Rum River Watershed Restoration and Protection Strategy Report

July 2017

RESPEC

Minnesota Pollution Control Agency

CLEAN WATER LAND & LEGACY

wq-ws4-34a

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Key Terms

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

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

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

Hydrologic Unit Code (HUC): A 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).

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

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

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

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

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

Executive Summary

The Rum River Watershed covers 1,013,760 acres of the Upper Mississippi River Basin in central Minnesota, stretching from Lake Mille Lacs in the north to the confluence with the Mississippi River in the city of Anoka. The watershed covers large portions of Aitkin, Mille Lacs, Isanti, and Anoka Counties and covers smaller areas of Crow Wing, Morrison, Benton, Kanabec, Chisago, and Sherburne County as well as portions of the Mille Lacs Band of Ojibwe Tribal land.

This Watershed Restoration and Protection Strategy (WRAPS) document is meant to serve as a foundation of technical information that can be used to assist in development of tools and prioritization of water quality efforts by local governments, landowners, and other stakeholder groups. The information can be used to determine what strategies will be best to make improvements and protect good quality water resources, as well as focus those strategies to targeted locations.

The topics of each chapter of this report and summary points are provided below.

Chapter 1 provides background information on the watershed.

- The upper one-third of the Rum River Watershed lies in the Northern Lakes and Forest ecoregion, with generally better water quality because of higher amounts of forests, lakes, and wetlands. The Rum River flows into the North Central Hardwood Forest ecoregion in southern Mille Lacs County with land uses shifting to more intense land covers (agriculture and developed lands), along with forests, pasture/hay, and wetlands.
- The Anoka Sand Plain is located along the lower one-third of the basin, and may be expected to strongly influence runoff characteristics because of greater infiltration potentials.

Chapter 2 details watershed conditions based on results from intensive watershed monitoring (IWM), Stressor Identification (SID), and Total Maximum Daily Load (TMDL) calculations.

- A TMDL was prepared to address 11 lakes impaired by excess nutrients, five streams impaired by *Escherichia coli* (*E. coli*) and 1 stream impaired by low dissolved oxygen (DO).
- SID was performed on 10 stream reaches with biological impairments. Flow alteration, elevated phosphorus (P), lack of physical habitat and low DO were primary factors causing stress on fish and invertebrates.
- Sixteen lakes were assessed by the Minnesota Department of Natural Resources (DNR) for fish community health as measured by the Index of Biological Integrity (IBI) in the Rum River Watershed. Three lakes had IBI scores below the impairment threshold.
- Trend data on the Rum River show increases in nitrates/nitrites and chloride during the long term (1953 through 2010) and short term (1995 through 2010,) and significant decreases for TSS, TP, ammonia, and BOD for the long-term record. The Rum River is near, but generally does not exceed, state water quality standards for nutrient eutrophication.

Chapter 3 summarizes priority areas for targeting actions to improve water quality, and geographically locates where watershed restoration and protection actions should take place. This prioritization and targeting is shown using several maps and an implementation table of strategies broken into four geographic regions or management zones of the watershed. The maps and corresponding strategy table are divided into Hydrologic Unit Codes (HUC) at the 10-digit level and provide specific protection and restoration strategies for those subwatersheds. Civic engagement efforts used during WRAPS development to assist with prioritization and strategy development are also discussed.

The main issues in the Rum River Watershed are:

- Intensifying land use changes and their implications on increased runoff, sediment and nutrients throughout the watershed.
- Excess P causing algae blooms in lakes. P sources are from both in-lake sources and from the watershed.
- High levels of dissolved P in the central part of the watershed.
- Widespread issue of high *E. coli* bacteria concentrations.
- Physical habitat of aquatic macroinvertebrates and fish are being affected by various practices in the watershed.

Key strategies that will help address these issues are:

- Protect existing buffers and forested land use, and create buffers in existing agricultural and developed areas.
- Utilize best management practices (BMPs) to reduce impacts from forest management.
- Discourage wetland disturbance and work to restore wetlands that have been degraded to improve nutrient and sediment assimilative capacity.
- Install projects that keep water on the land to address increasingly intense precipitation patterns. Discourage additional drainage from present day conditions.
- Stabilize shoreline erosion.
- Encourage agricultural BMPs to reduce livestock waste from entering lakes and streams.
- Ensure septic systems are compliant throughout the watershed.
- Restore and preserve continuous riparian corridor habitat to benefit water quality, aquatic life and the scenic nature of the river.
- Utilize minimum impact design standards (MIDS) in urbanizing areas.

Civic engagement efforts during WRAPS development included:

- Numerous local partner meetings and targeted citizen events
- Land owner/resident surveys
- Development of a watershed video

- Development of a story map

Chapter 4 documents a monitoring plan necessary to assess conditions in the watershed. This will include following the watershed approach framework model with the next IWM scheduled to occur beginning in 2023. Before that time, other more frequent monitoring is encouraged if funding is available, including local county or SWCD monitoring of lakes and streams, the Minnesota Pollution Control Agency's (MPCA's) watershed pollutant load monitoring network at two locations on the Rum River and the Metropolitan Council hydrology monitoring station at the Rum River outlet in Anoka. This is integral to understanding trends in the watershed, identifying BMP installation sites and determining the effectiveness of water quality improvement efforts so they can be refined.

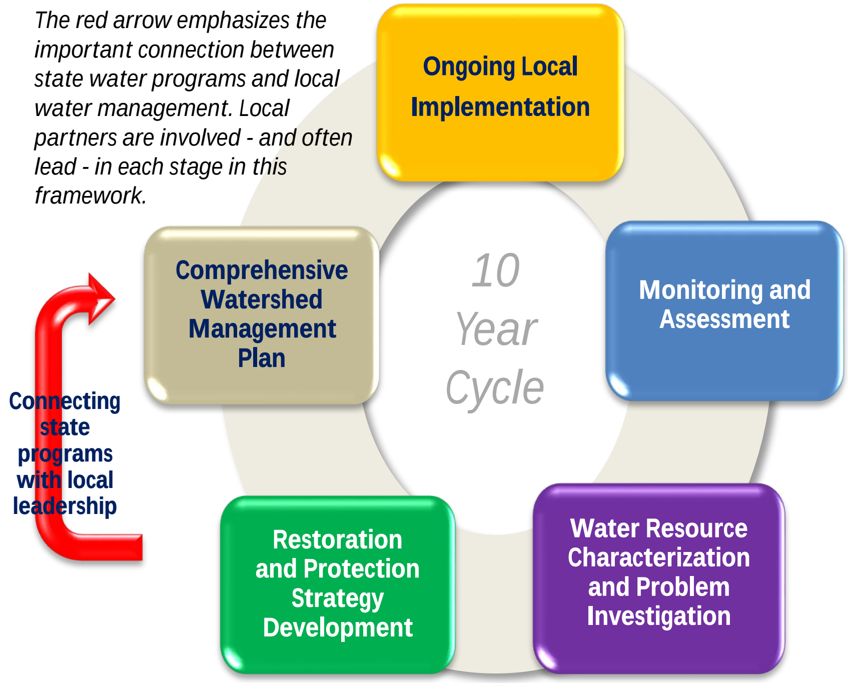
This document was developed based on information provided in the following documents:

- Rum River Watershed Monitoring and Assessment Report – findings of IWM in 2013 and 2014.
- Rum River Watershed Biotic SID Report – findings of intensive biotic monitoring in 2013 and 2014 and identification of stresses to biotic communities.
- Rum River Watershed TMDL Report – calculations of maximum pollutant loadings for impaired waters and pollutant reductions needed to achieve water quality standards.

What is the WRAPS Report?

The state of Minnesota has adopted a “watershed approach” to address the state’s 80 “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.

The red arrow emphasizes the important connection between state water programs and local water management. Local partners are involved - and often lead - in each stage in this framework.



As part of the watershed approach, waters not meeting state standards are still listed as impaired and TMDL studies are performed, 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 develop and utilize watershed-scale models and other tools to identify strategies and actions for point and nonpoint source pollution that will cumulatively achieve water quality targets. For nonpoint source pollution, this report informs local planning efforts, but ultimately the local partners decide what work will be included in their local plans. This report also serves as a watershed plan addressing Environmental Protection Agency’s (EPA’s) nine minimum elements to qualify applicants for eligibility for Clean Water Act Section 319 implementation funds.

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

1. Watershed Background and Description

The Rum River Watershed is an 8-digit HUC watershed situated within the Upper Mississippi River Basin. The watershed covers 1,013,760 acres of the Upper Mississippi River Basin in central Minnesota, stretching from Mille Lacs Lake in the north to the confluence with the Mississippi River in the city of Anoka. The Rum River flows out of Mille Lacs Lake, which drains southwest Aitkin, southeast Crow Wing, and northwest Mille Lacs counties. As the Rum River flows south, mainly within Mille Lacs and Isanti counties, its watershed also includes eastern Morrison, northeast Benton, and eastern Sherburne counties on the western border of the watershed; southwestern Kanabec and northwestern Chisago on its eastern borders; and northwestern Anoka county at the mouth of the Rum River.

The upper third of the Rum River Watershed is dominated by hardwood forest and large wetland complexes. This area also has two state parks and a wildlife management area. The middle third still has wetland complexes and hardwood forest, but cropland and rangeland make up the majority of the land use. Fenced cattle pastures and forage crops such as alfalfa and hay are more abundant than row crops like soybeans and corn. The lower third of the Rum River Watershed is the most densely populated area, with houses dotting its banks on small tracts of land. The river flows through downtown Anoka before cascading over a dam

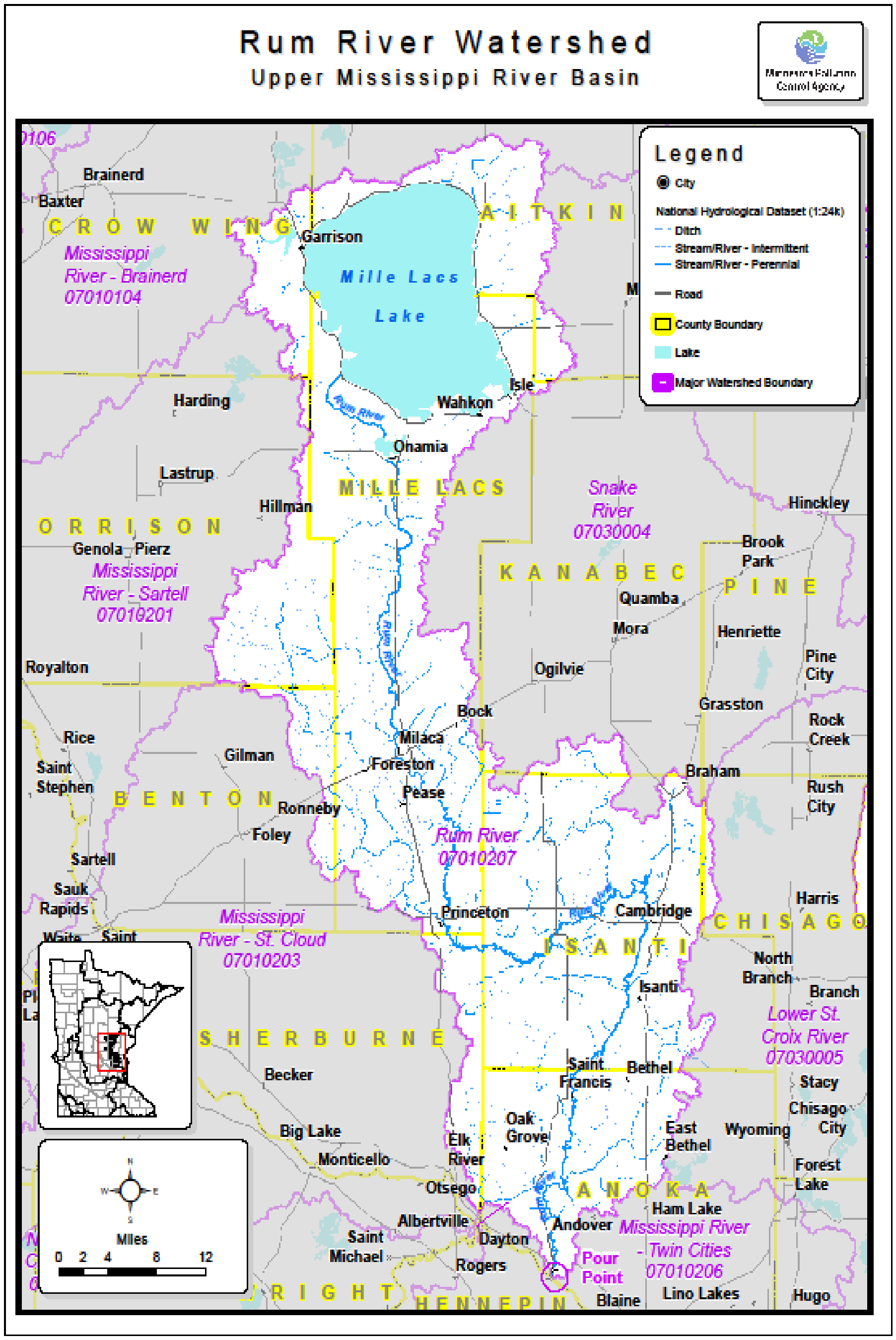


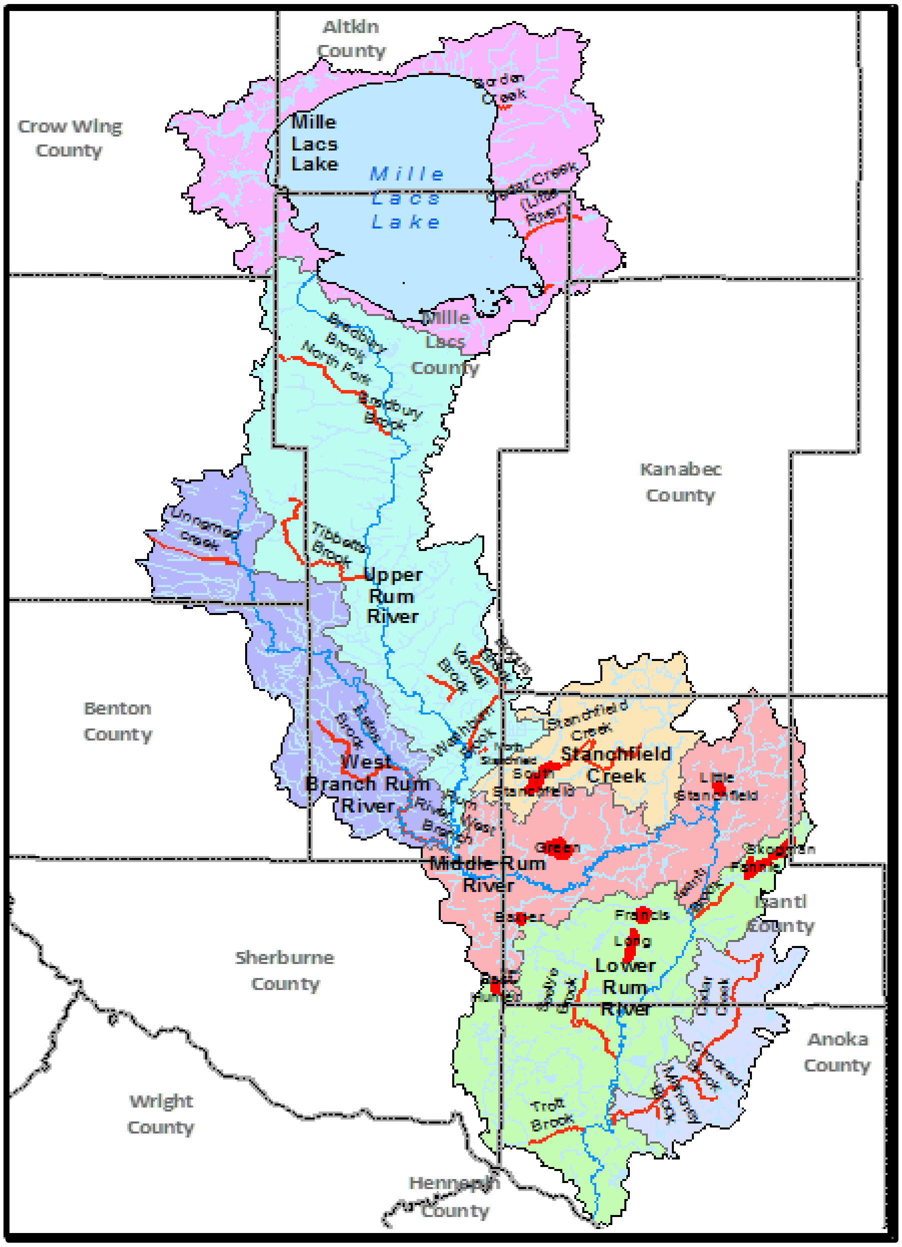
Figure 1-1: Rum River Watershed in Minnesota.

and into the Mississippi River. A general video about the Rum River Watershed is available on the Anoka Conservation District Website. Additional information about the Rum River can be found in Appendix A.

2. Watershed Conditions

Intensive watershed monitoring was conducted in the Rum River Watershed in 2013 and 2014 to determine the overall health of water resources, identify impaired waters, and to identify waters in need of additional protection. This data was combined with other available data collected within the last 10 years for the purpose of waterbody health assessment.

In order to break up the watershed into manageable areas, the majority of information in the WRAPS is broken down into the seven HUC10 subwatersheds. Figure 2-1 shows the location and name of these subwatersheds as well as the impaired lakes and streams within the watershed. Table 2-6 lists the impaired waters.



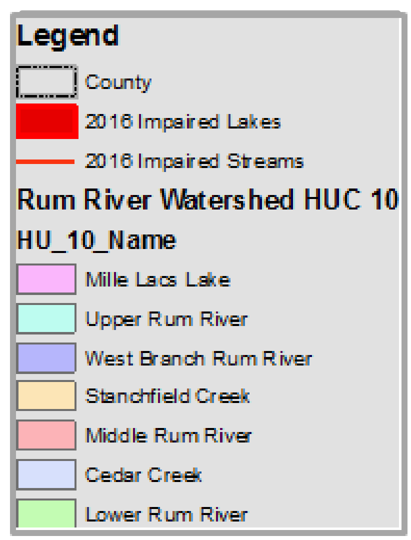


Figure 2-1 Rum River Watershed with Impaired Waters and HUC-10 Subwatersheds

2.1 Condition Status

This report addresses waters for protection or restoration of aquatic life uses based on the fishery, macroinvertebrate community, and DO concentration, and for aquatic recreation uses based on bacteria levels or nutrient levels and water clarity. Waters that are listed as impaired will be addressed through restoration strategies and a defined TMDL study. Waters that are not impaired will be addressed through protection strategies to help maintain water quality and recreation opportunities and reverse downward trends (see Section 2.5 and Section 3).

Some of the waterbodies in the Rum River Watershed are impaired by mercury; however, this report does not cover toxic pollutants.

For more information on mercury impairments, see the statewide mercury TMDL at: http://www.pca.state.mn.us/index.php/water/water-types-and-programs/minnesotas-impaired-waters-and-tmdls/tmdl-projects/special-projects/statewide-mercury-tmdl-pollutant-reduction-plan.html.

Streams

Streams are assessed for aquatic life and aquatic recreation designated uses. Aquatic life use impairments include:

- Low scores for the fish index of biotic integrity (Fish IBI); which means an unhealthy fish community is present,
- Low macroinvertebrate (i.e., aquatic bugs) index of biotic integrity (Invert IBI) scores ; which means an unhealthy macroinvertebrate community is present,
- DO levels are too low to support fish or macroinvertebrate life,

Stream aquatic recreation use impairments include: *E. coli* bacteria, found in the intestinal tracts of warm-blooded animals, which is an indicator of fecal pollution levels that are too high for safe human contact (wading or swimming).

The following table below summarizes the ability of the stream reaches to support aquatic life uses and aquatic recreation uses in the Rum River Watershed. A complete list of the results of the stream assessment, which includes all available data on the stream reaches within the Rum River Watershed, can be found in Appendix 3.1 of the Rum River Watershed Monitoring and Assessment Report at: https://www.pca.state.mn.us/water/watersheds/rum-river#overview.

Table 2-1: Assessment status of stream reaches in the Rum River Watershed

HUC-10 Subwatersheds	Total Stream Reaches	Aquatic Life Use				Aquatic Recreation Use			
		FS	NS	IF	NA	FS	NS	IF	NA
Mille Lacs Lake	4	0	3	1	0	1	0	1	2
Upper Rum River	16	8	4	3	1	4	1	1	10
West Branch Rum River	6	3	3	0	0	0	2	0	4
Stanchfield Creek	2	1	1	0	0	1	0	0	1
Middle Rum River	3	3	0	0	0	2	0	0	1
Cedar Creek	3	1	2	0	0	0	1	0	2
Lower Rum River	9	5	2	2	0	2	1	1	5

FS = found to meet the water quality standard, NS = does not meet the water quality standard and therefore, is impaired. IF = the data collected was insufficient to make a finding, NA = not assessed

Lakes

Lakes are assessed for aquatic recreation uses based on ecoregion specific water quality standards for total phosphorus (TP), chlorophyll-a (chl-*a*) (i.e., the green pigment found in algae), and secchi transparency depth. To be listed as impaired, a lake must fail to meet water quality standards for TP and either chl-*a* or secchi depth.

There are 212 lakes with surface water greater than 10 acres in the watershed; of these, 52 had sufficient water quality data collected to assess whether water quality met State standards. The MPCA's lake monitoring approach is described in more detail in the Rum River Watershed Monitoring and Assessment Report. Table 2-2 below summarizes the ability of the assessed lakes to support aquatic recreation uses in the Rum River Watershed. A complete list of the results of the lake assessment, which includes all available data on the lakes within the Rum River Watershed, can be found in Appendix 3.2 of the Rum River Watershed Monitoring and Assessment Report at: https://www.pca.state.mn.us/water/watersheds/rum-river#overview

Table 2-2 Assessment status of the Lakes in the Rum River Watershed

HUC-10 Subwatersheds	Total Number of Lakes Assessed	Aquatic Recreation Use			Impaired Lakes
		FS	NS	IF	
Mille Lacs Lake	17	12	0	5	
Upper Rum River	5	1	1	3	Twelve*
West Branch Rum River	0	0	0	0	
Stanchfield Creek	6	1	2	3	North and South Stanchfield
Middle Rum River	12	4	4	4	Little Stanchfield**, Baxter, Tennyson*, Green
Cedar Creek	1	1	0	0	
Lower Rum River	17	7	6	4	Skogman, Fannie, Long, Francis, West Hunter, East Hunter

FS = found to meet the water quality standard, NS = does not meet the water quality standard and therefore, is impaired. IF = the data collected was insufficient to make a finding.
*Lakes in red are very shallow, characteristic of wetland conditions and were not able to be modeled for a TMDL.
**Lake in blue needs a site-specific standard in order to prepare a TMDL due to high concentrations of background levels of P throughout the watershed.

Since 2013, the MPCA in coordination with the DNR has substantially increased the use of biological monitoring and assessment as a means to determine and report the condition of the state's lakes. This includes sampling fish communities of multiple lakes throughout a major watershed. The fish-based lake IBI (FIBI) utilizes data from trap net and gill net surveys, which focus on the gamefish community, as well as nearshore surveys which focus on the nongame-fish community. From this data, a FIBI score can be calculated, which provides a measure of overall fish community health. The DNR developed four FIBI tools to assess many different types of lakes throughout the state. More information on the FIBI can be found at the DNR Lake Index of Biological Integrity website. (http://www.dnr.state.mn.us/waters/surfacewater_section/lake_ibi/index.html)

When biological impairments are found, stressors to the aquatic community must be identified. Sixteen lakes were assessed by the DNR using the Fish IBI in the Rum River Watershed. The following table summarizes the results of the study.

Table 2-3: Summary of lakes in the Rum River Watershed assessed with fish-based lake IBI. Red=Fish IBI score is below the standard.

Subwatershed (HUC-10)	Lake Name	Lake ID	DNR Fish IBI Assessment Results	Fish IBI Score	Survey Year
Mille Lacs Lake	Big Pine	01-0157	Fully Support Aquatic Life	66	2011
Mille Lacs Lake	Borden	18-0020	Fully Support Aquatic Life	58	2014
Mille Lacs Lake	Camp	18-0018	Fully Support Aquatic Life	51	2014
Mille Lacs Lake	Round	01-0204	Fully Support Aquatic Life	56, 58	2008, 2013
Mille Lacs Lake	Smith	18-0028	Fully Support Aquatic Life	66	2010
Stachfield Creek	Lory	30-0096	Fully Support Aquatic Life	55	2013
Middle Rum River	Blue	30-0107	Impaired Aquatic Life	14	2013
Middle Rum River	Green	30-0136	Impaired Aquatic Life	17, 22	2007, 2012
Middle Rum River	Lit. Stanchfield	30-0044	Fully Support Aquatic Life	48	2013
Middle Rum River	Spectacle	30-0135	Fully Support Aquatic Life	34, 38	2007, 2013
Lower Rum River	Fannie	30-0043	Fully Support Aquatic Life	48	2013
Lower Rum River	Florence	30-0035	Fully Support Aquatic Life	64	2013
Lower Rum River	Francis	30-0080	Impaired Aquatic Life	22	2013
Lower Rum River	George	02-0091	Fully Support Aquatic Life	39, 37	2008, 2014
Lower Rum River	Long	30-0072	Fully Support Aquatic Life	42	2013
Lower Rum River	Skogman	30-0022	Fully Support Aquatic Life	38	2013

Detailed information on each impaired lake is available in the lake IBI Stressor Report at the following link https://www.pca.state.mn.us/water/watersheds/rum-river.

2.2 Water Quality Trends

According to the Rum River Watershed Monitoring and Assessment Report May 2016, Rum River water chemistry data was analyzed for trends (Table 2-4) for the long-term period of record (1953 through 2010). There were significant decreases in total suspended solids, TP, ammonia, and biological oxygen demand, likely due to wastewater treatment upgrades. Conversely, there were significant increases in nitrates/nitrites and chloride for both stations, however the stream still meets water quality standards.

Increases of chloride in surface waters can be due to road salt runoff and/or discharge from individual drinking water treatment systems, as well as other sources. The MPCA recently completed a Metro Chloride Feasibility Study to obtain a better understanding of the extent, magnitude, and causes of chloride contamination to surface waters in the seven county Twin Cities Metropolitan Area (TCMA), and to explore options and strategies for addressing chloride impacts to water resources. This project included extensive data analysis, a literature review, a telephone survey, and analysis of potential strategies for further research, public education, and potential regulation. The measured concentrations of chloride in the Rum River remain well below the Class 2 aquatic life standard of 230 mg/L. Additional information on the chloride study can be found at the link below. https://www.pca.state.mn.us/water/metro-area-chloride-project-history

The MPCA conducted a study of nitrogen in surface waters so that we can better understand the nitrogen conditions along with the sources, pathways, trends and potential ways to reduce nitrogen in waters. While there is an increasing trend, nitrogen levels in the Rum River Watershed are low compared to other areas of the state. https://www.pca.state.mn.us/news/report-nitrogen-surface-water

Table 2-4 Water quality trends of the Rum River at Isanti and Anoka, green values indicate an improving trend in water quality for that parameter while red values indicate a degrading trend in water quality for that parameter.

	Total Suspended Solids	Total Phosphorus	Nitrite/ Nitrate	Ammonia	Biochemical Oxygen Demand	Chloride
Rum River at Bridge on CSAH-5, 0.5 Mi W of Isanti (period of record 1955 - 2010)						
Overall trend (1953–2010)	decrease	decrease	increase	decrease	decrease	Increase
Estimated total change	-58%	-37%	44%	-77%	-75%	303%
Rum River at Bridge on Pleasant St in Anoka (period of record 1953 - 2010)						
Overall trend (1953–2010)	decrease	decrease	increase	No Trend	decrease	Increase
Estimated total change	-72%	-51%	22%		-65%	606%

Analysis was performed using the seasonal Kendall test for trends. Trends shown are significant at the 90% confidence level. Percentage changes are statistical estimates based on the available data. Actual changes could be higher or lower. A designation of "no trend" means that a statistically significant trend has not been found; this may simply be the result of insufficient data.
Concentrations are median summer (Jun-Aug) values, except for chlorides, which are median year-round values. All concentrations are in mg/L.

Nineteen lakes within the watershed have enough data to determine trends in water clarity. In order for a trend to be detected based on the seasonal Kendall-Mann statistical analysis, lakes needed a minimum of eight years of Secchi transparency data. Lakes with an increasing trend indicate that the water clarity is improving. Lakes with decreasing trend indicate that the lake clarity is getting worse. These lakes are listed below in Table 2-5 and a complete list of lake trend information can be found in Appendix B.

Table2- 5: Trends in Lake Transparency in the Rum River Watershed
Green=Water quality is getting better and Red=Water quality is getting worse

Subwatershed (HUC-10)	Lake Name	Lake ID	Mean Secchi (meters)	Presence of Trend	Trend Slope Description
Mille Lacs Lake	Big Pine	01-0157	3.75	No Trend	
Mille Lacs Lake	Borden	18-0020	2.97	Improving	Weak Evidence
Mille Lacs Lake	Camp	18-0018	2.43	No Trend	
Mille Lacs Lake	Holt	18-0029	2.78	No Trend	
Mille Lacs Lake	Kenney	18-0019	3.18	No Trend	
Mille Lacs Lake	Mille Lacs	48-0002	3.02	Improving	Strong Evidence
Mille Lacs Lake	Miller	18-0021	3.88	No Trend	

Subwatershed (HUC-10)	Lake Name	Lake ID	Mean Secchi (meters)	Presence of Trend	Trend Slope Description
Mille Lacs Lake	Round	01-0204	3.31	Improving	Strong Evidence
Mille Lacs Lake	Smith	18-0028	3.33	No Trend	
Mille Lacs Lake	Whitefish	18-0001	3.73	Improving	Evidence
Stachfield Creek	Lewis	33-0032	2.26	No Trend	
Middle Rum River	Blue	30-0107	1.40	No Trend	
Middle Rum River	Sandy	71-0040	4.45	No Trend	
Middle Rum River	Spectacle	30-0135	3.82	Improving	Strong Evidence
Lower Rum River	East Twin	02-0133	3.62	No Trend	
Lower Rum River	Florence	30-0035	1.62	Improving	Strong Evidence
Lower Rum River	George	02-0091	2.74	Declining	Strong Evidence
Lower Rum River	Pickerel	02-0130	1.23	Improving	Evidence
Lower Rum River	Round	02-0089	3.31	No Trend	

2.3 Stressors and Sources

In order to develop appropriate strategies for restoring or protecting lakes and streams, the stressors and/or sources impacting or threatening them must be identified and evaluated. A **stressor** is something that adversely impacts or causes fish and macroinvertebrate communities in streams to become unhealthy. Biological SID is done for streams with either fish or macroinvertebrate biota impairments and encompasses both evaluation of pollutants and non-pollutant-related (e.g., altered hydrology, fish passage, habitat) factors as potential stressors. Pollutant source assessments are completed where a biological stressor ID process identifies a pollutant as a stressor, as well as for the typical pollutant impairment listings. Sources of pollutants (such as P, bacteria or sediment) to lakes and streams include point sources (such as sewage treatment plants) or nonpoint sources (such as runoff from the land).

Stressors of Biologically-Impaired Stream Reaches

A SID study was conducted to identify the factors (i.e., stressors) that are causing the fish and macroinvertebrate community stream impairments in the Rum River Watershed, including pollutants and non-pollutant-related factors, such as altered hydrology, fish passage, or habitat. Table 2-6 summarizes the primary stressors identified in streams with aquatic life impairments in the Rum River Watershed. Common stressors were low DO, flow alteration, elevated levels of P and nitrogen, and lack of physical habitat.

Table 2-6: Primary stressors to aquatic life in biologically-impaired reaches in the Rum River Watershed

Subwatershed (HUC-10)	Stream Name	Stream AUID	Impairments	Primary Stressors If Impaired Biology				
				Dissolved Oxygen	Altered Hydrology	Elevated Phosphorus	Elevated Nitrogen	Lack of Habitat
Upper Rum River	Tibbetts Brook	07010207-676	Macroinvertebrates		x			x
Upper Rum River	Vondell Brook	07010207-567	Fish			x		x
Upper Rum River	Washburn Brook	07010207-641	Fish		x			x
Upper Rum River	Vondell Brook	07010207-687	Fish			x		x
West Branch Rum R.	Rum River	07010207-525	Macroinvertebrates, *Escherichia coli*		x	x		
West Branch Rum R.	Unnamed creek	07010207-667	Macroinvertebrates		x			x
West Branch Rum R.	Estes Brook	07010207-679	Macroinvertebrates *Escherichia coli*			x	x	
Stanchfield Creek	Stanchfield Creek	07010207-520	Fish	x	x	x		
Cedar Creek	Mahoney Brook	07010207-682	Fish	x		x		
Lower Rum River	Isanti Brook	07010207-592	Macroinvertebrates, Fish	x	x			
Lower Rum River	Trott Brook	07010207-680	Macroinvertebrates, Fish, Dissolved Oxygen	x	x	x		

Pollutant Sources

This section summarizes the sources of pollutants (such as P, bacteria or sediment) to lakes and streams in the Rum River Watershed, including point sources (such as sewage treatment plants) or nonpoint sources (such as runoff from the land).

Point Sources

Point sources are defined as facilities that discharge stormwater or wastewater to a lake or stream and/or have a National Pollutant Discharge Elimination System (NPDES)/State Disposal System (SDS) Permit (Permit). There are currently 37 NPDES point sources in the Rum River Watershed summarized in the following list.

- **Wastewater** – There are 19 municipal wastewater treatment facilities in the watershed. A majority of these permit holders have limits for bacteria, nutrients, and other parameters as well as routine monitoring to ensure wastewater meets the permit requirements.

- **Stormwater** – There are 17 Municipal Separate Storm Sewer Systems (MS4). These larger cities are regulated by NPDES Permits, which reduce the discharge of pollutants from their storm sewer system to the maximum extent practicable.
- **Feedlots** – There is one Concentrated Animal Feeding Operation (CAFO) in the watershed. These larger farms are regulated and are not allowed to discharge to waters of the state.

Nonpoint Sources

Nonpoint sources of pollution, unlike pollution from industrial and municipal sewage treatment plants, come from many diffuse sources. Nonpoint source pollution is accumulated by rainfall or snowmelt moving over and through the ground. As the runoff moves, it picks up and carries away natural and human-made pollutants, finally depositing them into lakes and streams. Common nonpoint pollutant sources in the Rum River Watershed are:

- **Field and stream erosion**: Field erosion can deliver sediment containing TSS and P when soil is disturbed or exposed to wind and rain; stream erosion can deliver sediment from destabilized banks or the transport of deposited sediment in the stream during very high flows. Road ditches can be areas that focus erosion to other bodies of water.
- **Internal loading**: Lake sediments contain large amounts of P that can be released into the lake water through physical mixing or under certain chemical conditions.
- **Upstream lakes and streams**: Some lakes and streams receive most of their pollutants from upstream waterbodies. For these lakes, restoration and protection efforts should focus on improving the water quality of the upstream contributing lake or stream.
- **Stormwater runoff:** Runoff from roads, parking lots and other hard surfaces can carry pollutants to lakes and streams.
- **Ditch maintenance and tile drainage:** Nonpoint source pollution can also occur from ditches and tile drainage through both the rate and type of runoff.
- **Wetland modification:** draining or filling wetlands.
- **Fertilizer and/or manure runoff**: Fertilizer and manure contains high concentrations of P, nitrogen, and bacteria that can runoff into lakes and streams when not properly managed.
- **Failing septic systems**: Septic systems that are not maintained or are failing near a lake or stream can contribute excess P, nitrogen, and bacteria.

2.4 TMDL Summary

A TMDL is a calculation of how much pollutant a lake or stream can receive before it becomes unfishable, unswimmable, or otherwise impaired. State water quality standards define the pollutant concentrations that constitute these conditions. TMDL studies are required by the Clean Water Act for all impaired lakes and streams. The Rum River Watershed TMDL Report was drafted in 2016 and 2017 alongside this WRAPS document, and addresses 10 impaired lakes and 6 impaired streams throughout the Rum River Watershed. For more detail, refer to the TMDL document on the MPCA Rum River Watershed webpage https://www.pca.state.mn.us/water/watersheds/rum-river#overview.

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

Table 2-7: Summary of impaired AUIDs. Waterbodies in **bold** are addressed in the Rum River Watershed TMDL Report.

HUC-10 Subwatershed	Stream/Reach (AUID) or Lake (ID)	Pollutant
Mille Lacs Lake	Borden Creek -554	Dissolved Oxygen
	Cedar Creek -546	Dissolved Oxygen
	Malone Creek -547	Dissolved Oxygen
Upper Rum River	**Bogus Brook -523**	***Escherichia coli***
	Vondell Brook -567	Fish
	Vondell Brook -687	Fish
	Washburn Brook -641	Fish
	Tibbets Brook -676	Fish
	Twelve Lake. 49-0006	Excess Nutrients
West Branch Rum River	**W. Branch Rum -525**	Macroinvertebrates, ***Escherichia coli***
	Unnamed -667	Macroinvertebrates
	Estes Brook -679	Macroinvertebrates, ***Escherichia coli***
Stanchfield Creek	Stanchfield Creek -520	Fish
	S. Stanchfield Lake 30-0138	**Excess Nutrients**
	N. Stanchfield Lake 30-0143	**Excess Nutrients**
Middle Rum River	Tennyson Lake 30-0113	Excess Nutrients
	Baxter Lake 30-0114	**Excess Nutrients**
	Green Lake 30-0136	**Excess Nutrients**
	L. Stanchfield Lake 30-0044	Excess Nutrients
Cedar Creek	**Cedar Creek -521**	***Escherichia coli***
	Crooked Brook -575	Dissolved Oxygen
	Mahoney Brook -682	Fish
Lower Rum River	**Seelye Brook -528**	***Escherichia coli***
	Isanti Brook -592	Fish, Macroinvertebrates
	Skogman 30-0022	**Excess Nutrients**
	Fannie Lake 30-0043	**Excess Nutrients**
	Long Lake 30-0072	**Excess Nutrients**
	Francis Lake 30-0080	**Excess Nutrients**
	Trott Brook -680	Fish, Macroinvertebrates, **Dissolved Oxygen**
	W. Hunter Lake 71-0022	**Excess Nutrients**
	E. Hunter Lake 71-0023	**Excess Nutrients**

2.5 Protection Considerations

Many of the lakes and streams in the Rum River Watershed already meet or exceed water quality goals. Protecting water quality from degrading is typically more cost effective than trying to restore degraded waters. The following list provides a short description of the major water quality protection concerns in the Rum River Watershed that were developed based on input from local partners and the public. These water quality concerns were used to guide the identification and prioritization of strategies in Section 3.3.

- Riparian habitat – The Rum River is a State Wild, Scenic and Recreational River. Preservation and restoration of continuous natural vegetation within the riparian corridor and preservation of floodplains is critical to wildlife, water quality, flood abatement and the scenic nature of the river.
- Protecting watershed hydrology from alteration – Similar to land use changes, alterations from ditching and other forms of drainage can have multiple impacts to downstream water resources. Maintenance of long-neglected ditches is of particular concern, as this can increase rates and volumes of runoff in ways that impact water quality, erode streambanks and increase flood risks.
- Lakes – Cisco lakes, shallow wild rice lakes and recreational lakes near water quality thresholds are priorities for protection.
- Land use changes – Changes in land use, including forested to agriculture, or agriculture to developed, are anticipated to occur in the future. Modeling scenarios have been performed to estimate the impacts of these conversions and should be used by local governments to mitigate these impacts.
- Surface waters used for drinking - In 2009, the U.S. Forest Service published a report titled Forests, Water, and People. This report analyzed the 80 watersheds in Minnesota (HUC 8) for their ability to produce clean water in relation to ownership and development pressure. In this assessment, the Rum River ranks as the second most important watershed in Minnesota for drinking water supply and forested lands based upon four primary metrics: watershed ability to produce clean water; the ability of a watershed to provide drinking water to the most people; the ability of the watershed to provide drinking water on private lands; and development pressure and land owner status.
- Protecting groundwater – Portions of the watershed are important for recharge of regional aquifers, including those serving the Twin Cities metro. It is important to keep water on the land in these areas, and certain areas sensitive to groundwater pollution should not host pollutant-generating facilities. Also, portions of this watershed are known to have high nitrates in the groundwater due to the combination of agricultural land use and sandy soils. The Minnesota Department of Agriculture 2013 Nitrogen Fertilizer Management Plan is the state's blueprint for prevention or minimization of the impacts of nitrogen fertilizer on groundwater.

3. Prioritizing and Implementing Restoration and Protection

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

This section of the report provides the results of such prioritization and strategy development. Because much of the nonpoint source strategies outlined in this section rely on voluntary implementation by landowners, land users and residents of the watershed, it is imperative to create social capital (trust, networks and positive relationships) with those who will be needed to voluntarily implement BMPs. Thus, effective ongoing civic engagement is a critical part of the overall plan for moving forward.

The implementation strategies, including associated scales of adoption and timelines, provided in this section are the result of watershed modeling efforts and professional judgment based on what is known at this time and, thus, should be considered approximate. Furthermore, many strategies are predicated on needed funding being secured. As such, the proposed actions outlined are subject to adaptive management—an iterative approach of implementation, evaluation and course correction.

Strategies presented here will be integrated into local plans and a comprehensive watershed management plan ("One Watershed, One Plan"), to direct actions and obtain funding. The goal is to achieve waters that meet standards for aquatic life, recreation, drinking, industry, agriculture and aesthetic enjoyment.

3.1 Targeting of Geographic Areas

The following list of information and tools gathered throughout the watershed project were used to develop restoration and/or protection strategies for the lakes and streams throughout the watershed.

- The MPCA Monitoring and Assessment Report – detailed water quality data gathered and assessed during the IWM phase https://www.pca.state.mn.us/water/watersheds/rum-river#overview
- SID Report – further investigation of causes of biologically impaired streams – https://www.pca.state.mn.us/sites/default/files/wq-ws5-07010207.pdf
- Lake IBI analysis – investigation of fish IBI on specific lakes – https://www.pca.state.mn.us/water/watersheds/rum-river
- Rum River Watershed TMDL Report – a study that calculates the amount of pollution reduction needed for impaired lakes and streams to meet water quality standards - https://www.pca.state.mn.us/sites/default/files/wq-ws5-07010207.pdf

It is understood that management needs for the Rum River Watershed exceed available resources, and therefore prioritization and focus is necessary to achieve goals in high priority areas. The following subsections provide several methods of prioritizing geographic areas. Later in the report, tables of management strategies were drafted to include those management approaches deemed most important. While this information provides substantial direction, it is expected that local water management authorities will further define the highest priority projects and geographic areas based on scientific, social, political, and financial considerations.

- Lake Prioritization tool – a tool used to determine lake water quality goals and those at most risk for decline (Appendix B).
- HSPF - a comprehensive watershed model of hydrology and water quality.
    - o **HSPF modeling** was used to estimate TP, total nitrogen, total suspended sediment and

runoff throughout the watershed as depicted in Figure 3.1-1 through 3.1-4 and Appendix C and D.

- o **HSPF scenarios** created "what if" models to predict the impact of likely land use changes on water resources (Figure 3.1-5 and 3.1-6). A detailed explanation of each scenario and additional maps can be found in Appendix E. Future Rum River Watershed managers may also explore other management scenarios using HSPF. A simple-to-use HSPF interface tool called Scenario Application Manager (SAM) has also been developed. Using SAM, a number of "what if" scenarios can be explored.

- The Nature Conservancy (TNC) has also developed a tool to score priorities according to specific but multiple cross-cutting needs, and looking for the "sweet spot" where multiple benefits overlap. Priority area mapping was conducted based on criteria and key attributes for determining freshwater priorities. The tool is composed of four primary modules and maps (Fish and Wildlife, Drinking Water and Groundwater Quality, Flooding and Erosion, and Groundwater Quantity) as well as the combined multiple benefit map, Figure 3.1-7. Additional information about this tool can be found in Appendix F.
- A map that identifies the specific waterbodies for short-term and long-term restoration and protections strategies is shown in Figure 3.1-8.
- The DNR Watershed Health Assessment Framework (WHAF). This tool provides a comprehensive overview of the ecological health of Minnesota's watersheds. By applying a consistent statewide approach, the WHAF expands the understanding of processes and interactions that create healthy and unhealthy responses in Minnesota's watersheds. Health scores are used to provide a baseline for exploring patterns and relationships in emerging health trends. A health report card and multiple maps are also available. This online tool can be found at http://www.dnr.state.mn.us/whaf/index.html.

HSPF Modeling

HSPF modeling was used to estimate TP, total nitrogen, total suspended sediment and runoff throughout the watershed shown in the figures below. These four maps combined with a human disturbance score and a biological score were used to develop a targeted map for restoration and protection activities, Appendix D.

