				Current Conditions	Goals / Targets	See Key Below for Details Regarding Strategies		Goodhue SWCD	Wabasha SWCD	Goodhue and Wabasha County Planning and	City of Red Wing	MPCA	NRCS	MNDNR	MDA	NGO (Trout Unlimited, Nature Conservancy, etc)		
Restoration Strategies for all Subwatersheds	All	E. coli	E. coli geometric means: (Units are org/ml) Hay Creek 249 Bullard Creek: 681 Gilbert Creek 647 Miller Creek 1063 Wells Creek 469	E. coli geometric mean 126 org/ml	SE Fecal TMDL - 2007 SEMN Bacteria Implementation Plan	Watershed-wide saturation effort, with focus provided by existing program criteria (i.e. feedlots, septics, grazing assistance)	x	x		x						Continue to study sources and background E. coli. Lower geometric means (all flows) by 2018	2035** (lock-stepping with phosphorus timeline)
					Local Land Use Ordinance Administration	100% compliance as it applies to shoreland, blufflands, feedlots, wetlands, erosion, mining, etc.			x	x							
					NPDES Point Source Compliance	Red Wing apply pet waste BMPs in the MS4 area of Hay Creek watershed				x	x					2018 SWPPP include new BMP language	
Strategies to Address Downstream Goals	All	Phosphorus and Sediment*	No local phosphorus or sediment-driven impairments; Downstream impairments: Mississippi River, Lake Pepin, Gulf of Mexico 2009: 2885 kg TP 1371100 kg TSS 2010: 9250 kg TP 9284621 kg TSS 2011: 3898 kg TP 1860354 kg TSS Measured at Wells Creek outlet	45% phosphorus load reduction per NRS (which would meet Pepin goal too); some progress already documented 20% TSS load reduction per South Metro Mississippi TMDL	Nutrient Reduction Strategy (NRS)	Saturation effort in upland segments of each subwatershed with focus provided by local partners.	x	x				x				Phosphorus and sediment loads continue to decrease; examine in 2025 (first NRS milestone) Subwatersheds with the lowest treatment percentage, increased to >20% treated (end goal of 40%)	2035**
					Local Land Use Ordinance Administration	100% compliance as it applies to shoreland, blufflands, feedlots, wetlands, mining	x	x	x			x					
					Stream and Streambank Restoration	Focus efforts in subwatersheds that have sufficient upland treatment (see figure 14)	x	x									
					Structural Impoundment BMP	Sub-watersheds with minimal upland treatment (see Figure 14) and higher % of land in Row Crop	x	x				x					
					Land Retirement/Acquisition	Focus easement, acquisition and stewardship planning on areas delineated by Nature Conservancy (see Figure 10).							x		x		
	All	Nitrogen	No local nitrogen-driven impairments; Downstream impairments: Gulf of Mexico 2009: 85147 kg NOx 2010: 97815 kg NOx 2011: 121046 kg NOx Measured at Wells Creek outlet	45% load reduction per NRS	Nutrient Reduction Strategy (NRS)	Saturation effort in upland segments of each subwatershed with focus provided by local partners. See Appendix B for Nitrogen BMP tool scenarios.	x	x				x				Decreased N loads by 2025 (first NRS milestone); observed change in nitrate trend at wells/springs (per MGS lag time analysis)	2045**
					Local Land Use Ordinance Administration	100% compliance as it applies to shoreland, blufflands, feedlots, wetlands, mining	x	x	x		x						
					Land Retirement/Acquisition	Focus easement, acquisition and stewardship planning on areas delineated by Nature Conservancy (see Figure 10).							x		x		
Protection Strategies	All	Habitat	MSHA scores: 11 sites good; 6 sites fair; 1 site poor	Maintain or improve current habitat quality	Stream Habitat Improvement	Efforts will focus in watersheds that have achieved upland treatment (see Figure 14)							x		x	NA	No timeline; Maintain or improve
					Stream and Streambank Restoration		x	x									

*These strategies address both phosphorus and sediment in the nonpoint landscape; they will also address peak discharge.