Figure 3.1-1 Total Phosphorus (Annual Load lbs./acre)

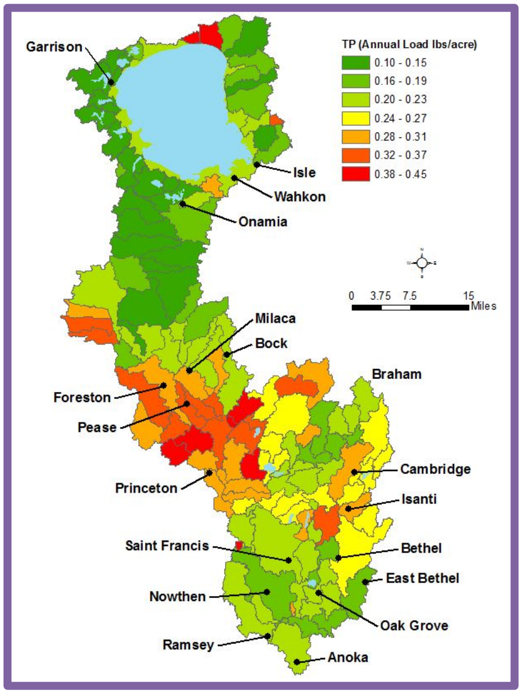


Figure 3.1-2 Sediment (Annual Load lbs./acre)

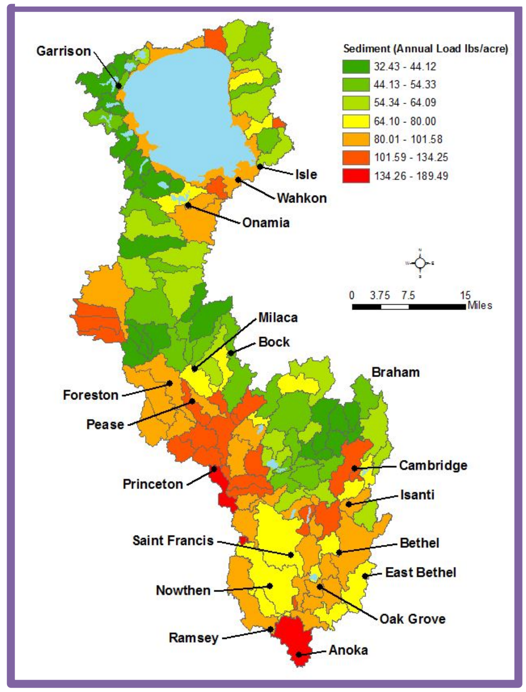


Figure 3.1-3 Annual Runoff (Inches)

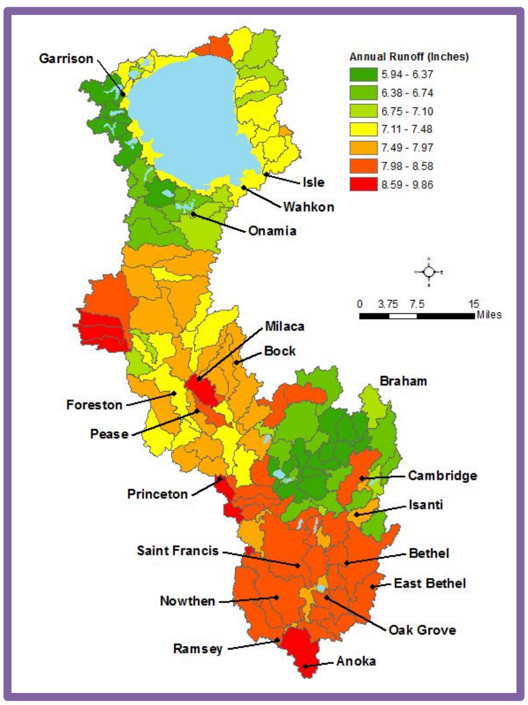
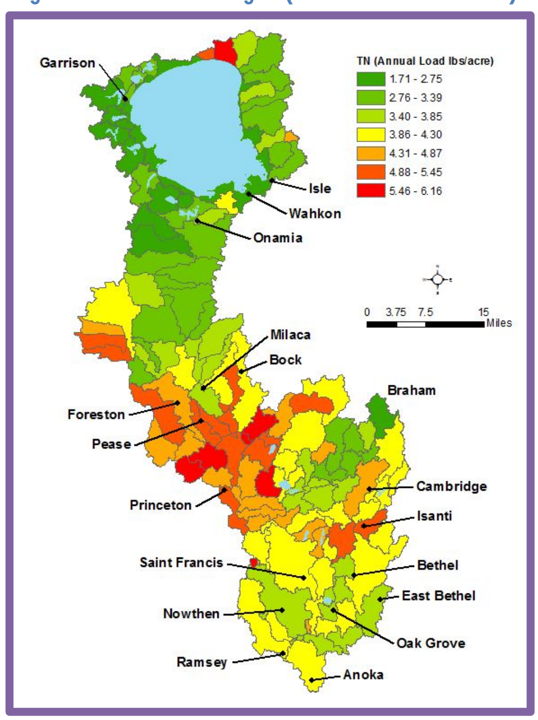


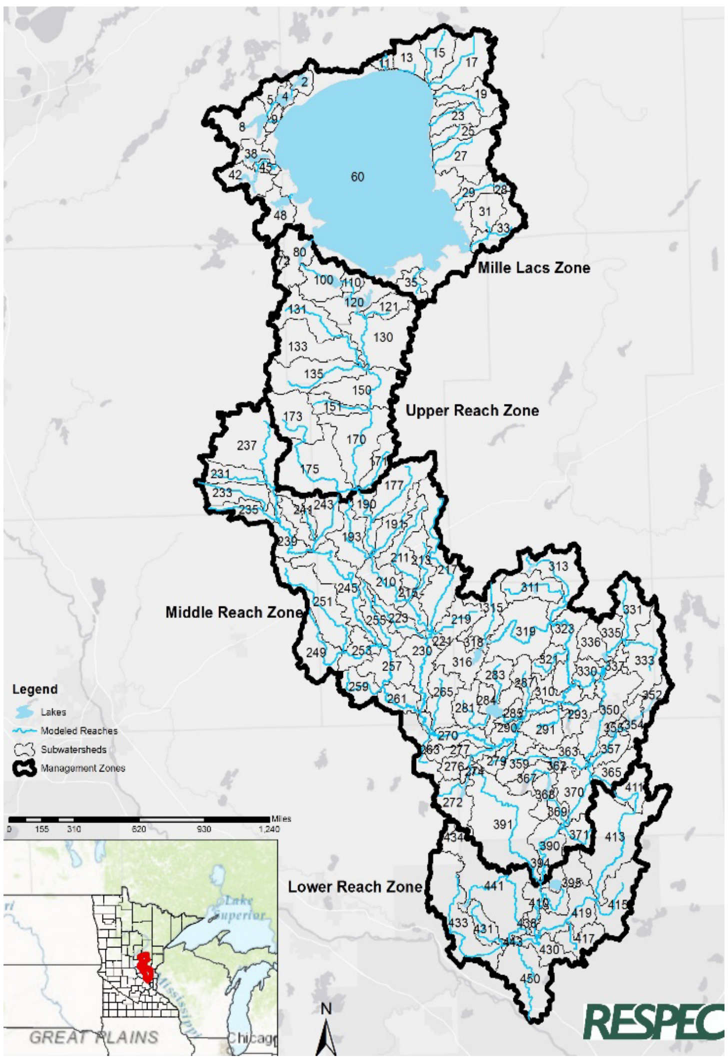
Figure 3.1-4 Total Nitrogen (Annual Load lbs./acre)



HSPF Scenarios

HSPF was also used to create scenarios (Appendix E) to predict impacts on watershed flows and water quality. The Rum River Watershed was divided into four management zones (Figure 3.1-5) with the upper two (Mille Lacs and Upper Reach) sharply differing from the lower two zones (Middle and Lower Reaches) in terms of land cover, runoff responses and water quality. The last downstream reach, the Lower Reach, is dominated by the Anoka Sand Plains, which may exert a large influence on runoff quantity and quality due to high rates of infiltration, filtration and groundwater recharge.

Figure3.1-5 Watershed Management Zones for HSPF Scenarios



The upper management zones primarily reside in the Northern Lakes and Forests ecoregion, and as such have background water quality pollutant values about one-half of those of the Middle and Lower Reach zones. Increased P and sediment (TSS) loading to the more sensitive waters in these the upper two zones would result in degradation, with likely measureable shifts and observable changes noticeable to residents and recreationists. Sensitive fisheries and associated macroinvertebrate communities would be negatively impacted by increased runoff and pollutant loads. Hence, protection efforts should be the primary emphasis in these two zones.

The Middle and Lower Reach waters of the watershed are in the North Central Hardwood Forests ecoregion. While these waters have higher background pollutant levels, increased P and TSS loading to these zones would result in higher stream and lake nutrient and sediment concentrations. These reaches contain the majority of the watershed's impaired waters. Hence, restoration efforts are a primary focus in these reaches, with a secondary focus on protection of waters that currently meet standards.

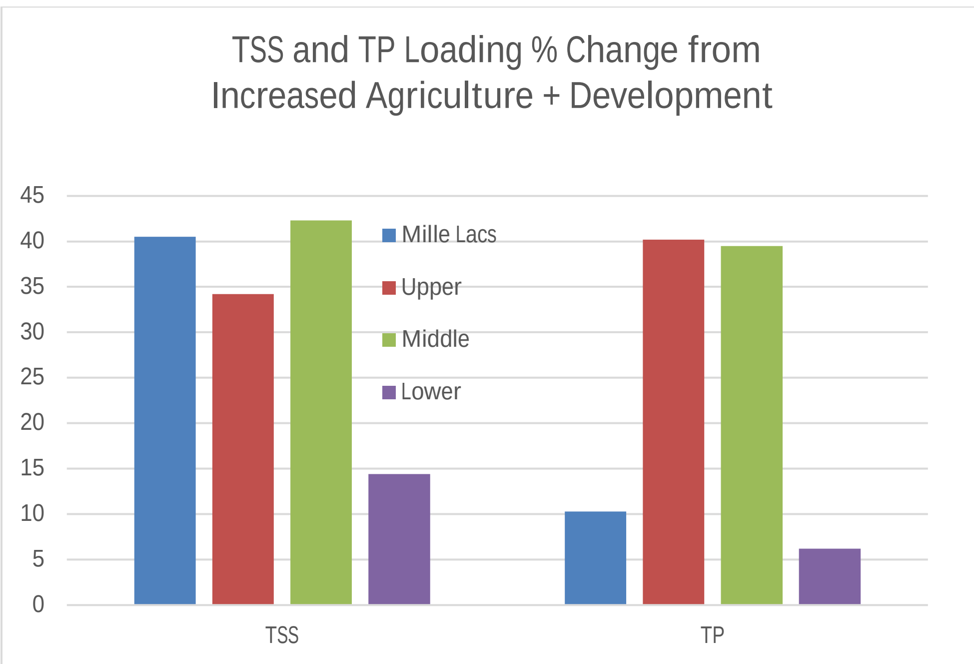
The Lower Reach stretches into the TCMA with greater urban influences and designated MS4 communities/entities.

While TP has been a key lake and stream nutrient, future management efforts should also focus on reducing dissolved P sources. Dissolved P provides a greater algal nutrient 'punch' than particulate P forms in most instances, and may be due to watershed factors such as increased soil P levels, wastewater, legacy sources, degraded wetlands, urban runoff and seasonal runoff from fertilized soils.

Multiple scenarios were developed within each of the four management zones with predicted impacts ranging from relatively low changes (from intensified forest harvest) to substantial TSS and TP load increases predicted from the collective impacts from conversion of various land uses to agriculture and urban development (shown in Figure 3.1-6).

- Predicted percent load increases are depicted in the below graphic by Rum River management zones (Mille Lacs, Upper Reach, Middle Reach and Lower Reach). As may be observed in this graphic, substantial increasing percentages of TSS loads were noted for all but the Lower Reach, where the percent increases are muted by higher flows/loads. A large majority (e.g. 70% to 80%) of this scenario's increased TSS loads were predicted from agricultural runoff.
- TP increase responses by management zone showed a somewhat different pattern. Mille Lacs Reach TP load increases were muted as the result of having little or no agricultural lands eligible for conversion. The 10% increase in TP load represents impacts from future development in the area. However, the Upper and Middle Reaches showed substantial increased TP loading (e.g. nearly 40%) while the Lower Reach again reflected higher existing loads, thus muting percentage increases.

Figure 3.1-6 Percent Increase in TP and TSS with increased land conversion and development scenario



Other key findings from the HSPF scenarios include:

- Implementation of low impact development standards (Minimal Impact Design Standards – MIDS) reduced TSS and TP loads from developed areas.
- Implementation of buffers were predicted to substantially reduce (about 30% and higher) sediment and nutrient loads.

In summary, it is recommended to reduce dissolved P sources to the maximum extent possible. Increasing storm intensities and dry/wet periods present additional challenges, with urban runoff likely adequately addressed by MIDS standards. Addressing the much larger geographic areas' agricultural runoff will require implementation of various agricultural BMPs in treatment trains. One approach may be to specify performance goals by tributary linked to BMP treatment train cumulative reductions, as identified by the Agriculture Department's BMP manual, including general maintenance needs.

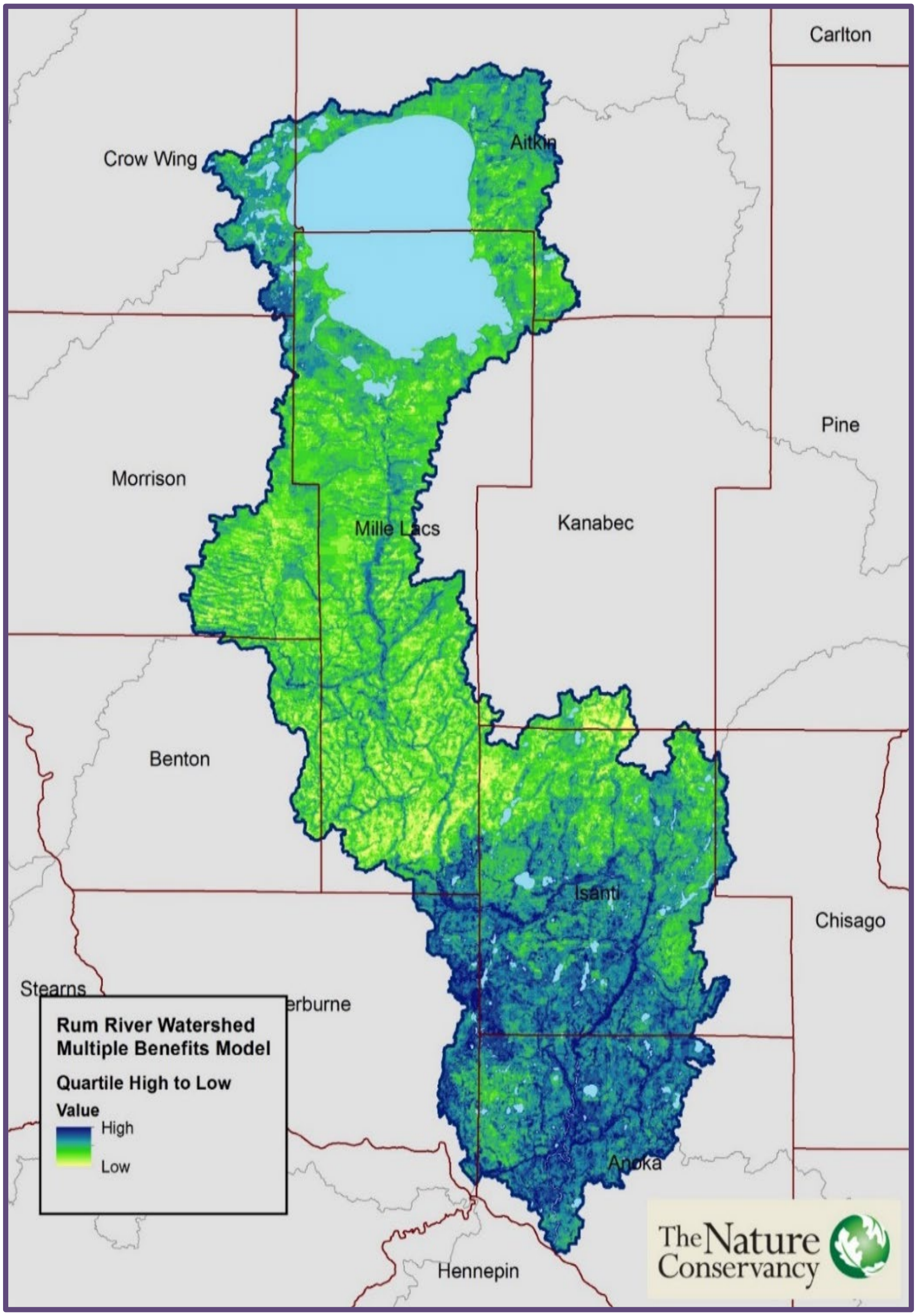


Figure 3.1-7 TNC Multiple Benefits Map

The Nature Conservancy Multiple Benefits Model

TNC's Multiple Benefits Model is a tool composed of four primary modules and maps (Fish and Wildlife, Drinking Water and Groundwater Quality, Flooding and Erosion, and Groundwater Quantity), as well as the combined multiple benefit map as seen below. This tool highlights areas that provide the most benefits (darker blue), and can be used to target areas for protection efforts. For more information, refer to the *Multiple Benefits for People and Nature: Mapping and Modeling Tools to Identify Priorities for TNCs Freshwater Program and the Minnesota Headwaters Fund in Appendix E.*

Targeting Waterbodies – The figure below identifies short-term and long-term priorities for protection and restoration of specific waterbodies. The protection priorities were taken from Section 2.5 of the WRAP (protection considerations), which were based on public input as well as the WRAPS protection strategy document (Appendix B). The restoration priorities were based on the findings in the TMDL.

Figure 3.1-8 Targeted Waterbodies

Short-Term Priorities

Protection:

Blue Lake, Isanti County. Lake near impairment threshold.

Lake George, Anoka County. Lake with declining water quality trend.

Rum River, multiple Counties. Vulnerable to riparian corridor land use changes, habitat degradation and erosion.

Restoration:

S. Stanchfield and Skogman Lake. Waterbodies upstream of impaired waters, where improvements will create benefits in multiple waterbodies.

Impaired waters used for contact recreation.

Long-Term Priorities

Protection:

Rum River, multiple counties. High value fishery and recreation. State Wild and Scenic Recreational River. Subject to land use change and increased drainage. Mentioned frequently in stakeholder feedback during civic engagement efforts.

Cedar Creek, Isanti and Anoka County. Decreasing IBI scores and threshold impairments.

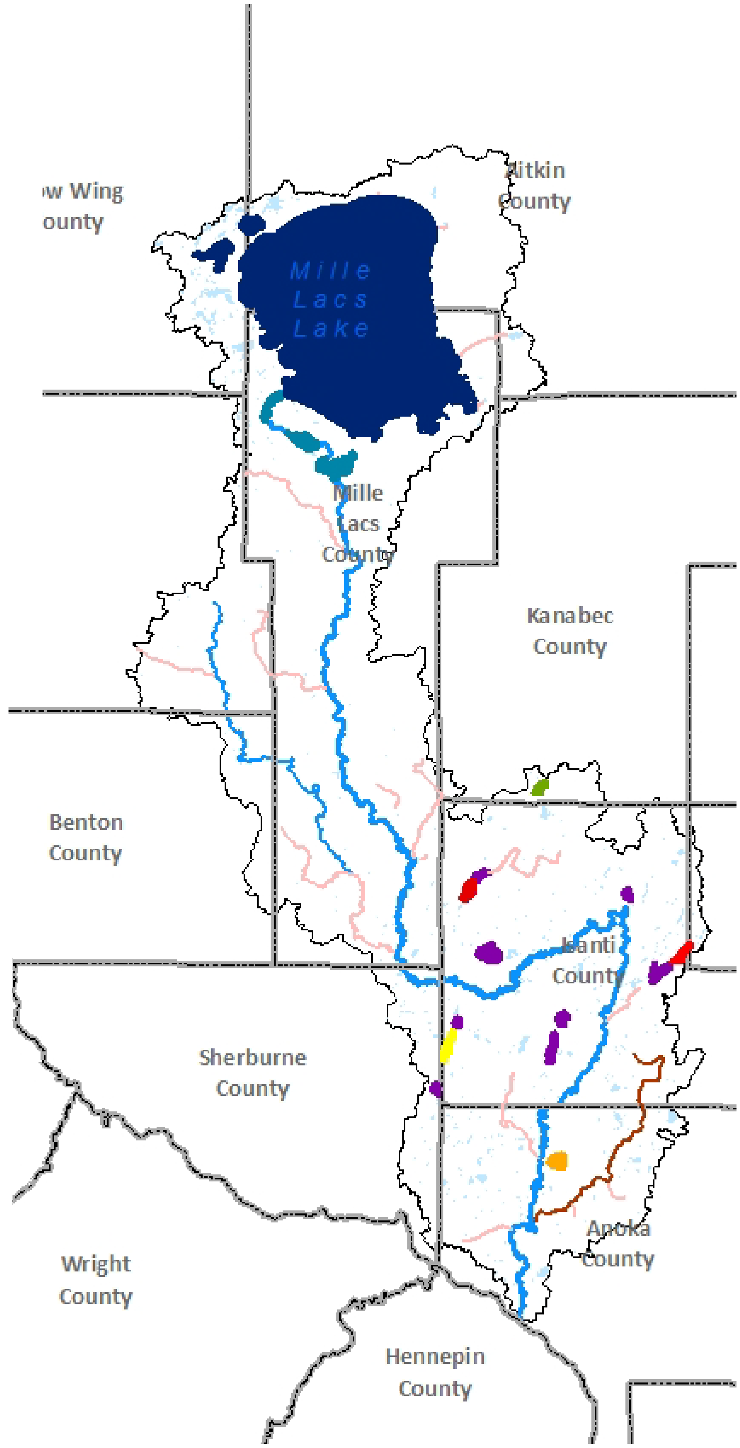
Onamia-Ogeechie-Shakopee chain of lakes in Mille Lacs County. Important to State Parks and Mille Lacs Band of Ojibwe.

Lewis Lake, Kanabec County. Monitoring volunteers and residents note declining water transparency and small watershed makes near lake management critical.

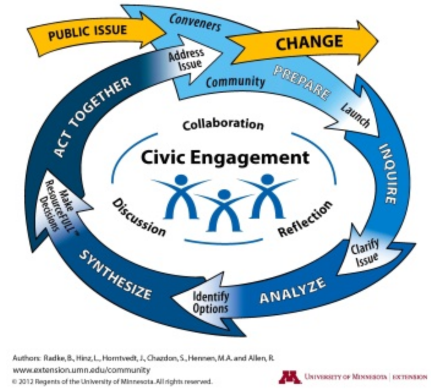
Mille Lacs, Borden and Round Lake. Lakes with Cisco, a sensitive fish species.

Restoration:

All other impaired waters



3.2 Civic Engagement



A key prerequisite for successful strategy development and on-the-ground implementation is meaningful civic engagement. This is distinguished from the broader term 'public participation' in that civic engagement encompasses a higher, more interactive level of involvement. Specifically, the University of Minnesota Extension's definition of civic engagement is "Making 'resourceFULL' decisions and taking collective action on public issues through processes that involve public discussion, reflection, and collaboration." A resourceFULL decision is one based on diverse sources of information and supported with buy-in, resources (including human), and competence. Further information on civic engagement is available at http://www1.extension.umn.edu/community/civic-engagement/.

The Rum River Watershed is made up of numerous local partners who have been involved at various levels throughout the project. A civic engagement workplan was developed in order to provide deliberate opportunities to engage citizens and local partners throughout the watershed during the four-year project. The plan focused on traditional partner and public meetings, one-on-one conversations and presentations with interested citizens and groups, the development of a video and story map, which can be found on the Anoka Conservation District Webpage at: https://www.youtube.com/watch?v=VVHBkHVLGjQ.

A long-term civic engagement plan was developed to encourage in-depth relationships within local communities regarding protecting and restoring water resources in the watershed that will carry this effort forward beyond the four year WRAPS process. The plan has the following seven phases:

Phase one – assessing communities to gain an understanding of the existing groups and interests
Phase two – approaching the community to understand their level of interest/knowledge of watershed issues
Phase three – identifying issues and preferred solutions
Phase four – building trust
Phase five – assist the community in civic empowerment
Phase six – community implementation of water quality projects
Phase seven – continued maintenance and implementation

The following list highlights the meetings that occurred during the Rum River WRAPS process, but excludes dozens of meetings that local partner agencies held with stakeholder groups such as lake associations.

- 8/27/2012 MPCA project intro meeting
- 3/28/2013 Public kickoff meeting
- 8/6/2013 Local partner meeting
- 3/10/2014 Local partner meeting
- 12/18/2014 Local partner meeting
- 6/3/2015 Local partner meeting
- 10/1/2015 TMDL public meeting
- 8/12/2015 Local partner meeting
- 1/28/2016 Local partner meeting
- 2/25/2016 Local partner meeting
- 5/24/2016 Local partner meeting
- 6/23/2016 Local partner meeting
- 9/8/2016 Local partner meeting and Meeting with a subcommittee of Anoka Co Commissioners
- 9/22/2016 Meeting with MS4 communities
- 10/19/2016 Meeting with Isanti County Lakes of concern

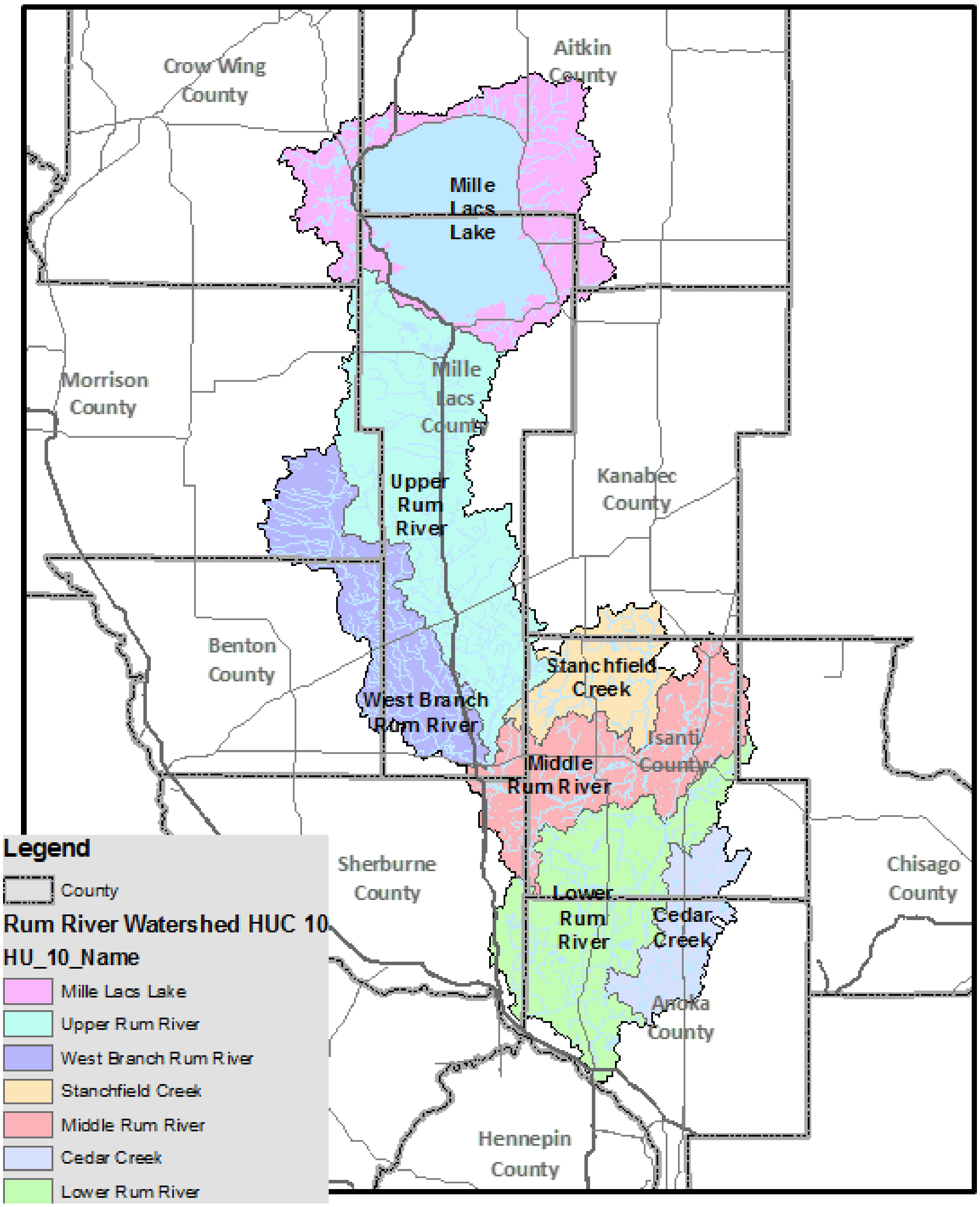
Public Notice for Comments

An opportunity for public comment on the draft WRAPS report was provided via a public notice in the State Register from May 1, 2017 to May 31, 2017.

3.3 Restoration and Protection Strategies

This section provides detailed tables identifying restoration and protection strategies for individual lakes and streams in each HUC10 subwatershed.

Figure 3.3-1 Rum River Watershed by HUC 10 Subwatersheds



Mille Lacs Lake Subwatershed Strategies

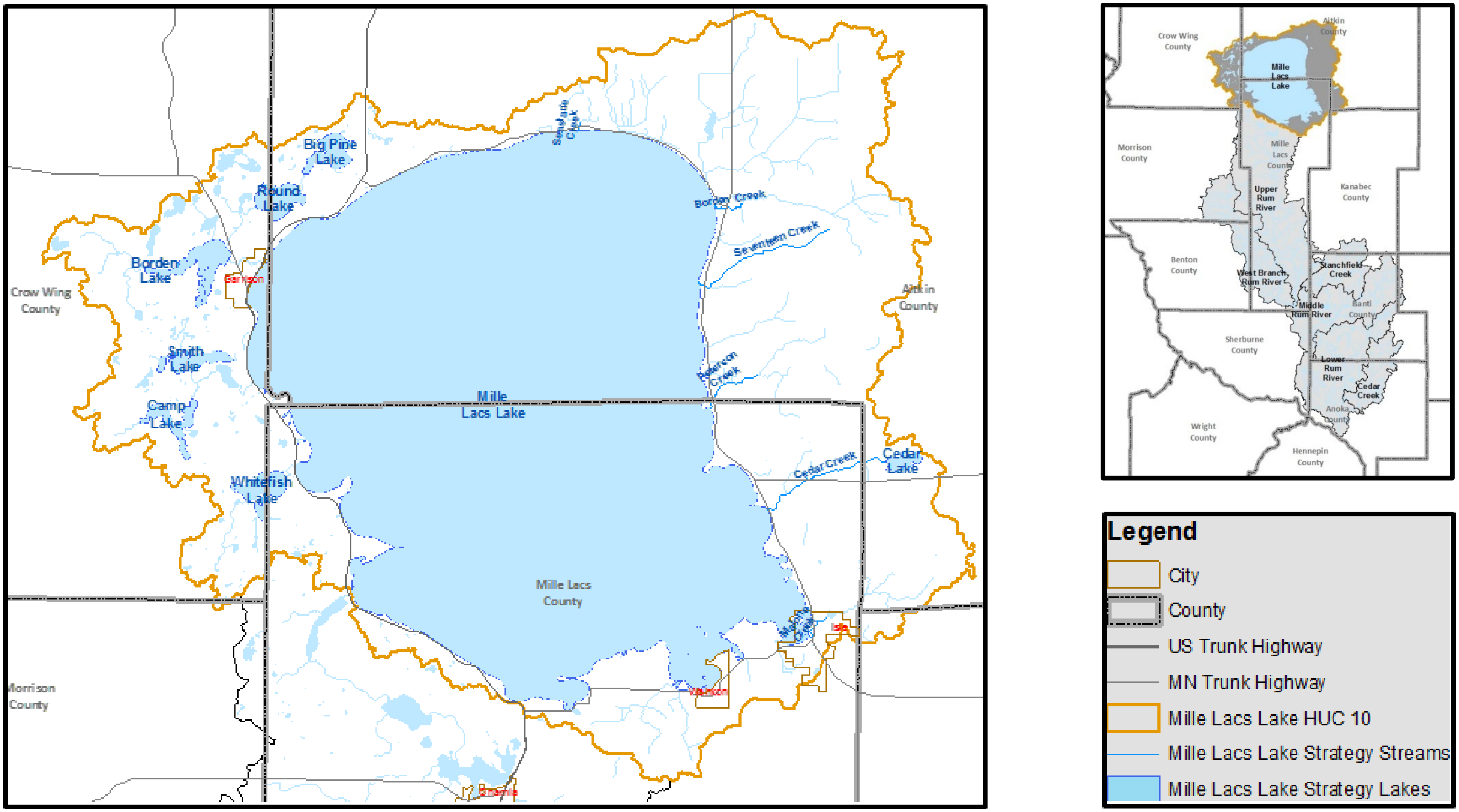
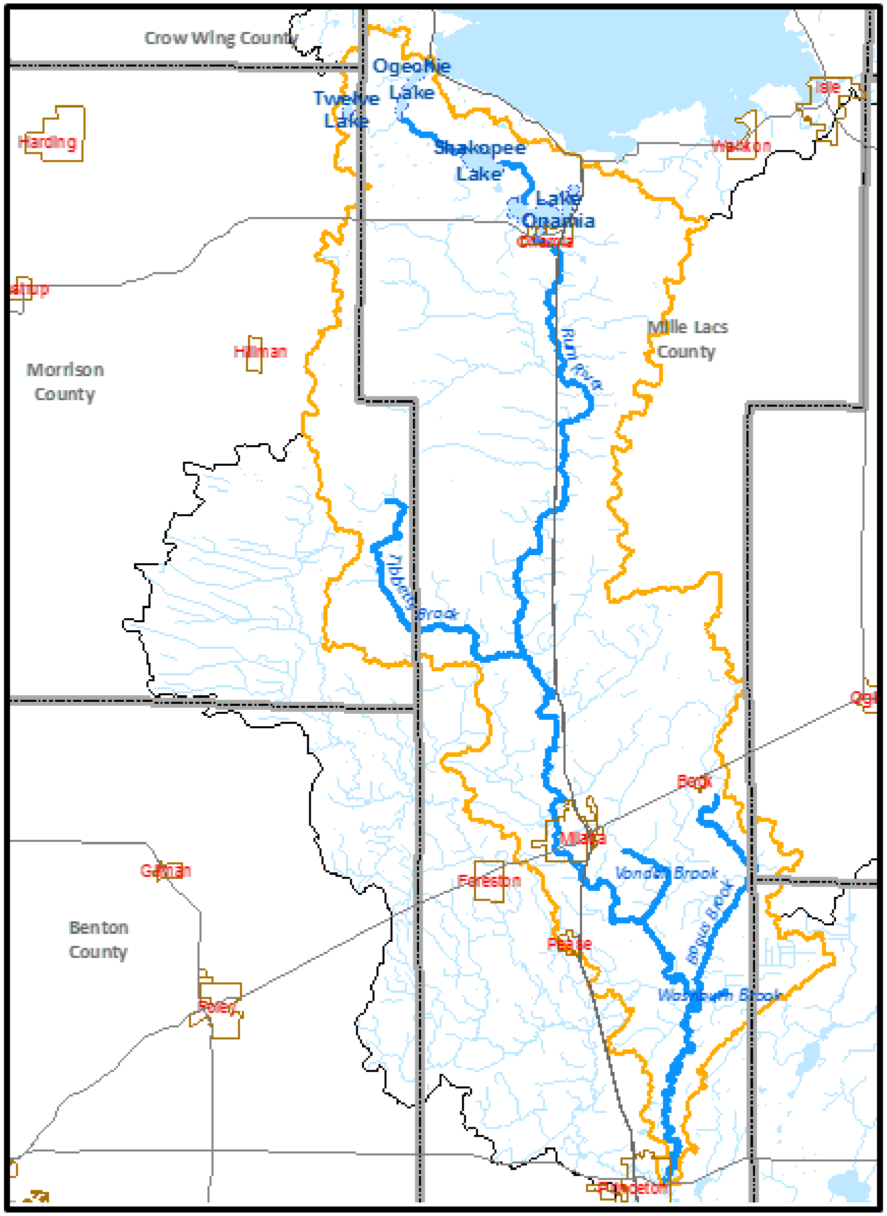


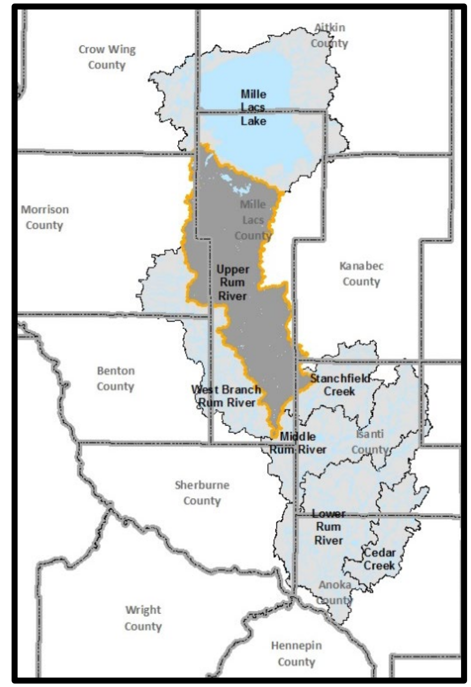
Table 3.3-1: Strategy Table for the Mille Lacs Lake HUC10 Subwatershed.

Waterbody and Location		Parameter	Water Quality		Strategies	Strategy Type	Estimated Scale of Adoption Needed	Primary Responsibility							Time-line to reach WQ goal	Interim 10-yr Mile-stone
Waterbody ID	Location and Counties		Current Conditions	Goals/Targets				MDA	SWCD	MPCA	MS4	County	DNR	Other		
Big Pine 01-0157	Aitkin	TP	TP: 13.5 mg/L	TP: 11.7 mg/L												
Borden 18-0020	Crow Wing	TP	TP: 20.6 mg/L	TP: 17.5 mg/L												
Camp 18-0018	Crow Wing	TP	TP: 14.5 mg/L	TP: 11.2 mg/L												
Cedar 01-0065	Aitkin	TP	TP: 28 mg/L	TP: 26.9 mg/L												
Mille Lacs Lake 48-0002	Aitkin, Crow Wing Mille Lacs	TP	TP: 29.4 mg/L	TP: 24.7 mg/L	See general protection strategies below											
Round 01-0204	Aitkin	TP	TP: 11 mg/L	TP: 9.9 mg/L												
Smith Lake 18-0028	Crow Wing	TP	TP: 17.5 mg/L	TP: 15.1 mg/L												
Whitefish Lake 18-0001	Crow Wing	TP	TP: 19.2 mg/L	TP: 16.3mg/L												
General Protection Strategies for Above Lakes					Urban Stormwater Management Practices	Combination of practices such as raingardens, rain barrels, filter strips.	60% of shoreline owners		x						45 years	35%
					Streambank or Shoreline Protection	Implement erosion stabilization practices	75% of shoreline owners		x				x			40%
						Est. 50' native buffer on shoreline except where shoreline ordinance allows other.	75% of shoreline owners		x							30%
						Easements for priority sites – wild rice habitat and cisco lakes	5% property owners		x							3%
					Subsurface Sewage Treatment Systems	Replace systems deemed Imminent Threat to Public Health and encourage proper maintenance	100% of shoreline owners		x			x				50%
					Forestry Practices	Implement forestry BMPs to control runoff and sediment loading (managed timber harvest, stewardship, etc.)	80% of shoreline owners		x			x	x			60%
					Outreach/CE	Promote active citizenship in lake health BMPs	60% of shoreline owners		x					x		40%

Waterbody and Location		Parameter	Water Quality		Strategies	Strategy Type	Estimated Scale of Adoption Needed	Primary Responsibility							Time-line to reach WQ goal	Interim 10-yr Mile-stone
Waterbody ID	Location and Counties		Current Conditions	Goals/Targets				MDA	SWCD	MPCA	MS4	County	DNR	Other		
Borden Creek 07010207-554	Aitkin	DO	DO exceeds standards and elevated TP	DO at or above 5mg/L	See general strategies below											
Peterson Creek 07010207-559	Aitkin, Mille Lacs	NA	Not Assessed	Reduce TP												
Seastade Creek 07010207-558	Aitkin	NA	Not Assessed	Assessment												
Seventeen Creek 07010207-553	Aitkin	NA	IF for Aquatic Live and NA for Aquatic Recreation.	Assessment												
Cedar Creek 07010207-558	Aitkin, Mille Lacs	DO	Low DO	Assessment												
General Protection Strategies for Above Streams					Streambank or Shoreline Protection	50-ft buffers on all streams and all buffer requirements met	Buffers installed		x						45 years	50% done
						Restore/Maintain riparian wetlands	1 restoration		x			x				1 site
						Streambank stabilization	2 sites fixed						x			1 site
						Address ditching impacts	2 sites fixed		X			X				1 site
					Forestry Practices	Implement forestry BMPs that control runoff and minimize sediment loading to surface waters	80% of shoreline owners		x			x	x			60%
					Monitoring /Data Collection	Collect additional data to develop TMDL	2 years data		x	x						N/A
					Inventory/Mapping	Inventory problem crossing areas	All crossings						x			50%
					Special Projects	Remove beaver dams where appropriate	Dams removed.							x		ID dam sites.
					Livestock Management	Livestock exclusion on streams	2 sites	x	x	x						1 site
						All Minn. R. ch. 7020 manure spreading setbacks are met	All sites meet standards.	x	x	x						Inventory completed.
						Winter manure spreading reduced		x	x	x						
						Total containment of manure storage		x	x	x						
						Inject or immediately incorporate manure where currently surface applied		x	x	x						
Malone Creek 07010207-558	Mille Lacs	DO	Low DO	Assessment	Monitoring /Data Collection	Collect additional data to develop a TMDL	2 years data		x	x					10 years	N/A

Upper Rum River Subwatershed Strategies





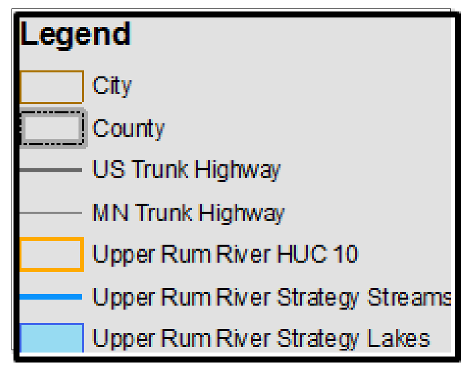
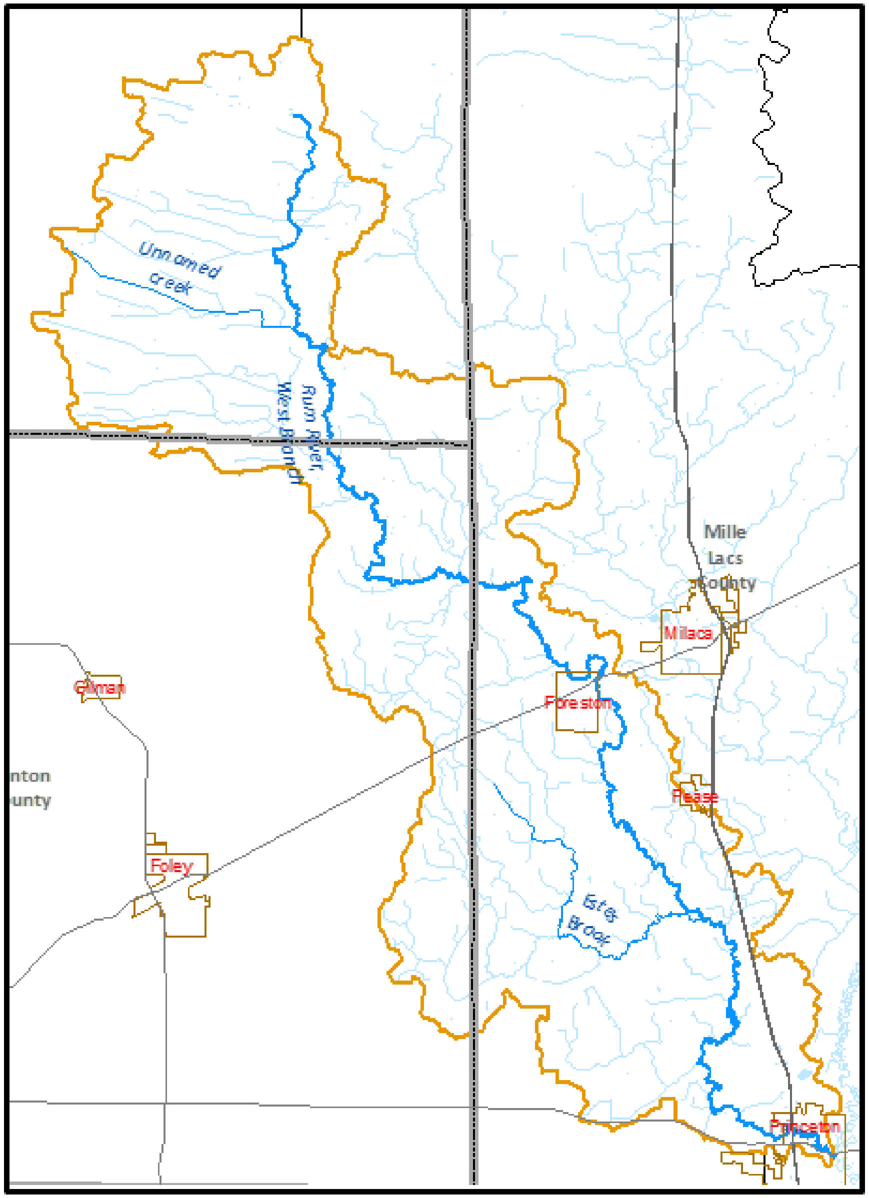


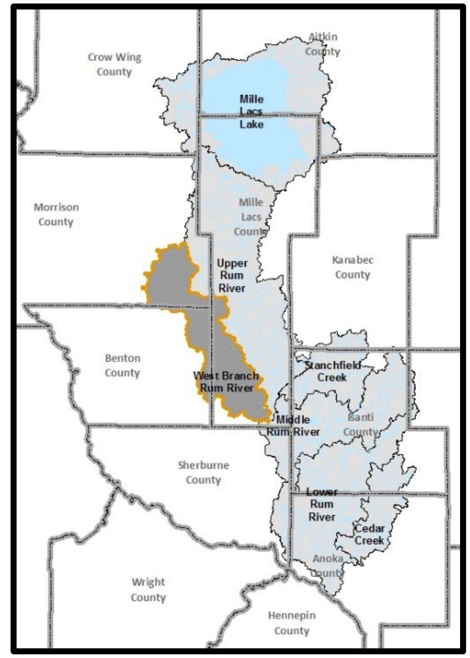
Table 3.3-2: Strategy Table for the Upper Rum River HUC10 Subwatershed.

Waterbody and Location		Parameter	Water Quality		Strategies	Strategy Type	Estimated Scale of Adoption Needed	Primary Responsibility							Time-line to reach WQ goal	Interim 10-yr Mile-stone
Waterbody ID	Location and Counties		Current Conditions	Goals/Targets				MDA	SWCD	MPCA	MS4	County	DNR	Other		
Onamia 48-0009	Mille Lacs	TP	TP: 62 mg/L	TP: 60 mg/L	Urban Stormwater Management Practices	Combination of practices such as raingardens, rain barrels, filter strips.	60% of shoreline owners		x							35%
Ogechie 48-0014	Mille Lacs	TP	TP: 22.2 mg/L	TP: 19.6 mg/L	Inventory/Mapping	Investigate watershed for potential sources of TP	Watershed-wide		x	x			x	x	5 years	All sources of TP identified.
Shakopee 48-0012	Mille Lacs	TP	TP: 37.1 mg/L	TP: 22.7 mg/L												
Twelve 49-0006	Morrison	TP	TP: 52 mg/L	TP: 26.9 mg/L	Streambank or Shoreline Protection	Reduce runoff from surrounding watershed	100% runoff mitigated		x						20 years	50% mitigated.
Rum River	Mille Lacs	MSHA and TP	MSHA scores are rated "good". TP exceeds standard TSS has exceeded standard	Keep MSHA scores in "good: rating. Reduce TP to fall below standard. Reduce TSS to below standard.	Regulations/Ordinances/ Enforcement	Ensure new gravel extraction does not increase sediment or P loading.	100% compliance					x			10 years	100% compliance.
						Ensure compliance with shoreland, floodplain, and wild and scenic ordinances.						x	x			
						Ensure new and active commercial operations (sawmills) are operating with BMPs.						x				
						Collaborate with community development authorities to encourage planned development to protect forested corridors and key runoff treatment areas.						x				
						Ensure active and brownfields (inactive) junkyards do not contribute pollutants to the watershed.						x				
					Streambank or Shoreline Protection	Investigate cause of severely unstable channel at 13UM045 monitoring location.	Investigation completed						x		5 years	Investigation completed.
						Restore segment of the Rum River due to outdated rail bridge.	Restoration complete.						x		20 years.	
Bogus Brook 07010207-523	Kanabec, Mille Lacs	*E. coli*	Exceeded Geo Mean 11/16 samples	Geo Mean <126/100 ml and Ind. <1,260/100 ml	Monitoring /Data Collection	Investigate possible *E. coli* incorporated into old beaver dams south of Bock from historic wastewater discharge.	86%, 59%, 2%, and 51% reductions in V. high, high, mid and low flows.		x						30 years	Exceedance in < 25% samples
					Subsurface Sewage Treatment Systems	Replace all systems deemed Imminent Threat to Public Health (e.g., straight pipes, surface seepage)						x				
						Encourage proper septic system maintenance						x				

Waterbody and Location		Parameter	Water Quality		Strategies	Strategy Type	Estimated Scale of Adoption Needed	Primary Responsibility							Time-line to reach WQ goal	Interim 10-yr Mile-stone
Waterbody ID	Location and Counties		Current Conditions	Goals/Targets				MDA	SWCD	MPCA	MS4	County	DNR	Other		
					Livestock Management	Manure management; rotational grazing and livestock exclusion (pasture management)		x	x							
						Conduct feedlot inspections to ensure compliance with Minn. R. ch. 7050		x	x	x						
Vondell Brook 07010207-567 and -687	Mille Lacs	Elev. Nutrients (Fish IBI)	TP standard exceeds .1mg/L standard	Reduce TP levels to below .1mg/L	Streambank or Shoreline Protection	Increase riparian buffers	Watershed wide riparian management.		x						30 years	TP levels reduced
					Inventory/Mapping	Regular inspection and maintenance intervals per ditch law; consider conservation redesign.						x				
		Poor Habitat (Fish IBI)	MSHA score = 65.4 and 56.1	Increase MSHA score > 66	Livestock Management	Rotational grazing and livestock exclusion (pasture management)		x	x							MSHA score >66
Washburn Brook 07010207-641	Mille Lacs	Poor Habitat (Fish IBI)	MSHA score = 14	Increase MSHA score > 66	Streambank or Shoreline Protection	Increase vegetation adjacent to streams.	75% increase of riparian vegetation		x						30 years	MSHA score is >14
		Altered Hydrology (Fish IBI)	100% channelized		Special Projects	Design and construct a two-stage ditch to allow for the movement of sediment and less frequent clean-outs and could possibly allow for biological recolonization.	Design completed and constructed.		x						50 years	
Tibbetts Brook 07010207-676	Morrison and Mille Lacs	Alt. Hydro Fish and Invert IBI	IBI=9	IBI=40	Special Projects	Increase baseflow	Watershed wide riparian management.		x						30 years	IBI >9
						Manage beaver dams							x			
Tibbetts Brook 07010207-677		Poor Habit Fish IBI	IBI-22.8	IBI-52	Livestock Management	Rotational grazing and livestock exclusion (pasture management)		x	x							IBI>23

West Branch Rum River Subwatershed Strategies





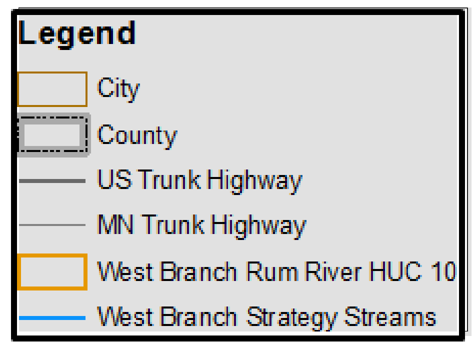


Table 3.3-3: Strategy Table for the West Branch Rum River HUC10 Subwatershed.

Waterbody and Location		Parameter	Water Quality		Strategies	Strategy Type	Estimated Scale of Adoption Needed	Primary Responsibility							Time-line to reach WQ goal	Interim 10-yr Mile-stone
Waterbody ID	Location and Counties		Current Conditions	Goals/Targets				MDA	SWCD	MPCA	MS4	County	DNR	Other		
Unnamed Ck. Trib. to W. Branch Rum River 07010207-667	Morrison	Alt. Hydro at low flow for MIBI	IBI=34.4	IBI=53	Special Projects	Provide treatment areas to control the release of water through the channelized areas.	Improve hydrology of channelized areas to manage for low flows.		x						>40 years	IBI=40
		Poor Hab. MIBI			Streambank or Shoreline Protection	Install a minimum of 25 ft. buffer along channel/stream.			x							
Estes Brook 07010207-679	Mille Lacs	Invert	IBI=43	IBI=53	Streambank or Shoreline Protection	50 ft. buffer along stream and all buffer requirements met.	100% of required buffers installed		x						30 years	IBI-50
		E. coli	Exceeded the Geo Mean 14/16 samples	Geo Mean: 126/100 ml Individual 1,260/100 ml	Livestock Management	Conduct feedlot inspections to ensure compliance with Minn. R. ch. 7050	76%, 93% and 81% reduction in V. high, mid and low flow	x	x	x					25 years	Exceedance in only 50% samples
						Implement BMPs such as cattle exclusion to restore habitat along shoreline and reduce runoff.		x	x							
Rum River West Branch 07010207-525	Mille Lacs	Alt. Hydro at low flow for MIBI	IBI=34.4	IBI=53	Streambank or Shoreline Protection	Improve drainage management to store and control the release of water through channelized areas	50% increase of native riparian vegetation		x						>40 years	IBI=40
					Special Projects	Investigate historic impoundments at Bogus Brook 31										
					Wetland Restoration/Creation	look for opportunities to do wetland restorations/wetland banking			x							
		Elev. Nutr. at peak flow			Streambank or Shoreline Protection	Install a minimum of 25 ft. buffer along channel/stream.	25 ft. new buffer and no net loss existing buffers.		x						20 years	10 ft.
		E. coli	Exceeded the Geo Mean 21/39 samples	Geo Mean: 126/100 ml Individual 1,260/100 ml	Livestock Management	Manure management; rotational grazing and livestock exclusion (pasture management)	20% reduction in high and mid flows and 35% and 15% in low and v. low flows	x	x					x	30 years	Exceedance in only 25% samples
						Conduct feedlot inspections to ensure compliance with Minn. R. ch. 7050		x		x		x				
					Streambank or Shoreline Protection	Stabilize eroding streambanks with native vegetation plantings; forested plantings on outside river bends; no variances for buildings on outside bends.			x							
					Regulations/Ordinances/ Enforcement	Ensure new gravel extraction does not increase sediment or P loading.						x				

Waterbody and Location		Parameter	Water Quality		Strategies	Strategy Type	Estimated Scale of Adoption Needed	Primary Responsibility							Time-line to reach WQ goal	Interim 10-yr Mile-stone
Waterbody ID	Location and Counties		Current Conditions	Goals/Targets				MDA	SWCD	MPCA	MS4	County	DNR	Other		
					Regulations/Ordinances/ Enforcement	Ensure active and brownfields (inactive) junkyards do not contribute pollutants to the watershed.				x						
					Regulations/Ordinances/ Enforcement	WWTP status check and need for infrastructure upgrades (Foreston)				x						

Stanchfield Creek Subwatershed Strategies

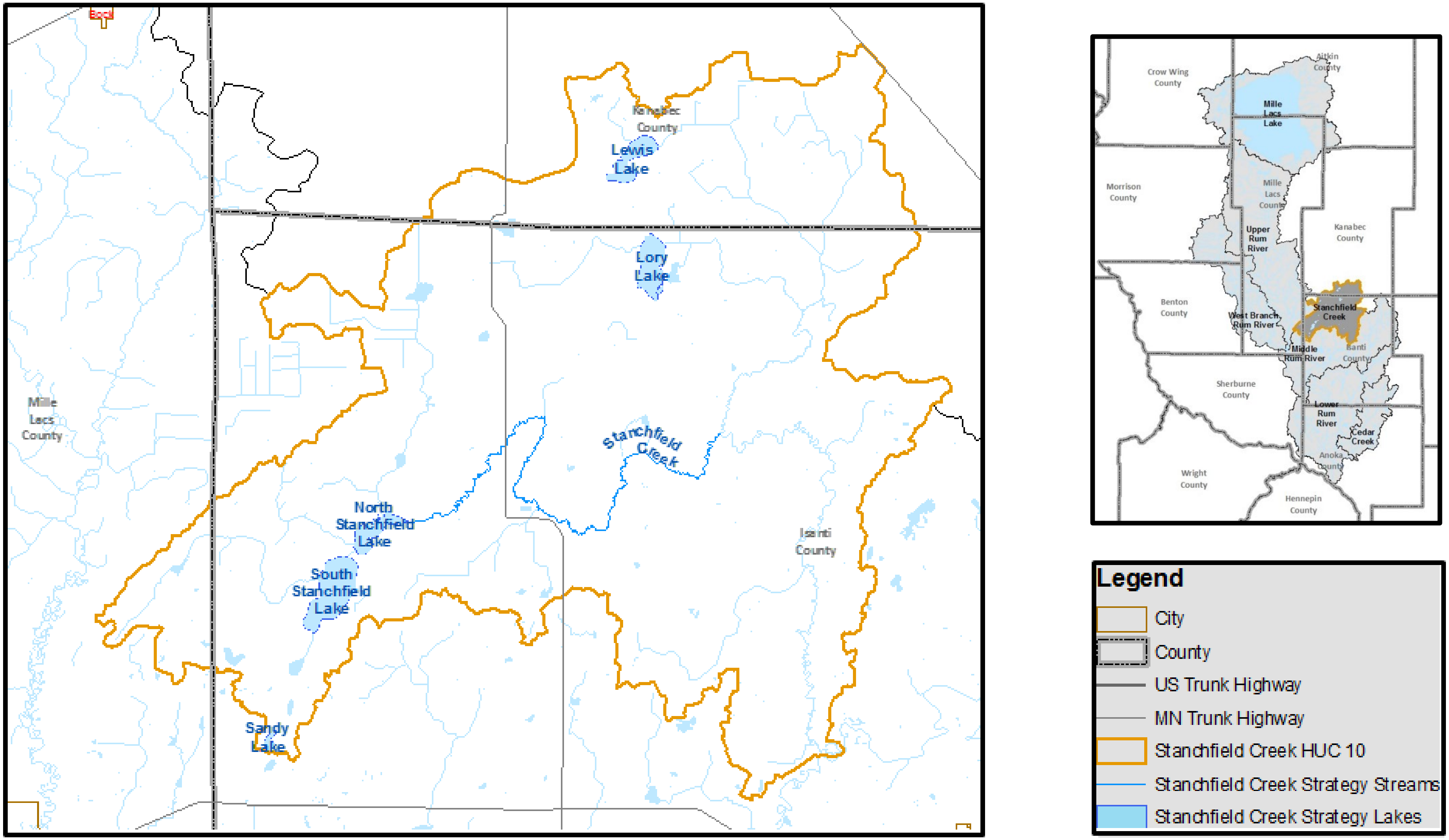
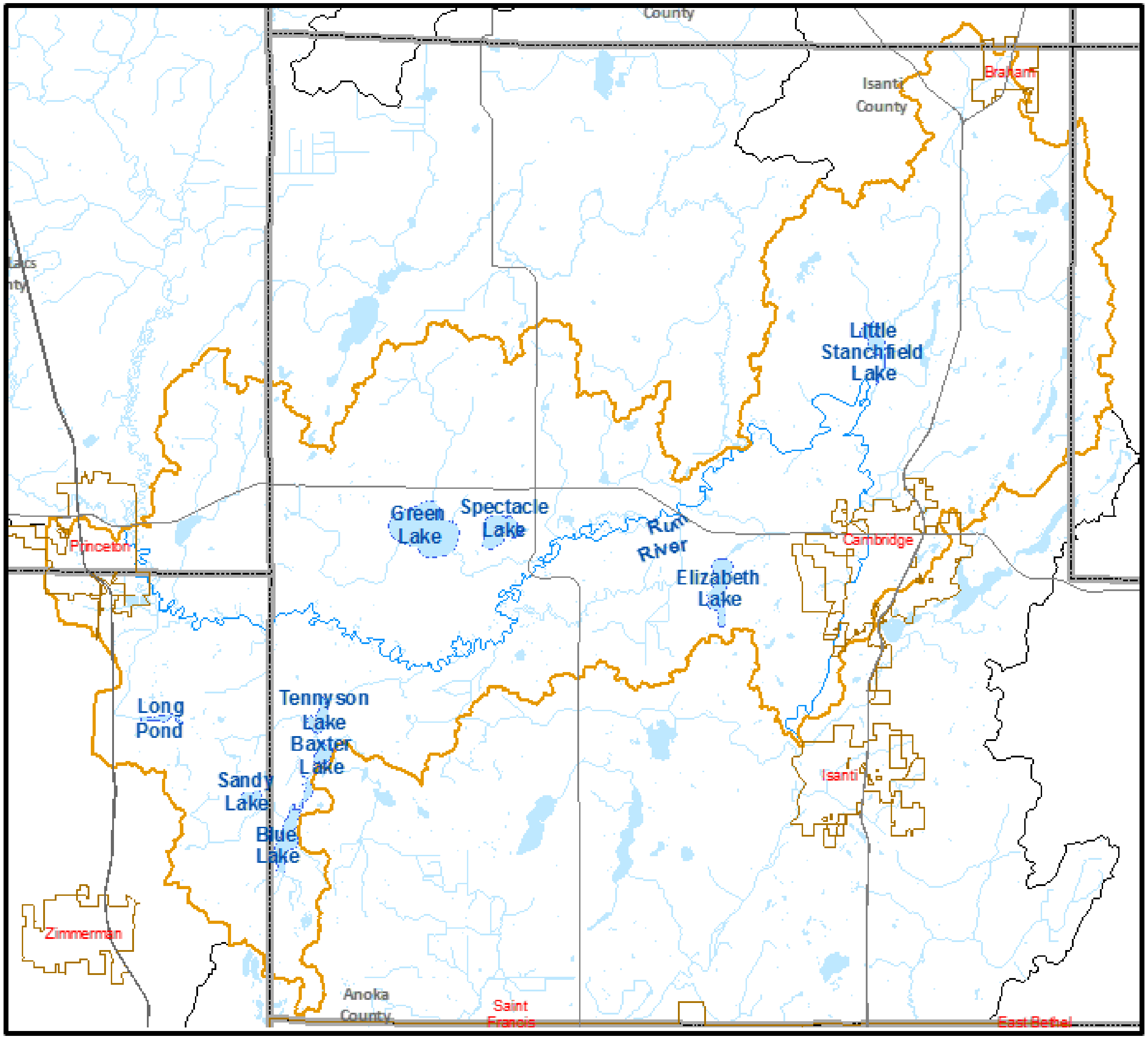


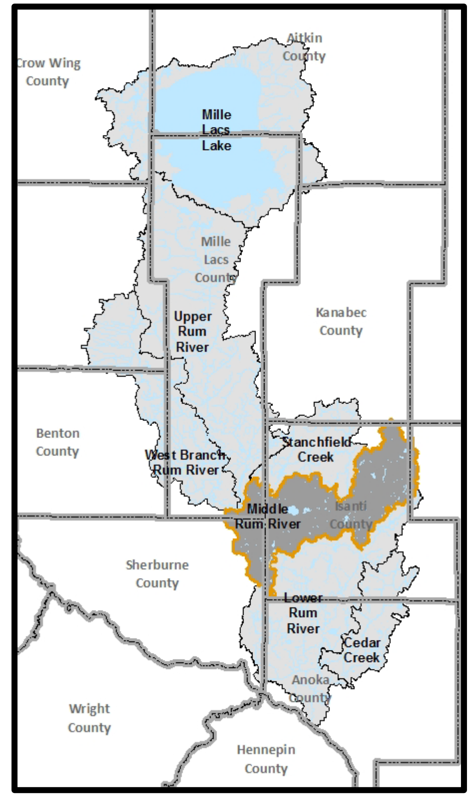
Table 3.3-4: Strategy Table for the Stanchfield Creek HUC10 Subwatershed.

Waterbody and Location		Parameter	Water Quality		Strategies	Strategy Type	Estimated Scale of Adoption Needed	Primary Responsibility							Time-line to reach WQ goal	Interim 10-yr Mile-stone
Waterbody ID	Location and Counties		Current Conditions	Goals/Targets				MDA	SWCD	MPCA	MS4	County	DNR	Other		
Lewis 33-0032	Kanabec	TP	TP=29.7mg/L	TP=22.6mg/L	Monitoring/Data Collection	This waterbody is a high priority for trend monitoring due to reports of declining transparency.	5 years of lake and inlet monitoring.		x						5 years	TP <27 mg/L
					Streambank Shoreland protection	Secure easements or similar measures to maintain natural shoreland habitat and buffers. Lake has a small, mostly forested watershed sensitive to large land use changes.	No net loss of existing forested areas.		x						>30 years	
Lory 30-0096	Isanti	TP	TP=41.9mg/L	TP=22.8mg/L	Streambank Shoreland protection	Secure easements or similar measures to maintain natural shoreland habitat and buffers.	20% increase buffers.		x				x		30 years	TP<38 mg/L
					Inventory/Mapping	Assess locations and benefits from agricultural BMPs.	Assessment completed		X							
North Stanchfield 30-0143	Isanti	TP	TP=193.8mg/L	TP < 60mg/L	Streambank or Shoreline Protection	Implement strategies for South Stanchfield Lake	75% reduction in watershed loading		X						>40 years	TP<180 mg/L
					Wetland Restoration/Creation	Evaluate upland wetlands for impairment. Restore wetlands in or near drainage ways to the lake			x	x						
					Special Projects	Consider rough fish and curly-leaf pondweed management							x			
						Encourage conservation drainage practices and buffers on ditches			x			x				
South Stanchfield 30-0138	Isanti	TP	TP=112.9mg/L	TP < 60mg/L	Livestock Management	Livestock exclusion - focus on southwest side of the lake	44% reduction in watershed loading	x	x						>40 years	TP < 100 mg/L
					Special Projects	Fix perched culvert at inlet of Leisure Heath Lake and consider water drawdown			x			x	x	x		
						Widespread adoption of BMPs that increase infiltration and build soil health.			x					x		
					Streambank or Shoreline Protection	Shoreline habitat protection in developing areas			x			x				
					Regulations/Ordinances/Enforcement	Consider development standards that further protect shoreland						x				
Sandy 71-0040	Sherburne	TP and sediment runoff	TP=13.6mg/L	TP=10.4mg/L	Streambank or Shoreline Protection	Native vegetation plantings	Watershed wide.		x						25 years	TP <12 mg/L
						Reduction of erosion "hot spots"			x							
						Protect existing stands of native plants										
					Education/Information	Develop relationship with lake association and develop educational strategy			x							
	Isanti, Kanabec	Elevated	IBI=36	IBI=42	Wetland Restoration/Creation	Minimize wetland drainage (channelization) including maintenance of	No net loss of wetlands.		x	x		x			20 years	IBI-39

Waterbody and Location		Parameter	Water Quality		Strategies	Strategy Type	Estimated Scale of Adoption Needed	Primary Responsibility							Time-line to reach WQ goal	Interim 10-yr Mile-stone
Waterbody ID	Location and Counties		Current Conditions	Goals/Targets				MDA	SWCD	MPCA	MS4	County	DNR	Other		
Stanchfield Creek 07010207-520		Nutrients (Low Fish - IBI)				neglected historic ditches, particularly in headwaters and fluctuating water levels.										
						Initiate wetland restoration work in headwaters area and tributaries	2 restoration projects.		x							
					Streambank or Shoreline Protection	Reconnect creek to historical channel (currently a short cut exists that bypasses the historic channel)	Restoration completed.						x			
					Streambank or Shoreline Protection	Restore straightened sections of stream channel							x			
						Ensure ditched areas in north watershed (tributaries) are buffered with perennial vegetation	100% required buffers		x							
						Install agricultural BMPs to problem areas	All sites in compliance					x				
					Special Projects	Acquire easements areas around Dalbo WMA	1 easement		x					x		
					Wastewater BMPs	Look into sewage treatment ponds at Dalbo as to sources of elevated nutrients	100% compliance			x		x				

Middle Rum River Subwatershed Strategies





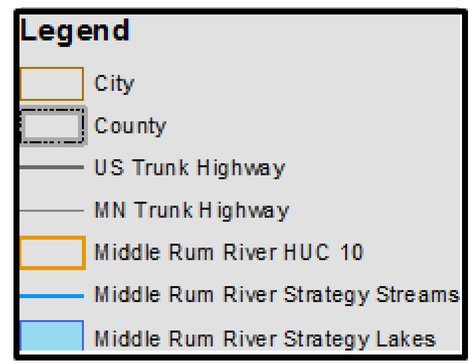


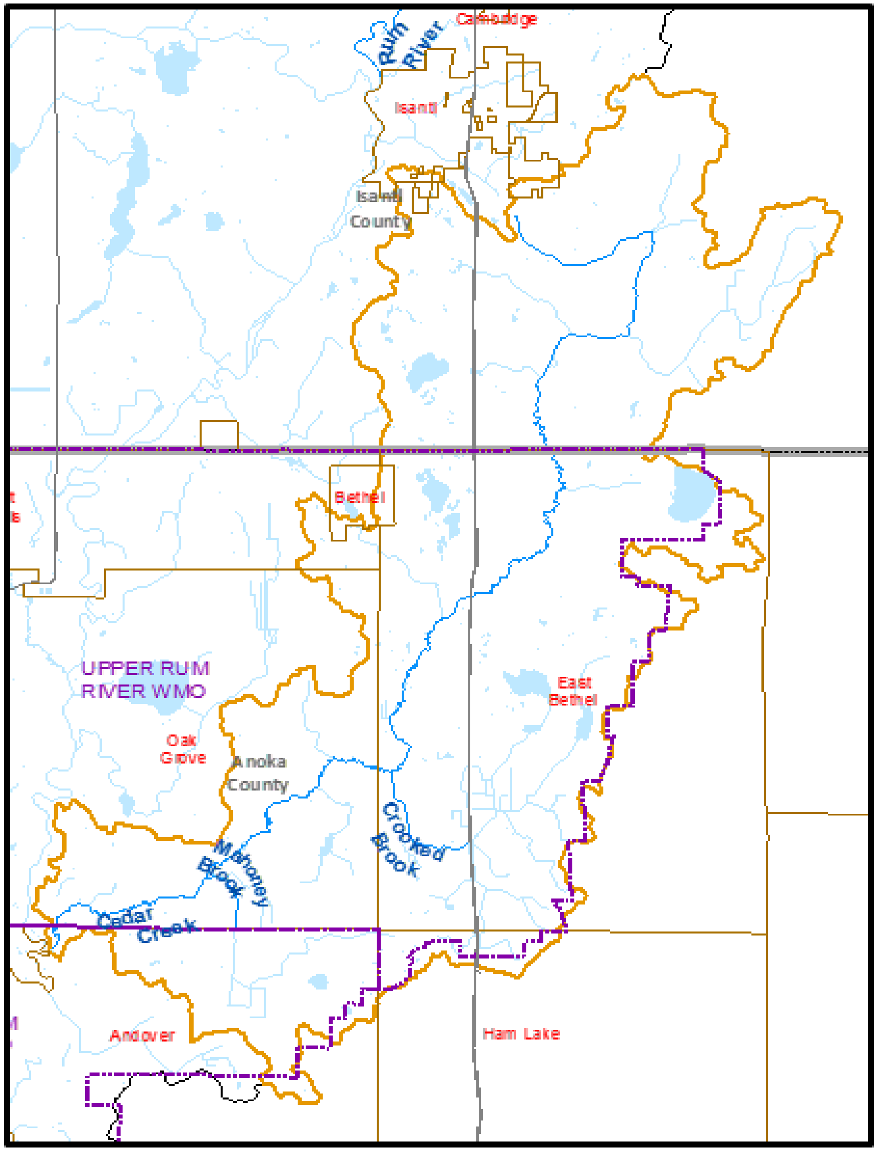
Table 3.3-5: Strategy Table for the Middle Rum River HUC 10 Subwatershed.

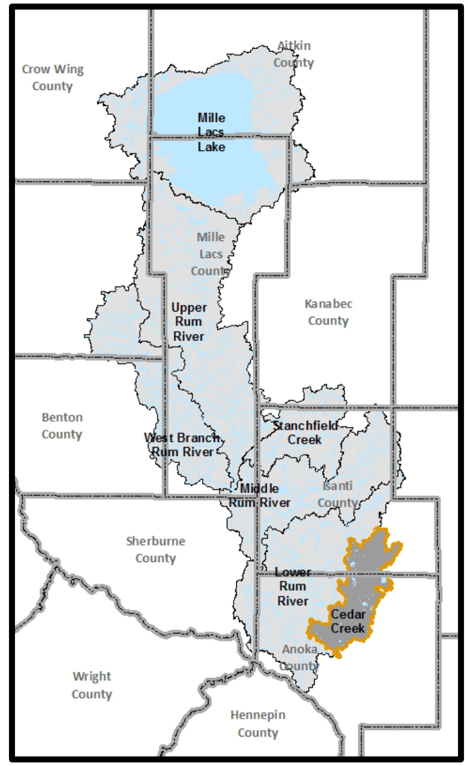
Waterbody and Location		Parameter	Water Quality		Strategies	Strategy Type	Estimated Scale of Adoption Needed	Primary Responsibility							Time-line to reach WQ goal	Interim 10-yr Mile-stone
Waterbody ID	Location and Counties		Current Conditions	Goals/Targets				MDA	SWCD	MPCA	MS4	County	DNR	Other		
Blue 30-0107	Isanti	TP	TP=41.1mg/L	TP=31.4mg/L	Monitoring /Data Collection	Continue monitoring at tributary locations to inform restoration practices and ensure this near-impaired lake remains unimpaired.	5 years data.		x						25 years	TP=35 mg/L
					Special Projects	Increase acres of conservation easements and forest health focusing on management of high quality forested areas	Minimum of 25% of watershed forested.		x					x		
						Consider alum or iron treatments to prevent internal recycling of P after watershed sources addressed.	Treatment options investigated.		x				x			
						Implement strategies that include soil health, filter strips, cover crops etc.	Watershed wide.		x							
					Urban Stormwater Management Practices	Install near-lake stormwater treatment BMPs, including those already identified by Isanti and Sherburne SWCDs.	75% BMPs installed.		x							
					Regulations/Ordinances/ Enforcement	Pursue adoption of new development standards to keep stormwater on-site during new development and other MIDs standards/BMPs	Standards adopted.					x				
					Wetland Restoration/Creation	Wetland restoration or other applicable BMP, particularly in or near drainage ways to the lake.	Minimum 1 restoration project.		x					x		
Elizabeth 30-0083	Isanti	TP	TP=15mg/L	TP=14.1mg/L	Special Projects - Shoreland protection	Secure shoreland protection through easement, fee title purchase, or other means.	Minimum 1 easement.							x	10 years	TP=14 mg/L
Green 30-0136	Isanti	TP	TP=51mg/L	TP < 40mg/L 39% reduction in TP	Monitoring /Data Collection	Complete and implement subwatershed assessment on North Brook and Wyanett Creeks to identify rural BMPs.	39% reduction in watershed TP		x						20 years	TP <45 mg/L
						Complete monitoring on North Brook and Wyanett to identify priority starting point.			x							
					Streambank or Shoreline Protection	Install near-lake stormwater treatment BMPs including those already identified by Isanti SWCD.			x							
					Wetland Restoration/Creation	Wetland restorations or other applicable practice, particularly in or near drainage ways to the lake.			x							
					Education and Outreach	Work with townships and others.								x		
						Review LID management Plan and coordinate on activities where applicable.							x			
					Special Projects	Consider alum or iron treatments to prevent internal recycling of P after all watershed sources are addressed.							x			

Waterbody and Location		Parameter	Water Quality		Strategies	Strategy Type	Estimated Scale of Adoption Needed	Primary Responsibility							Time-line to reach WQ goal	Interim 10-yr Mile-stone
Waterbody ID	Location and Counties		Current Conditions	Goals/Targets				MDA	SWCD	MPCA	MS4	County	DNR	Other		
					Regulations/Ordinances/ Enforcement	Pursue adoption of new development standards to keep stormwater on-site during new development and other BMPs	Standards adopted.					x			10 years	Standards adopted.
Little Stanchfield 30-0044	Isanti	TP	TP=127.7mg/L	TP < 60mg/L	Special Projects	Develop Site Specific Standard TMDL for lake impairment.	TMDL approved.			x		x			20 years	TMDL draft.
						Conservation easements and other opportunities to keep forested and natural areas from conversion.	No net loss of forested areas.		x			x		x		1 easement.
Spectacle 30-0135	Isanti	TP	TP=21mg/L	TP=15.3mg/L	Special Projects	Increase acres of conservation easements and forest health focusing on management of high quality forested areas.	25% of watershed forested		x					x	15 years	TP <20 mg/L
					Streambank or Shoreline Protection	Install near-lake stormwater treatment BMPs including those already identified by Isanti SWCD.	Minimum of 2 projects		x						20 years	
					Education and Outreach	Collaborate with lake association and township for future projects	Watershed wide.		x						2 years	
					Regulations/Ordinances/ Enforcement	Pursue adoption of new development standards to keep stormwater on-site during new development and other BMPs	Standards adopted.		x						10 years	
Tennyson 30-0113	Isanti	TP	TP=107.1mg/L	TP < 60mg/L	Streambank or Shoreline Protection	Encourage retention of existing natural areas around the lake. Secure shoreland protection through easement, fee title purchase, or other means.	No net loss of forested areas.		x				x		20 years	TP <100
Sandy 71-0040	Sherburne	TP and sediment runoff	TP=13.6mg/L	TP=10.4mg/L	Streambank or Shoreline Protection	Native vegetation plantings	Watershed wide.		x						35 years	TP<12 mg/L
						Reduction of erosion "hot spots"			x							
						Protect existing vegetated habitat			x							
					Education/Information	Develop relationship with lake association			x						1 year	
						Develop educational plan for lake riparian property owners									2 years	
Long Pond 71-0036	Sherburne	Unknown			Monitoring/Data Collection	Collect baseline data on aquatic ecosystem (transparency, nutrients)	2 years of data		x						2 years	Lake asses-sed
					Education/Information	Initiate educational campaign to protect and extend current buffers.	Majority property owners		x						2 years	
Baxter 30-01114	Isanti	TP	TP=98mg/L	TP < 60mg/L	Urban Stormwater Management Practices	Encourage Baldwin MS4 to adopt MIDS performance goals	Reduce watershed loads by 49% Blue Lake strategies to be implemented first.							x	>40 years	TP< 90 mg/L
					Wetland Restoration/Creation	Examine wetlands to determine if they are impaired and restore			x							
					Special Projects	Rough fish and curly-leaf pondweed management							x			
						Consider alum or iron treatments to prevent internal recycling of P							x			

Waterbody and Location		Parameter	Water Quality		Strategies	Strategy Type	Estimated Scale of Adoption Needed	Primary Responsibility							Time-line to reach WQ goal	Interim 10-yr Mile-stone
Waterbody ID	Location and Counties		Current Conditions	Goals/Targets				MDA	SWCD	MPCA	MS4	County	DNR	Other		
					Streambank or Shoreline Protection	Install riparian BMPs to reduce TP and TSS			x							
Rum River 07010207-512	Sherburne	Excess nutrients and sediment runoff	TP mean 100.6 mg/L	TP <100mg/L	Streambank or Shoreline Protection	Stabilize eroding streambanks with native vegetation plantings; forested plantings on outside river bends; no variances for buildings on outside bends.	Watershed wide		x						10 years	TP=100 mg/L
					Special Projects - Conservation Drainage	Encourage two-stage ditch design, impoundments and peak water flow management.			x					x		
					Education/Information	Initiate educational campaign to protect existing buffers.			x							
					Livestock Management	Install animal stream crossings where necessary and managed grazing systems near streams.		x	x							

Cedar Creek Subwatershed Strategies





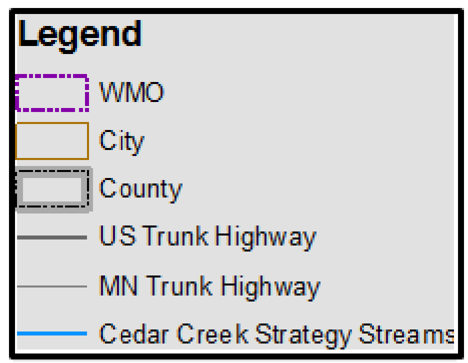


Table 3.3-6: Strategy Table for Cedar Creek HUC 10 Subwatershed.

Waterbody and Location		Parameter	Water Quality		Strategies	Strategy Type	Estimated Scale of Adoption Needed	Primary Responsibility							Time-line to reach WQ goal	Interim 10-yr Mile-stone
Waterbody ID	Location and Counties		Current Conditions	Goals/Targets				MDA	SWCD	MPCA	MS4	County	DNR	Other		
Mahoney Brook 07010207-682	Anoka	Fish	IBI=31.5	IBI above threshold	Livestock Management	Livestock and horse exclusion from stream channel	100% exclusion.	x	x						30 years?	IBI>31.5
Cedar Creek 07010207-521	Anoka, Isanti	*E. coli*	13/16 samples above the standard.	Geo Mean: 126/100 ml Individual 1,260/100 ml	Streambank or Shoreline Protection	Focus on protection of existing natural areas via easements. Consider MIDS or similar development standards.	Reduction of 81%, 69% and 27% in V. High, Mid and Low flow regimes		x			x			30 years?	<50% samples above standard
					Urban Stormwater Management Practices	Work with MS4 to implement BMPs to target V. High and Mid flows.						x		x		
					Monitoring /Data Collection	Investigate *E. coli* source areas to better target BMPs.			x			x				
Crooked Brook 07010207-575	Anoka, Isanti	DO	DO < 5.0 mg/l	5.0 mg/l 50% reduction	Wetland Restoration/Creation	Lateral ditch abandonment to address ditched wetlands as a source of low DO. (this would need to occur in active sod farms).	100% mitigation of ditched wetlands.		x						50 years?	DO levels increased

Lower Rum River Subwatershed Strategies

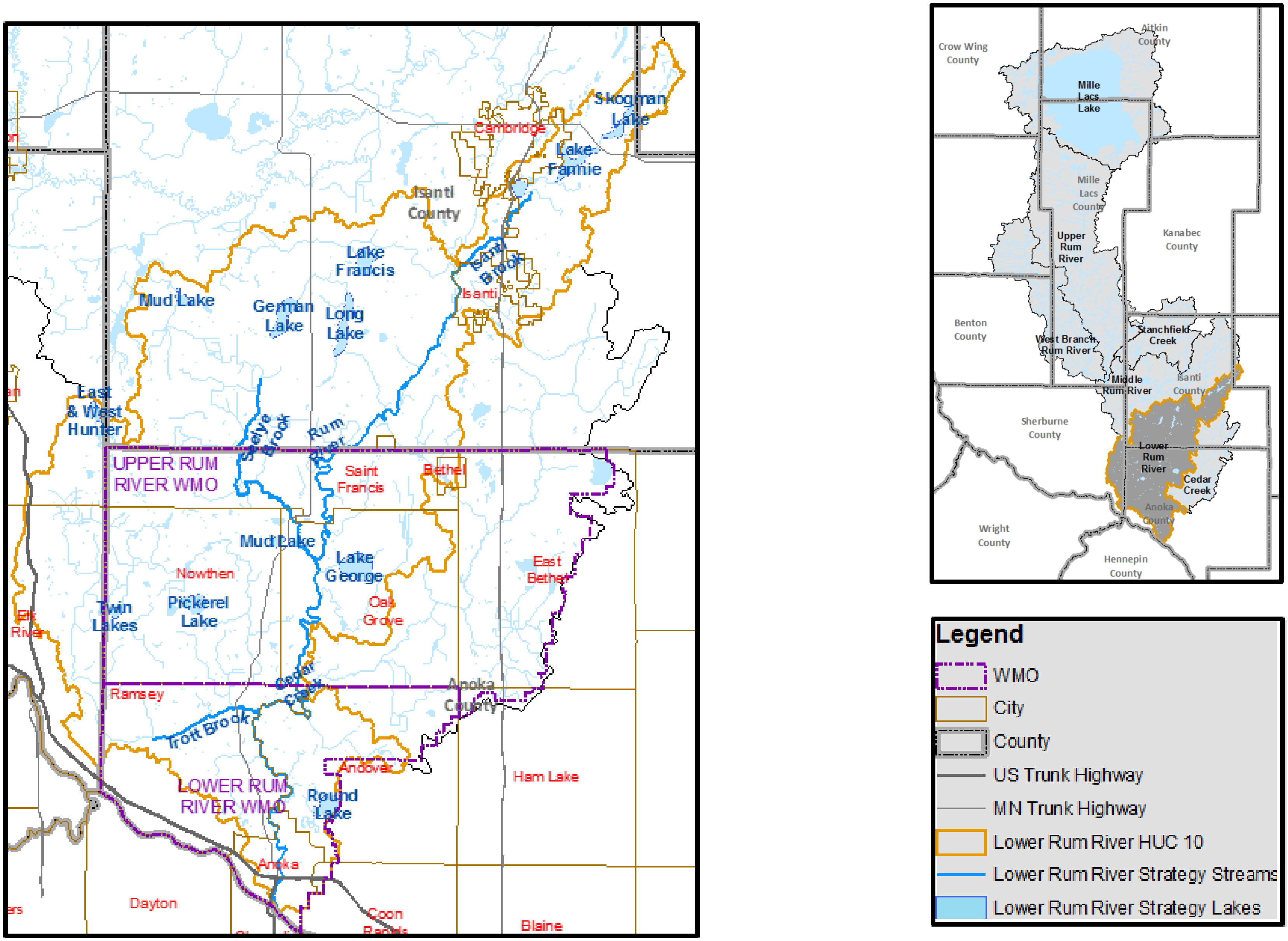


Table 3.3-7: Strategy Table for the Lower Rum River HUC 10 Subwatershed.

Waterbody and Location			Water Quality		Strategies	Strategy Type	Estimated Scale of Adoption Needed	Primary Responsibility							Time-line to reach WQ goal	Interim 10-yr Mile-stone
Waterbody ID	Location and Counties	Parameter	Current Conditions	Goals/Targets				MDA	SWCD	MPCA	MS4	County	DNR	Other		
Florence 30-0035	Isanti	TP	TP=24.5mg/L	TP=14.2mg/L	Education/Information	Foster relationship with lake group.	75% strategies implemented.		x						>20 years	TP<22 mg/L
					Urban Stormwater Management Practices	Implement strategies in subwatershed assessments.			x							
					Streambank or Shoreline Protection	Protect existing stands of near shore habitat.	100% protected.		x							
German 30-0100	Isanti	TP	TP=28.9mg/L	TP=24mg/L	Streambank or Shoreline Protection	Protect existing stands of near shore habitat. This is a wild rice lake.	100% protected.		x						10 years.	TP<28 mg/L
Fannie 30-0043	Isanti	TP	TP=51.8mg/L	TP ≤ 40 26% reduction in TP	Urban Stormwater Management Practices	Cambridge (MS4) should install stormwater treatment identified in an early subwatershed assessment study, and others.	14% reduction from Cambridge MS4 and 23% reduction in watershed loading.		X			x			25 years	TP ≤ 47mg/L
						Promote new development standards to keep stormwater on-site during new development and other BMPs/MIDs						x				
						NPDES compliance - follow MS4 permitted minimal control measures.						x				
					Streambank or Shoreline Protection	Restore upstream Skogman Lake and install near-lake stormwater treatment BMPs, including those identified by Isanti SWCD.			x							
					Subsurface Sewage Treatment Systems	Upgrade failing septic systems						x				
Francis 30-0080	Isanti	TP	TP=235mg/L	TP ≤ 60 mg/L 86% reduction in TP	Subsurface Sewage Treatment Systems	Upgrade failing septic systems	86% reduction in watershed loading with a large focus on internal loading					x			>40 years	TP<200 mg/L
					Streambank or Shoreline Protection	Protect/restore existing habitat - tamarack swamp, wetland habitat, especially on the north end of the lake.			x							
						Add riparian buffers per the 2015-16 state buffer law. Isanti SWCD and Isanti Co should consider these tributaries for additional buffer requirements or support.			x			x				
						Initiate management on upstream waterbodies.			x							
					Special Projects	Curly-leaf pondweed management per DNR Invasive Aquatic Plant Management permit and/or consider drawn down.							x			
						Rough Fish Management.							x			
					Monitoring /Data Collection	Monitor at tributary location to inform restoration practices – potential wetland restoration areas.			x							

Waterbody and Location		Parameter	Water Quality		Strategies	Strategy Type	Estimated Scale of Adoption Needed	Primary Responsibility							Time-line to reach WQ goal	Interim 10-yr Mile-stone
Waterbody ID	Location and Counties		Current Conditions	Goals/Targets				MDA	SWCD	MPCA	MS4	County	DNR	Other		
						Evaluate wetlands to determine if impaired.	Wetlands evaluated.		x	x					10 years	Eval. done
George 02-0091	Anoka	TP	TP=25.6mg/L	TP=22.5mg/L	Streambank or Shoreline Protection	Install projects identified in an accelerated implementation plan.	75% projects installed.		x						20 years	TP <24 mg/L
					Non-Structural Management Practices	Manage curly-leaf pondweed and Eurasian watermilfoil	Mgmt plan followed.						x			
						Near-shore management projects	1000 ft.		x					x		500 ft.
Long 30-0072	Isanti	TP	TP=119 mg/L	TP≤ 60 mg/L	Streambank or Shoreline Protection	Riparian buffers per the 2015-16 state buffer law. Isanti SWCD and Isanti Co should consider these tributaries for additional buffer requirements or support.	reduce nonpoint sources by 40%, to drive down lake P below 90 ug/L and then evaluate. It is likely additional in-lake measures may be necessary to achieve lake standards		x			x			40 years	TP≤ 90 mg/L
						Continue and enhance shoreline buffer and stormwater treatment BMP program in partnership with lake groups.			x					x		
					Education/Information	Ag producer outreach and enrollment in the MN Ag Water Quality Certification Program, including BMP installation.		x	x							
					Regulations/Ordinances/ Enforcement	Pursue adoption of new development standards to keep stormwater on-site during new development and other BMPs										
					Inventory/Mapping	Complete/implement a subwatershed assessment to identify locations for rural and high-impact near-shore BMPs.										
					Monitoring /Data Collection	Work with LID to collect data that prioritizes tributaries for BMPs based on water quality and flow volumes. Focus on north and west inlets.								x		
					Special Projects	Continue management of curly-leaf pondweed and consider other in-lake treatment options.							x			
						Implement strategies identified by Isanti SWCDs – this includes soil health, filter strips, cover crops and other BMPs										
Mud 30-0117	Isanti	TP	TP=31mg/L	TP=24.4mg/L	Inventory/Mapping	Complete/implement a subwatershed assessment to identify locations for rural and high-impact near-shore BMPs.	75% BMPs installed.								>30 years	TP < 28 mg/L
Pickerel 02-0130	Anoka	TP	TP=24.3mg/L	TP=17.8mg/L	Special Projects	Secure shoreland protection through easement, fee title purchase, or other means.	2 easement projects.		x					x	30 years	TP < 23 mg/L
Round 02-0089	Anoka	TP	TP=27.9mg/L	TP=21.3mg/L	Streambank or Shoreline Protection	Protect native vegetation, such as chara, during any efforts to manage aggressive species such as narrow leaf cattail.	No net loss native vegetation.		x						30 years	TP < 25 mg/L

Waterbody and Location: Waterbody ID	Waterbody and Location: Location and Counties	Parameter	Water Quality: Current Conditions	Water Quality: Goals/Targets	Strategies	Strategy Type	Estimated Scale of Adoption Needed	MDA	SWCD	MPCA	MS4	County	DNR	Other	Time-line to reach WQ goal	Interim 10-yr Mile-stone
Skogman 30-0022	Isanti	TP	TP=50mg/L	TP ≤ 40 21% reduction in TP	Streambank or Shoreline Protection	Restoration work in headwaters per subwatershed assessment- Chisago Co, includes agricultural BMPs, wetland restorations and similar projects	14% reduction in WLA from Cambridge MS4 and		x						30 years	TP <47 mg/L
						Install near-lake stormwater treatment BMPs, including those identified by Isanti SWCD.			x							
					Urban Stormwater Management Practices	New development and re-development stormwater treatment meeting or exceeding MS4 requirements, with emphasis on total and dissolved P removal. See subwatershed study completed by SWCD.						x		x		
					Non-Structural Management Practices	Curly-leaf pondweed management per DNR Invasive Aquatic Plant Management permit							x			
					Subsurface Sewage Treatment Systems	Upgrade failing septic systems						x				
					Wetland Restoration/Creation	Implement tributary wetland restoration projects identified in 2014 subwatershed study by Anoka Conservation District.							x	?		
					Inventory/Mapping	Historic feedlot and dairy operation soils should be tested for P levels. If found, these areas should be disconnected from channelized flows or neutralized with chemical treatments or other BMPS			x	x						
East Twin Lake 02-0133	Anoka	TP	TP=21.1mg/L	TP=18.7mg/L	Special Projects	Secure shoreland protection through easement, fee title purchase, or other means.	2 easement projects.		x						20 years	TP= 20 mg/L
					Regulations/Ordinances/Enforcement	Ensure new development adheres to strict runoff standards to prevent eutrophication of this high quality lake.	100% compliance of standards.					x				
East Hunter 71-0023	Sherburne	TP	TP=73.4mg/L	TP < 60mg/L 52% reduction in TP	Streambank or Shoreline Protection	Native vegetation plantings	Reduce watershed TP loading by about 32% to reduce internal loading with a goal of ~42% reduction in internal		x						25 years	TP=65 mg/L
						Restore upstream West Hunter Lake			x							
						Reduction of erosion "hot spots"			x							
					Subsurface Sewage Treatment Systems	Upgrade failing septic systems						x				
					Education/Information	Develop educational plan for lake riparian property owners			x							
					Special Projects	Investigate methods to reduce internal loading. Given the lake's relatively short water residence time of 0.6 years, it is recommended to reduce watershed P sources and track lake water quality							x			

Waterbody and Location		Parameter	Water Quality		Strategies	Strategy Type	Estimated Scale of Adoption Needed	Primary Responsibility							Time-line to reach WQ goal	Interim 10-yr Mile-stone
Waterbody ID	Location and Counties		Current Conditions	Goals/Targets				MDA	SWCD	MPCA	MS4	County	DNR	Other		
						changes. Additional sediment P release data will be required to assess chemical treatment efficacy such as alum or iron enhancement. Macrophyte management will be aided over time by P load reductions.	loading to achieve lake standards									
West Hunter 71-0022	Sherburne	TP	TP=71.6mg /L	TP < 60 mg/L 22% reduction in TP	Streambank or Shoreline Protection	Native vegetation plantings	Reduce lake shed loading by 23%		x						25 years	TP=65 mg/L
						Reduction of erosion "hot spots"			x							
					Urban Stormwater Management Practices	Install BMP to intercept runoff at public access point			x				x			
					Monitoring /Data Collection	Lake bottom water total iron conc. should be monitored and compared to TP with a goal of a 3:1 concentration ratio being optimal for iron control of sediment released P. Follow-up lake monitoring should include growing season TP and total dissolved P or soluble reactive P concentrations to track potential dissolved P exported to East Hunter Lake.			x							
					Subsurface Sewage Treatment Systems	Upgrade failing septic systems						x				
Seelye Bk 07010207-528	Anoka, Isanti	*E. coli*	Exceeded the Geo Mean 10/15 times	Geo Mean: 126/100 ml Individual 1,260/100 ml	Special Projects	Pursue easement establishment with a focus on areas identified in existing priority areas (i.e. MN Land Trust Maps)	86% reduction in V. high flows and 51% reduction in mid flows.							x	35 years	Exceedance < 25%
					Livestock Management	Install BMPs that minimize runoff and/or enhanced enforcement of existing regulations at feedlots in the headwaters		x	x							
					Wetland Restoration/Creation	Identify headwaters or lateral ditches which can be restored to wetlands. Consider using wetland restoration banking credit sales to fund these activities.			x				x			
					Urban Stormwater Management Practices	Meet MS4 requirements.						x		x		
					Streambank or Shoreline Protection	Stream restoration with channel work plus removal of perched culverts							x			
Isanti Brook 07010207-592	Isanti	Low DO for Fish and	MIBI=34	MIBI>34	Streambank or Shoreline Protection	Ensure culverts are properly sized and aligned	100% compliance							x	>30 years	MIBI>34
						Consider remeandering stream channels and address channelization and beaver dam issues.	Evaluation completed and issues addressed.						x			
													x			

Waterbody and Location		Parameter	Water Quality		Strategies	Strategy Type	Estimated Scale of Adoption Needed	Primary Responsibility							Time-line to reach WQ goal	Interim 10-yr Mile-stone
Waterbody ID	Location and Counties		Current Conditions	Goals/Targets				MDA	SWCD	MPCA	MS4	County	DNR	Other		
		Invert IBI			Wetland Restoration/Creation	Restore wetland upstream of 13UM052 and between 13UM052 and Florence Lake	Wetland restored.		x					x		
					Livestock Management	Livestock exclusion, such as near 305th Ave crossing.	100% exclusion.	x	x							
					Streambank or Shoreline Protection	Riparian buffers per the 2015-16 state buffer law. Isanti SWCD and Isanti Co should consider these tributaries for additional buffer requirements or support.	Buffers meet standards and additional requirement adopted.		x							
Trott Brook 07010207-680	Anoka	Inverts, Fish, DO	34% DO readings fall below 5 mg/L	DO > 5 mg/L	Wetland Restoration/Creation	Wetland restoration particularly of ditched wetlands directly connected to Trott Brook such as lateral ditch blocking.	50% reduction in Oxygen Demand.		x						20 years?	75% DO samples above 5 mg/L
					Urban Stormwater Management Practices	Meet MS4 requirements utilizing MIDS						x		x		
Rum River	Anoka, Isanti	MSHA and TP	MSHA average score rated "good". TP mean is 123.1 mg/L	Keep MSHA average scores at "good: rating. Reduce TP to fall below standard.	Streambank or Shoreline Protection	Riverbank stabilization and near-shore gully stabilization. Stabilize eroding streambanks with native vegetation plantings; forested plantings on outside river bends; no variances for buildings on outside bends.	Determine through inventory work		X						>30 years	1 mi. eroding riverbank stabilized
					Inventory/Mapping	Identify parcels with high values for water quality, riparian corridor connectivity and habitat. Protect through easement for fee title acquisition.	100% of river corridor		X					X	5 years	100% of river corridor
						Inventory and prioritize erosion sites.			X							
					Special Projects	Feasibility study of fish passage improvements at Anoka Dam, taking into consideration maintaining a recreational pool, water quality impacts, flood control and invasive species.	N/A						x		10 years	Study completed
					Streambank or Shoreline Protection	Secure shoreland protection through easement, fee title purchase, or other means. Or improve habitat on private parcels. Highest priority on ecological restoration of rivers-edge ag fields.	2 easements obtained		x				x		20 years	1 easement.
					Urban Stormwater Management Practices	Stabilize outfalls and stormwater discharge points.	Watershed wide				x	x			10 years	Completion
						Install stormwater treatment identified in SWCD subwatershed assessments and elsewhere.		x	x		x					

Table 3.3-8 Strategy Table for the Entire Rum River HUC 10 Subwatershed.