**Assuming adequate funding is available.

Table 9: Key for Strategies Column

Strategy	Description
Nonpoint Source	
Nitrogen Reduction Strategies Nutrient Reduction Strategy "Phase I Milestone" Nitrogen BMPs (Chapter 5.3.3 Nitrogen Reduction Strategies)	Manage marginal lands in perennials, optimize nutrient management planning, timing and implementation, expand the use of cover crops, encourage managed grazing throughout the watershed also referenced NRCS Job Codes; Nutrient Management (590), Prescribed Grazing (528), Cover Crop (340), Filter Strip (393), Waste Storage Facility (313)
Phosphorus Reduction Strategies Nutrient Reduction Strategy "Phase I Milestone" Phosphorus BMPs (5.3.2 Phosphorous Reduction Strategies)	Reduce sediment transport from row crop lands and promote sound residue management practices. Impoundments, contour farming, no-till farming, grassed buffer strips, etc. are all BMPs used to reduce soil erosion. (also referenced NRCS Job Codes Cover Crop (340), Residue and Tillage Management (345 & 329), Filter Strip (393), Contour Farming (330), Contour Buffer Strips (332)
SE MN Bacteria Implementation Plan (2007)	http://www.pca.state.mn.us/index.php/view-document.html?gid=8013
Structural Impoundment BMP	Water impoundment structures that reduce peak flows of rain events. These impoundments are located within row crop fields as well as edge of fields and in managed pastures. Using the information gathered from the Little Cannon River SWAT Model, as well as professional observations of stream conditions in MRLP sub-watersheds, BMP treatment of 40% of land surface is the goal for this strategy. These practices include but are not limited to Water and Sediment Control Basins (638), Grade Control Structures (410), Terraces (600) and Diversions (632) (as a component)
Stream Habitat Improvement	Provide habitat improvement practices in an effort to reach a streams full potential of sustaining game and non-game species. Incorporating natural design concepts to restoration projects as well as working with a streams' evolution should be a priority in the well treated watersheds. Practices referenced: All practices listed in the Nongame Wildlife Habitat Guide (TU), Toewood design concept and cedar tree revetments. Also referenced NRCS Job Code; Stream Habitat Improvement and Management (395),
Stream and Streambank Restoration	Streambank stabilization is often required to 'patch' a section of a stream when failing conditions are present. The risk of losing infrastructure is typically the impetus behind implementing these practices. In actuality, these failing bank locations are major contributors to the sediment loading in the stream system Common practices include, sloping and shaping banks, natural riprap placement, weirs, stream barbs, log deflectors, cedar tree revetments and Toewood design concept. Referenced NRCS Job Code: Streambank and Shoreline Protection (580), Critical Area Planting (342), Bank Vegetation (322)

Strategy	Description
Local Zoning Ordinance Administration	Administration and enforcement of the County Planning and Zoning Ordinance is an effective protection strategy if implemented in the MRLP. Activities such as land clearing, erosion control, new and expanding feedlot projects, wetland impacts, shoreland buffer requirements, bluffland protection and sand and gravel mining operations all are regulated in Goodhue and Wabasha Planning and Zoning Ordinance. Implementing the ordinance often requires assistance from various local/state agencies that are familiar with the above mentioned practices.
Land Retirement and Acquisition	Fee title acquisition (DNR, TNC, LSP) and long-term conservation easements (RIM) are strategies for protecting the outstanding resources within the MRLP. Using the TNC protection polygon shapefile as a guide (see Figure 10), willing landowners will be fairly compensated for enrolling set-a-side lands.
Point Source	
NPDES point source compliance	All NPDES-permitted sources shall comply with conditions of their permits, which are written to be consistent with any assigned wasteload allocations

4. Monitoring Plan

Future monitoring in the MRLP watershed will be according to the watershed approach framework. The Intensive Watershed Monitoring (IWM) strategy utilizes a nested watershed design allowing the aggregation of watersheds from a course to a fine scale. The foundation of this comprehensive approach is the 81 major watersheds within Minnesota. Streams are segmented by HUC. IWM occurs in each major watershed once every 10 years (MPCA 2012). The *Mississippi River Lake Pepin Watershed Monitoring and Assessment Report* provides detailed discussion of IWM and how it will be applied going forward (it will be repeated in MRLP in 2018).

Load monitoring at the Wells Creek outlet (S004-859 at Highway 61) is on-going and will be used to track reductions in nitrogen and phosphorus loads in the MRLP watershed; this site is instrumented and gauged to track flow volumes, and is intensively monitored by the MPCA staff and partners (currently Goodhue SWCD). See Appendix A for load monitoring data accumulated to date. Given the inventory work done in support of watershed planning, local partners are well-equipped to track BMP installation in the watershed.