Waterbody and Location		Parameter	Water Quality		Strategies	Strategy Type	Estimated Scale of Adoption Needed	Primary Responsibility							Time-line to reach WQ goal	Interim 10-yr Mile-stone
Waterbody ID	Location and Counties		Current Conditions	Goals /Targets				Wshd. Distt.	SWCD	MPCA	MS4	County	DNR	Other		
All applicable lakes and streams	All applicable counties	multiple	Varies		Monitoring /Data Collection	See section 4 of this report for water monitoring recommendations.	N/A	x	x	x					>30 years	Data collected.
					Urban Stormwater Management Practices	MIDS or similar should be adopted for new development and redevelopment.	MIDS adopted.				x	x				MIDS drafted
					Conservation Drainage	Minimize cleaning of ditches or similar improvements that export water from the landscape more quickly.	No net increase of water.		x							No net increase of water.
					Inventory/Mapping	Inventory sizing and elevation of culverts. An inventory will allow future unpermitted changes to be detected and corrected.	Inventory completed.	x	x		x	x	x	x	5 years	Inventory completed
						Inventory/upgrade stormwater infrastructure that may be undersized based on projected changes in storm volume and frequency.		x	x		x	x	x	x	30 years	
					Streambank or Shoreline Protection	Riparian habitat protection and restoration through BMPs, and easements.	Acres of protected habitat increased.		x						20 years.	No net loss of habitat
						Correct bank erosion, including a modest number of large bank failures and large number of modest bank failures.	75% problem areas fixed.		x				x			25% sites fixed.
					Regulations/Ordinances/Enforcement	Local enforcement of existing regulations including buffer law, scenic and recreational river rules, and ordinances.	100% compliance.					x	x		10 years	100% compliance.

Management Considerations for the Entire Rum River Watershed While the tables above provide waterbody-specific management direction, cohesive management across the entire Rum River Watershed is critical. The State of Minnesota has recognized this, and is transitioning watershed management to this level with "One Watershed One Plans" that coordinate the efforts across multiple jurisdictions. For the Rum River Watershed, some of the important consideration for cross-jurisdictional coordination include:

- **Focus efforts –** watershed-wide, efforts must focus substantial resources on the highest priorities. Efforts that are broadly scattered geographically are less likely to be effective.
- **Hydrological changes and flooding** – Increased drainage, including that which occurs by cleaning ditches which have been idle for long periods, has the potential to negatively impact all downstream entities with flooding. Similarly, wetland restoration and floodplain reconnection efforts benefit all downstream jurisdictions. More frequent large rain storms compound potential flood risks, so management efforts that minimize volume increases are a priority.
- **Education/Outreach and Implementation Planning** - The Minnesota Agricultural Water Quality Certification Program (MAWQCP; http://www.mda.state.mn.us/awqcp) is a voluntary opportunity for farmers and agricultural landowners to take the lead in implementing conservation practices that protect our water; producers seeking certification can obtain specially designated technical and financial assistance to implement practices that promote water quality."
- **Water quality** – While downstream impacts of water quality in the river are obvious, many of the lakes in the watershed are inter-connected with the river as well.
- **River's scenic nature** – This State Wild, Scenic and Recreational River is a high priority regionally.
- **Consistency** – Studies and inventories, such as culvert inventories, are best done in a coordinated fashion with the same methods and outputs in order to best direct management efforts.
- **Modeling** – The HSPF model and Scenario Application Manager (SAM) tool, developed as part of this WRAP, can be used to evaluate management scenarios in the future.

4. Monitoring Plan

Future monitoring in the watershed will include intense monitoring every 10 years by the MPCA and more frequent, focused monitoring led by local water planning agencies shown in figure 4-1 and table 4-1 below. The MPCA's Intensive Watershed Monitoring (IWM) Strategy occurs in each major watershed once every 10 years: for streams it includes chemical analysis of grab samples, hydrological monitoring, biological monitoring and some fish consumption testing; for lakes it includes water chemistry and water clarity monitoring, and DNR fish and aquatic plant monitoring. The MPCA Watershed Pollutant Load Monitoring Network also has two river/stream sites (one near Milaca and the other on the West Branch, Rum River) that will be monitored to track implementation effectiveness of sediment, nitrogen, and phosphorus loads in the watershed. The more frequent local monitoring is key to detecting trends and adjusting management on reasonable time scales. The MPCA's less frequent monitoring is a broader assessment of the entire watershed, and important for long term planning.

The map and table below provide a list of recommended water monitoring sites for locally lead water monitoring efforts in the next 10 years, subject to funding and staffing resources availability. These recommendations may be refined at the local water planning scale. The sites were selected for monitoring because they are larger recreational lakes, outfalls of larger streams into the Rum River, or smaller streams identified by local water planners due to their significance. It is intended that monitoring at these sites would:

- Allow consistency throughout the watershed, particularly for waterbodies flowing across political boundaries.
- Allow upstream to downstream water quality analysis for the Rum River.
- Determine if major tributaries are having a positive or negative impact on the Rum River.
- Allow trend analysis.

Several types of monitoring are recommended.

- **Chemical analysis of grab samples.** In streams, the highest priority parameters are DO, TP, and TSS. Measurements in streams eight times per year, half during baseflow and half during storm flows is desirable. In lakes the priority parameters are Secchi transparency, TP and chl-*a*. Measurements in lakes every two weeks from May-September is desired. For all monitoring, in order to allow trend analysis gathering an initial baseline of data for three years within a five year period is recommended, followed by monitoring every two to three years to detect changes.
- **Hydrology monitoring (streams only)**. At a minimum, stream level should be recorded during any water quality sampling. When possible, stage should be recorded with a data logging device and a rating curve developed to calculate flow from the stage readings.
- **Real time hydrology monitoring (rivers only)**. Establishing long-term flow and water level monitoring stations that display data real time on the internet is strongly recommended in this watershed for the purpose of flood forecasting. Officials from Mille Lacs, Isanti and Anoka

Counties in particular stressed this as a high priority. Presently no flood forecasting is available for the Rum River or tributaries but flooding is impacting communities regularly. Collaboration with the U.S. Geological Survey, DNR, and/or MPCA is anticipated. Further analysis of appropriate sites is likely needed.

Figure 4-1 Recommended Water Monitoring Sites

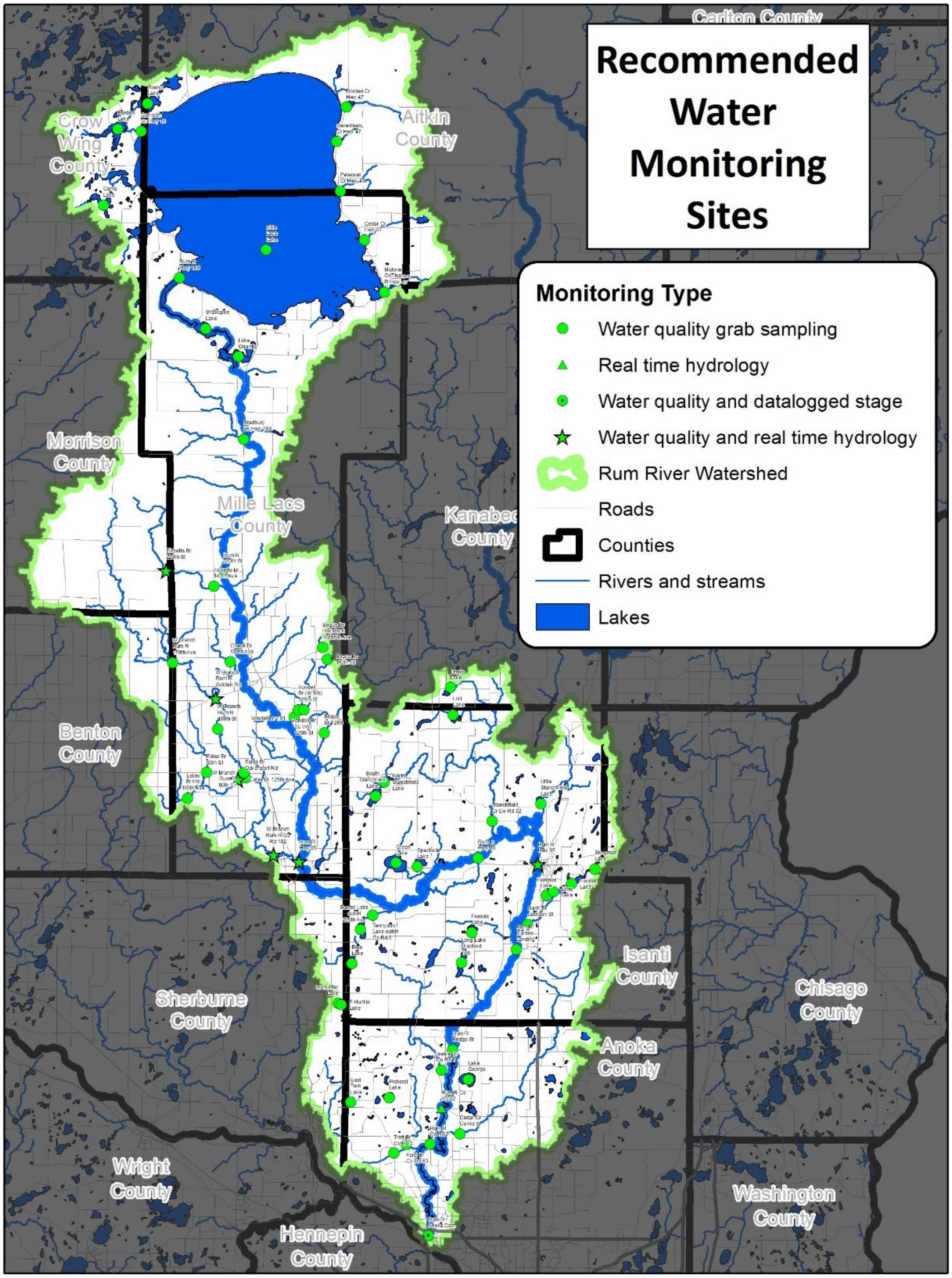


Table 4-1 Recommended Monitoring Locations

Waterbody	Site	County	Municipality	Lead	Monitoring Type
Baxter Lk. outlet	295th Ave	Isanti	Stanford Twp.	Isanti Co/SWCD	Water Quality
Blue Lake		Isanti	Spencer Bk Twp.	Isanti Co/SWCD	Water Quality
Bogus Br	T200	Mille Lacs	Bogus Bk Twp.	Mille Lacs Co/SWCD	Water Quality
Bogus Br	Haystack Rd/65th Ave	Mille Lacs	Bogus Bk Twp.	Mille Lacs Co/SWCD	Water Quality
Bogus Br	160th St	Mille Lacs	Bogus Bk Twp.	Mille Lacs Co/SWCD	Water Quality
Borden Cr	Hwy 47	Aitkin	Malmo Twp.	Aitkin SWCD	Water Quality
Borden Lake		Crow Wing	Garrison Twp.	Crow Wing SWCD	Water Quality
Bradbury Bk	Hwy 169	Mille Lacs	Bradbury Twp.	Mille Lacs Co/SWCD	Water Quality
Camp Lake		Crow Wing	Roosevelt Twp.	Crow Wing SWCD	Water Quality
Cedar Cr	Co Rd 9	Anoka	Oak Grove	Upper Rum River WMO	Water Quality
Cedar Cr	Hwy 47	Mille Lacs	Eastside Twp.	MLLWMG*	Water Quality
Chase Br	130th Ave	Mille Lacs	Milaca Twp.	Mille Lacs Co/SWCD	Water Quality
E Hunter Lake		Sherburne	Livonia Twp.	Sherburne SWCD	Water Quality
East Twin Lake		Anoka	Nowthen	Upper Rum River WMO	Water Quality
Elms Lake		Isanti	Isanti Twp.	Isanti Co/SWCD	Water Quality
Estes Br	Davenport Rd	Mille Lacs	Greenbush Twp.	Mille Lacs Co/SWCD	Water Quality
Estes Br	80th St	Mille Lacs	Milo Twp.	Mille Lacs Co/SWCD	Water Quality
Estes Br	125th Ave	Mille Lacs	Greenbush Twp.	Mille Lacs Co/SWCD	WQ, Hydrology-real time
Estes Br trib.	160th Ave	Mille Lacs	Greenbush Twp.	Mille Lacs Co/SWCD	Water Quality
Fannie Lake		Isanti	Cambridge	Isanti Co/SWCD and LID	Water Quality
Florence Lake		Isanti	Isanti Twp.	Isanti Co/SWCD	Water Quality
Ford Br	Co Rd 63	Anoka	Ramsey	Upper Rum River WMO	Water Quality
Francis Lake		Isanti	Bradford Twp.	Isanti Co/SWCD	Water Quality
Garrison Cr	Hwy 18	Crow Wing	Garrison Twp.	MLLWMG*	Water Quality
Green Lake		Isanti	Wyanett Twp.	Isanti Co/SWCD	Water Quality
Isanti Br	Jackson St	Isanti	Isanti Twp.	Isanti Co/SWCD	Water Quality
Lake George		Anoka	Oak Grove	Upper Rum River WMO	Water Quality
Lake Onamia		Mille Lacs	Kathio Twp.		Water Quality
Lewis Lake		Kanabec	Brunswick Twp.	Kanabec SWCD	Water Quality
Lit. Stanchfield Lk		Isanti	Cambridge Twp.	Isanti Co/SWCD and LID	Water Quality
Long Lake	Bradford Twp.	Isanti	Bradford Twp.	Isanti Co/SWCD and LID	Water Quality
Lori Lake		Isanti	Maple Ridge Twp.	Isanti Co/SWCD	Water Quality
Malone Cr/Thaines R	Hwy 47	Mille Lacs	Isle	MLLWMG*	Water Quality
Mille Lacs Lake		Multiple	Multiple		Water Quality
N. Stanchfield Lk.		Isanti	Dalbo Twp.	Isanti Co/SWCD	Water Quality
Peterson Cr	Hwy 47	Aitkin	Lakeside Twp.	Aitkin SWCD	Water Quality
Pickerel Lake		Anoka	Nowthen	Upper Rum River WMO	Water Quality

Waterbody	Site	County	Municipality	Lead	Monitoring Type
Round Lake		Aitkin	Hazelton Twp.	Aitkin SWCD	Water Quality
Rum River	Co Rd 22	Anoka	Oak Grove	USGS	Hydrology- real time
Rum River	Co Rd 7	Anoka	Ramsey	Up./Lower Rum R. WMOs	Water Quality
Rum River	Bridge St	Anoka	St. Francis	Upper Rum River WMO	Water Quality
Rum River	Anoka Dam	Anoka	Anoka	Lower Rum River WMO, Met Council	WQ, hydro
Rum River	Martins Landing	Isanti	Isanti	Isanti Co/SWCD	Water Quality
Rum River	Hwy 95	Isanti	Springvale Twp.	Isanti Co/SWCD	Water Quality
Rum River	Hwy 95	Isanti	Cambridge	Isanti Co/SWCD and LID	WQ, Hydrology- real time
Rum River	220th St	Mille Lacs	Page Twp.	USGS	Hydrology- real time
Rum River	Hwy 169	Mille Lacs	Kathio Twp.	MLLWMG*	Water Quality
Rum River	Hwy 95	Mille Lacs	Princeton	Mille Lacs Co/SWCD	WQ, Hydrology- real time
Seelye Br	Co Rd 7	Anoka	Oak Grove	Upper Rum River WMO	Water Quality
Seventeen Cr	Hwy 47	Aitkin	Lakeside Twp.	Aitkin SWCD	Water Quality
Shakopee Lake		Mille Lacs	Kathio Twp.		Water Quality
Skogman Lake		Isanti	Cambridge Twp.	Isanti Co/SWCD and LID	Water Quality
S. Stanchfield Lk.		Isanti	Wyanett Twp.	Isanti Co/SWCD	Water Quality
Spectacle Lake		Isanti	Wyanett Twp.	Isanti Co/SWCD	Water Quality
Stanchfield Cr	Co Rd 32	Isanti	Springvale Twp.	Isanti Co/SWCD	Water Quality
Tennyson Lk. Out	Co Rd 5	Isanti	Stanford Twp.	Isanti Co/SWCD	Water Quality
Tibbetts Br	140th Ave	Mille Lacs	Page Twp.	Mille Lacs Co/SWCD	Water Quality
Tibbetts Br	220th St	Morrison		Mille Lacs Co/SWCD or Morrison SWCD	WQ, Hydrology- real time
Trott Br	Co Rd 5	Anoka	Ramsey	Lower Rum River WMO	Water Quality
Vondell Br	T91	Mille Lacs	Bogus Br Twp.	Mille Lacs Co/SWCD	Water Quality
Vondell Br E. trib	125th St	Mille Lacs	Bogus Bk Twp.	Mille Lacs Co/SWCD	Water Quality
Vondell Br W trib	125th St	Mille Lacs	Bogus Bk Twp.	Mille Lacs Co/SWCD	Water Quality
W Branch Rum R	110th St	Mille Lacs	Milo Twp.	Mille Lacs Co/SWCD	Water Quality
W Branch Rum R	80th St	Mille Lacs	Milo Twp.	Mille Lacs Co/SWCD	Water Quality
W Branch Rum R	Co Rd 102	Mille Lacs	Princeton Twp.	Mille Lacs Co/SWCD	WQ, Hydrology- real time
W Branch Rum R	Golden Rd	Mille Lacs	Milaca Twp.	Mille Lacs Co/SWCD	WQ, Hydrology- real time
W Branch Rum R	170th Ave	Mille Lacs/Benton	Milaca Twp.	Mille Lacs/Benton Co/SWCD	Water Quality
W Hunter Lake		Sherburne	Livonia Twp	Sherburne SWCD	Water Quality

*MLLWMG = Mille Lacs Lake Watershed Management Group

Appendices

APPENDIX A – **ADDITIONAL RUM RIVER WATERSHED DATA AND REPORTS**

APPENDIX B – **RUM RIVER WATERSHED LAKE TREND DATA**

APPENDIX C – **RUM RIVER HSPF MAPS**

APPENDIX D – **RUM RIVER HSPF MAP DOCUMENTATION**

APPENDIX E – **THE NATURE CONSERVANCY'S MULTIPLE BENEFITS MODEL**

APPENDIX F – **RUM RIVER HSPF SCENARIO REPORT**

Appendix A Additional Rum River Watershed Data and Reports

Study	Author	Date Completed	Where to access it	Contact Name	Brief Description
City of Anoka Subwatershed Retrofit Analysis	Anoka Conservation District	August 2016	www.AnokaSWCD.org	Jamie Schurbon	Inventory of stormwater quality improvement projects, ranked by cost effectiveness.
City of Ramsey Subwatershed Retrofit Analysis	Anoka Conservation District	June 2016	www.AnokaSWCD.org	Jamie Schurbon	Inventory of stormwater quality improvement projects, ranked by cost effectiveness.
City of St. Francis Subwatershed Retrofit Analysis	Anoka Conservation District	August 2016	www.AnokaSWCD.org	Jamie Schurbon	Inventory of stormwater quality improvement projects, ranked by cost effectiveness.
City of Isanti Subwatershed Retrofit Analysis	Anoka Conservation District	Oct 2011	www.AnokaSWCD.org	Jamie Schurbon	Inventory of stormwater quality improvement projects, ranked by cost effectiveness.
City of Cambridge Subwatershed Retrofit Analysis	Anoka Conservation District	Feb 2012	www.AnokaSWCD.org	Jamie Schurbon	Inventory of stormwater quality improvement projects, ranked by cost effectiveness.
Lake George Feasibility Analysis	Anoka Conservation District	To be completed in 2017	www.AnokaSWCD.org	Jamie Schurbon	Investigation into water quality decline in Lake George and a cost effectiveness analysis to address the problem.
Skogman-Fannie-Elms-Florence Lakes Chain Stormwater Retrofit Analysis	Anoka and Isanti SWCDs	Nov 2014	www.AnokaSWCD.org	Jamie Schurbon	Inventory of stormwater quality improvement projects, ranked by cost effectiveness.
Green Lakeshore Stormwater Retrofit Analysis	Isanti SWCD	2014	Isanti SWCD	Tiffany Determan	Inventory of stormwater quality improvement projects, ranked by cost effectiveness.
Green Lake Improvement District Lake Management Plan	?	2013-2018	www.greenlakemnid.com	Tiffany Determan	
"Forests, Water and People" full report.	USDA Forest Service	June 2009	http://na.fs.fed.us/pubs/misc/watersupply/forests_water_people_watersupply.pdf	**Kathryn Maloney**, Director kmaloney@fs.fed.us	The Forests, Water and People analysis identified private forests that are most important for drinking water supply and most in need of protection from development pressure.

Appendix B Rum River Watershed Lake Trend Data

Lake Trends and Priorities for Protection (Unimpaired Lakes) Per MPCA/DNR WRAPS Protection Strategy Guidance

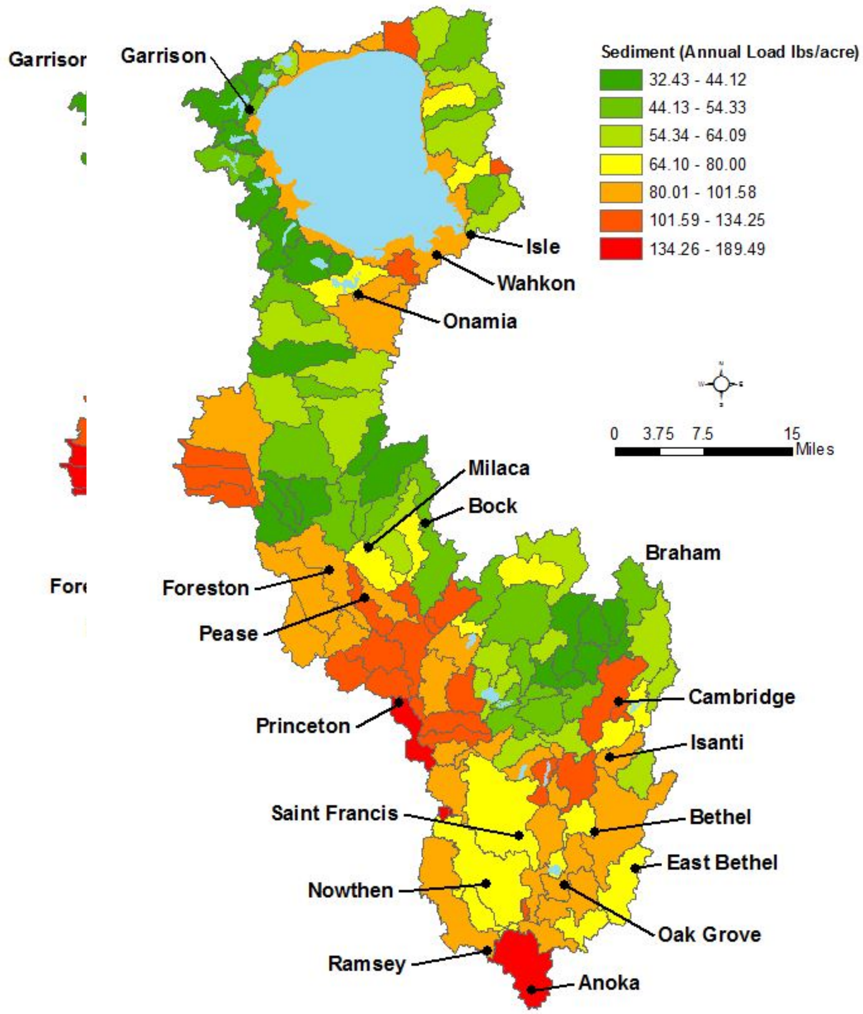
DNR ID	Lake Name	Depth Type	Lake Area Acres	Watershed Acres	Ecoregion	Percent Disturbed Land Use	Mean TP	Years TP	Mean Secchi	Presence of Trend	Trend Slope Description	Target TP	Load Reduction to meet Target	Percent Load Reduction to meet Target	Priority
48-0002-00	Mille Lacs	DEEP	128,227	265,982	NLF	0.05	29.4	5	3.02	Increasing Trend	Strong evidence for trend	24.7	8053	12	A
01-0065-00	Cedar	DEEP	249	1,154	NLF	0.22	28.0	2	1.96			26.9	9	4	A
18-0048-00	Partridge	DEEP	188	418	NLF	0.13	18.0	1	3.67			14.1	15	21	A
18-0021-00	Miller	DEEP	132	492	NLF	0.12	17.5	2	3.88	No Evidence of Trend		17.2	1	1	A
18-0028-00	Smith	DEEP	491	3,415	NLF	0.08	17.5	5	3.33	No Evidence of Trend		15.1	52	13	A
18-0018-00	Camp	DEEP	534	6,284	NLF	0.11	14.5	5	2.43	No Evidence of Trend		11.2	113	21	A
01-0157-00	Big Pine	DEEP	635	2,340	NLF	0.07	13.5	7	3.75	No Evidence of Trend		11.7	32	12	A
01-0204-00	Round	DEEP	733	4,102	NLF	0.05	11.0	4	3.31	Increasing Trend	Strong evidence for trend	9.9	34	9	A
30-0107-00	Blue	DEEP	318	7,198	NCHF	0.47	41.4	6	1.40	No Evidence of Trend		31.4	209	24	A
33-0032-00	Lewis	DEEP	179	1,787	NCHF	0.48	29.7	5	2.26	No Evidence of Trend		22.6	47	24	A
02-0091-00	George	DEEP	488	1,856	NCHF	0.24	25.6	9	2.74	Decreasing Trend	Strong evidence for trend	22.5	24	12	A
30-0135-00	Spectacle	DEEP	243	860	NCHF	0.32	21.0	13	3.82	Increasing Trend	Strong evidence for trend	15.3	22	27	A
02-0133-00	East Twin	DEEP	92	445	NCHF	0.26	21.0	10	3.62	No Evidence of Trend		18.7	4	11	A

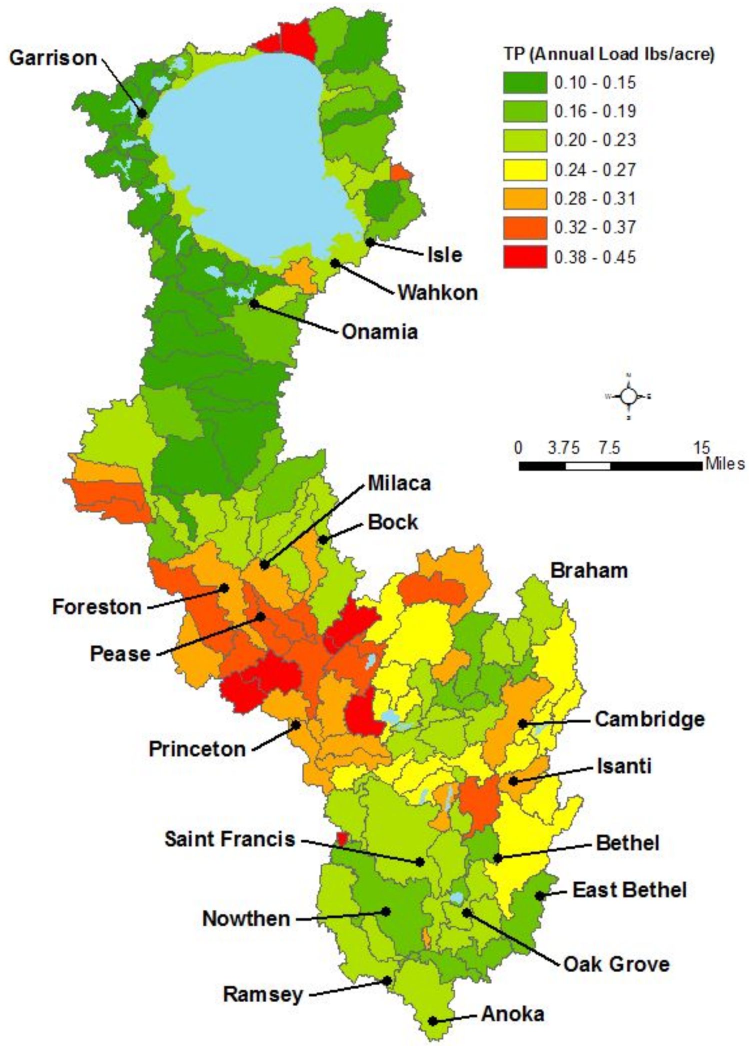
DNR ID	Lake Name	Depth Type	Lake Area Acres	Watershed Acres	Ecoregion	Percent Disturbed Land Use	Mean TP	Years TP	Mean Secchi	Presence of Trend	Trend Slope Description	Target TP	Load Reduction to meet Target	Percent Load Reduction to meet Target	Priority
30-0056-00	Long	SHALLOW	133	937	NCHF	0.37	29.1	2	2.16			28.8	1	1	A
30-0100-00	German	SHALLOW	353	2,076	NCHF	0.41	28.9	2	0.87			24.0	32	18	A
02-0130-00	Pickerel	SHALLOW	238	615	NCHF	0.22	24.3	8	1.23	Increasing Trend	Evidence for trend	17.8	16	28	A
30-0083-00	Elizabeth	SHALLOW	275	1,656	NCHF	0.43	15.0	2	1.99			14.1	5	7	A
18-0033-00	Scott	DEEP	157	561	NLF	0.09	21.6	2	4.12			17.7	18	18	B
18-0020-00	Borden	DEEP	1,012	16,843	NLF	0.08	20.6	4	2.97	Increasing Trend	Weak evidence for possible trend	17.5	273	14	B
18-0001-00	Whitefish	DEEP	709	6,941	NLF	0.09	19.2	3	3.73	Increasing Trend	Evidence for trend	16.3	114	15	B
18-0019-00	Kenney	DEEP	109	1,381	NLF	0.11	15.2	3	3.18	No Evidence of Trend		14.5	6	5	B
30-0096-00	Lory	DEEP	214	4,193	NCHF	0.63	41.9	3	1.17			22.8	229	46	B
30-0035-00	Florence	DEEP	135	8,545	NCHF	0.58	24.5	3	1.62	Increasing Trend	Strong evidence for trend	14.2	207	43	B
71-0040-00	Sandy	DEEP	64	7,198	NCHF	0.47	13.6	4	4.45	No Evidence of Trend		10.4	53	24	B
02-0067-00	Minard	SHALLOW	119	1,586	NCHF	0.45	88.6	2	1.08			28.3	298	71	B
30-0117-00	Mud	SHALLOW	99	1,248	NCHF	0.41	31.0	1	0.90			24.4	22	24	B
18-0029-00	Holt	DEEP	164	10,697	NLF	0.09	21.5	4	2.78	No Evidence of Trend		20.0	65	7	C
48-0009-00	Onamia	SHALLOW	1,040	292,657	NLF	0.06	148.8	3	0.75			5.4	99422	96	C
01-0086-00	Deer	SHALLOW	47	6,598	NLF	0.18	69.0	1	0.91			54.2	335	24	C
01-0085-00	Twenty	SHALLOW	123	6,318	NLF	0.26	57.0	1	0.76			44.8	277	23	C
48-0012-00	Shakopee	SHALLOW	585	282,800	NLF	0.05	37.1	4	1.73			22.7	9590	38	C

DNR ID	Lake Name	Depth Type	Lake Area Acres	Watershed Acres	Ecoregion	Percent Disturbed Land Use	Mean TP	Years TP	Mean Secchi	Presence of Trend	Trend Slope Description	Target TP	Load Reduction to meet Target	Percent Load Reduction to meet Target	Priority
48-0014-00	Ogechie	SHALLOW	410	275,018	NLF	0.05	22.2	5	1.39			19.6	1460	12	C
02-0089-00	Round	DEEP	256	1,014,051	NCHF	0.34	27.9	10	2.72	No Evidence of Trend		21.3	7128	24	C
48-0004-00	Silver	SHALLOW	148	5,886	NCHF	0.68	198.0	1	0.50			155.6	652	23	C

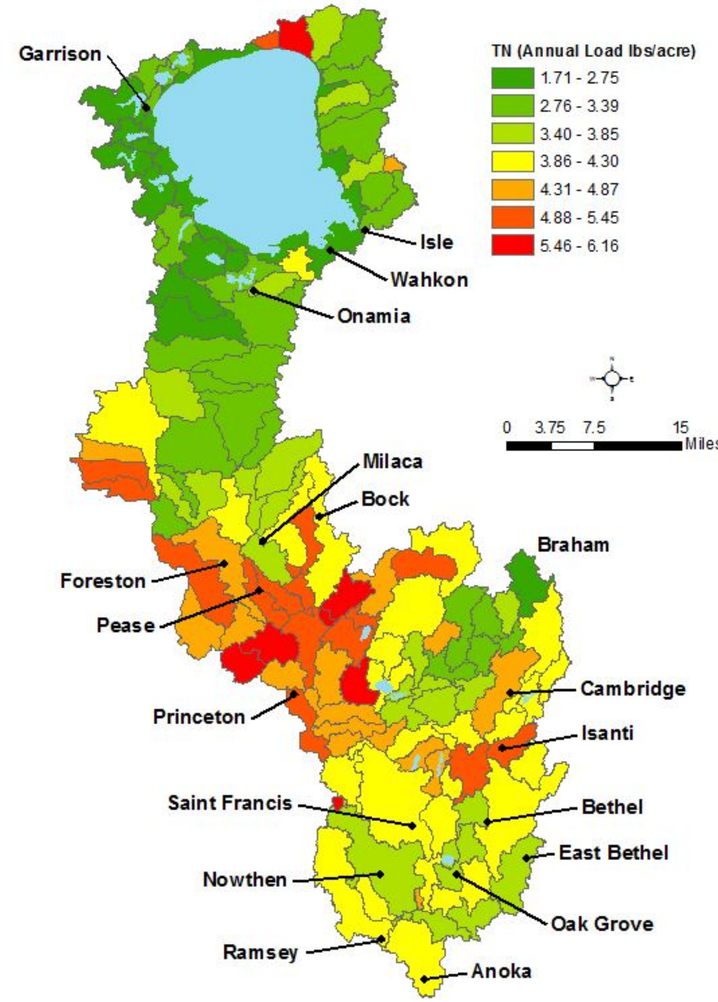
Legend:

DNR ID	Lake ID as assigned by the Department of Natural Resources
LAKE_NAME	Lake name as assigned by the Department of Natural Resources
DEPTH_TYPE	Depth categorization for assessment based on definition in statute
LAKE Acres	Lake acres based on the 24K NHD
Watershed acres	Watershed Acres based on DNR's lake catchments layer
ECOREGION	Omnerik's Level III Ecoregion
% Disturbed Land Use	% land use in the watershed composed solely of urban and row crop cultivated based on the 2011 National Land Cover Dataset
Mean TP	10 year average Total Phosphorus in ug/L (June-September)
Years TP	Number of years with total phosphorus data occurring June - September
Mean Secchi	10 year average Secchi transparency (June-September)
Presence of Trend	If a trend was detected based on the Seasonal Kendall-Mann statistical analysis completed on lakes with a minimum of 8 years of Secchi transparency
Trend Slope Description	The description of the trend
Target TP	Based on the 25 percentile of the standard deviation of the historical dataset for the lake in ug/L
Load Reduction to meet Target	Pounds of phosphorus to be reduced based on watershed size and retention time to meet the target from current conditions.
Percent Load Reduction to meet Target	Percent of the current annual loading that would need to be reduced to meet the target TP.
Priority	Grouping of waterbodies based on their potential for risk; A is the highest priority; C is the lowest. Based on sensitivity to loss in clarity based on increase in phosphorus, watershed disturbance, lake size, proximity to current WQ standard, and presence of a declining trend.


Garrison
Garrison
Isle
Wahkon
Onamia
Sediment (Annual Load lbs/acre)
32.43 - 44.12
44.13 - 54.33
54.34 - 64.09
64.10 - 80.00
80.01 - 101.58
101.59 - 134.25
134.26 - 189.49
0 3.75 7.5 15 Miles
Milaca
Bock
Braham
Foreston
Pease
Cambridge
Princeton
Isanti
Saint Francis
Bethel
East Bethel
Nowthen
Oak Grove
Ramsey
Anoka



TP (Annual Load lbs/acre)
0.10 - 0.15
0.16 - 0.19
0.20 - 0.23
0.24 - 0.27
0.28 - 0.31
0.32 - 0.37
0.38 - 0.45
0 3.75 7.5 15 Miles
Garrison
Isle
Wahkon
Onamia
Milaca
Bock
Braham
Foreston
Pease
Cambridge
Princeton
Isanti
Saint Francis
Bethel
East Bethel
Nowthen
Oak Grove
Ramsey
Anoka



TN (Annual Load lbs/acre)
1.71 - 2.75
2.76 - 3.39
3.40 - 3.85
3.86 - 4.30
4.31 - 4.87
4.88 - 5.45
5.46 - 6.16
0 3.75 7.5 15 Miles
Garrison
Isle
Wahkon
Onamia
Milaca
Bock
Braham
Foreston
Pease
Cambridge
Princeton
Isanti
Saint Francis
Bethel
East Bethel
Nowthen
Oak Grove
Ramsey
Anoka

Steps to Create the Watershed Fact Sheet Restoration and Protection Strategy Map 4/14/16

HSPF Scoring

Step 1.

Create a file geodatabase and import the HSPF HUC 12 data layer with columns for TN, TP and TSS output values. A key field required in this layer is the HUC12 code (string data type i.e. “070101061106”). This code will be used to join other tables and calculate field values and scores.

Step 2.

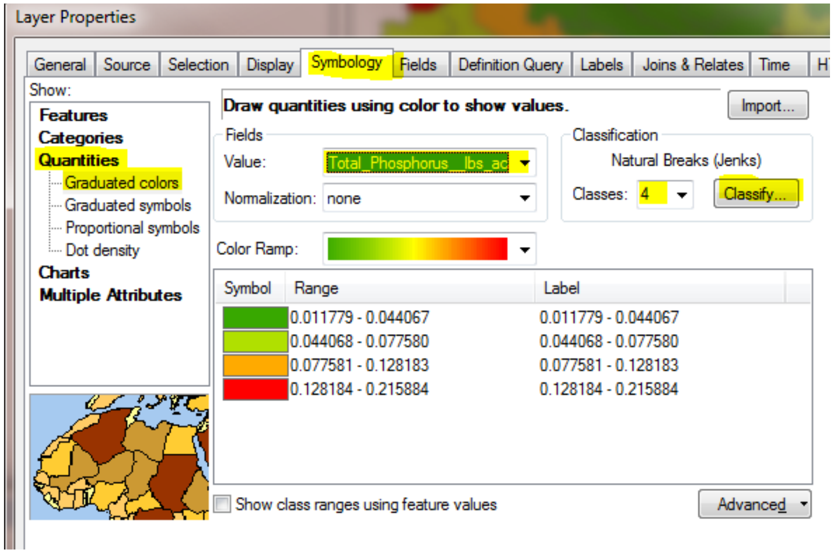
Create a table to hold the final scores. This is optional, but recommended. Export either the subwatershed layer provided by RESPEC (with **SUBBASIN** field) or HSPF output subwatershed layer (with **ReachID** field) to create a new table in the geodatabase. Ensure that this table has a **HUC12** field. Drop/remove all fields that you do not need. Add fields (numeric field type) for **HDS_Score, TP_Score, TN_Score, TSS_Score, Bio_Score**, and **Final_Score**. This will give you a table to store final scores which can be joined to a HUC12 layer for making the map. Example below:

final_table

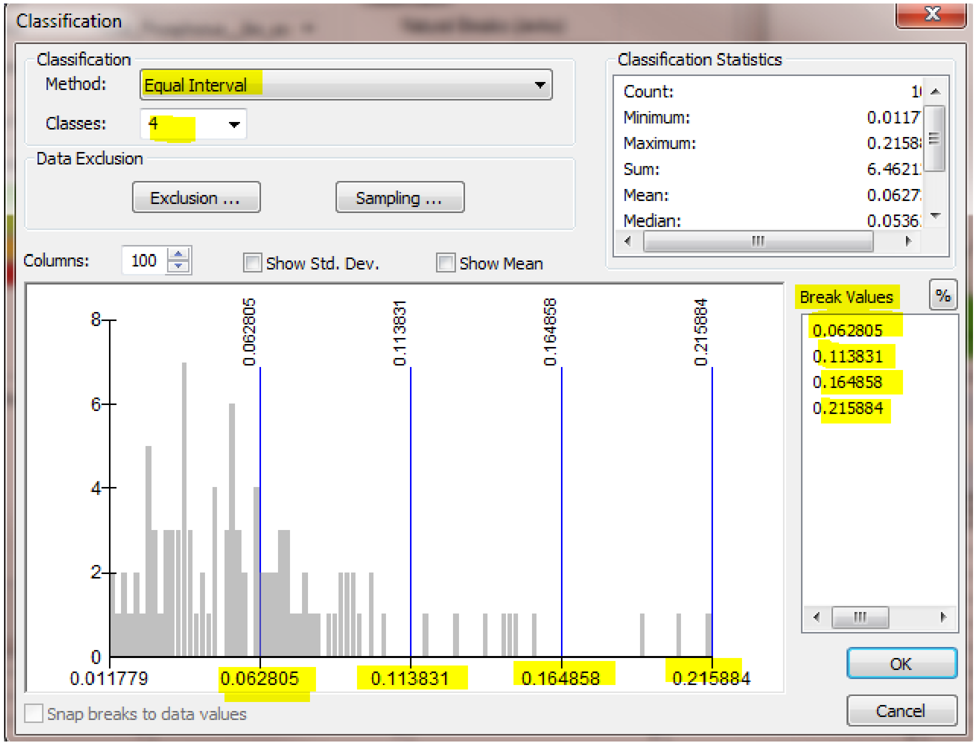
OBJECTID *	ReachID *	HUC12	Name	HDS_Score	TP_Score	TN_Score	TSS_Score	Bio_Score	Final_Score
1	583	070101061106	Lake Placid-Crow Wing River	2	1	2	3	1	9
2	530	070101060405	Shell River	1	2	2	1	2	8
3	576	070101061104	City of Motley-Crow Wing River	2	1	2	2	1	8
4	546	070101060606	First Crow Wing Lake-Crow Wing River	1	1	1	1	2	6
5	564	070101060806	City of Nimrod-Crow Wing River	2	2	2	2	2	10
6	567	070101060808	Farnham Creek	1	1	1	1	3	7
7	575	070101061102	Swan Creek	1	3	3	3	2	12
8	504	070101060202	Basswood Creek	1	2	2	3	0	8
9	578	070101061103	Mosquito Creek	1	1	1	2	2	7

Step 3.