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

4.1 Focused Monitoring & Research Needs

In addition to monitoring for both assessment and effectiveness purposes, there are research needs pertaining to pathogens in surface water. The *Revised Regional Total Maximum Daily Load Evaluation of Fecal Coliform Bacteria Impairments In the Lower Mississippi River Basin in Minnesota Implementation Plan* notes that these points of need include, but are not limited to:

- Study of sources of pathogens in cities and urban areas;
- Better understanding of load reduction capabilities for applicable structural and non-structural BMPs;
- Models to evaluate loading sources and track load reductions;
- Methods to evaluate pollutant migration pathways and delivery mechanisms from pathogen sources to surface waters, both generally and in karsted landscapes;

- DNA “fingerprinting” to identify pathogen sources.

Such research would further understanding of pathogens in surface water, and greatly support both future TMDL studies and implementation efforts by allowing for more quantified approaches to both. In the MRLP, this focused work is needed to better understand high *E.coli* counts observed during relatively calm, low flow and clear water conditions in trout streams.

MRLP Watershed Monitoring Plan Summary	
	• Aquatic life use support: Intensive Watershed Monitoring every 10 years. • Aquatic recreation use support: Intensive Watershed Monitoring provide milestone check-points, other monitoring focused on research needs and better understanding. • Drinking water use support: continue to monitor wells and baseflow of trout streams, track nitrate concentration in St. Johns Lutheran Church well. • Tracking goals in pollutant load reductions: Wells Creek load monitoring site, on-going. • BMP tracking: SWCD inventories, BWSR eLink, NRCS reporting at watershed scale .

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Mississippi River Lake Pepin Watershed Reports

Many reports referenced in this watershed report are available at the Mississippi River Lake Pepin Watershed webpage: http://www.pca.state.mn.us/index.php/water/water-types-and-programs/watersheds/mississippi-river-lake-pepin.html. Much of the historical material, data and reports can be found at the Goodhue County SWCD website: http://www.goodhueswcd.org/#!mississippi-river-lake-pepin-/caom

Appendix A: Wells Creek Load Monitoring Summary

HydstraID	SITE_STNAME	EquisID	HUC12	FLX_PARAM	FLX_START	FLX_END	FWMC (mg/L)	Mass (kg)	Vol (acre ft)
H38006002	Wells Creek nr Frontenac, US61	S004-859	070400010602	TP	1/1/2009	12/31/2009	0.108	2885.359	21647
H38006002	Wells Creek nr Frontenac, US61	S004-859	070400010602	TSS	1/1/2009	12/31/2009	51.3	1371100	21647
H38006002	Wells Creek nr Frontenac, US61	S004-859	070400010602	NO2+NO3	1/1/2009	12/31/2009	3.19	85147.915	21647
H38006002	Wells Creek nr Frontenac, US61	S004-859	070400010602	TKN	1/1/2009	12/31/2009	0.489	13058	21647
H38006002	Wells Creek nr Frontenac, US61	S004-859	070400010602	DOP	1/1/2009	12/31/2009	0.051	1362.6	21647
H38006002	Wells Creek nr Frontenac, US61	S004-859	070400010602	TSS	1/1/2010	12/31/2010	293	9284621	25680
H38006002	Wells Creek nr Frontenac, US61	S004-859	070400010602	TP	1/1/2010	12/31/2010	0.292	9250.55	25680.4
H38006002	Wells Creek nr Frontenac, US61	S004-859	070400010602	DOP	1/1/2010	12/31/2010	0.133	4228	25680
H38006002	Wells Creek nr Frontenac, US61	S004-859	070400010602	NO2+NO3	1/1/2010	12/31/2010	3.09	97815.737	25680
H38006002	Wells Creek nr Frontenac, US61	S004-859	070400010602	TKN	1/1/2010	12/31/2010	1.015	32173.85	25680
H38006002	Wells Creek nr Frontenac, US61	S004-859	070400010602	TSS	1/1/2011	12/31/2011	53.1	1860354	28423
H38006002	Wells Creek nr Frontenac, US61	S004-859	070400010602	TP	1/1/2011	12/31/2011	0.111	3898	28423
H38006002	Wells Creek nr Frontenac, US61	S004-859	070400010602	NO2+NO3	1/1/2011	12/31/2011	3.45	121046	28423
H38006002	Wells Creek nr Frontenac, US61	S004-859	070400010602	TKN	1/1/2011	12/31/2011	0.479	16802	28422.8
H38006002	Wells Creek nr Frontenac, US61	S004-859	070400010602	DOP	1/1/2011	12/1/2011	0.054	1885	28422.8

Appendix B: Nitrogen BMP Spreadsheet Scenarios

These scenarios were discussed and designed by th MPCA staff and local partners. They describe estimated scales of adoption that correspond to ~16% and 27% reductions in nitrogen loading from the MRLP watershed.

5		0.137	million acres in watershed or state			acres treated (000),
6	Watershed: Mississippi River - Lake Pepin (32)	% suitable	% adoption	% treated	% treated, combined	combined
7	Corn acres receiving target N rate, no inhibitor or timing shift	49.49%	70%	34.64%	33.58%	45.89
8	Fall N target rate acres receiving N inhibitor	8.69%		0.00%	0.00%	0.00
9	Fall N applications switched to spring, % of fall-app. acres	8.69%		0.00%	0.00%	0.00
10	Fall N switch to split spring/sidedressing, % of fall acres	8.69%		0.00%	0.00%	0.00
11	Restored wetlands	7.98%	0%	0.00%	0.00%	0.00
12	Tile line bioreactors	7.02%	0%	0.00%	0.00%	0.00
13	Controlled drainage	7.02%	0%	0.00%	0.00%	0.00
14	Saturated buffers	7.02%	0%	0.00%	0.00%	0.00
15	Riparian buffers	2.25%	100%	2.25%	2.25%	3.08
16	Cereal rye cover crop after corn grain, before soybeans	28.12%	5%	1.41%	1.37%	1.87
17	Short season crops planted to a rye cover crop	7.41%	50%	3.71%	3.65%	4.99
18	Perennial crop % of corn & soy area: marginal only	17.67%	0%	0.00%	0.00%	0.00
19	Weather scenario: Average weather - all of preplant N is available	of preplant	Load default data			
20	For wet spring scenario 2, fertilizer & manure N lost	30%				
21	The rate of sidedressed N is increased to offset the lost preplant N.					
22	N load reduction with these adoption rates:	16.7%	of cultivated ag land source load			More results===>
23	Treatment cost before fertilizer cost savings & corn yield impacts	$0.83	million/year			
24	N fertilizer cost savings & corn yield impacts	-$1.00				
25	Net BMP treatment cost	-$0.18	million/year			
26						

5		0.137	million acres in watershed or state			acres treated (000),
6	Watershed: Mississippi River - Lake Pepin (32)	% suitable	% adoption	% treated	% treated, combined	combined
7	Corn acres receiving target N rate, no inhibitor or timing shift	49.49%	100%	49.49%	46.45%	63.49
8	Fall N target rate acres receiving N inhibitor	8.69%	0%	0.00%	0.00%	0.00
9	Fall N applications switched to spring, % of fall-app. acres	8.69%	0%	0.00%	0.00%	0.00
10	Fall N switch to split spring/sidedressing, % of fall acres	8.69%	100%	8.69%	8.34%	11.40
11	Restored wetlands	7.98%	0%	0.00%	0.00%	0.00
12	Tile line bioreactors	7.02%	0%	0.00%	0.00%	0.00
13	Controlled drainage	7.02%	0%	0.00%	0.00%	0.00
14	Saturated buffers	7.02%	1%	0.07%	0.07%	0.10
15	Riparian buffers	4.50%	100%	4.50%	4.50%	6.16
16	Cereal rye cover crop after corn grain, before soybeans	28.12%	20%	5.62%	5.33%	7.28
17	Short season crops planted to a rye cover crop	7.41%	100%	6.94%	6.72%	9.18
18	Perennial crop % of corn & soy area: marginal only	17.67%	0%	0.00%	0.00%	0.00
19	Weather scenario: Average weather - all of preplant N is available	of preplant	Load default data			
20	For wet spring scenario 2, fertilizer & manure N lost	30%				
21	Sidedressing is done after the rains. The average-year rate of sidedressed N is applied.					
22	N load reduction with these adoption rates:	27.0%	of cultivated ag land source load			More results===>
23	Treatment cost before fertilizer cost savings & corn yield impacts	$1.76	million/year			
24	N fertilizer cost savings & corn yield impacts	-$1.25				
25	Net BMP treatment cost	$0.51	million/year			
26						