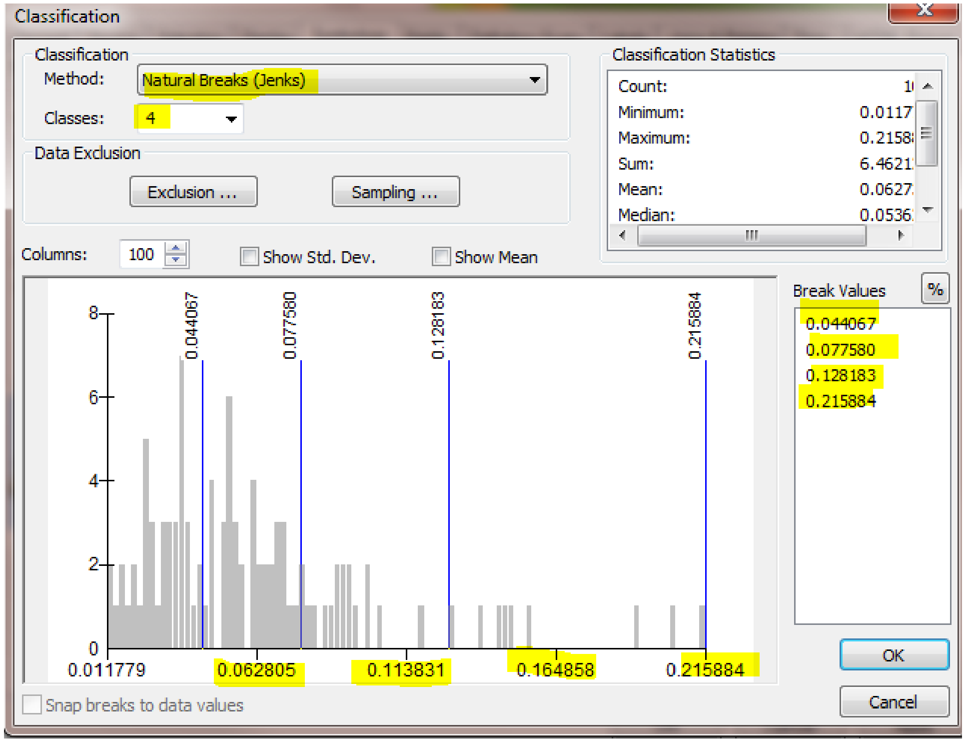
Calculate scores for TN, TP and TSS. Open the HSPF layer table. Add new fields for holding each score (i.e. **TN_Score, TP_Score and TSS_Score**). You will be classifying each field into 4 categories and calculating a score (1, 2, 3, or 4). Lower HSPF values will get a lower score (lower is better here and in the final score). The field calculator will be used to calculate scores for each category. To determine the break point value for each category, start by opening **Layer Properties** for the HSPF layer and click on Symbology tab. Select **Quantities – Graduated Colors**.



Next, select a classification method that best suites the watershed. Take a look at a number of classification methods and review with the PM and the HSPF modeler to select which one will be used. For the North Fork River Watershed, we used **Equal Interval** and for Crow Wing River Watershed we used **Natural Breaks**. (Note: The final combined score was classified by equal interval to create the final map for Crow Wing).

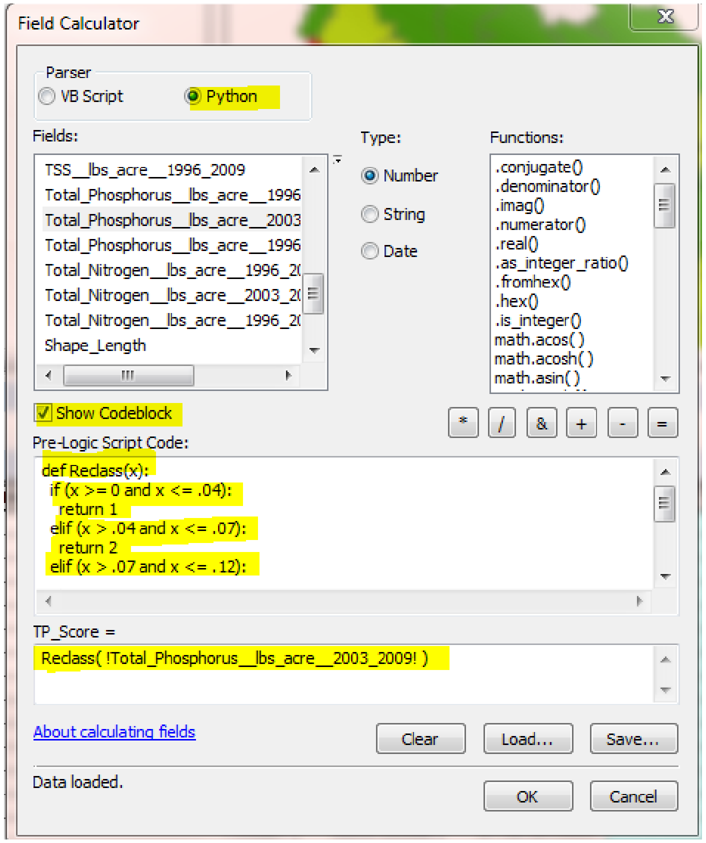


Classification
Classification
Method: Equal Interval
Classes: 4
Data Exclusion
Exclusion ...
Sampling ...
Classification Statistics
Count:
Minimum: 0.0117
Maximum: 0.2158
Sum: 6.4621
Mean: 0.0627
Median: 0.0536
Columns: 100
Show Std. Dev.
Show Mean
Break Values
%
0.062805
0.113831
0.164858
0.215884
0.011779
OK
Cancel
Snap breaks to data values



Record the break values of the classification method you chose for each TP, TN and TSS fields. Next, reclassify the data and calculate a score using the **Field Calculator**. Open the layer's table and right click on one of the empty fields that will hold the scores (i.e. TP_Score) to open the field calculator - select **Python** and checkbox for **Show Codeblock**. Enter the **Pre-Logic Script Code** (this allow you to create and use a python function to calculate field values) in the window and enter the function to calculate the score (indentation matters with Python). The python function below includes the break point values you recorded earlier. Enter the function – type in "**Reclass( )**" and then you can place cursor in brackets and double-click on the field you want to use – make sure it's Python syntax which is exclamation marks surrounding the field name (! fieldname !).

```
def Reclass(x):
 if (x >= 0 and x <= .04):
  return 1
 elif (x > .04 and x <= .07):
  return 2
 elif (x > .07 and x <= .12):
  return 3
 elif (x > .12):
  return 4
```



TP_Score	TN_Score	TSS_Score
1	2	3
2	2	1
1	2	2
1	1	1
2	2	2
1	1	1
3	3	3

Do this for each TP, TN and TSS score fields (3 times – change the break point values each time). Save the pre-logic script code for each by clicking on **Save**.

Step 4.

Join HSPF table to the final table to calculate (transfer) HSPF scores. Calculate **TP_Score, TN_Score** and **TSS_Score** fields in the final table equal to the **TP_Score, TN_Score** and **TSS_Score** fields in your HSPF table. Join tables based on HUC12 field (these may work as well - **SUBBASIN** or **ReachID**).

Human Disturbance Score (HDS) Scoring

Step 5.

Calculate the HDS score. A table containing the HDS score for each HUC12 exists and can be found at the path below. Scores were calculated based on a statewide equal interval classification – scores 1, 2, 3, 4 with higher HDS values being scored lower. So, higher is better here, but remember lower is better for final scores.

S:\Knutson_Pete.PK\Data\HDS\subwatershed_strategy.gdb\HDS_Total_Rankings

Join this table to the final table by HUC12 (**HDS_Total_Rankings** layer HUC12 field is named **FIELDNUM**) and calculate the **HDS_Score** field equal to **Fact_Sheet_Score** field in the HDS_Total_Rankings table. (**Note:** Further discussion may be needed to decide on what human disturbance data should be used and how to classify and score it.

HDS_Total_Rankings

OBJECTID *	FIELDNUM *	TotalScoreWOCorrections_Combined	Fact_Sheet_Score
197	070200041001	23.380078	4
198	070200041002	23.563791	4
199	070200041003	30.451134	3
200	070200041004	30.277148	3
201	070200080704	18.501241	4
202	070200080705	25.890835	3
203	070200080706	23.384243	4
204	070200080707	21.760183	4

Biological Data Scoring

Step 6.

Calculate the biological data scores. Kevin Stroom documented steps 1-7, below, which he followed to calculate a score.

Step 1. Removed the non-reportable and/or non-assessable biological samples.

Step 2. Removed samples older than 10 years prior the IWM year (e.g., for Crow Wing watershed, IWM was in 2010 and I removed any data collected earlier than 2000). I did utilize data (new biological sampling data) that was collected after the IWM year, so, since we are through the 2015 field season, there is actually a 15-year window for the biological data used in the Crow Wing map for the biological component.

Step 3. I averaged IBI scores for biological sites with more than one sample within the 15-year assessment window described above (keeping the fish and inverts separate - i.e., this gives an average fish IBI score and an average invertebrate IBI score for each biological site).

Step 4. For a number of 12-HUCs, there will be several IBI scores… I scored each site's IBI (fish and inverts separately) with the good/fair/poor/extra-poor rating (i.e., gave each a 1, 2, 3, or 4 respectively). Scores are given according to their relation to the IBI thresholds. The IBI thresholds are different for each stream class, so be sure to use the correct thresholds for a given site's stream class designations (i.e., each site has an invert class and a fish class designation). If the IBI score is above the upper confidence interval, score it 1. If IBI score is above the threshold, but below the upper confidence interval, score it 2. If IBI score is below the threshold, but above the confidence interval, score it 3. If IBI score is below the lower confidence interval, score it 4.

Note: Any biological impairment that was *officially* attributed to natural background was now removed from inclusion in scoring for that site (since this map is supposed to be a “where to take action” map - i.e., you can’t fix a natural “problem”.

Step 5. Next I calculated the average for each bio site, averaging the single fish score with the single invertebrate score to get a single biological score for each biological site.

Step 6. All of the final biological site scores from Step 5 within each 12-HUC were then averaged to give a single, final biological score for each HUC-12.

Step 7. There needs to be a final categorization into the 4 categories that go into making the map. For example, the final biological score coming out of Step 6 might be 2.33. What category should that go into? To break up the scores into 4 equal sections, it would mean scores from Step 6 that are:

from 1.0 - 1.74 = Good (score of 1)
from 1.75 - 2.49 = Fair (score of 2)
from 2.50 - 3.24 = Poor (score of 3)
from 3.25 - 4.0 = Very Poor (score of 4)

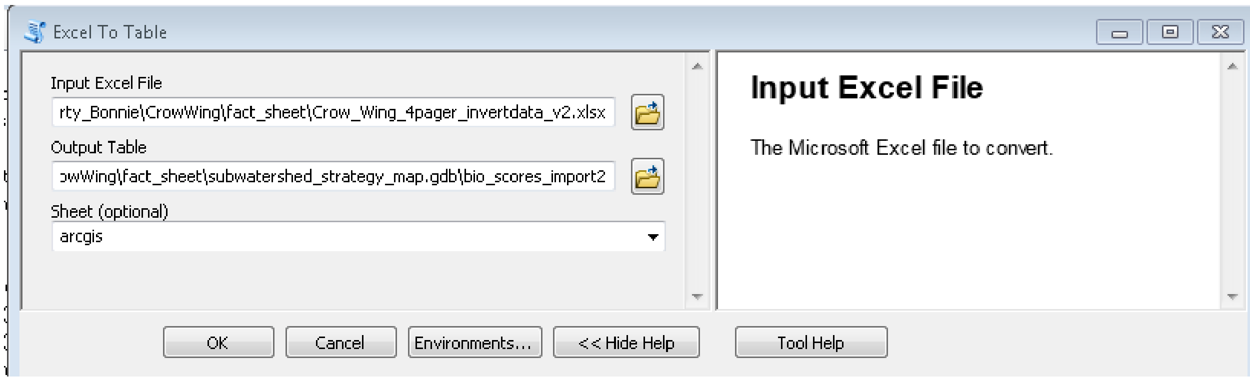
The screenshot below shows the data format in Excel provided by Kevin.

	A	B	C	D	E	F	G	H
1								
2	**HUC12**	Overall HUC12 bio score	Overall HUC12 bio score **categorized**	Narrative Category		**Categories**		
3	70101060101	3.00	3	Poor		Good	1.0 -1.74	1
4	70101060102	1.83	2	Fair		Fair	1.75 - 2.49	2
5	70101060203	2.50	3	Poor		Poor	2.50 - 3.24	3
6	70101060204	2.00	2	Fair		Bad	3.25 - 4.0	4
7	70101060205	2.00	2	Fair				
8	70101060210	1.25	1	Good				
9	70101060301	1.33	1	Good				

The worksheet above was copied to a new one and reformatted to prepare it for importing to ArcGIS using Excel to Table Tool. The HUC12 code needs to be text/string format with a ‘0’ (zero) as the first character. The column headers need to be single, short, one line format to be imported to ArcGIS. This screenshot shows the new worksheet which I named “arcgis.”

HUC12	Avg_Bio_Score	Bio_Score
070101060101	3.00	3
070101060102	1.83	2
070101060203	2.50	3
070101060204	2.00	2
070101060205	2.00	2
070101060210	1.25	1

Next, run the Excel to Table Tool to import to your geodatabase. Specify the worksheet you want to import.



The imported table will look like this:

bio_scores_import

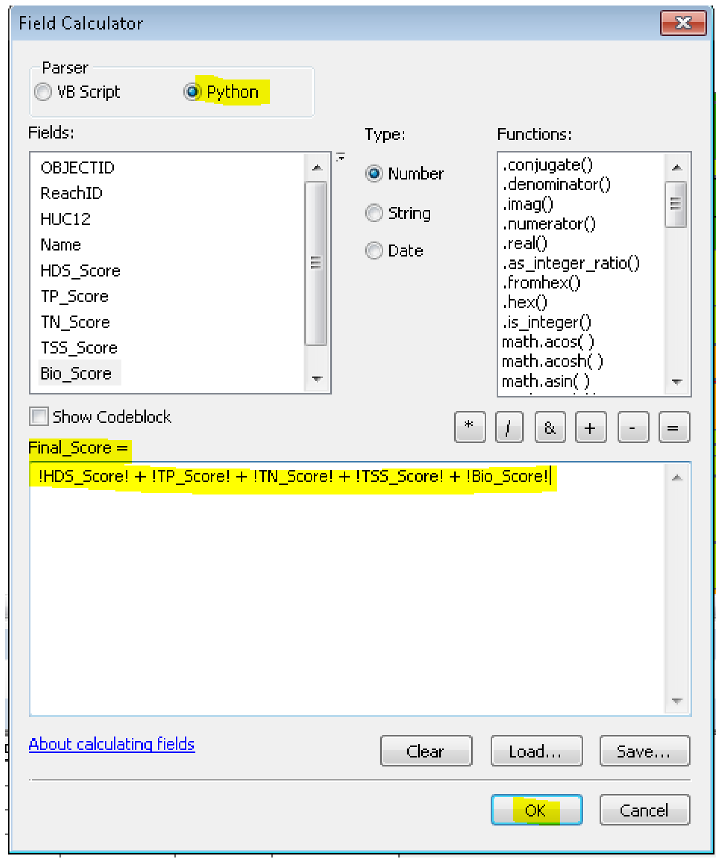
OBJECTID *	HUC12 *	Avg_Bio_Score	Bio_Score
1	070101060101	3	3
2	070101060102	1.833333	2
3	070101060203	2.5	3
4	070101060204	2	2
5	070101060205	2	2
6	070101060210	1.25	1

Next, join the imported biological score table to your final table by HUC12 and calculate the Bio_Score field equal to the Bio_Score found in the imported table. Verify that it was calculated correctly and then remove the join.

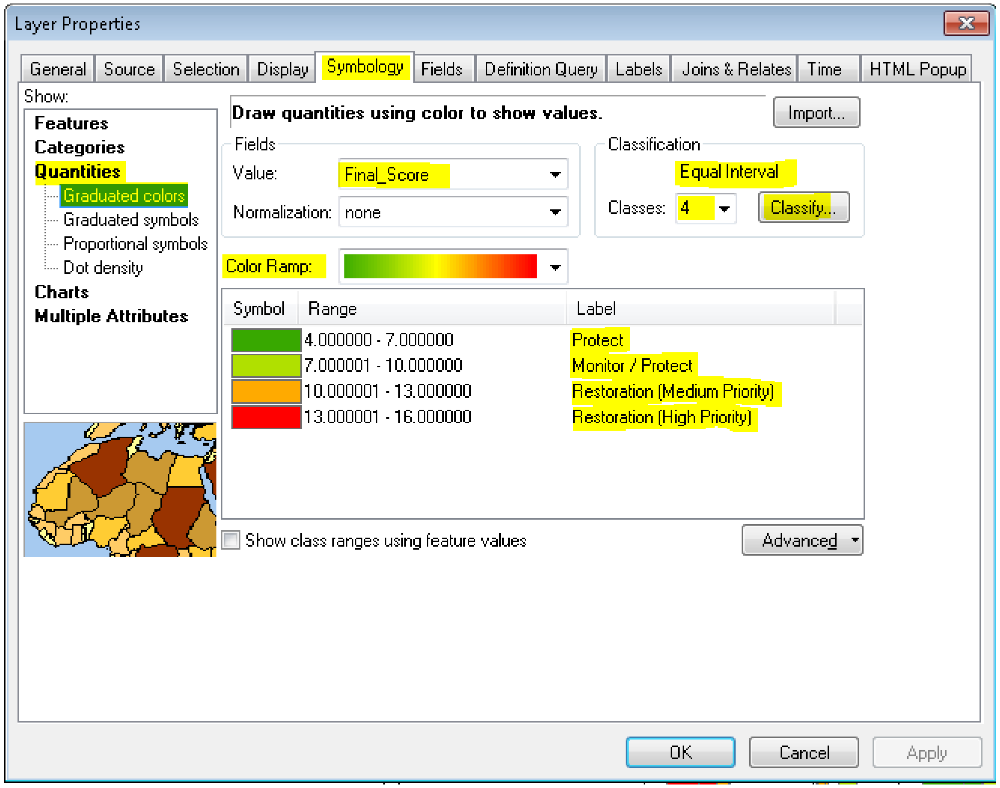
Final Score Calculation and Map Creation

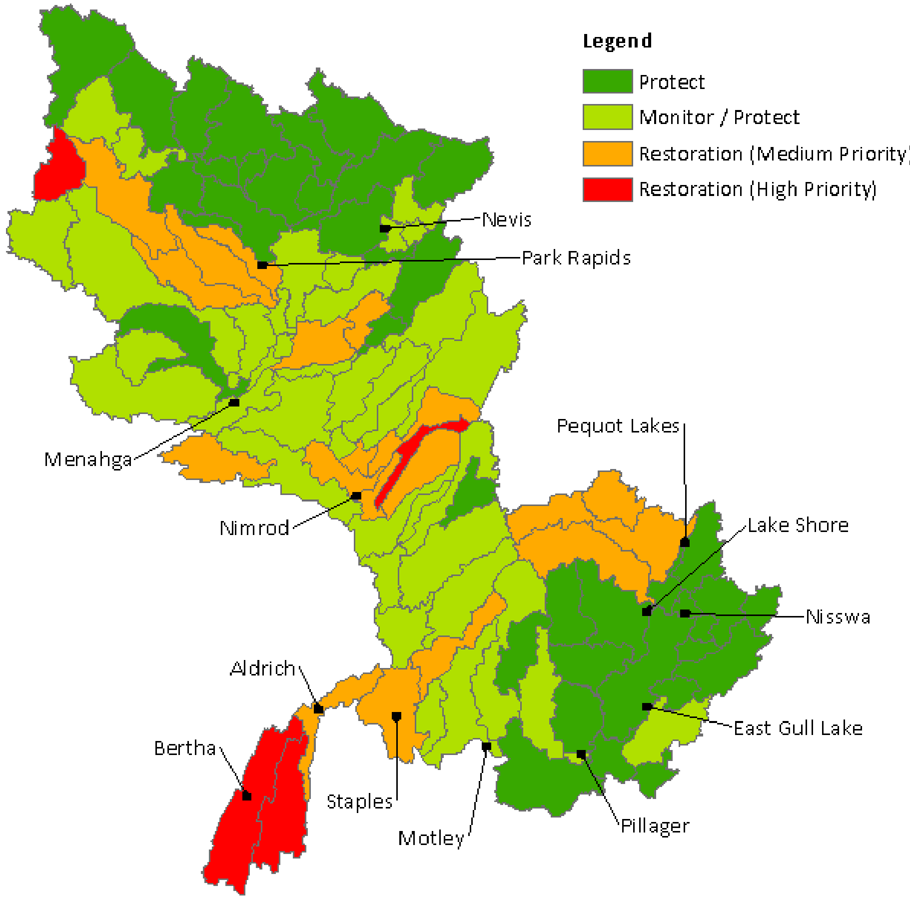
Step 7

Calculate the final score. With the final table open, right-click on the Final_Score field and select Field Calculator. Select Python (or VB Script) and create the statement !HDS_Score! + !TP_Score! + !TN_Score! + !TSS_Score! + !Bio_Score! by double-clicking on each field and the '**+**' button. When you're done, click '**OK**.'



Now that you have the final score, all you need to do is create the map. Join the final table to your HSPF layer using the HUC12 field. Right-click or double-click on the HSPF layer in the table of contents and open the Layer Properties window. Using the screenshot below as a guide, classify the Final_Score field into 4 classes. Using the Equal Interval classification method, select the green to red color ramp and type in the Label text – lower score is better – Protect, Monitor / Protect, Restoration (Medium Priority), and Restoration (High Priority).


Layer Properties
General
Source
Selection
Display
Symbology
Fields
Definition Query
Labels
Joins & Relates
Time
HTML Popup
Show:
Features
Categories
Quantities
Graduated colors
Graduated symbols
Proportional symbols
Dot density
Charts
Multiple Attributes
Draw quantities using color to show values.
Import...
Fields
Value: Final_Score
Normalization: none
Classification
Equal Interval
Classes: 4
Classify...
Color Ramp:
Symbol
Range
Label
4.000000 - 7.000000
Protect
7.000001 - 10.000000
Monitor / Protect
10.000001 - 13.000000
Restoration (Medium Priority)
13.000001 - 16.000000
Restoration (High Priority)
Show class ranges using feature values
Advanced
OK
Cancel
Apply



Points of contact in the North Central Watershed Unit:

Mark Evenson – HSPF
Kevin Stroom – Bio
Pete Knutson - GIS

Methodology Background – Methodology developed by Chris Klucas and Jeff Strom (Wenck) and first applied for the Snake River WRAPS project.

Multiple Benefits for People and Nature:

Mapping and Modeling Tools to Identify Priorities for the Nature Conservancy's Freshwater Program and the Minnesota Headwaters Fund

The goal of the Conservancy's freshwater program is to conserve the lands that protect clean water, and to support high-impact conservation projects to protect clean water in Minnesota's lakes and rivers for the benefit of nature, people and the economy. As threats to continue to mount, it is becoming increasingly important to identify and conserve high-priority areas for habitat and clean water benefits. Identifying where in the landscape conservation can provide multiple, overlapping benefits can help more effectively target efforts and more efficiently utilize limited resources. Examples of protection and conservation approaches throughout the Upper Mississippi River basin include easements, stream bank and floodplain restoration, and other projects that prevent pollutants such as nitrates and sediment from entering key rivers and lakes.

This document and accompanying spreadsheet describes the methodology and criteria developed to make recommendations for investments to support clean water for people and nature. The purpose of this exercise was initially to support TNC in developing programmatic priorities for freshwater, and to set goals and targets for the Freshwater Business Plan. This includes recommendations for Protection, Restoration & Management, as well as investments in natural infrastructure for multiple ecosystem service benefits.

The intent of the process was to develop and score priorities **according to specific but multiple cross-cutting needs, and looking for the "Sweet Spot"** where multiple benefits overlap (habitat, water quality, water user benefit, flood benefit). We conducted priority area mapping based on criteria and key attributes for determining freshwater priorities.

Evaluation criteria should be dynamic, reflecting the evolution of better and more accurate tools, and may include

- Aquatic Protection priorities
- Terrestrial protection priorities
- Lands important to drinking water quality or other benefits to people
    - Close to a threshold
    - Vulnerable to conversion
    - Important or disproportionate impact on water quality

We also attempted to develop a map-based classification for STRATEGY (Protection vs Restoration). Ongoing needs include the need to better understand threats, thresholds, and how much conservation is enough at multiple watershed scales (small watersheds, large watersheds, and river basins); to identify management/habitat improvement opportunities on already public/protected land;
which lands need to be acquired to reach those desired goals; measuring and documenting the effectiveness of habitat restoration and protection activities; and setting targets and goals for landscape scale conservation. Interpretation of output needs to consider appropriate SCALE (major Huc8 watershed, minor Huc12 watershed, project-based).

MULTIPLE BENEFITS MODULES FOR PRIORITIZING FRESHWATER CONSERVATION INVESTMENTS

We built on a systematic approach originally pursued by NCCR in 2014, working with MNDNR's Division of Ecological Resources team in Brainerd (Paul Radomski and Kristin Carlson), to develop a "blueprint" of conservation priorities across the Mississippi headwaters region. The approach uses a software tool called "Zonation", which allows stakeholders to aggregate multiple layers representing landscape features and conservation criteria, using an objective weighting function. The weighting is based on the relative value participants ascribe to each layer. The result is a map showing weighted priorities within the landscape for conservation, protection or restoration. This approach has been widely adopted at the major watershed (Huc-8) scale in the context of the MPCA's Watershed Restoration and Protection Strategy (WRAPS) planning process. In part because not all WRAPS in the Mississippi headwaters basin are on the same timeline, nor are they being done exactly the same way, the NCCR chose to conduct a prioritization model that would be consistent across the entire Mississippi headwaters.

The initial blueprint was reviewed, tweaked, and adopted by NCCR to help inform and coordinate support for partner priority projects across the Headwaters. However, at the time it was observed that the blueprint scored equally high large areas across, and that in some cases component layers may have contributed to scores that were counterintuitive to that which best professional judgement. Furthermore a number of new data layers became available only after the NCCR Zonation model was completed. In addition, partners were concerned that the final output layer showing all the combined outputs for protection, drinking water, and restoration was difficult to interpret. For example, priority scores for pollutant load reduction might effectively "cancel out" priority areas for habitat protection in the final weighting; therefore, there was a desire to separate out the major model components to facilitate interpretation and development of appropriate strategies.

Finally, the NCCR geographic scope did not include the entire Mississippi headwaters, rather it extended only as far downstream as the Mississippi River – Platte River major watershed at Little Falls.

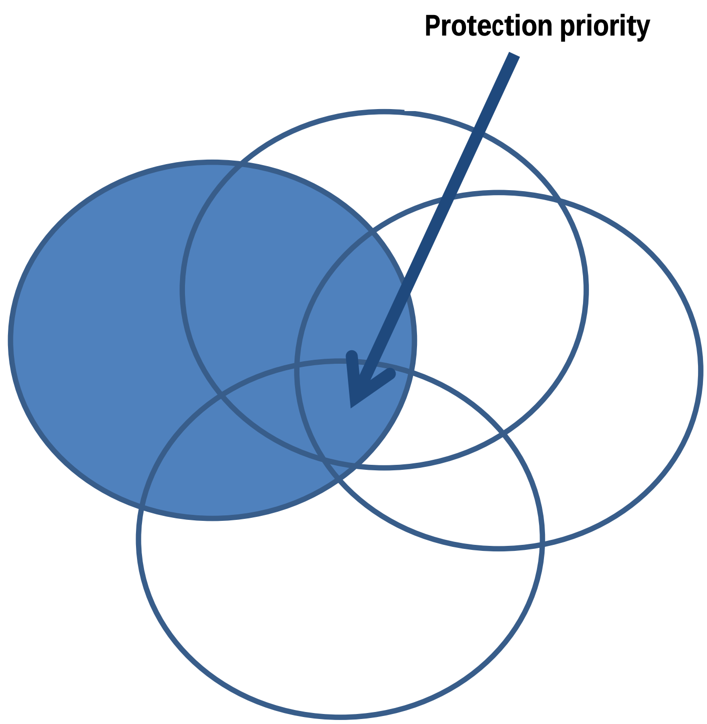
Based on all of these considerations, the Nature Conservancy took the initiative to develop a second iteration of this approach for the entire Mississippi headwaters that would incorporate newly available data layers, include the entire Mississippi headwaters, and be designed to be modular based on similar types of benefits.

Multiple Benefits$^{v2.0}$ Methods and Data Layers

The tool is composed of 4 primary modules:

1. Fish and Wildlife
2. Drinking Water and Groundwater Quality
3. Flooding and Erosion
4. Groundwater Quantity

The Shoreland module was not used; shoreland protection is identified as a priority for its own sake.



Fish & Wildlife Habitat Benefits

- Ecological patches and connections
- Protected lands
- Rare features
- Areas of biodiversity significance
- Lakes of biological significance
- High quality wild rice lakes
- High quality cisco lakes
- Forest conservation value/
  - Drinking water value

Drinking Water/Source Water Benefits

- Drinking water management supply area vulnerability
- Groundwater contamination susceptibility
- Proximity to water

Reduce Erosion, Enhance Storage, and Reduce Hydrologic Alteration

- Existing wetlands, riparian areas, and floodplains providing storage and retention benefits
- Areas vulnerable to erosion

Protect Groundwater Quantity – Protect recharge and manage withdrawals

- Groundwater recharge
- Water use intensity relative to sustainable supply

Detailed Methods

Fish and Wildlife Module

The Fish and Wildlife module is intended to represent priority areas for ***protection*** based primarily on aquatic habitat protection value and secondarily on terrestrial fish and wildlife benefits. The module incorporates available data layers designed to represent parts of the basin where protection will have the highest benefits to fish and wildlife and their habitats. Much of the northern half of the Basin, including Itasca State Park, Leech and Cass Lake, the area around the Chippewa National Forest, northern Brainerd Lakes and Gull lake areas, Lake Alexander, Mille Lacs, and the Mississippi River corridor score highest on this module.

Components – Each of the component layers described below is re-scaled so that contributes equal weight in the final fish and wildlife module (3 of 30 points). For more information on how each individual layer is scored and weighted in the model, see the Appendix.

1. <u>RWI Benefit to Species Value:</u> This layer is a component of the Restorable Wetland Prioritization Tool developed by researchers at the University of Minnesota- Duluth Natural Resources Research Institute to prioritize wetland restoration and protection[1]. The *Species benefits* layer was developed using a subset of the individual habitat components from the Ecological Benefits Index (EBI) including sites of biodiversity significance, Species of greatest conservation need (SGCN) (number of species of greatest conservation need for which the land may provide suitable habitat); Potential bird habitat (probable number of birds from a modeled set of 17 that might use that habitat); and weighted habitat protection – the number of terrestrial vertebrate species potentially using this land weighted by the current level of habitat protection statewide for each species. The individual EBI inputs were combined using a weighting process to form a single species benefits decision layer designed to predict potential habitat enhancements that would result from wetland restoration or protection. This layer was included in the module as a statewide data layer representing overall habitat value weighted approximately equally for aquatic and terrestrial species and SGCN.
Caveats: this layer is more updated and less redundant with the layers below than the layer from the LCCMR Strategic Habitat Plan used by LSOHC. It should perhaps be replaced by the Wildlife Action Network from the 2015 MN Wildlife Action Plan Update.

2. <u>Biodiversity Significance Score:</u> The Minnesota Biological Survey has assigned a biodiversity significance rank to surveyed sites across the state intended to reflect landscape context and ecological function, existing native plant community quality and rarity, and species quality and rarity. There are four biodiversity significance rankings: outstanding, high, moderate, and below. This layer is included in the freshwater Fish and Wildlife module to give greater weight in the final model to areas with moderate (1 pt), high (2 pts) and outstanding (3 pts) biodiversity.

3. <u>Lakes of Biological Significance</u>: This layer is based on the lake catchment for lakes designated as **Lakes of Biological Significance (LBS)**[2]. Lakes were identified and classified by DNR subject matter experts on objective criteria for four community types (aquatic plants, fish, amphibians, birds); or if the lake is included in the Conservancy's lake portfolio. Scored meeting standard (1 pt), higher (2 pts) and highest (3 pts).

4. <u>Index of Biological Integrity</u>: This layer includes lake catchments with outstanding IBI scores based on the preliminary fisheries lake IBI[3]. The IBI *(Index of Biotic Integrity)* is a biologically-based, multi-metric method for measuring the integrity of aquatic systems. Minnesota DNR Fisheries Research has developed a fish-based lake IBI that incorporates fish data collected by various methods (trap nets, gill nets, shoreline seines, and backpack electrofishing units) into 8-15 metrics in three categories: species richness, community assemblage, and trophic composition. Lake catchments are scored based on the highest scoring lake meeting the IBI standard: meeting standard (1 pt) above standard (2 pts) and exceptional (3 pts), plus (+1 pt) if catchment contains a lake in the TNC lake portfolio.

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[1] http://www.mnwetlandrestore.org/project-description/subtopic-copy/subtopic-copy-2/
[2] https://gisdata.mn.gov/el/dataset/env-lakes-of-biological-signific
[3] https://gisdata.mn.gov/el/dataset/env-ibi-lakes-fisheries

5. Wild rice catchments: Wild rice is a unique resource in Minnesota, important culturally as well as to migrating waterfowl and other wildlife. Because wild rice is so important as well as sensitive to hydrologic and water quality disturbance, lake catchments identified as having significant wild rice were included as a layer in this module.
6. Coldwater refuge - cisco – This layer represents the level 8 DNR lake catchments for lakes identified by the Minnesota DNR to be the most resilient, likely refugia for ciscoes (tullibee, *Coregonus artedi*), a keystone species for Minnesota's deep, coldwater lake class. Because these lakes are likely to be the most resilient in the face of climate change, they are priorities for protection in the Minnesota DNR Aquatic Habitat Strategic Plan.
7. High Conservation Value Forests: The original NCCR model only included forests designated as "old-growth". We used FLEET results (ecological value) for northern headwaters. However, because FLEET does not extend beyond the Superior Mixed Forest ecoregion to include the entire Mississippi River headwaters basin, we rescaled the USFWS Upper Mississippi River Forest Partnership Priority Forest for Drinking Water to use those scores for the portion of the Basin not covered by FLEET. Caveat: This obviously results in a problem, since the methodology is not the same across the study area, especially significant when evaluating finer scale scores along the Superior Mixed Forest border. Future iterations of the tool could be revised to use a cumulative forest disturbance layer currently being developed by MN DNR (Corcoran 2015). For this version we made the choice to use the ecological value layer.
8. Ecological Patches or Connections: Statewide, riparian corridors constitute some of the most extensive and complete terrestrial habitat corridors for fish and wildlife, particularly in areas disturbed by urban or agricultural land use. We created a layer representing landscape habitat connectivity for both aquatic and terrestrial species based on perennial lands within the Active River Area (ARA) layer as derived for the Mississippi headwaters (2014).
9. Proximity (inverse distance) to protected lands This layer is scaled 0-100 based on inverse distance to protected lands, on the assumption that all else being equally, lands more closely connected to an existing network of protected lands are of relatively higher conservation value.
10. Proximity (inverse distance) to water. This layer is scaled 0-33 based on inverse distance to water features, on the assumption that the value of lands to fish and wildlife is in direct proportion to their distance from water.

Drinking Water Quality Module

The Drinking Water module is intended to represent priority areas for protection ***and/or*** restoration, weighted on the relative potential impact on estimated actual users where they obtain their drinking water. This module may be used with or without the groundwater recharge module. Inclusion of the groundwater recharge module reduces the apparent resolution of the visual output from the module, because the latter is based on larger, coarser grid cell resolution of the Smith et al. (2015) analysis.

Caveats:

- Because of the limitations of the resolution and projection accuracy of the groundwater susceptibility component in particular, parcel scores evaluated on this module should not be over-interpreted in local project context.
- The methodology for assigning relative importance of ARA lands upstream in terms of influence on downstream surface water drinking intakes is approximate, and could be improved in collaboration with the drinking water utilities and others working to develop similar tools.

Module Components

1. Drinking Water Management Supply Area Vulnerability: This is a delineation of areas of concern for and relative risk for a potential contaminant source within the drinking water supply management are to contaminate a public water supply well based on the aquifer's inherent geological sensitivity; and the chemical and isotopic composition of the ground water. Source: MDH.

   Wellhead Protected Areas: WPA is the surface and subsurface area surrounding a public water supply well or well field that supplies a public water system, through which contaminants are likely to move toward and reach the well or well field. Source: MDH.

   The maximum score for these two layers is scored 1-5 (0 for non-DWSMA or WHPA areas). (They do not have 100% overlap).

2. Groundwater Contamination Susceptibility: A broad, generalized interpretation of ground water contamination susceptibility for the state, based on modeling relying on data inputs from the MLMIS40 (40-acre raster) soils and geology data, with additional geology inputs[4]. The parameters that control ground water susceptibility to contamination are quite varied and overlapping, and include: soil media, topography, depth to water, aquifer media, vadose zone materials, net recharge, hydraulic conductivity of aquifer, hydraulic gradient, distance to nearest drinking water supply, depth to bedrock, unsaturated zone permeability and thickness, and net precipitation. *Caveats: this layer does not display accurately into UTM15 NAD83 projection; it is offset by up to 300 m. Metadata reinforces that it is not appropriate for site-specific use.*

3. Proximity to mainstem river water supply (Mississippi River and Major Tributaries) Lands within the ARA upstream of surface water intakes for major drinking water supply areas are assigned zonal values based on downstream distance to the supply area.

4. Private well density – This layer summarizes the County Well Index (CWI) layer (Source: MDH[5]) by Huc12 watershed to summarize the number of private domestic water supply wells in each 12-digit watershed that are located in a vulnerable or highly vulnerable groundwater area, and is converted to 10 density classes by Huc12. The CWI layer is known to be dated and incomplete, but represents an accurate representation of the population density relying on private domestic groundwater wells.

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[4] http://www.mngeo.state.mn.us/chouse/metadata/gwc.html

[5] http://www.health.state.mn.us/divs/eh/cwi/

Flooding and Erosion Module Components:

1. Benefits to Water (RWI)[6]: This water quality later predicts the potential water quality benefits in the form of reduced erosion risk from wetland restoration or protection. The layer utilizes the data inputs soil erosion risk and water quality risk from the Environmental Benefits Index along with the downstream flow distance to open water. The EBI is an ecological ranking tool (30 m grids) developed by Minnesota Board of Soil and Water Resources (MNBWSR) and NRRI.
    - The soil erosion layer estimates the potential risk of soil erosion on a 0-100 scale based on components of the Universal Soil Loss Equation (USLE) (rainfall runoff factor, slope length slope gradient, and soil erodibility factor) at a 30 m resolution. NRRI modified the layer to predict the potential flow accumulated soil erosion risk downstream to the nearest second order stream for each 30 m cell.
    - The water quality risk layer estimates each 30 m cell's risk to water quality based on the likelihood of overland flow during a rain event and its proximity to water. The likelihood of overland flow was estimated from stream power index (SPI). The downstream flow distance to water measures the closest downstream distance to water.

    The flow accumulated soil erosion risk, water quality risk and downstream flow distance to water were combined through a weighting process to form a single water quality/erosion benefits layer.

2. Sediment Retention Benefits: Mosaic of the following 3 layers, then averaged over a focal statistics rectangle 9 cells wide & tall.
    - Existing Perennial cover x Sediment Retention from Invest Model: InVest – Integrated Valuation of Ecosystem Services and Tradeoffs is an open-source software suite aimed at quantifying and mapping ecosystem services. The nutrient and sediment loading models are described elsewhere. The sediment results were generated January-February 2015 using InVEST 3_1_0b1 version of the sediment delivery and retention model. This layer represents the lands already in perennial land cover that had the highest scores for sediment retention.
    - Existing ARA x Sediment Retention from Invest Model : This layer represents the lands within the Active River Area that had the highest scores for sediment retention (see above).
    - Existing NWI x Sediment Retention from Invest model : This layer represents wetlands with the highest scores for sediment retention (see above).

3. Total upstream contributing area / wetland acres (storage) : Relative ecosystem service value of existing wetland storage. This layer represents the ratio of upstream watershed delivery area to existing wetlands, on the assumption that the greater the upstream contributing area, the greater the relative contribution to storage of any given area of wetland storage. Research suggests that the value of remaining wetland storage increases exponentially as percentage of wetlands decreases, and that there is a hydrologic threshold at around 10% wetlands.

Groundwater Recharge Module Components

1. Groundwater Recharge (inches/year) (Smith et. al 2015) and Groundwater recharge (inches/year) (Lorenz and Delin 2007)

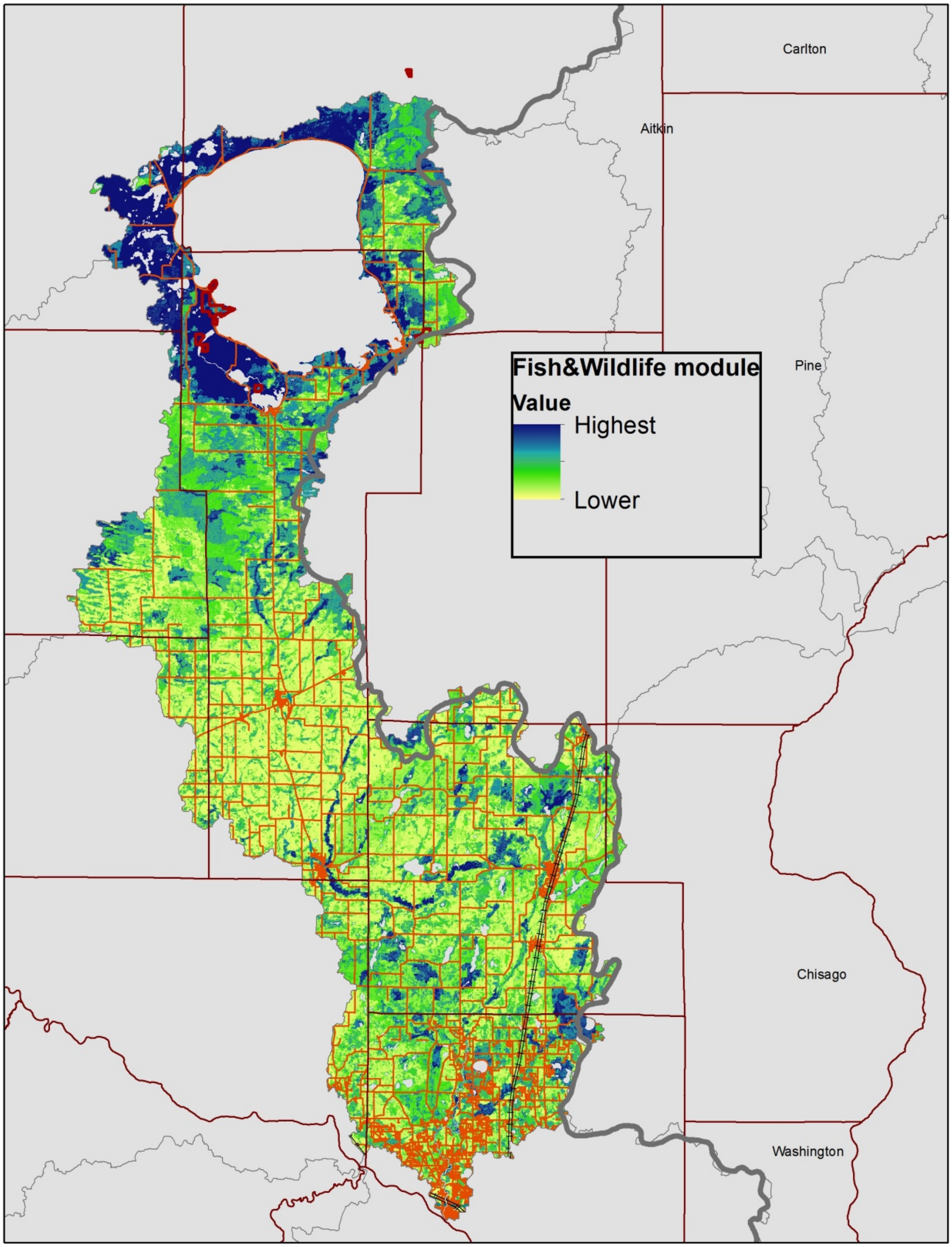
    The two layers are averaged together to yield a long term potential average recharge (in inches / year of rainfall that recharges groundwater and supports streamflow).

2. Water use vulnerability Index, Predicted Vulnerability -- DNR Watershed Health Assessment Framework Catchment Score http://www.dnr.state.mn.us/whaf/about/scores/hydrology/waterwithdraw.html

    The index is based on the sum of permitted withdrawal from surface water and groundwater. Using the State Water Use Database (SWUD), total potential consumption was calculated by summing permitted use and

[6] http://www.mnwetlandrestore.org/project-description/subtopic-copy/subtopic-copy-2/

comparing to annual runoff. The “water use vulnerability index” is scaled as the greater the amount of water used as percent of runoff, the lower the score. The **Catchment Predicted Vulnerability is t**he five year trend in reported use as a percentage of runoff.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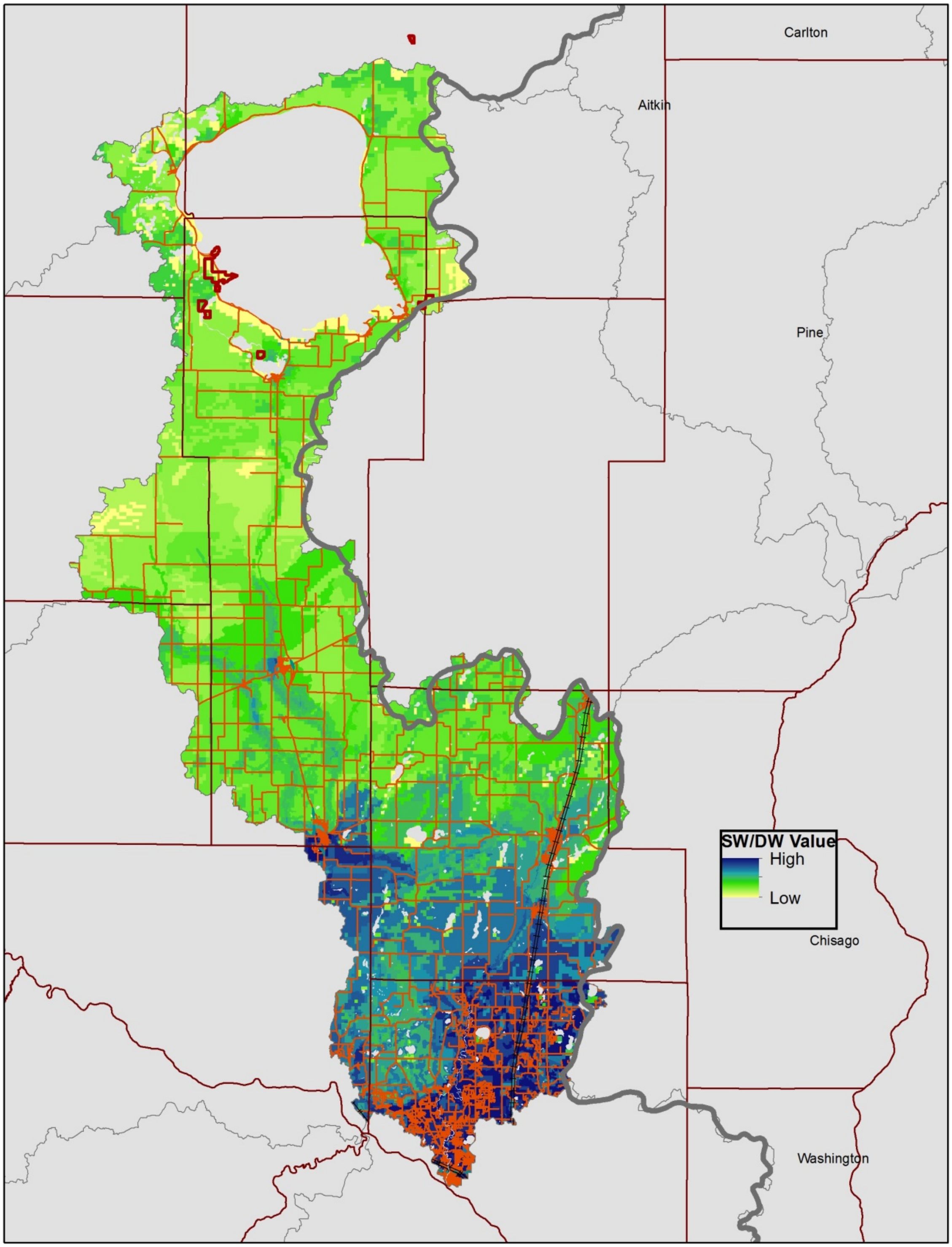
Aitkin
Pine
Fish&Wildlife module
Value
Highest
Lower
Chisago
Washington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Aitkin
Pine
SW/DW Value
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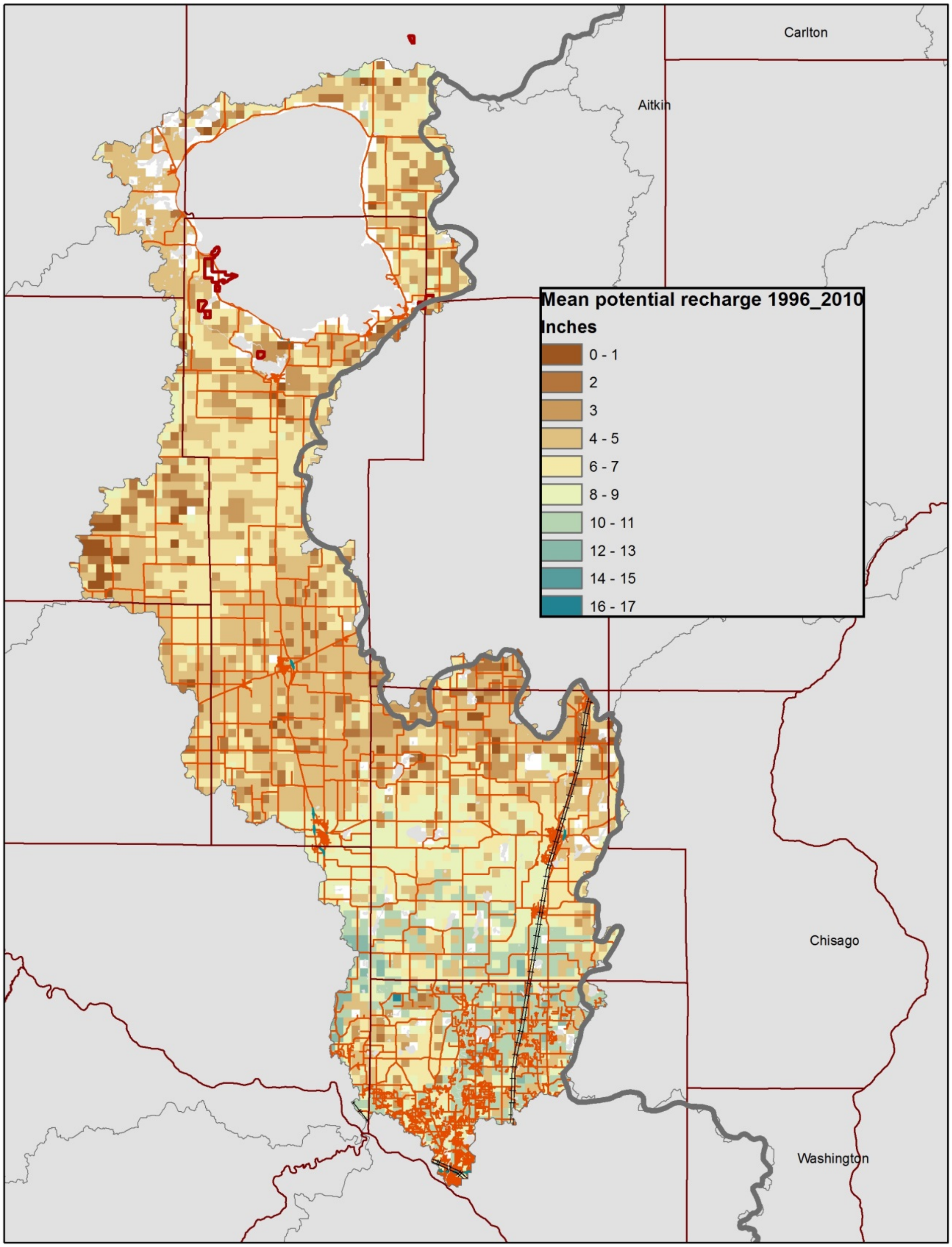
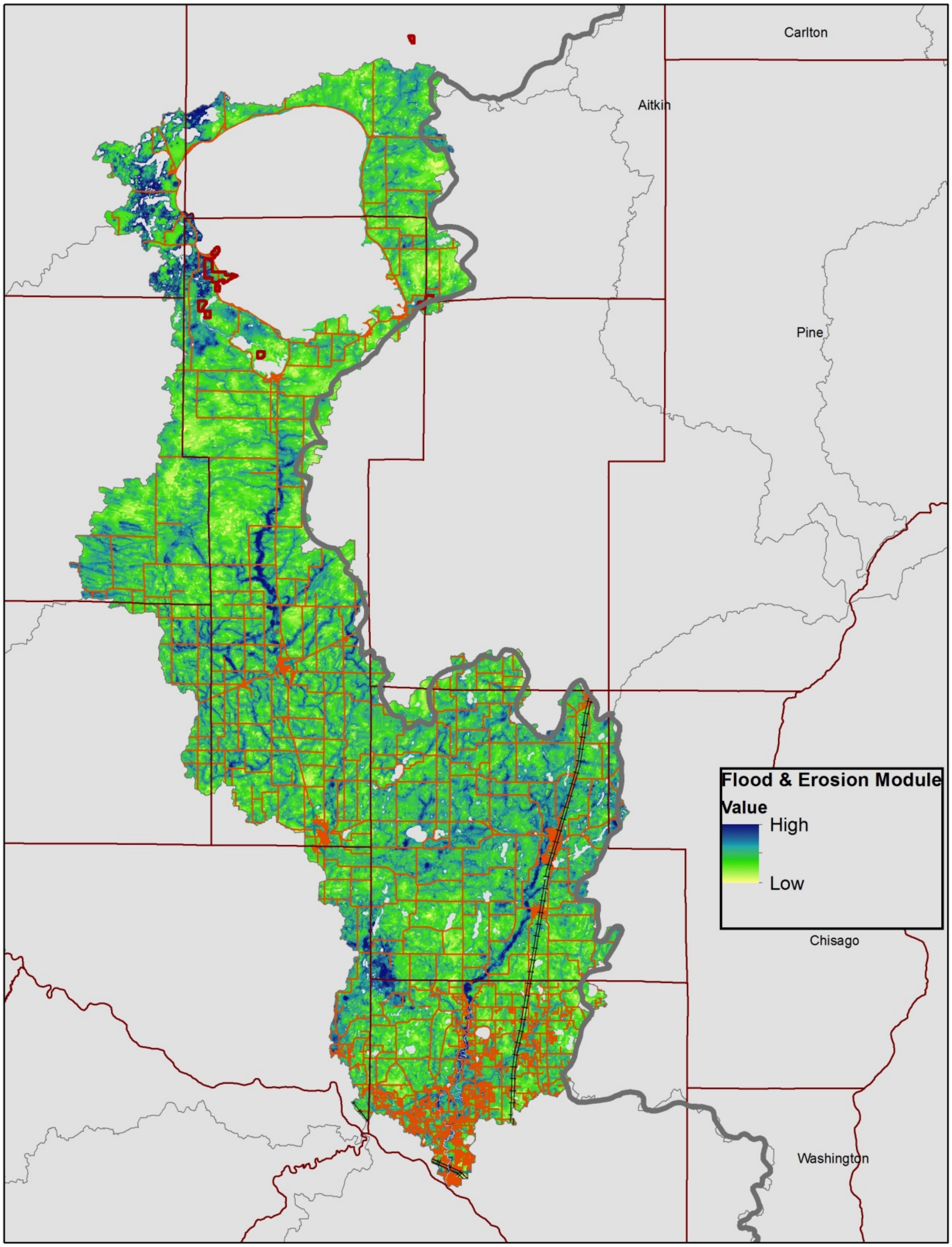
Low
Chisago
Washington


Carlton
Aitkin
Mean potential recharge 1996_2010
Inches
0 - 1
2
3
4 - 5
6 - 7
8 - 9
10 - 11
12 - 13
14 - 15
16 - 17
Chisago
Washington


Carlton
Aitkin
Pine
Chisago
Washington
Flood & Erosion Module
Value
High
Low

Appendix F Rum River Watershed HSPF Scenario Report

RUM RIVER WATERSHED: FUTURE LAND-USE CHANGE SCENARIOS AND PROJECTION OF IMPACTS TO WATER QUALITY

Topical Report RSI-2665

prepared for

Anoka County Conservation District
1318 McKay Drive NE #300
Ham Lake, Minnesota 55304

October 2016

RESPEC

RUM RIVER WATERSHED: FUTURE LAND-USE CHANGE SCENARIOS AND PROJECTION OF IMPACTS TO WATER QUALITY

Topical Report RSI-2665

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October 2016

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1.0 SCENARIO EVALUATION

The Rum River Watershed (RRW) contains many high-quality surface waters from its headwaters of Lake Mille Lacs and including mainstem Rum River segments classified as Wild, Scenic, or Recreational by the Minnesota Department of Natural Resources (MNDNR). Middle and lower portions of the Rum River are approaching or have exceeded phosphorus levels identified for the Central River Nutrient Region, and several tributaries and upland lakes have exceeded water quality standards and are listed as impaired. Accordingly, Rum River Watershed Restoration and Protection Strategies (WRAPS) team members are trying to better define the nature of the future challenges by assessing the potential cumulative impacts of future land-use changes as well as gauging potential off-setting effects of typical Best Management Practices (BMPs).

The draft RRW TMDL report [Minnesota Pollution Control Agency, 2016] defined north-south gradients of climate, population, land cover, and water quality as the Rum River flows from its headwaters of Lake Mille Lacs to its outlet in Anoka. The RRW begins in the Northern Lakes and Forests (NLF) ecoregion of the upper approximately one-third of Mille Lacs County, which is predominantly forested. By the middle reach, land cover transitions to more urban and agricultural areas with increasing development in the RRW's Lower Reach. Anticipated Middle and Lower Reach tributaries shift in land uses to more intense urban development and agriculture with corresponding increases in artificial drainage practices may present additional runoff volume and quality challenges within the basin.

As part of the future forecasting, stakeholder inputs and local and regional experts' professional judgment were used to define likely areas of potential, future land-use changes. The Rum River Basin HSPF model was calibrated based on 20 years of hydrologic, climate, and monitoring data and was used to predict impacts of future land-use changes as well as restorative or protective effects from employing BMPs.

Present-day tributary water quality was compared to projected future water quality with results expressed by percent change. These assessments allow a broad-brush projection of potential impacts, both geographically and propagated along flow networks, which should be used for a relative comparison of effects. For this assessment, the Rum River has been organized into the Mille Lacs Management Zone, the Upper Reach Management Zone, the Middle Reach Management Zone, and the Lower Reach Management Zone from north to south, as shown in Figure 1-1.

Most of the focus of these future projections are based on changes in loading for total suspended solids (TSS) and total phosphorus (TP), which are well defined in the scientific literature and by Minnesota water quality rules. Total nitrogen (TN) loading changes were added to reflect increasing concern related to groundwater protection and cumulative effects of altered nitrogen to phosphorus (N:P) ratios in receiving waters. As N:P ratios decline, conditions may begin to favor nuisance cyanobacteria.

Five potential, future land-use change scenarios that can be appropriately evaluated with the HSPF model were developed to predict potential impacts on watershed flows and water quality as estimated by percent change in annual average loading for TSS, TP, and TN. Modeling-period average runoff and average loads are tabulated in Appendix A. Evaluated scenarios included the following changes:

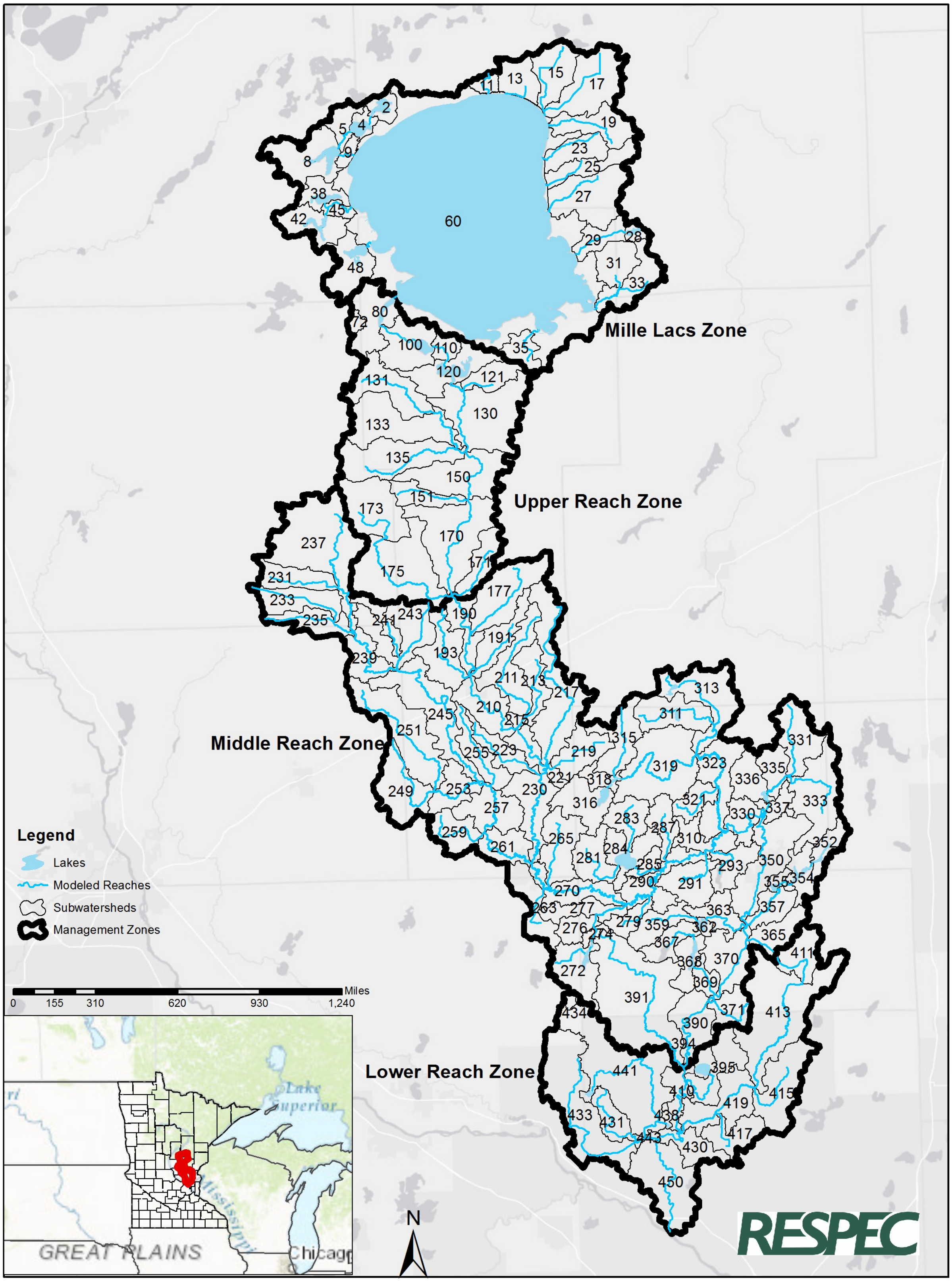

Figure 1-1. Management Zones.

1. Conversion of mature forests to young forests
2. Conversion of forest, grassland, and pasture/hay to row crops
3. A - Conversion of forest, grassland, pasture/hay, and row crops to developed land with an increase in septic loads

   B – Conversion of forest, grassland, pasture/hay, and row crops to developed land with an increase in septic loads and Minimal Impact Design Standards (MIDS) represented on all converted land
4. Cumulative effects from increases in forest harvest (Scenario 1), row crops (Scenario 2), and development (Scenario 3A)
5. Implementation of water quality buffers to portions of agricultural croplands.

Each scenario was developed from information provided by stakeholders and local experts and described herein by scenario. Not all of the subwatershed areas were predicted as having substantial land-use changes; therefore, no changes will be noted in summary graphics unless impacted by upgradient changes (e.g., effects that were propagated to the downstream flow network). Explicitly modeled subwatersheds have been indicated as stippled areas in graphics for each scenario.

The draft RRW TMDL report [Minnesota Pollution Control Agency, 2016] defined north-south gradients of climate, population, land cover, and water quality. Hence, when reviewing the projected changes, note that the top approximately one-third of the watershed is in the Northern Lakes and Forests (NLF) aquatic ecoregion and North River Nutrient Region and, as such, has much lower phosphorus and sediment concentrations. The lower approximately two-thirds of the watershed is located in the North Central Hardwood Forest (NCHF) aquatic ecoregion with corresponding river phosphorus and TSS standards that are double those of the NLF portion, which is also referred to as the Central River Nutrient Region. Interpreting the percent change should consider, for example, that a 10 percent change of phosphorus or TSS in Mille Lacs and Upper Reach (NLF) portions is one-half of a 10 percent change in the Middle and Lower Basin areas in the NCHF as summarized in Table 1-1.

Table 1-1. Water Quality Standards

Pollutant Standards	NLF (North River Nutrient Region Standard)	NCHF (Central River Nutrient Region Standard)
Total Phosphorus (µg/L or ppb)	50	100
10% Change	5	10
Total Suspended Solids (mg/L or ppm)	15	30
10% Change	1.5	3

Waterbodies of the Mille Lacs Lake and Upper Reach Zones will have much greater sensitivity to increased TP and TSS than waters of the Middle and Lower Reach Zones. The 10 percent increases in TP and TSS will be measurable and may be expected to cause observable degradation of these waters. The majority of the RRW impaired waters are located in the F and Lower Reaches, and as such, already have exceeded their assimilative capacities. Additional TP and TSS loads to these waters will be reflected in increased impairment levels. Lastly, increased TP and TSS loads may be expected to increase Rum River concentrations, which will negatively affect habitat, fisheries, aquatic invertebrates, recreation, aesthetics and associated real estate values.

1.1 SCENARIO 1

Scenario 1 estimates the impacts from converting 15 percent of mature forest to young forest for select subwatersheds. These subwatersheds are indicated by the stippled areas on Figures 1-2 through 1-5. Present-day water quality was compared to projected, future water quality with results expressed by percent change in positive (increasing loads or flows) or negative fashion (decreasing loads or flows)

HSPF-estimated watershed responses for modeled parameters are depicted by subwatershed in Figures 1-2 through 1-5 for flow, TSS, TP, and TN, respectively.

- Runoff increases of up to 2 percent were noted for the Mille Lacs Management Zone subwatersheds, up to 1.1 percent for Upper Reach Management Zone subwatersheds, up to 0.8 percent for Middle Reach Management Zone subwatersheds, and up to 0.7 percent for Lower Reach Management Zone subwatersheds.
- TSS increases of up to 4.8 percent were noted for the Mille Lacs Management Zone subwatersheds, up to 3.2 percent for Upper Reach Management Zone subwatersheds, up to 0.7 percent for Middle Reach Management Zone subwatersheds, and up to 0.5 percent for Lower Reach Management Zone subwatersheds.
- TP increases of up to 3.9 percent were noted for the Mille Lacs Management Zone subwatersheds, up to 1.5 percent for Upper Reach Management Zone subwatersheds, up to 1.0 percent for Middle Reach Management Zone subwatersheds, and up to 0.9 percent for Lower Reach Management Zone subwatersheds.
- TN increases of up to 2.8 percent were noted for the Mille Lacs Management Zone subwatersheds, up to 1.3 percent for Upper Reach Management Zone subwatersheds, up to 1.0 percent for Middle Reach Management Zone subwatersheds, and up to 0.8 percent for Lower Reach Management Zone subwatersheds.
- In the context of the broad RRW, the cumulative basin increases were 0.2 percent for annual flow, TSS loads, TP loads, and TN loads.

1.2 SCENARIO 2

Scenario 2 estimates watershed responses from increased row crops. For this scenario, in subwatersheds identified by stakeholders to be at risk for each conversion, 15 percent of forestland, grassland, and pasture/hay was converted to row crops. Converted lands are represented as stippled areas in the associated graphics by scenario. Present day water quality was compared to projected, future water quality with results expressed by percent change in positive (increasing loads or flows) or negative fashion (decreasing loads or flows).

Modeled watershed responses by subwatershed are depicted for Scenario 2 in Figures 1-6 through 1-9 for flow, TSS, TP, and TN, respectively.

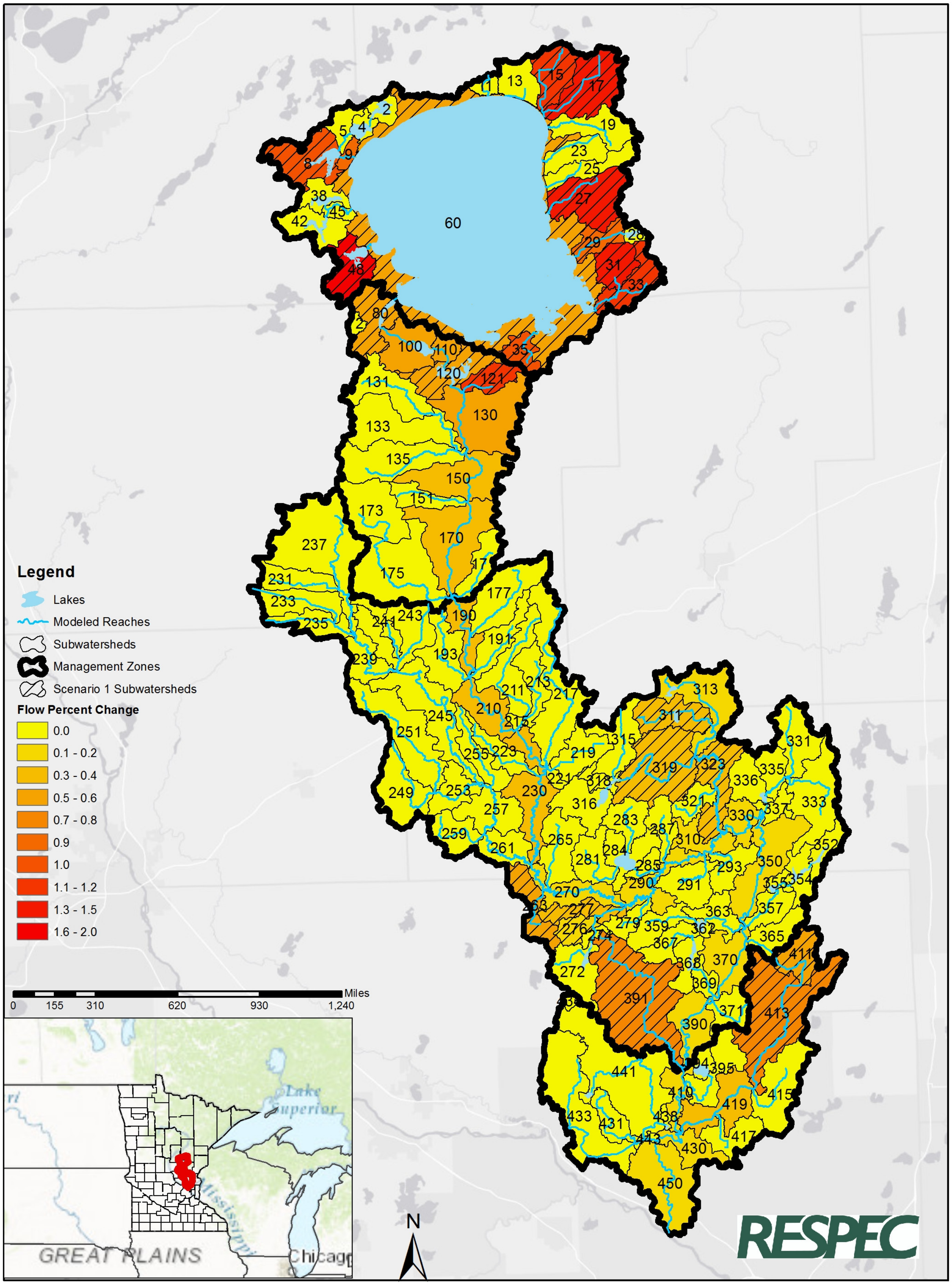

Figure 1-2. Scenario 1 Flow Percent Change.

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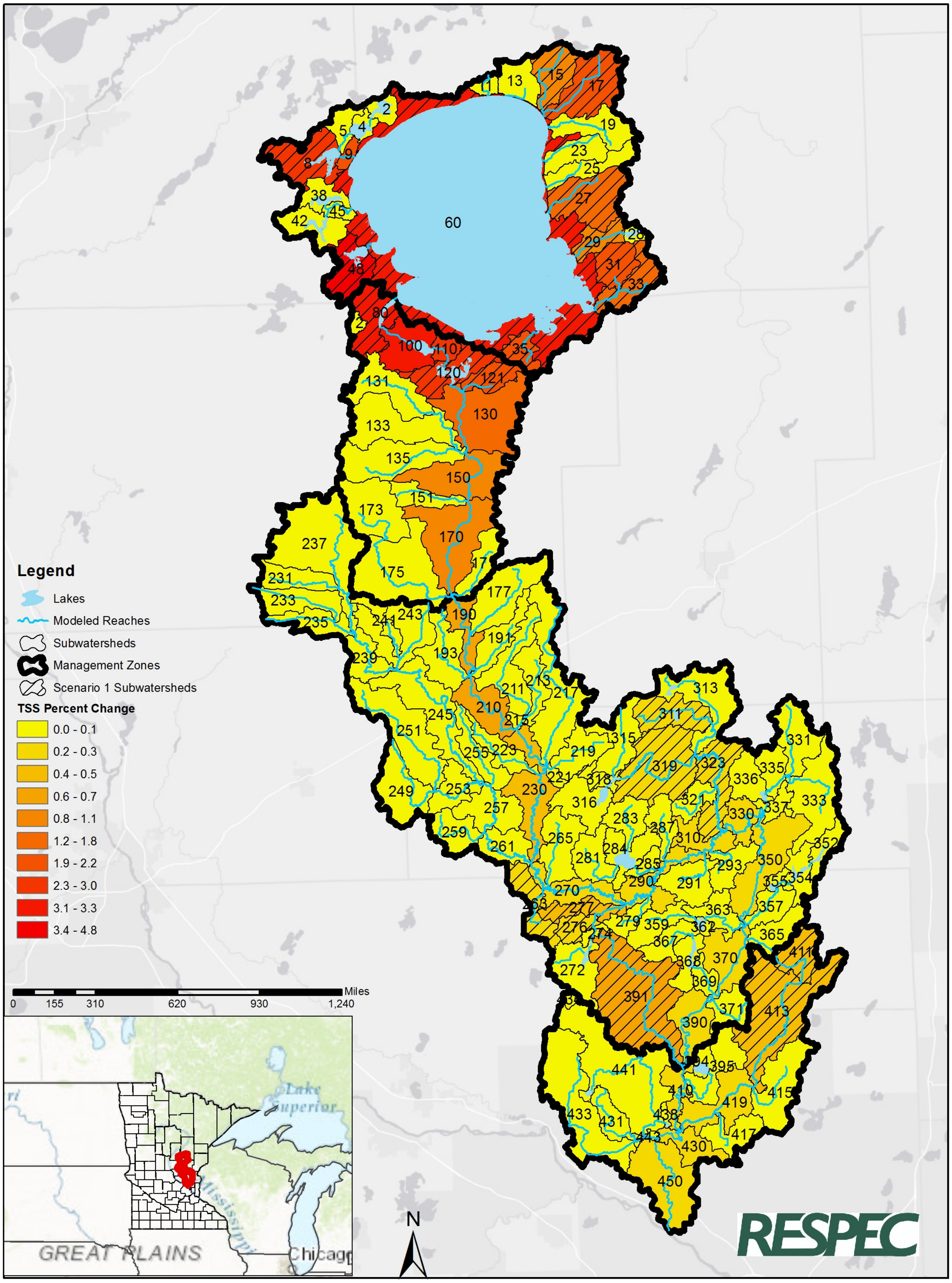

Figure 1-3. Scenario 1 Total Suspended Solids Percent Change.

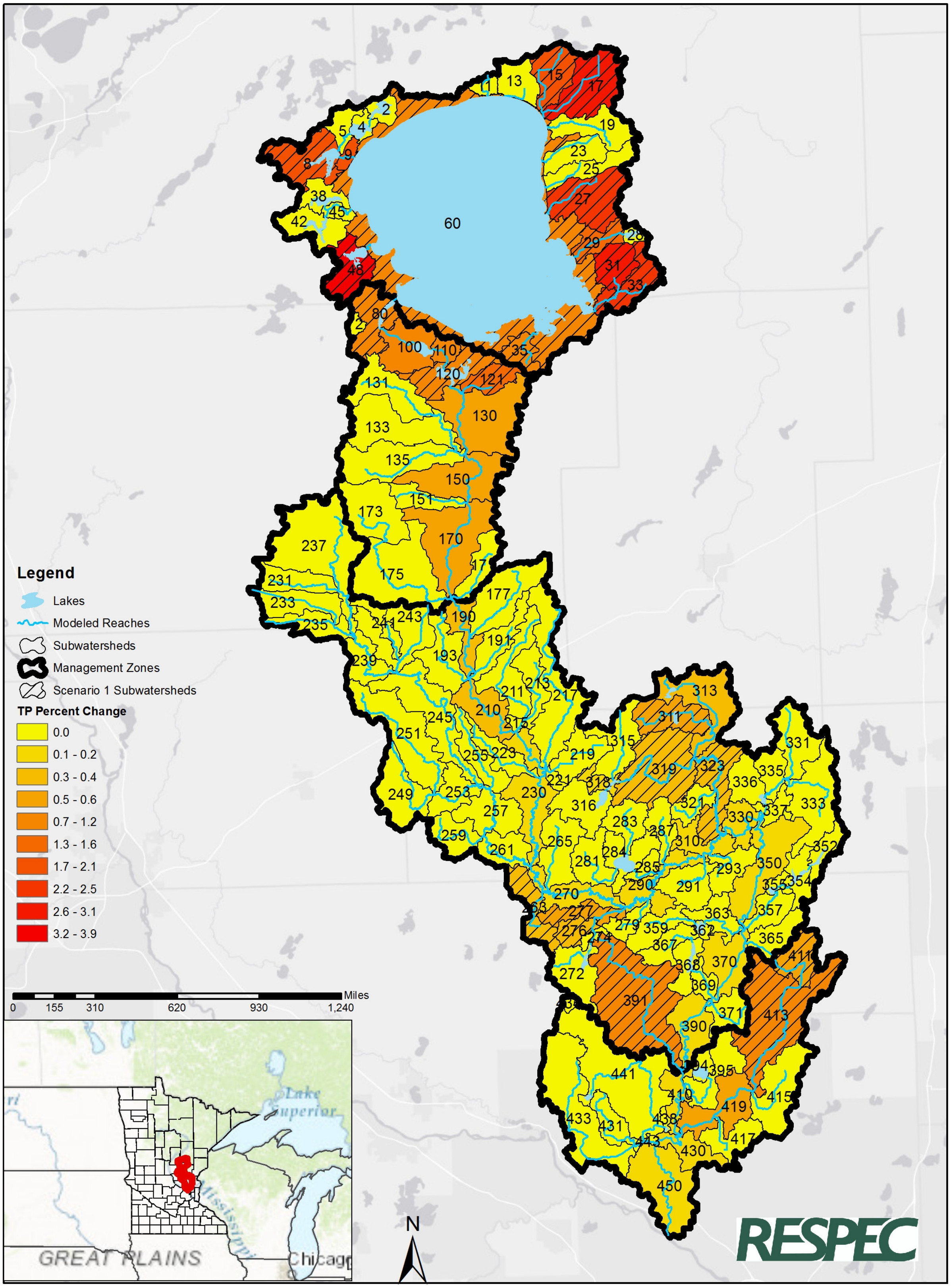

Figure 1-4. Scenario 1 Total Phosphorus Percent Change.

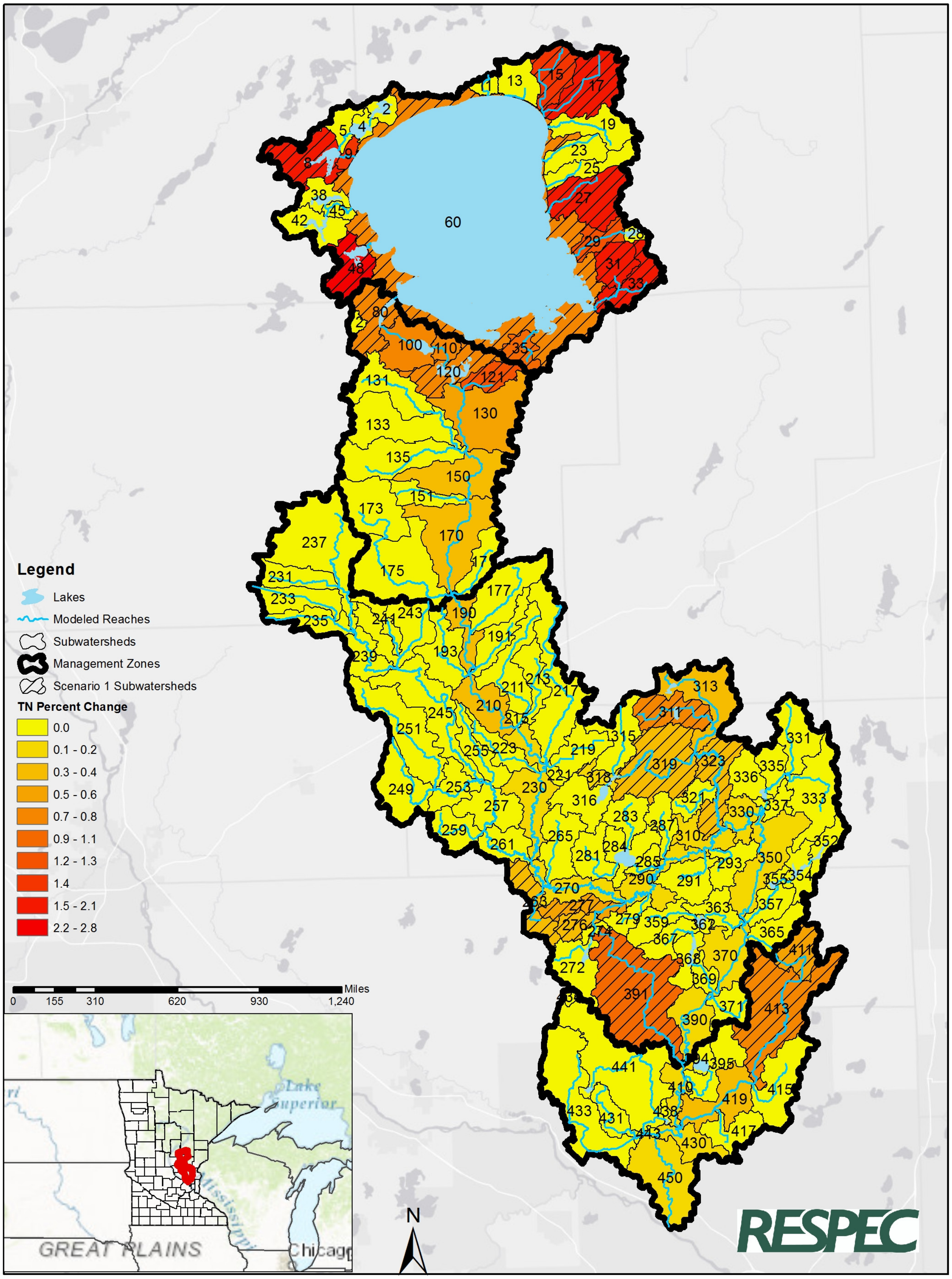

Figure 1-5. Scenario 1 Total Nitrogen Percent Change.

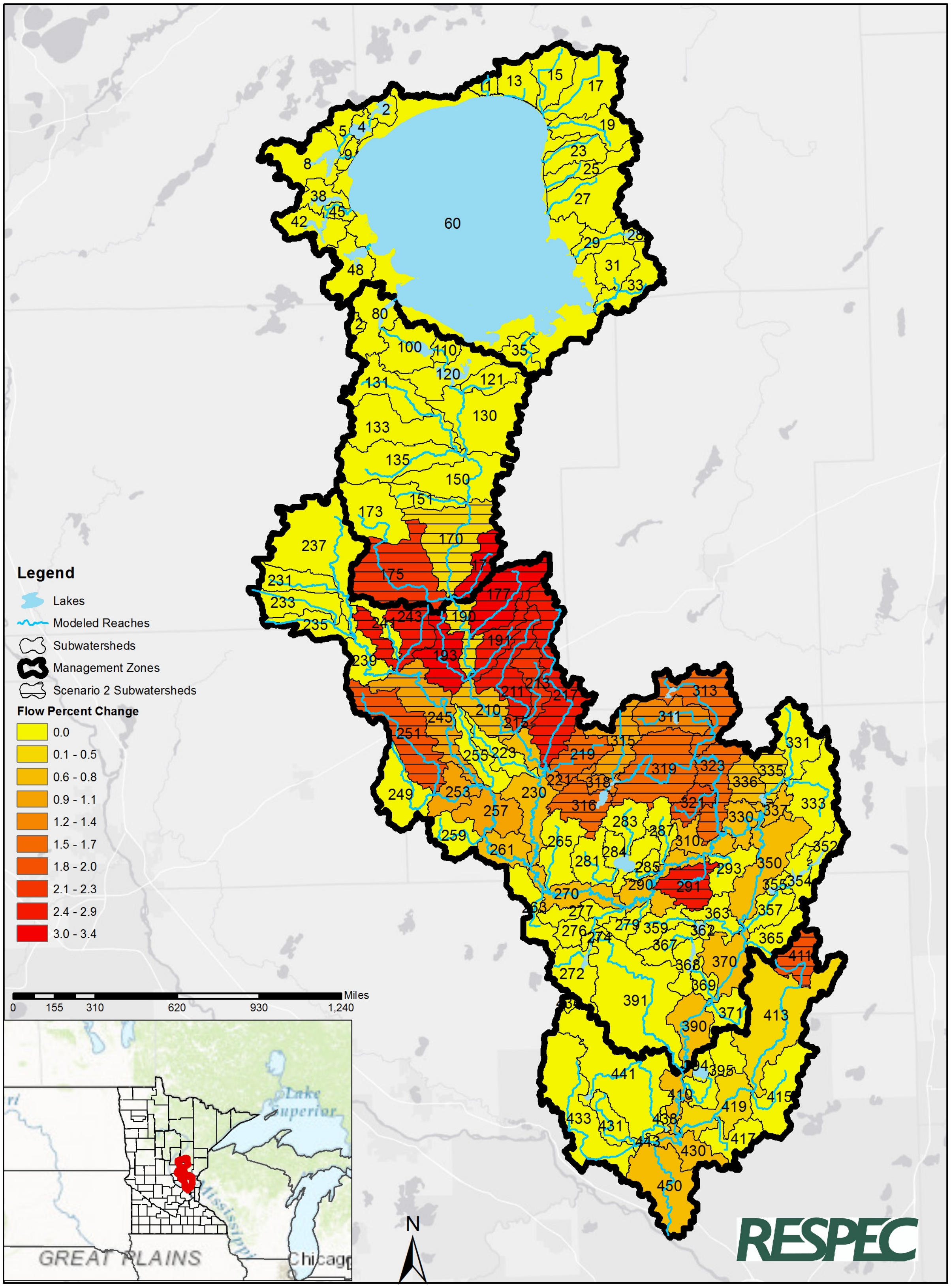

Figure 1-6. Scenario 2 Flow Percent Change.

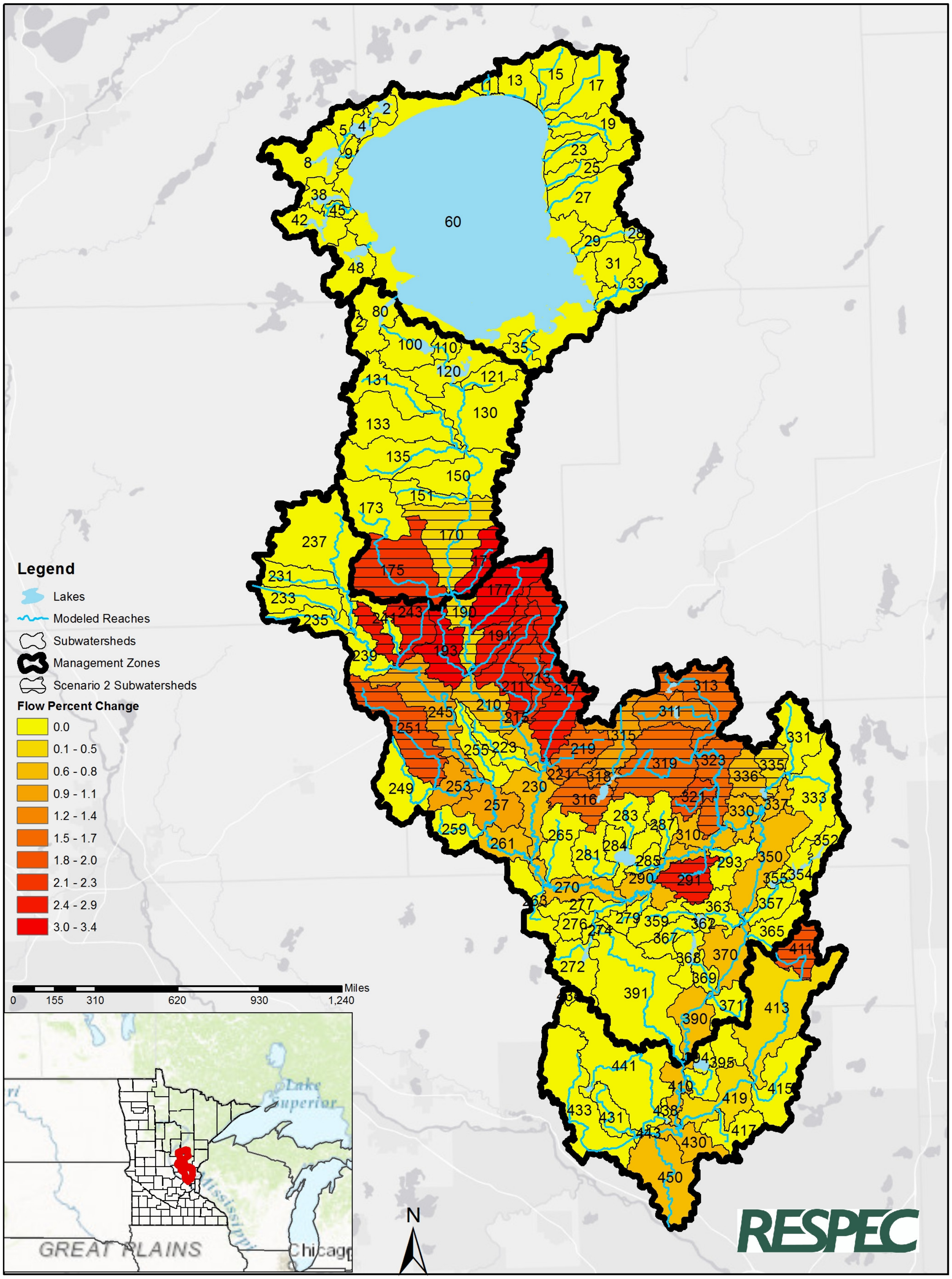

Figure 1-7. Scenario 2 Total Suspended Solids Percent Change.

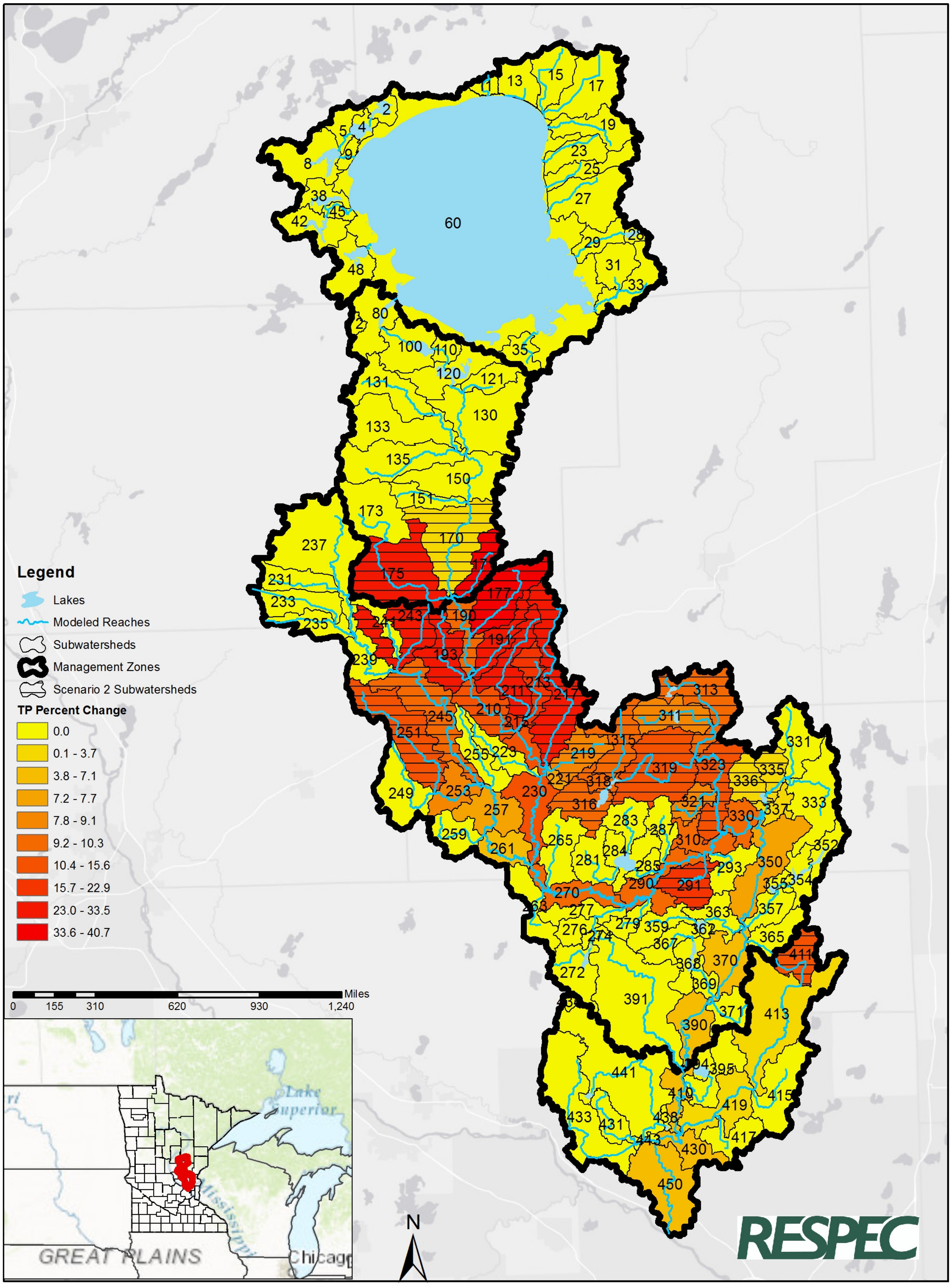

Figure 1-8. Scenario 2 Total Phosphorus Percent Change.

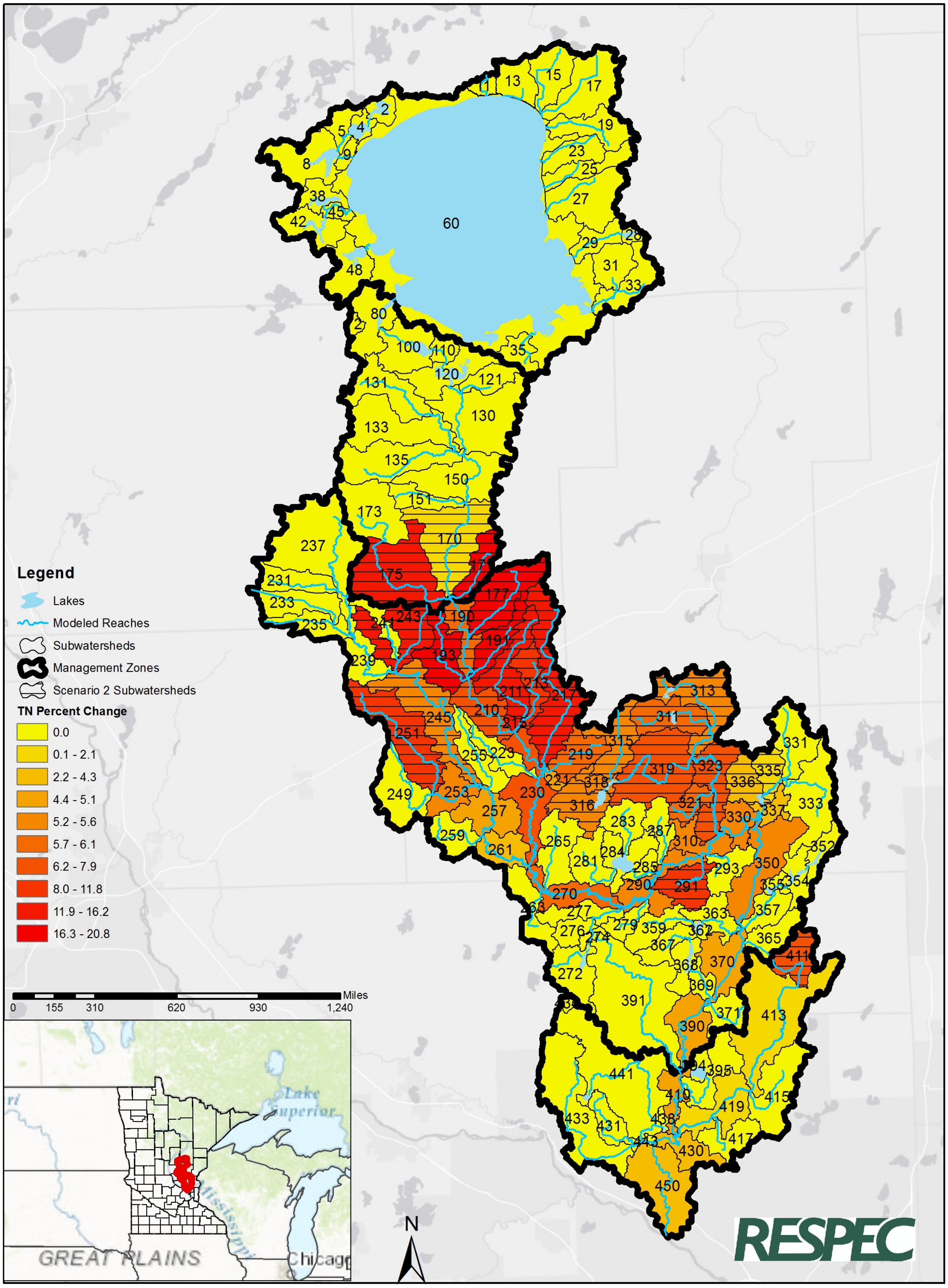

Figure 1-9. Scenario 2 Total Nitrogen Percent Change.

- Runoff increases of up to 3.1 percent for Upper Reach Management Zone subwatersheds, up to 3.4 percent for Middle Reach Management Zone subwatersheds, and up to 2 percent for Lower Reach Management Zone subwatersheds.
- TSS increases of up to 34.2 percent for Upper Reach Management Zone subwatersheds, up to 32.6 percent for Middle Reach Management Zone subwatersheds, and up to 11.5 percent for Lower Reach Management Zone subwatersheds.
- TP increases of up to 40.2 percent for Upper Reach Management Zone subwatersheds, up to 40.7 percent for Middle Reach Management Zone subwatersheds, and up to 12.7 percent for Lower Reach Management Zone subwatersheds.
- TN increases of up to 18.8 percent for Upper Reach Management Zone subwatersheds, up to 20.8 percent for Middle Reach Management Zone subwatersheds, and up to 7.9 percent for Lower Reach Management Zone subwatersheds.
- In the context of the broad RRW, the cumulative basin increases were 2 percent for annual flow, 5 percent for TSS loads, 6.2 percent for TP loads, and 4 percent for TN loads.

1.3 SCENARIO 3

Scenario 3 estimates the impacts of converting 15 percent of forestland cover, grassland, pasture/hay, and row crops to developed land in subwatersheds identified by stakeholders as lands for potential development. These subwatersheds are indicated by the stippled areas in the graphics for this scenario.

In addition to these conversions, loads from septic systems were increased by 15 percent in selected subwatersheds identified by stakeholders to be at risk for conversion to developed lands.

Scenario 3B estimates the combined impacts of developing Scenario 3A as moderated by broadly implementing urban BMPs defined by MIDS [Minnesota Pollution Control Agency (MPCA), 2014] over all of the lands converted to developed lands in Scenario 3A. MIDS reductions that were used in this analysis included 81 percent for TP, 91 percent for TSS, 20 percent for TN, and 91 percent for flows. TP, TSS, and flow reductions were based on removal efficiencies to match present-day native forest and prairie conditions [Barr Engineering, Inc., 2011]. Conservative TN removal efficiencies for multiple BMPs were based on Chesapeake Bay recommendations [Hirschman et al., 2008].

Modeled watershed responses by subwatershed are depicted first for Scenario 3A and then for Scenario 3B in Figures 1-10 through 1-17 for flow, TSS, TP, and TN, respectively. Present day water quality was compared to projected future water quality with results expressed by percent change in positive (increasing loads or flows) or negative fashion (decreasing loads or flows).

- Runoff increases of up to 4.8 percent were noted for the Mille Lacs Management Zone subwatersheds, up to 1.3 percent for Upper Reach Management Zone subwatersheds, up to 3.1 percent for Middle Reach Management Zone subwatersheds, and up to 2.8 percent for Lower Reach Management Zone subwatersheds. Occasionally, when the primary land cover in a subwatershed was cropland and was converted to developed land, flow and load decreases occurred. When MIDS were represented on all of the lands that were converted to developed, runoff decreases occurred in all of the management zones.

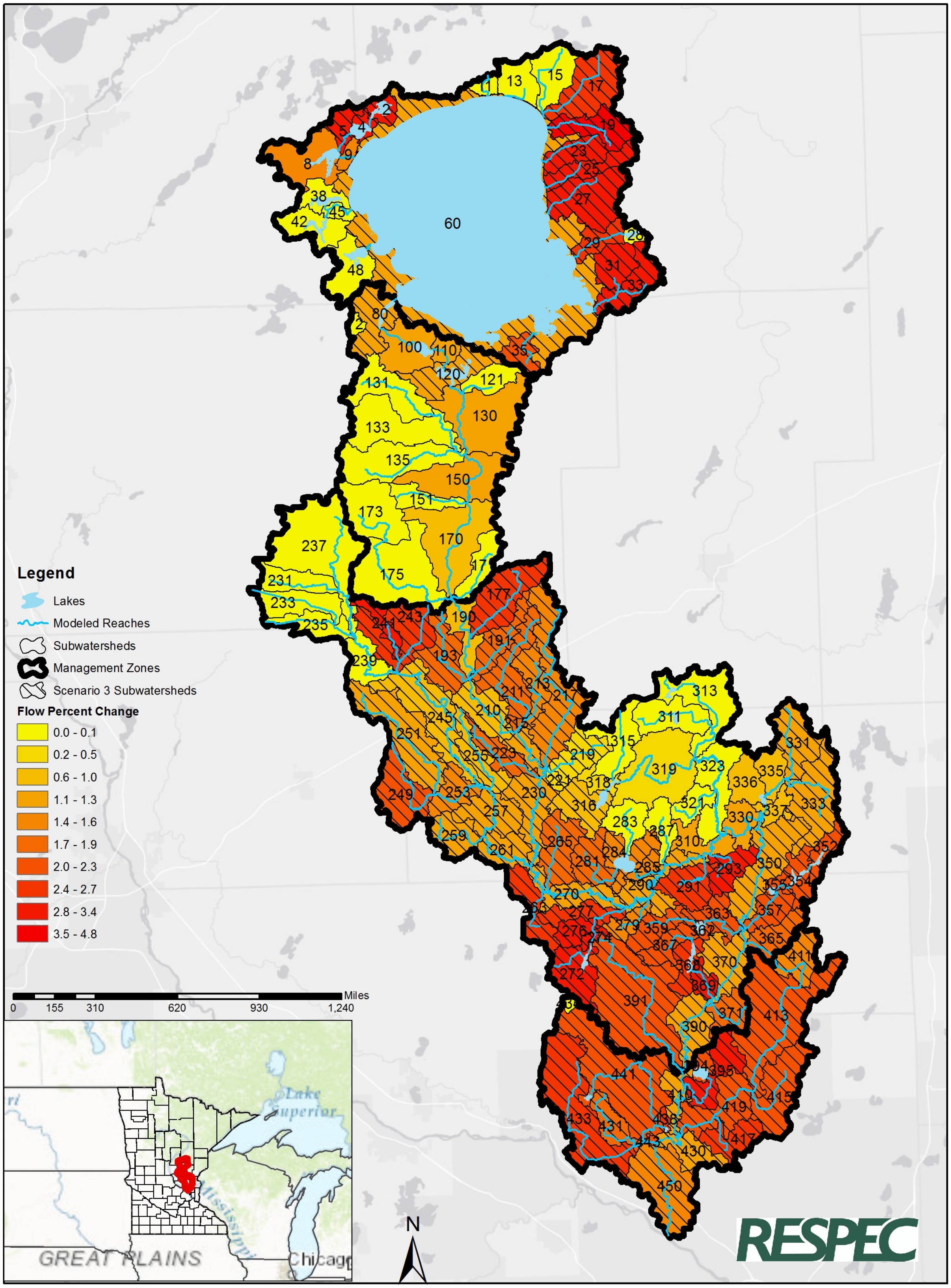

Figure 1-10. Scenario 3A Flow Percent Change.

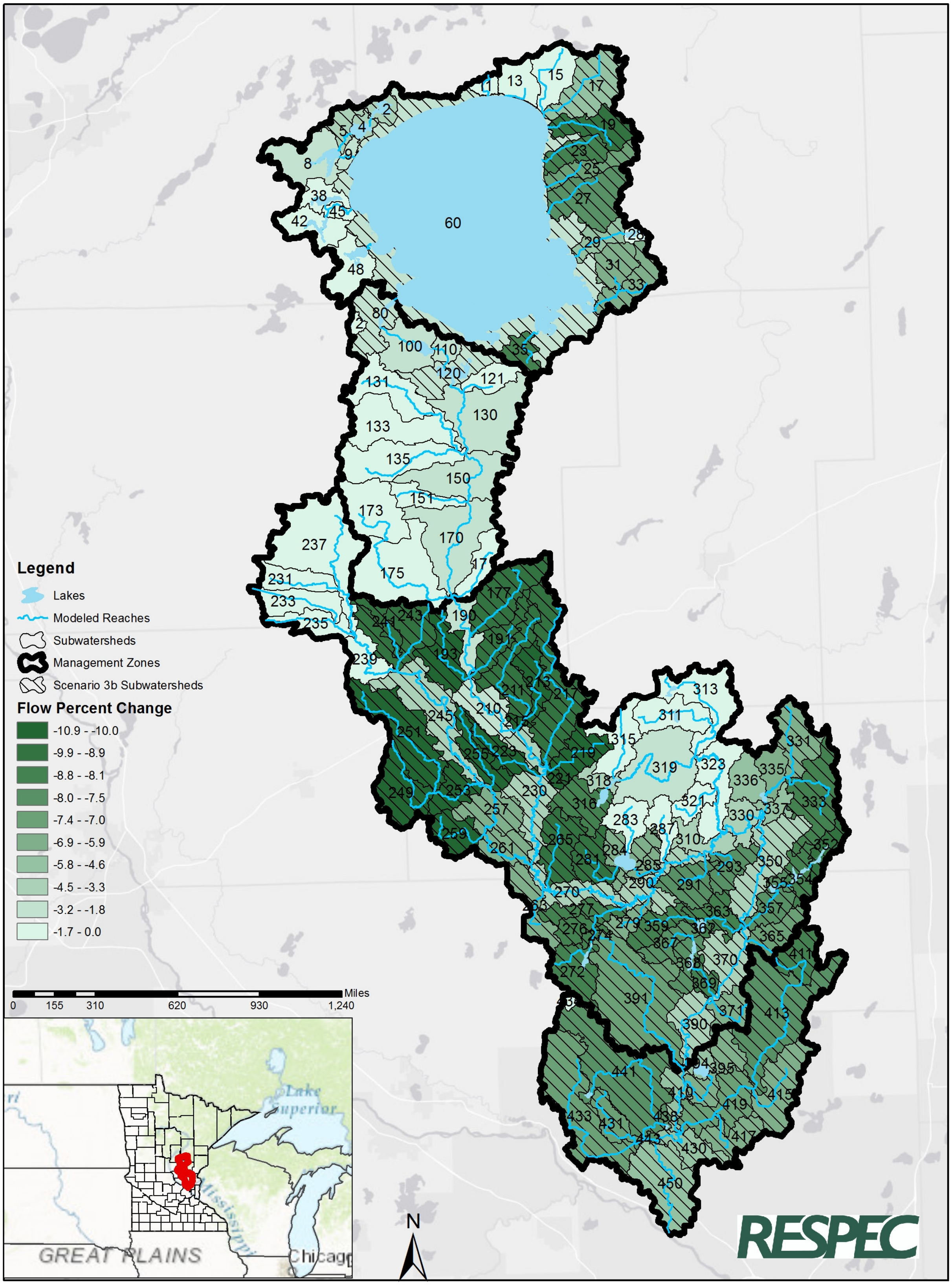

Figure 1-11. Scenario 3B Flow Percent Change.

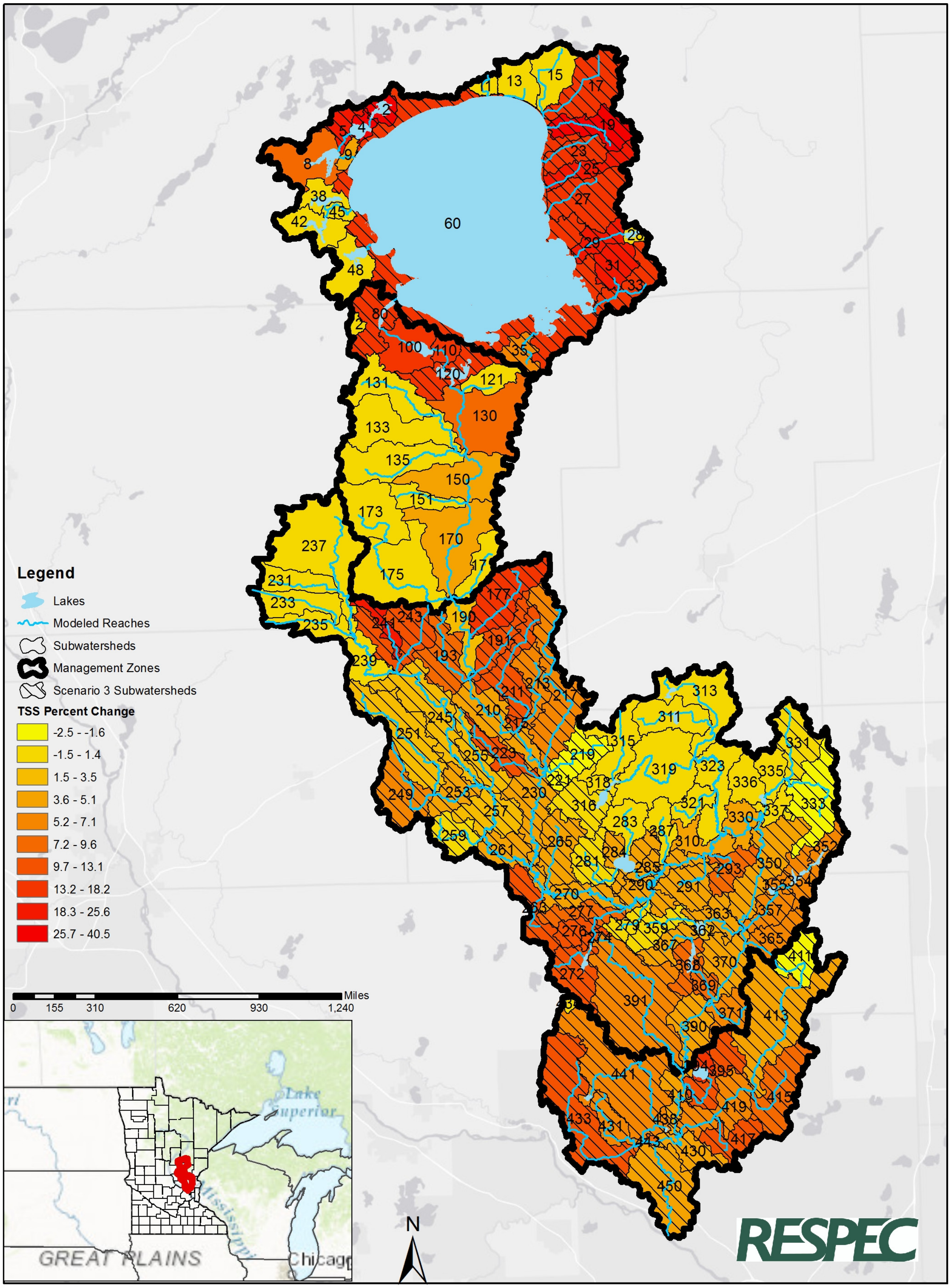

Figure 1-12. Scenario 3A Total Suspended Solids Percent Change.

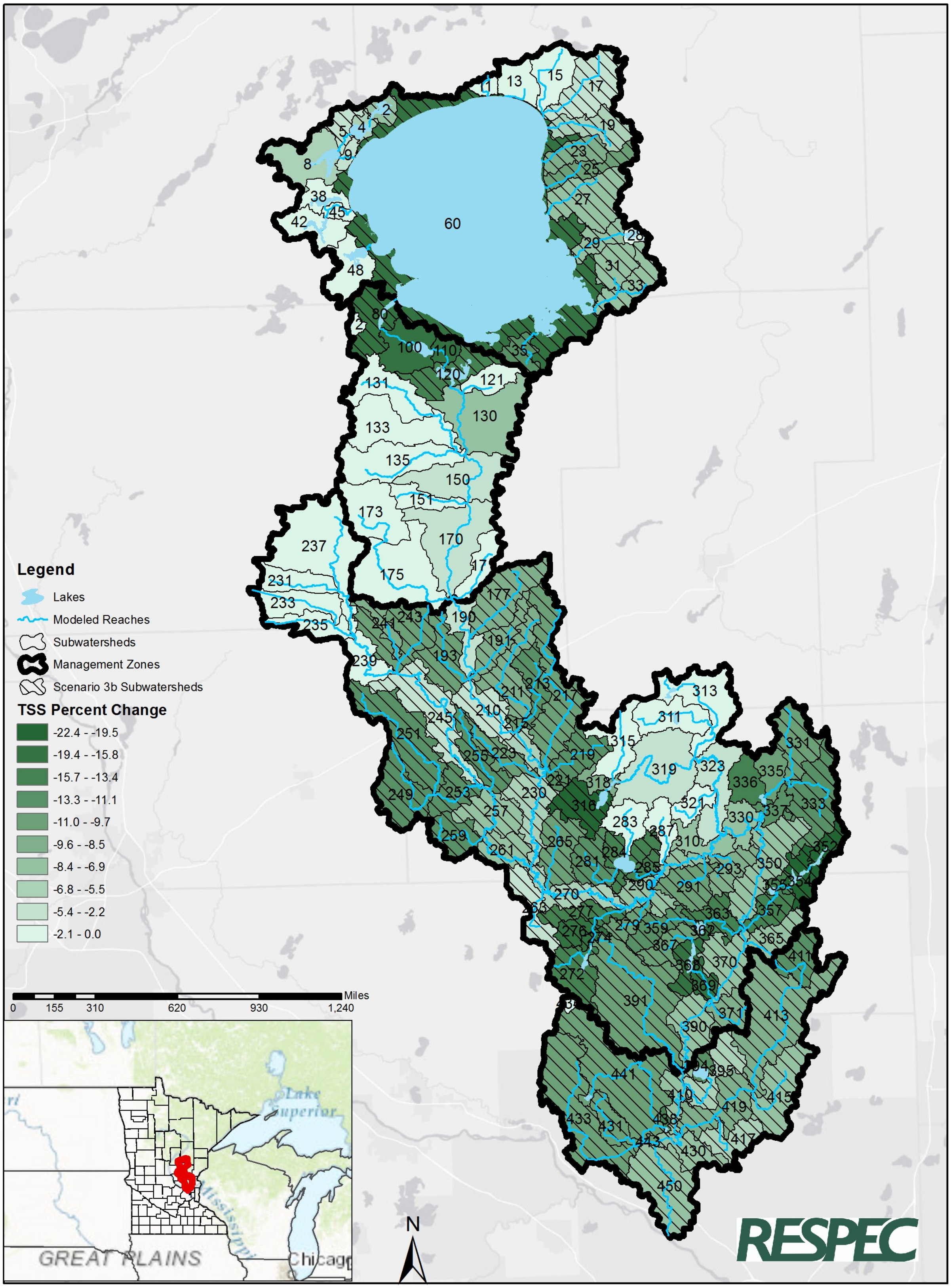

Figure 1-13. Scenario 3B Total Suspended Solids Percent Change.

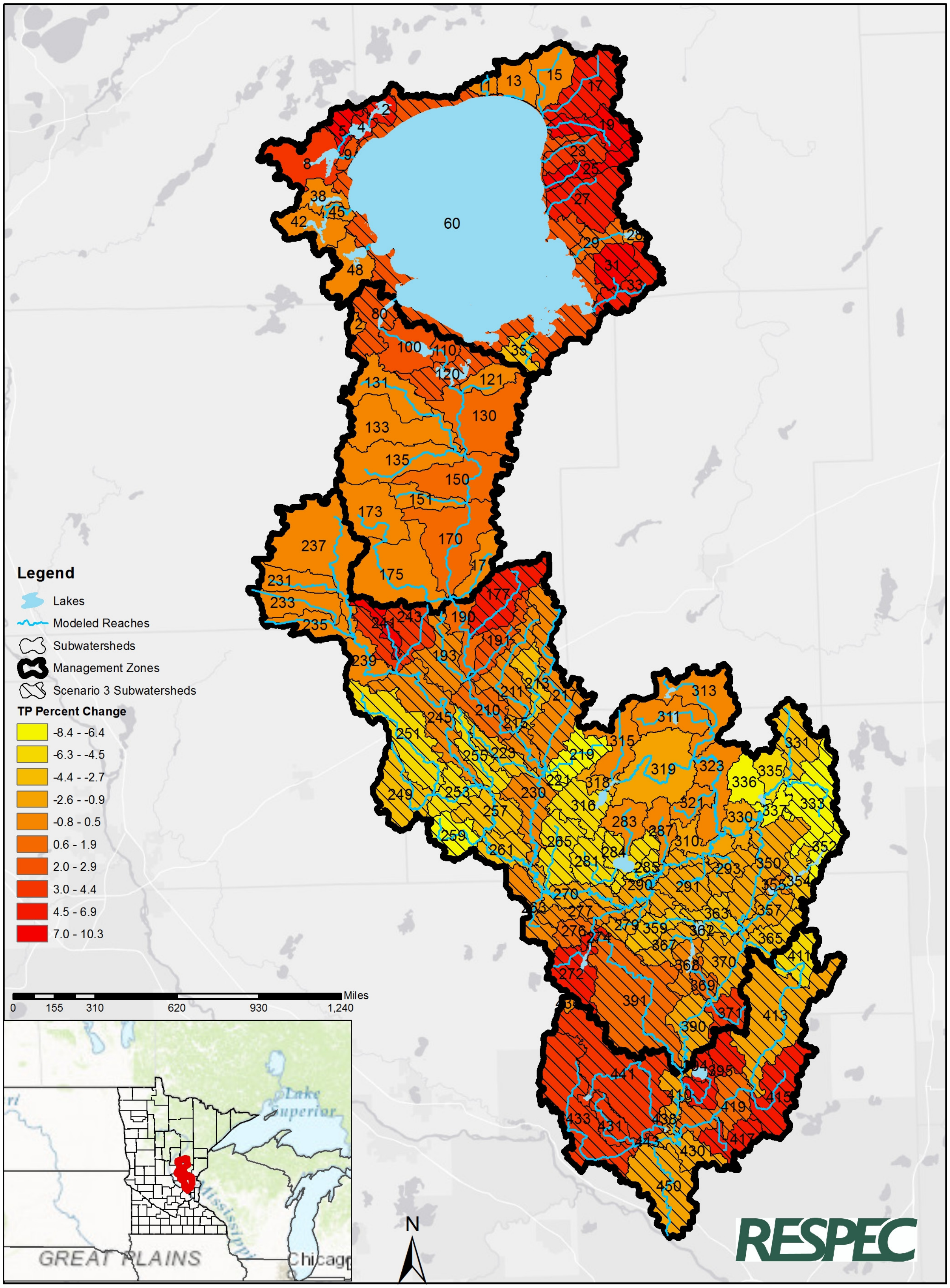

Figure 1-14. Scenario 3A Total Phosphorus Percent Change.

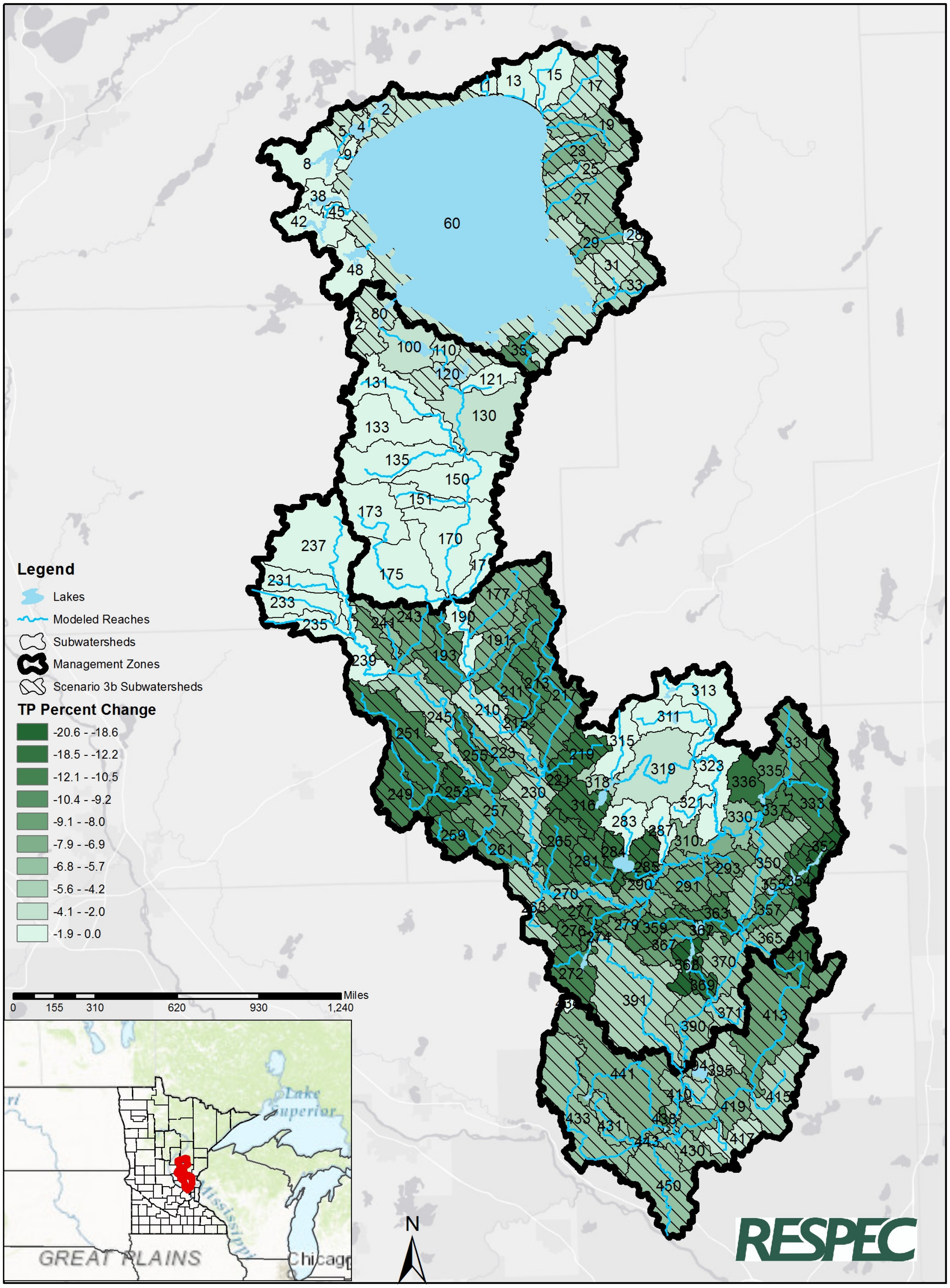

Figure 1-15. Scenario 3B Total Phosphorus Percent Change.

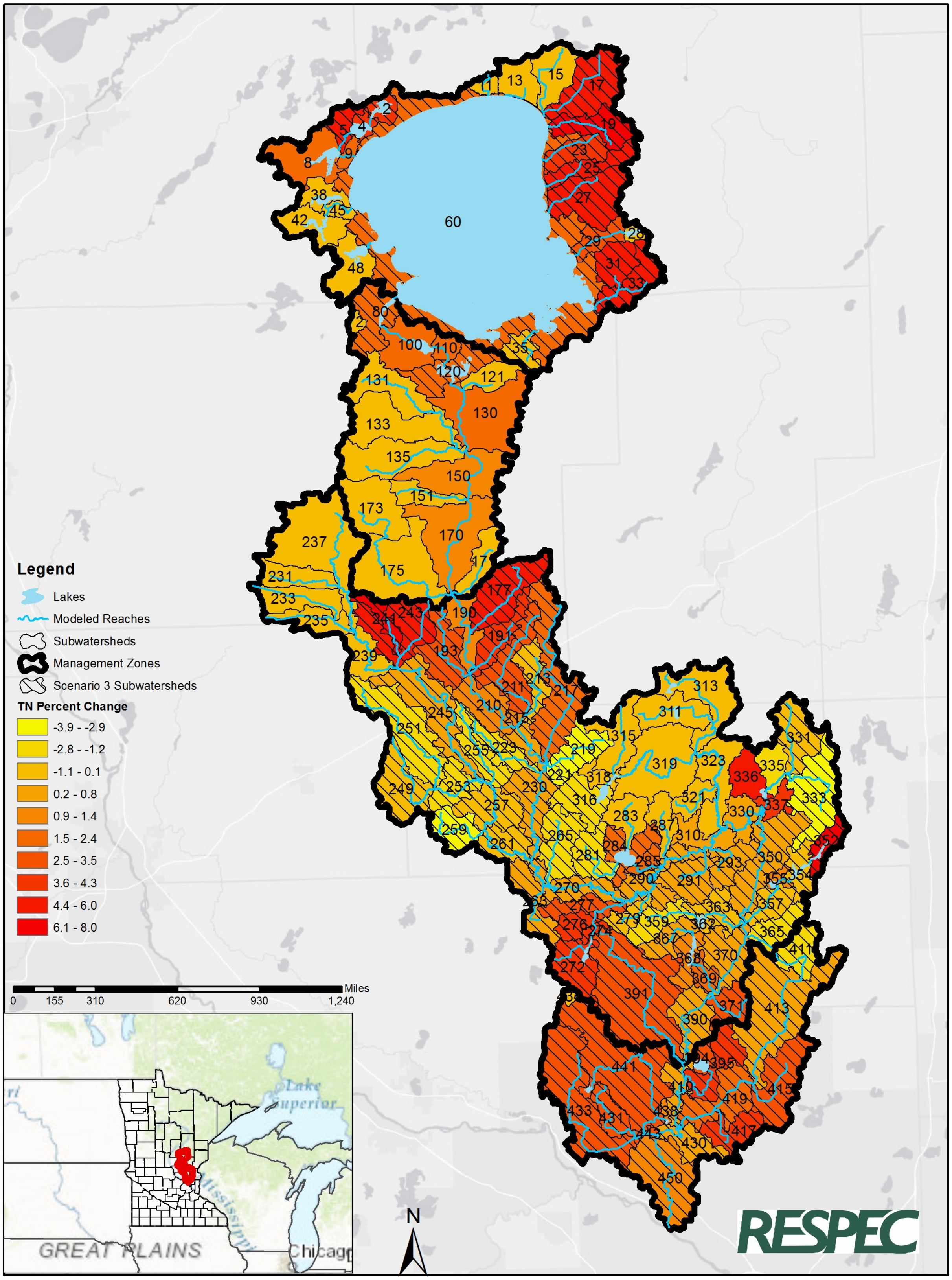

Figure 1-16. Scenario 3A Total Nitrogen Percent Change.

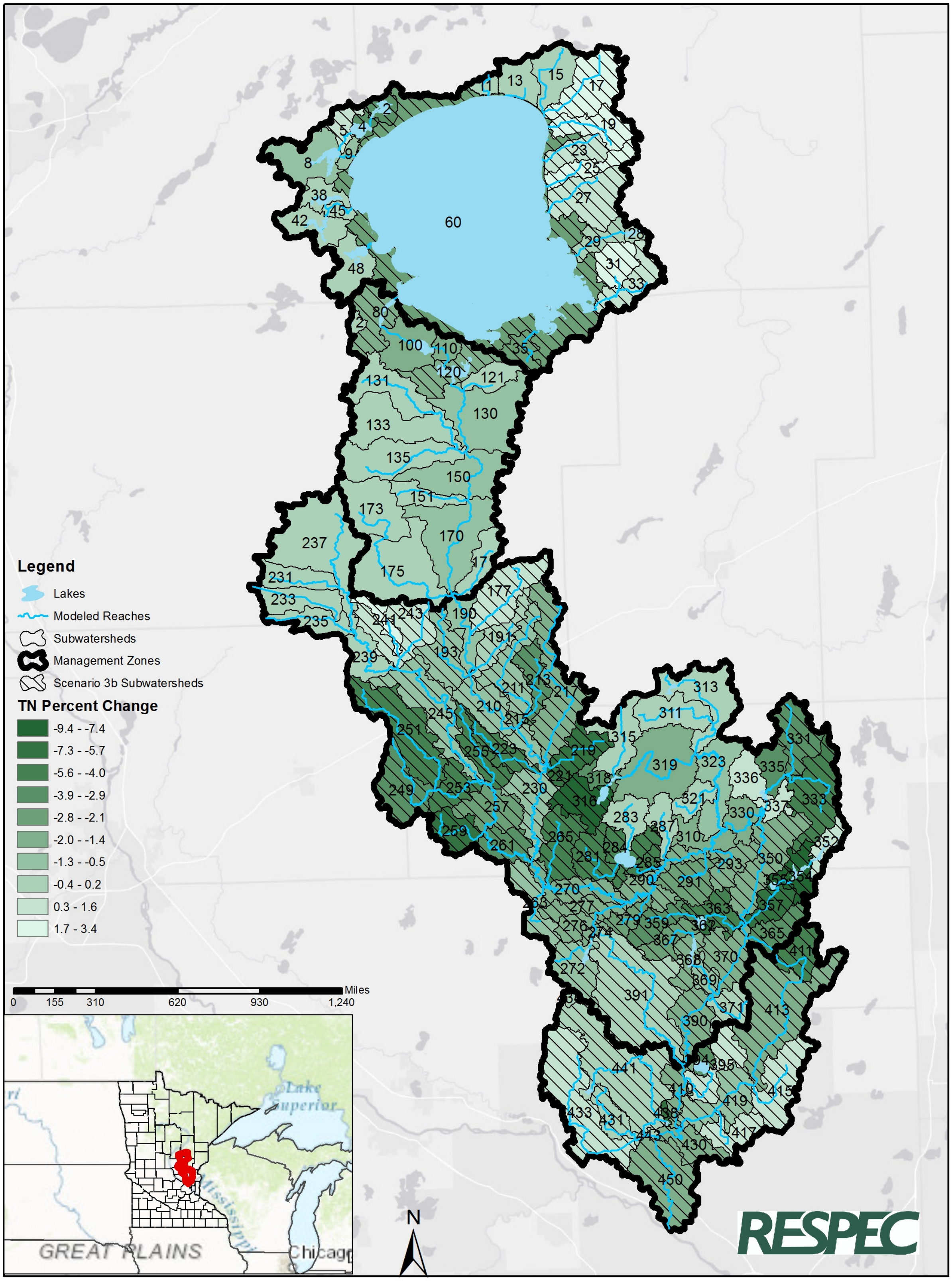

Figure 1-17. Scenario 3B Total Nitrogen Percent Change.

- TSS increases of up to 40.5 percent were noted for the Mille Lacs Management Zone subwatersheds, up to 15.9 percent for Upper Reach Management Zone subwatersheds, up to 19.5 percent for Middle Reach Management Zone subwatersheds, and up to 14.4 percent for Lower Reach Management Zone subwatersheds. When MIDS were represented on all of the lands converted to developed, TSS decreases occurred in all of the management zones.
- TP increases of up to 10.3 percent were noted for the Mille Lacs Management Zone subwatersheds, up to 2.9 percent for Upper Reach Management Zone subwatersheds, up to 8.4 percent for Middle Reach Management Zone subwatersheds, and up to 5.7 percent for Lower Reach Management Zone subwatersheds. When MIDS were represented on all of the lands converted to developed, TP decreases occurred in all of the management zones.
- TN increases of up to 8.0 percent were noted for the Mille Lacs Management Zone subwatersheds, up to 2.4 percent for Upper Reach Management Zone subwatersheds, up to 7.9 percent for Middle Reach Management Zone subwatersheds, and up to 4.2 percent for Lower Reach Management Zone subwatersheds. When MIDS were represented on all lands converted to developed, TN decreases occurred in the Upper Reach Management Zone subwatersheds, and some TN increases occurred (up to 3.4 percent) in the other three management zones.
- In the context of the broad RRW, the cumulative basin increases were 2.8 percent for annual flow, 14.4 percent for TSS loads and 4.2 percent for TN loads and a reduction of 1.1 percent for TP loads. Reductions were projected to occur as subwatersheds dominated by row crops are converted to developed. When MIDS were represented on all of the lands that were converted to developed, decreases in flow, TSS, TP, and TN occurred at the outlet of the Rum River.

1.4 SCENARIO 4

Scenario 4 estimates the cumulative impacts of the previous scenarios, including intensified forest harvest and increases in developed lands and row crops (Scenarios 1, 2, and 3A) in the subwatersheds that were identified by stakeholders to be at risk for each conversion. Present-day water quality was compared to projected, future water quality with results expressed by percent change in positive (increasing loads or flows) or negative fashion (decreasing loads or flows)

HSPF-estimated watershed responses for modeled parameters are depicted by the assessed subwatersheds in Figures 1-18 through 1-21 for flow, TSS, TP, and TN, respectively.

- Runoff increases of up to 4.8 percent were noted for the Mille Lacs Management Zone subwatersheds, up to 3.1 percent for Upper Reach Management Zone subwatersheds, up to 5.3 percent for Middle Reach Management Zone subwatersheds, and up to 3.4 percent for Lower Reach Management Zone subwatersheds.
- TSS increases of up to 40.5 percent were noted for the Mille Lacs Management Zone subwatersheds, up to 34.2 percent for Upper Reach Management Zone subwatersheds, up to 42.3 percent for Middle Reach Management Zone subwatersheds, and up to 14.4 percent for Lower Reach Management Zone subwatersheds.
- TP increases of up to 10.3 percent were noted for the Mille Lacs Management Zone subwatersheds, up to 40.2 percent for Upper Reach Management Zone subwatersheds, up to 39.5 percent for Middle Reach Management Zone subwatersheds, and up to 6.2 percent for Lower Reach Management Zone subwatersheds.

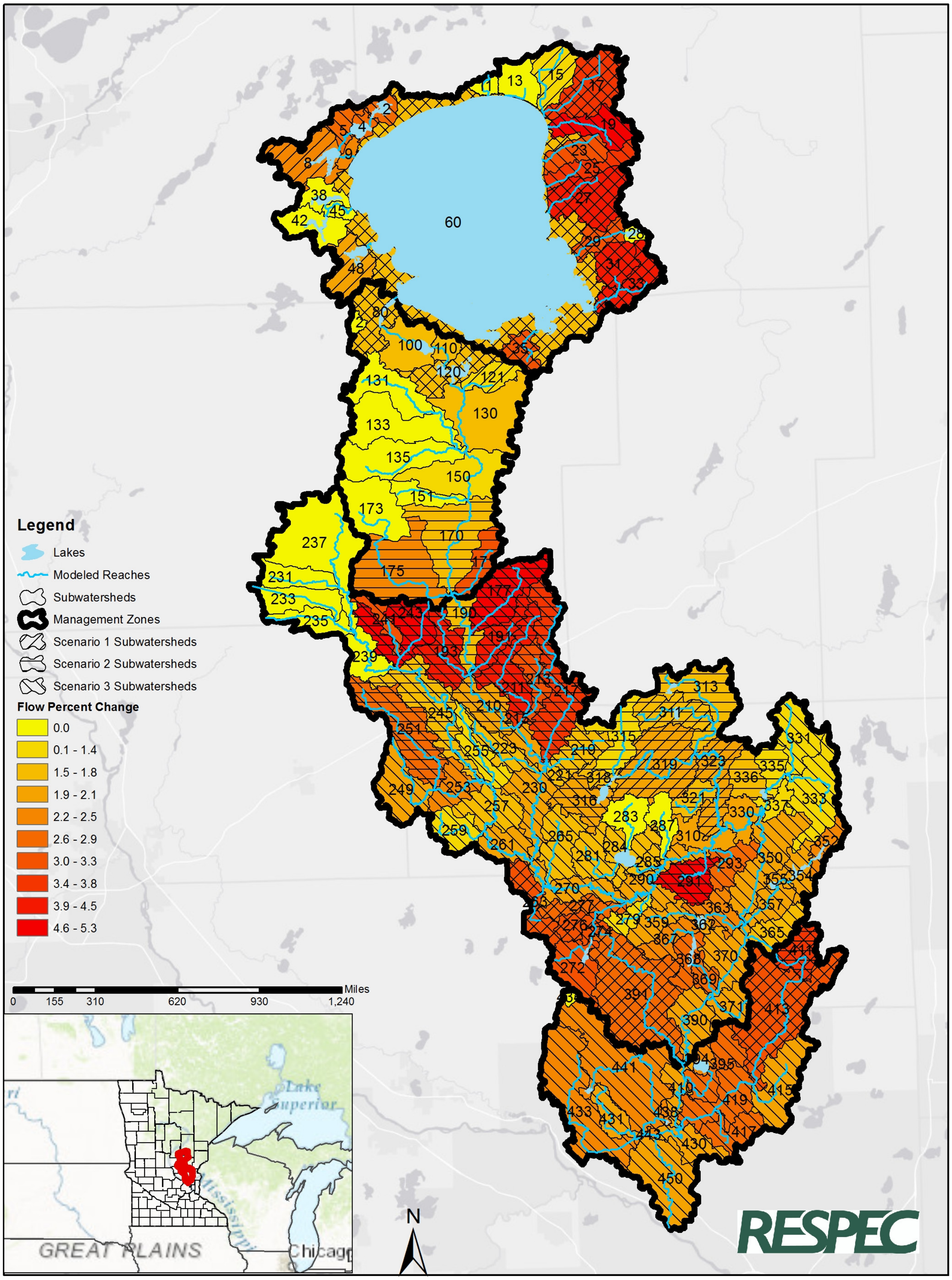

Figure 1-18. Scenario 4 Flow Percent Change.

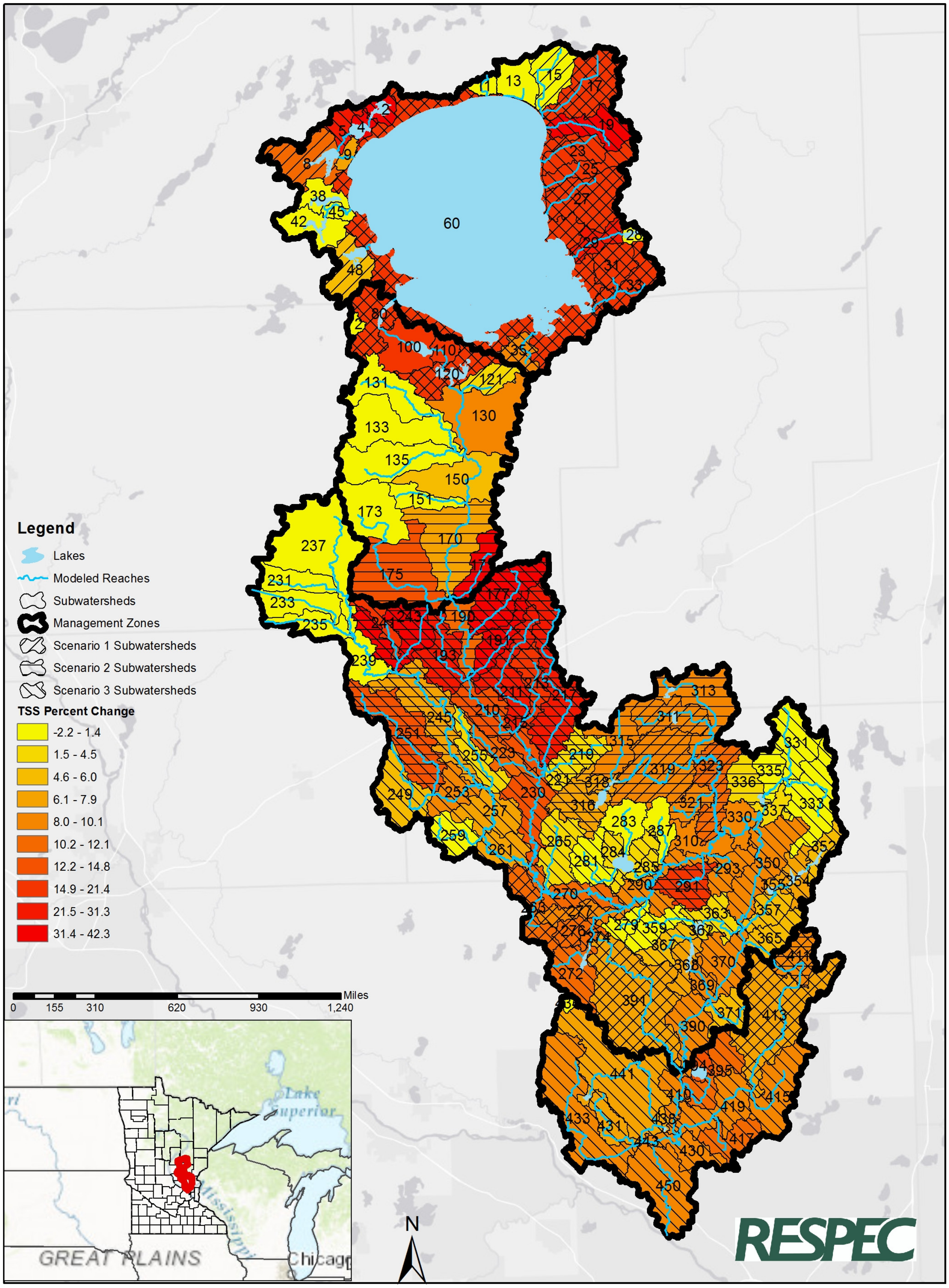

Figure 1-19. Scenario 4 Total Suspended Solids Percent Change.

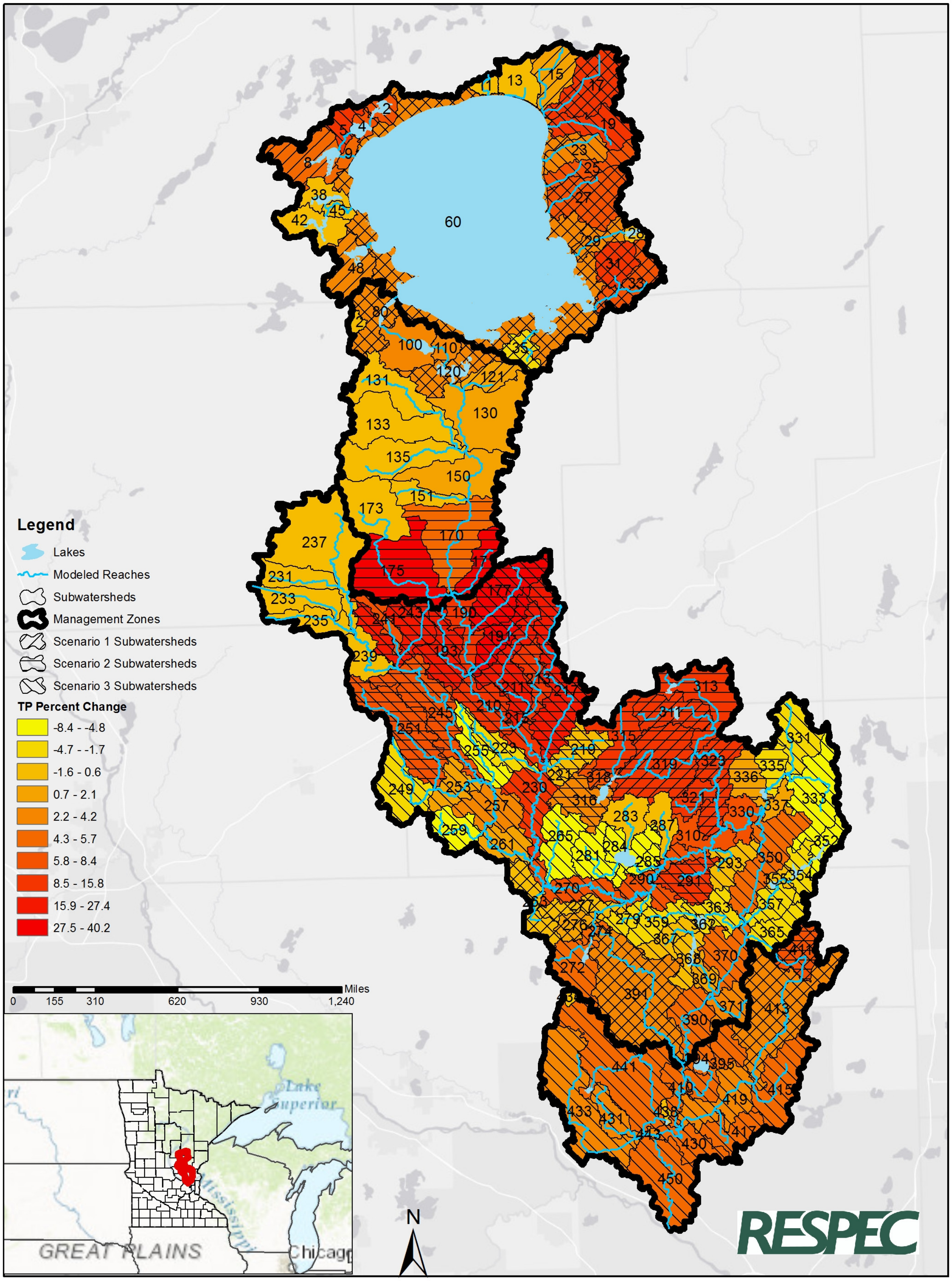

Figure 1-20. Scenario 4 Total Phosphorus Percent Change.

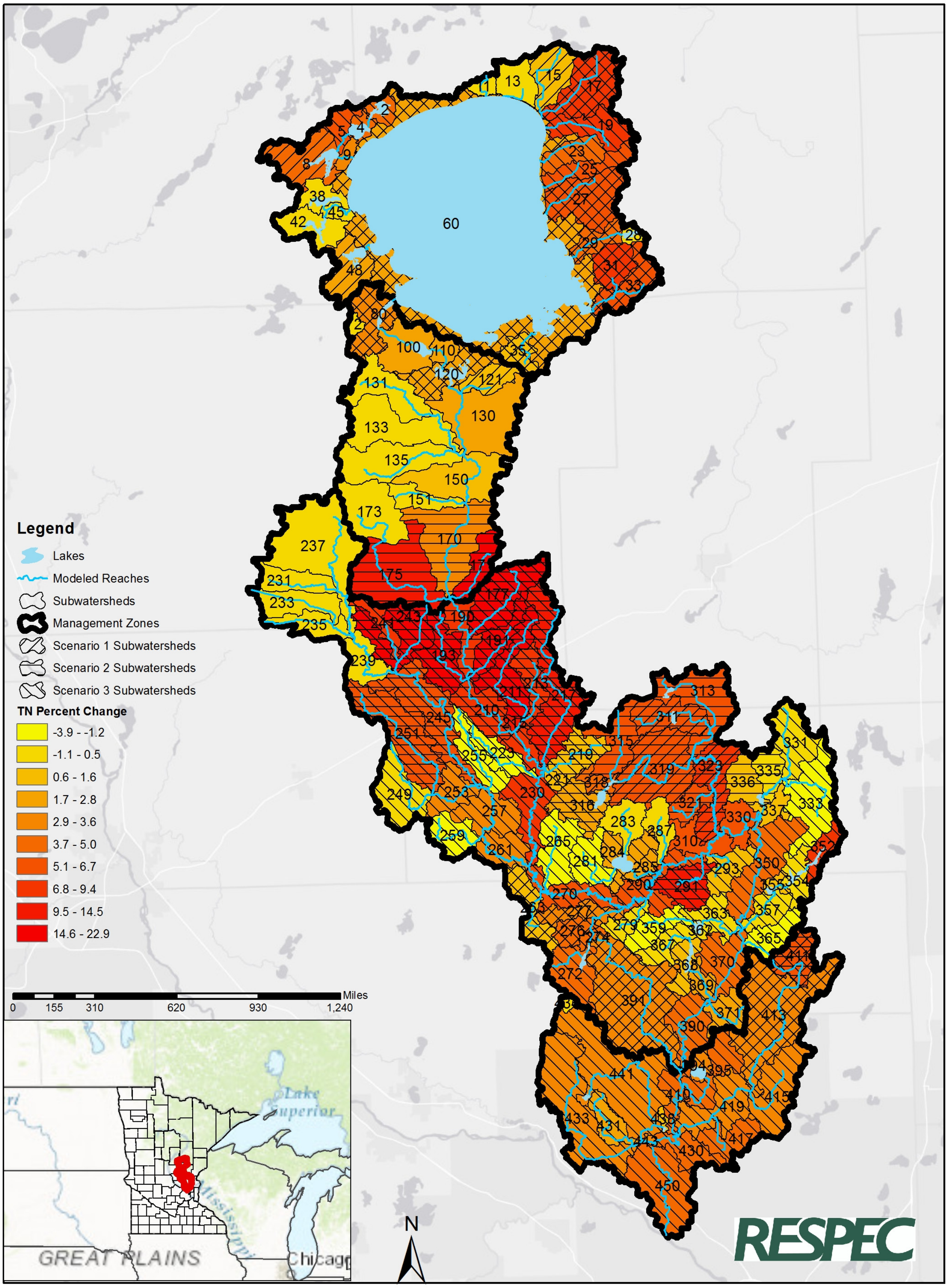

Figure 1-21. Scenario 4 Total Nitrogen Percent Change.

- TN increases of up to 8.0 percent were noted for the Mille Lacs Management Zone subwatersheds, up to 18.8 percent for Upper Reach Management Zone subwatersheds, up to 22.9 percent for Middle Reach Management Zone subwatersheds, and up to 5.1 percent for Lower Reach Management Zone subwatersheds.
- In the context of the broad RRW, the cumulative basin increases were 2.1 percent for annual flow, 9.4 percent for TSS loads, 4.8 percent for TP loads, and 4.4 percent for TN loads.

1.5 SCENARIO 5

Scenario 5 estimates the impacts of buffers being applied to 25 percent of the cropland in each subwatershed. Buffer reductions used in this assessment were based on values cited by the Minnesota Department of Agriculture's (MDA's) BMP Handbook [Miller et al., 2012] and included 76 percent for TSS, 67 percent for TP, 68 percent for TN, and 0 percent reductions for flow.

HSPF-estimated watershed responses are depicted by assessed subwatersheds in Figures 1-22 through 1-24 for TSS, TP and TN, respectively.

- Based on the cited reference, no change in flows was estimated.
- TSS decreases of up to 12.7 percent were noted for the Mille Lacs Management Zone subwatersheds, up to 8.3 percent for Upper Reach Management Zone subwatersheds, up to 15.3 percent for Middle Reach Management Zone subwatersheds, and up to 13.9 percent for Lower Reach Management Zone subwatersheds.
- TP decreases of up to 15.8 percent were noted for the Mille Lacs Management Zone subwatersheds, up to 11.2 percent for Upper Reach Management Zone subwatersheds, up to 20.5 percent for Middle Reach Management Zone subwatersheds, and up to 14.6 percent for Lower Reach Management Zone subwatersheds.
- TN decreases of up to 12.7 percent were noted for the Mille Lacs Management Zone subwatersheds, up to 7.1 percent for Upper Reach Management Zone subwatersheds, up to 13.3 percent for Middle Reach Management Zone subwatersheds, and up to 10.6 percent for Lower Reach Management Zone subwatersheds.
- In the context of the broad RRW, the cumulative basin decreases were 7.1 percent for TSS loads, 8.3 percent for TP loads, and 5.7 percent for TN loads.

1.6 SUMMARY OF SCENARIO RESULTS

To convey the range of potential changes from the future land-use scenarios, seven subwatersheds were selected as pulse points along the flow networks of the Mille Lacs, Upper Reach, Middle Reach, and Lower Reach Management Zones. These pulse points are described in Table 1-2. The Mille Lacs location that was used in this analysis as a relative change pulse point focused on the outlet of the lake (Reach 60). The Upper Reach location that were chosen as a pulse point was Rum River above Tibbets Brook and Whitney Brook (Reach 170). The Middle Reach locations that were chosen as pulse points were the outlet of West Branch Rum River (Reach 261), the outlet of Stanchfield Creek (Reach 323), and Rum River above Seelye Brook (Reach 390). The Lower Reach locations that were chosen as pulse points were the outlet of Cedar Creek (Reach 419) and the outlet of the Rum River (Reach 450).

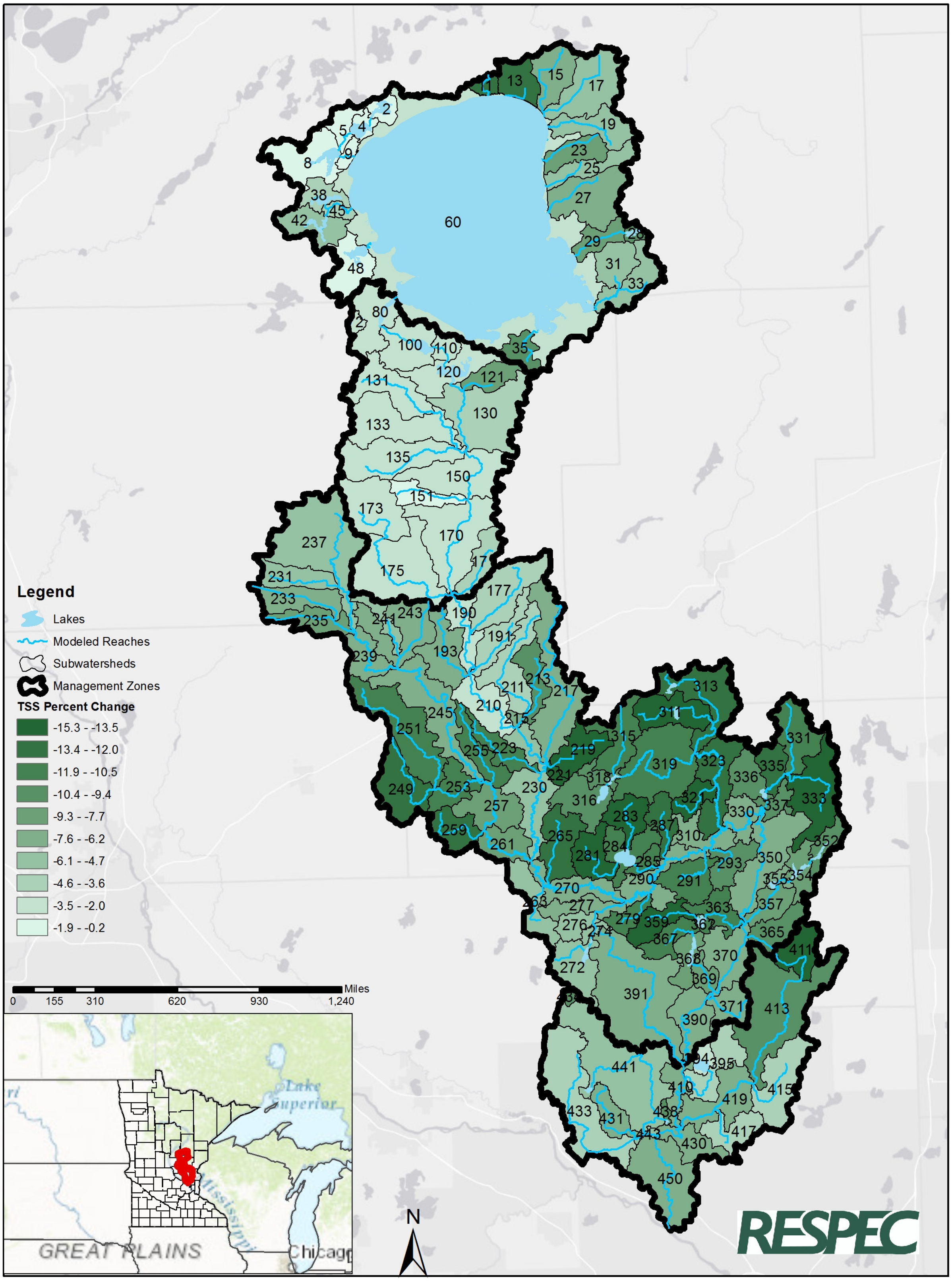

Figure 1-22. Scenario 5 Total Suspended Solids Percent Change.

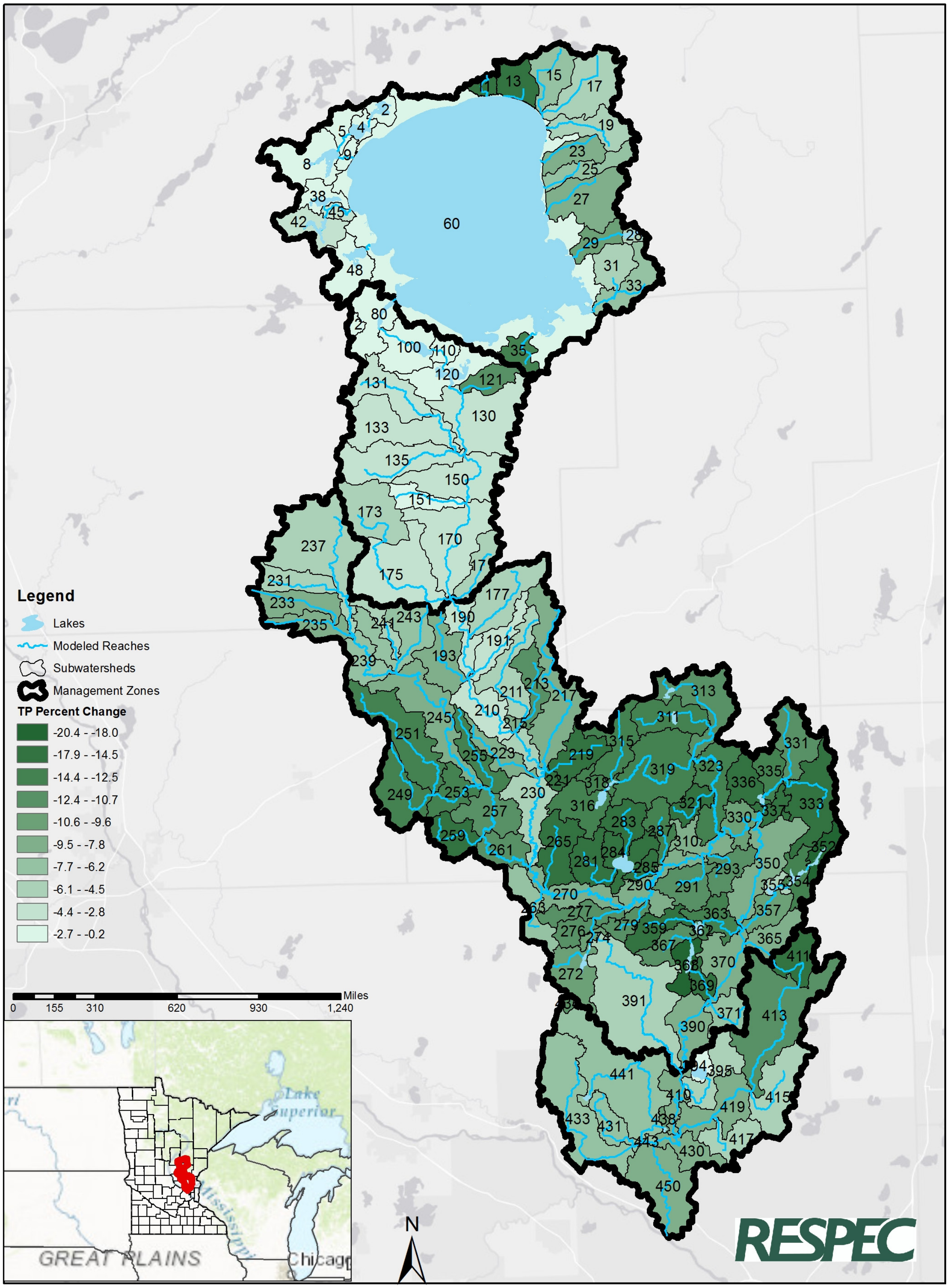

Figure 1-23. Scenario 5 Total Phosphorus Percent Change.

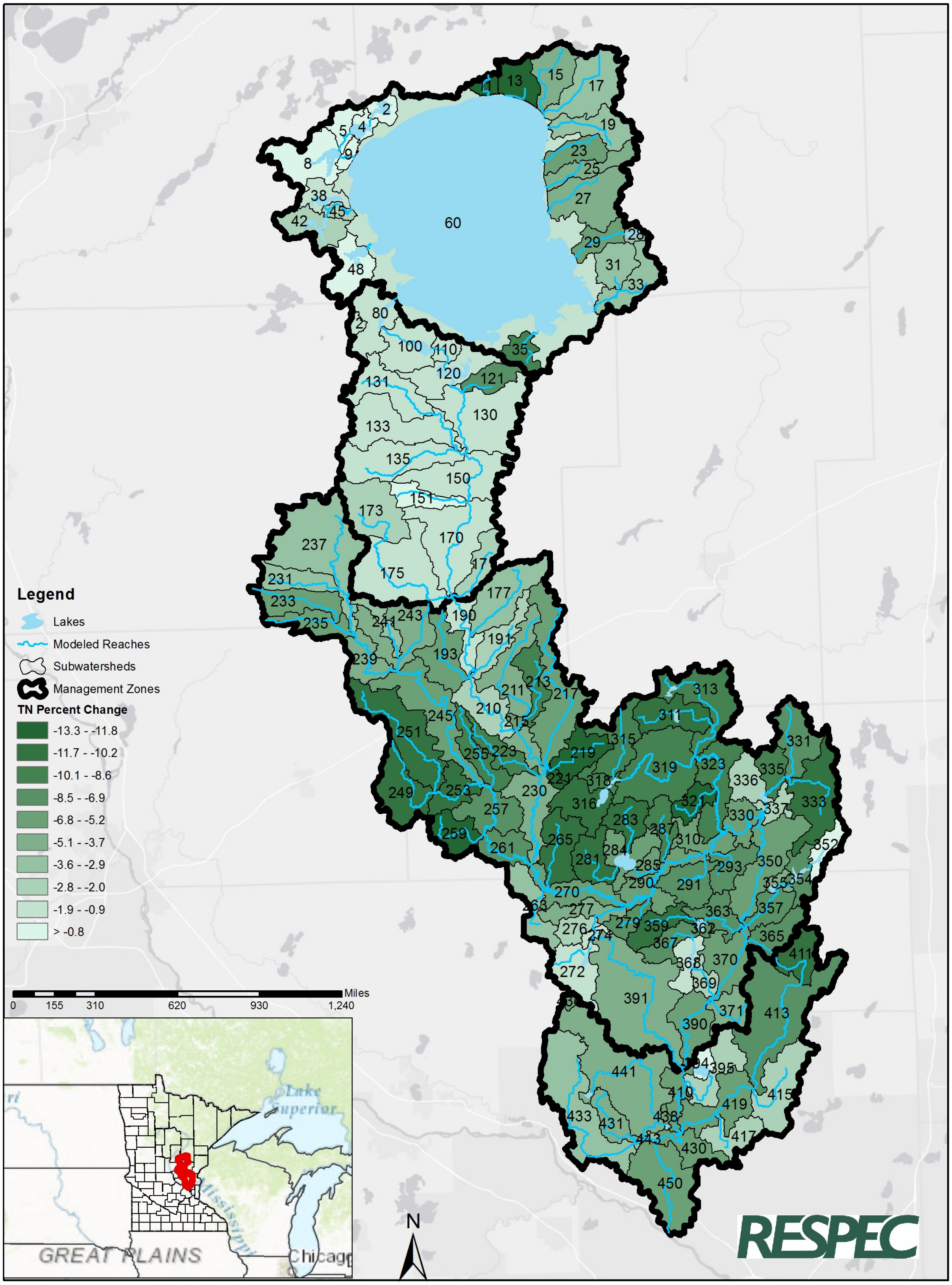

Figure 1-24. Scenario 5 Total Nitrogen Percent Change.

Table 1-2. Watershed Scenario Reaches

Management Area	Description	Reach
Mille Lacs	Outlet of Mille Lacs	60
Upper Reach	Rum River above Tibbets Brook and Whitney Brook	170
Middle Reach	West Branch Rum River Outlet	261
Middle Reach	Stanchfield Creek Outlet	323
Middle Reach	Rum River above Seelye Brook	390
Lower Reach	Cedar Creek Outlet	419
Lower Reach	Rum River Outlet	450

To provide context for scenario results, an analysis was carried out to compare average present-day and estimated future scenario-derived TSS and TP Flow-Weighted Mean Concentrations (FWMCs) at key pulse-point locations in each of the four management basins. Modeling-period FWMCs were estimated as the mean annual load divided by mean annual discharge for the 20-year modeling period. Below Mille Lacks, the ecoregion shifts from the North River Nutrient Region to the Central River Nutrient Region. From a water quality standard perspective, the North River Nutrient Region standards are 15 milligrams per liter (mg/L) for TSS and 50 mg/L for TP, and the Central River Nutrient Region standards are 30 mg/L for TSS and 100 mg/L for TP. Similarly, the NLF ecoregion shifts from the NCHF ecoregion. In the NLF ecoregion, the lake TP standard is 30 mg/L, and in the NCHF ecoregion, the deep lake TP standard is 40 mg/L, and the shallow lake TP standard is 60 mg/L. Hence, as stream and river TP concentrations increase toward the river phosphorus standard, lakes along major flow paths will be more likely to experience increased TP and potentially exceed lake eutrophication standards. River water quality standards collection periods are as follows: (1) April 1 to September 30 for TSS and (2) June 1 to September 30 for TP and eutrophication response variables [Minnesota State Legislature, 2008]. FWMCs reported in this report are based on annual averages and, therefore, do not directly correspond to the river water quality standard time periods. Comparing relative scenario changes in FWMCs allow for assessing the effects of many impacts along the RRW flow network. FWMC estimates for TSS and TP are shown in Figures 1-25 and 1-26 and in Tables 1-3 and 1-4, respectively.

1.6.1 Mille Lacs

Land-conversion scenario results, particularly conversion to agricultural and developed land covers, indicate the highest increases in TSS and TP concentrations from present-day conditions of the summarized pulse-point location. However, at the outlet of Mille Lacs, TSS was well below the 15 mg/L standard, and TP was well below the 50 μg/L standard for all of the scenarios. The cumulative impacts of converted land uses (Scenario 4) showed the highest TSS concentration at the outlet of Mille Lacs. Using agricultural buffers and MIDS, BMPs were noted to reduce TSS concentrations for agricultural and developed land uses.

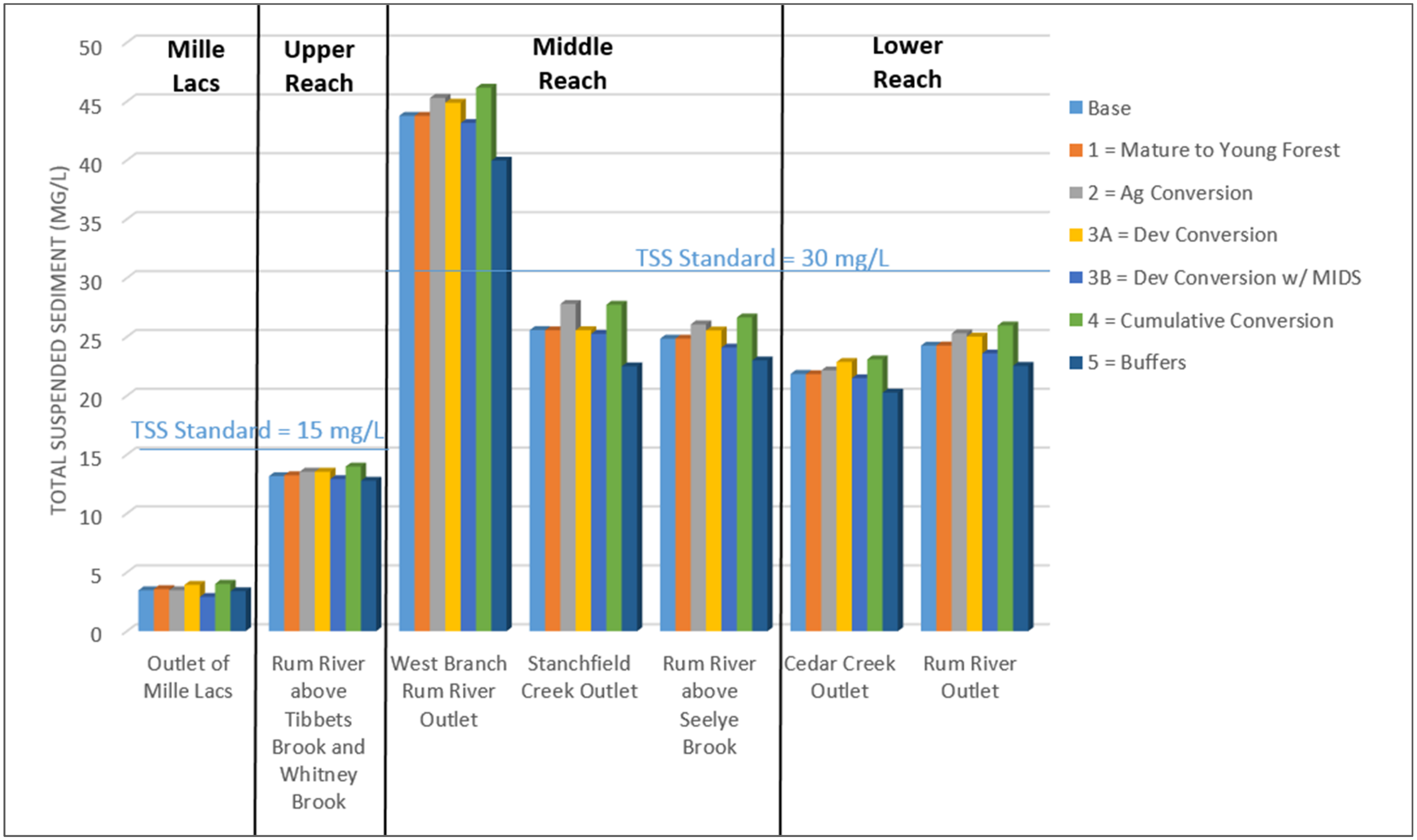

Figure 1-25. Watershed Total Suspended Solids Scenario Summary by Basin and Subwatershed Pulse Point.

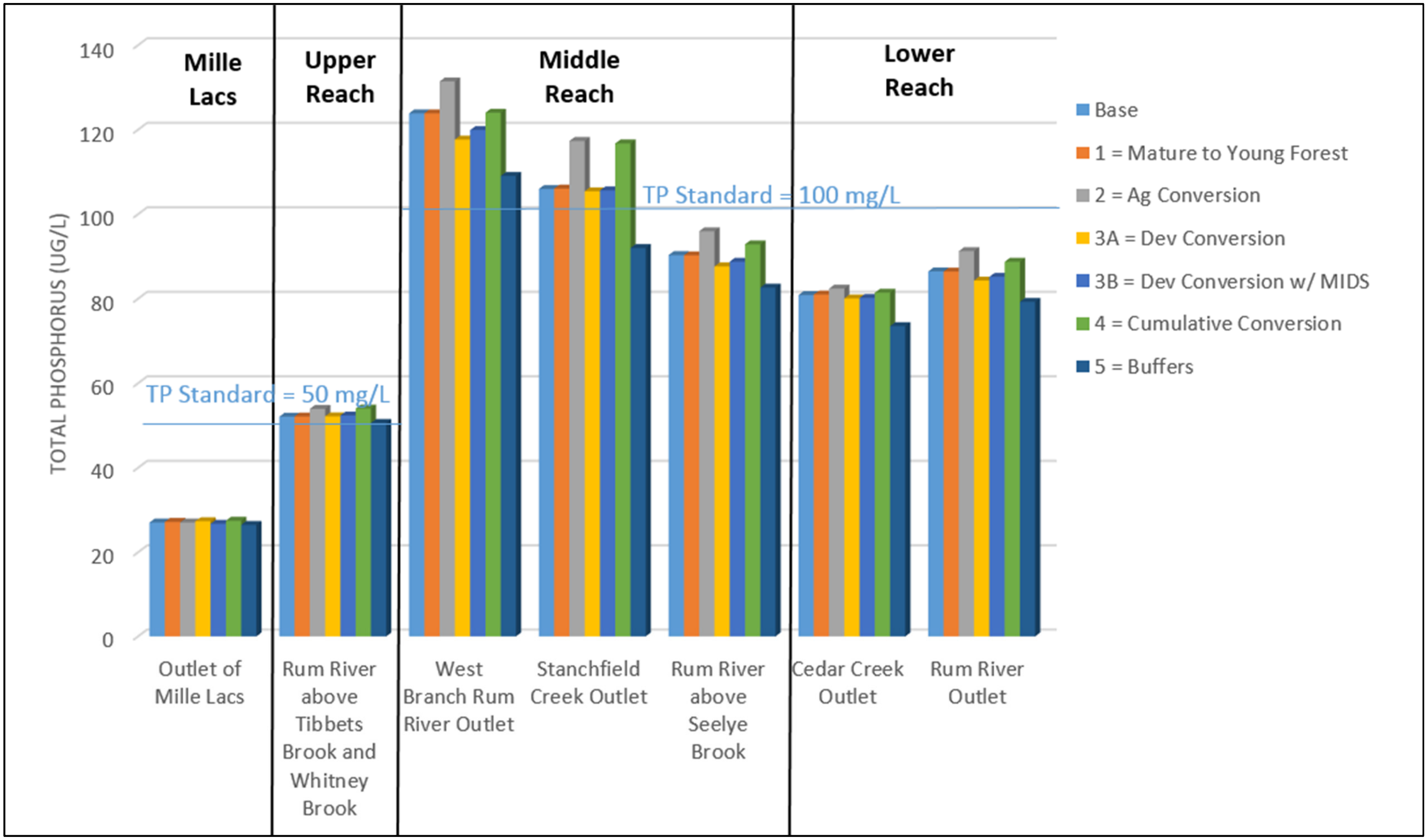

Figure 1-26. Watershed Total Phosphorus Scenario Summary by Basin and Subwatershed Pulse Point.

Table 1-3. Watershed Scenario Predicted Total Suspended Solids Concentrations by Subwatershed (Significant Digits Presented for Comparison Purposes)

Management Area	Description	Reach	Base (mg/L)	1 = Mature to Young Forest (mg/L)	2 = Ag Conversion (mg/L)	3A = Dev Conversion (mg/L)	3B = Dev Conversion w/ MIDS (mg/L)	4 = Cumulative Conversion (mg/L)	5 = Buffers (mg/L)
Mille Lacs	Outlet of Mille Lacs	60	3.5	3.6	3.5	3.9	2.9	4.0	3.4
Upper Reach	Rum River above Tibbets Brook and Whitney Brook	170	13.2	13.2	13.5	13.5	12.9	14.0	12.8
Middle Reach	West Branch Rum River Outlet	261	43.8	43.8	45.3	44.9	43.2	46.2	40.0
Middle Reach	Stanchfield Creek Outlet	323	25.6	25.6	27.8	25.6	25.2	27.7	22.5
Middle Reach	Rum River above Seelye Brook	390	24.8	24.8	26.1	25.5	24.1	26.6	23.0
Lower Reach	Cedar Creek Outlet	419	21.8	21.8	22.1	22.9	21.5	23.1	20.3
Lower Reach	Rum River Outlet	450	24.3	24.3	25.3	25.0	23.6	26.0	22.5

Table 1-4. Watershed Scenario Predicted Total Phosphorus Concentrations by Subwatershed (Significant Digits Presented for Comparison Purposes)

Management Area	Description	Reach	Base (mg/L)	1 = Mature to Young Forest (mg/L)	2 = Ag Conversion (mg/L)	3A = Dev Conversion (mg/L)	3B = Dev Conversion w/ MIDS (mg/L)	4 = Cumulative Conversion (mg/L)	5 = Buffers (mg/L)
Mille Lacs	Outlet of Mille Lacs	60	27.1	27.2	27.1	27.4	26.8	27.5	26.5
Upper Reach	Rum River above Tibbets Brook and Whitney Brook	170	52.1	52.1	53.9	52.2	52.4	54.0	50.6
Middle Reach	West Branch Rum River Outlet	261	123.9	123.9	131.4	117.7	119.9	124.0	109.0
Middle Reach	Stanchfield Creek Outlet	323	106.0	106.1	117.3	105.4	105.6	116.7	92.0
Middle Reach	Rum River above Seelye Brook	390	90.3	90.3	96.0	87.6	88.8	92.9	82.6
Lower Reach	Cedar Creek Outlet	419	80.9	81.0	82.4	80.1	80.2	81.4	73.5
Lower Reach	Rum River Outlet	450	86.5	86.4	91.3	84.3	85.2	88.7	79.3

1.6.2 Upper Reach

The assessed reach of the Upper Reach Basin included the Rum River above Tibbets Brook and Whitney Brook. Land-conversion scenario results, particularly conversion to agricultural and developed land covers, indicate the highest increases in TSS and TP concentrations from present-day conditions of the summarized pulse-point location. However, at Rum River above Tibbets Brook and Whitney Brook, TSS remained below the 15 mg/L standard, and TP remained below the 50 µg/L standard for all scenarios. The cumulative impacts of converted land uses (Scenario 4) showed the highest TSS concentration at Rum River above Tibbets Brook and Whitney Brook. Using agricultural buffers was noted to reduce TSS and TP concentrations for agricultural land uses.

1.6.3 Middle Reach

Of the Middle Reach's three pulse-point reaches, the highest estimated TSS concentrations were noted for West Branch of the Rum, with predicted concentrations exceeding the 30 mg/L standard for present and converted land uses. In contrast, Stanchfield Creek predicted TSS concentrations remained relatively low, which was likely caused by upgradient lake sedimentation influences. Rum River above Seelye Brook also remained below the 30 mg/L standard for all of the scenarios.

TP concentrations predicted for West Branch of the Rum and Stanchfield Creek exceeded the 100 mg/L TP standard for present and converted land uses. Implementing agricultural buffers was predicted to reduce TP concentrations in Stanchfield Creek to below the 100 mg/L standard. Implementing MIDS practices on scenario-developed areas was predicted to reduce future development TP concentrations. Present-day and converted land uses at Rum River above Seelye Brook were predicted remain below the 100 mg/L TP standard. The largest noted increases came from agricultural conversion.

1.6.4 Lower Reach

Two pulse-point reaches were selected for the Lower Reach; one at the outlet of Cedar Creek and one at the outlet of the Rum River. FWMC TSS concentrations remained below the 30 mg/L standard and FWMC TP concentrations remained below the 100 µg/L standard for present and converted land uses.

1.7 SUMMARY

In an effort to forecast the future, broad changes in land uses that most affect water quality were defined by stakeholders and local experts across the RRW. Specific subwatersheds were identified as likely candidates for intensified forest harvest and an increase in row crops and development. The potential impacts of these broad changes were estimated by using a basin runoff model calibrated by 20 years of flow and water quality data. Similarly, the model was employed to predict the impacts from buffer use (agricultural scenario) and urban BMPs. Future predictions of relative water quality changes were based on percent increases or decreases of runoff (flow) and associated key pollutant-loading rates (TSS, TP, and TN) from present-day conditions. Representative pulse points along the basins were chosen to illustrate the changes in TSS and TP FWMCs.

Conversion to intense land uses (agriculture and developed) was estimated to result in variable but generally substantial increases in TSS-, TP-, and TN-loading rates and FWMCs noted for representative pulse points within each of the management basins. The effects of these changes were depicted by subwatershed with effects that propagate through downstream waters. Widespread buffer use in agricultural areas was noted to reduce pollutant-loading rates. Similarly, widespread use of low-impact development practices in urban areas helped to offset development impacts.

2.0 REFERENCES

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APPENDIX A
POLLUTANT-LOADING TABLES

APPENDIX A FLOW AND POLLUTANT-LOADING TABLES

Subwatershed flow and loading rates for sediment, phosphorus, and nitrogen are provided in Tables A-1, A-2, A-3, and A-4, respectively. Figure A-1 contains the key of the subwatershed locations

.

Table A-1. Scenario Average Annual Flow Rates (Acre-Foot per Year) by Subwatershed, 1996–2015 (Page 1 of 6)

ReachID	Base	S1	S2	S3A	S3B	S4	S5
2	672	672	672	691	644	691	672
3	672	672	672	692	644	692	672
4	1151	1151	1151	1184	1106	1184	1151
5	1940	1940	1940	1996	1856	1996	1940
8	3770	3806	3770	3825	3685	3862	3770
9	4093	4129	4093	4149	4009	4185	4093
11	462	462	462	462	462	462	462
13	1338	1338	1338	1338	1338	1338	1338
15	1674	1693	1674	1674	1674	1693	1674
17	4180	4242	4180	4284	3958	4339	4180
19	1557	1557	1557	1632	1409	1632	1557
23	1146	1146	1146	1181	1048	1181	1146
25	1169	1169	1169	1209	1084	1209	1169
27	2657	2693	2657	2739	2455	2770	2657
28	425	425	425	425	425	425	425
29	1357	1368	1357	1391	1281	1401	1357
31	1205	1221	1205	1240	1126	1253	1205
33	2819	2854	2819	2900	2629	2929	2819
35	883	892	883	903	807	910	883
38	601	601	601	601	601	601	601
42	1230	1230	1230	1230	1230	1230	1230
43	1230	1230	1230	1230	1230	1230	1230

Table A-1. Scenario Average Annual Flow Rates (Acre-Foot per Year) by Subwatershed, 1996–2015 (Page 2 of 6)

ReachID	Base	S1	S2	S3A	S3B	S4	S5
45	2127	2127	2127	2127	2127	2127	2127
48	1314	1340	1314	1314	1314	1340	1314
49	1315	1340	1315	1315	1315	1340	1315
60	65496	65804	65496	66340	63806	66614	65496
70	65497	65805	65497	66341	63807	66615	65497
72	198	198	198	198	198	198	198
80	67436	67768	67436	68344	65627	68638	67436
90	67436	67769	67436	68344	65628	68639	67436
100	68933	69265	68933	69841	67124	70135	68933
110	69449	69782	69449	70357	67640	70652	69449
120	71339	71691	71339	72293	69420	72604	71339
121	1002	1012	1002	1002	1002	1012	1002
130	76573	76936	76573	77527	74654	77849	76573
131	2125	2125	2125	2125	2125	2125	2125
133	5112	5112	5112	5112	5112	5112	5112
135	8471	8471	8471	8471	8471	8471	8471
150	88249	88612	88249	89203	86330	89525	88249
151	1063	1063	1063	1063	1063	1063	1063
170	93722	94084	93875	94675	91803	95150	93722
171	1612	1612	1662	1612	1612	1662	1612
173	2986	2986	2986	2986	2986	2986	2986
175	7891	7891	8075	7891	7891	8075	7891
177	3383	3383	3500	3464	3060	3563	3383

Table A-1. Scenario Average Annual Flow Rates (Acre-Foot per Year) by Subwatershed, 1996–2015 (Page 3 of 6)

ReachID	Base	S1	S2	S3A	S3B	S4	S5
190	108187	108550	108743	109222	105945	110081	108187
191	1756	1756	1804	1786	1594	1827	1756
193	2495	2495	2571	2543	2236	2607	2495
210	115018	115381	115750	116192	112135	117202	115018
211	2906	2906	2980	2961	2620	3024	2906
213	1596	1596	1632	1618	1427	1649	1596
215	4738	4738	4849	4819	4256	4913	4738
217	5306	5306	5445	5390	4816	5508	5306
219	2011	2011	2041	2019	1807	2044	2011
221	2313	2313	2343	2325	2080	2351	2313
223	1651	1651	1651	1678	1482	1678	1651
230	132645	133009	133660	134096	128023	135347	132645
231	1896	1896	1896	1896	1896	1896	1896
233	2308	2308	2308	2308	2308	2308	2308
235	4102	4102	4102	4102	4102	4102	4102
237	8994	8994	8994	8994	8994	8994	8994
239	14692	14692	14692	14692	14692	14692	14692
241	839	839	839	866	758	866	839
243	3961	3961	4071	4060	3575	4154	3961
245	22939	22939	23160	23115	22115	23303	22939
249	2876	2876	2876	2932	2572	2932	2876
251	4643	4643	4737	4699	4170	4778	4643
253	9137	9137	9230	9282	8190	9362	9137

Table A-1. Scenario Average Annual Flow Rates (Acre-Foot per Year) by Subwatershed, 1996–2015 (Page 4 of 6)

ReachID	Base	S1	S2	S3A	S3B	S4	S5
255	1811	1811	1811	1828	1630	1828	1811
257	36320	36320	36636	36722	34105	36989	36320
259	1820	1820	1820	1841	1621	1841	1820
261	39836	39836	40151	40315	37296	40584	39836
263	2250	2260	2250	2308	2116	2317	2250
265	2465	2465	2465	2508	2244	2508	2465
270	179378	179752	180709	181468	171702	182998	179378
272	2127	2127	2127	2191	1941	2191	2127
274	2379	2379	2379	2451	2174	2451	2379
276	3234	3242	3234	3328	2963	3334	3234
277	4519	4535	4519	4636	4142	4649	4519
279	853	853	853	865	798	865	853
281	1777	1777	1777	1807	1617	1807	1777
283	1378	1378	1378	1378	1378	1378	1378
284	4683	4683	4683	4754	4402	4754	4683
285	5181	5181	5181	5264	4867	5264	5181
287	1049	1049	1049	1049	1049	1049	1049
290	192943	193333	194275	195289	184364	196833	192943
291	1678	1678	1726	1718	1549	1759	1678
293	1278	1278	1278	1314	1178	1314	1278
310	197128	197519	198509	199550	188318	201136	197128
311	2513	2523	2548	2513	2513	2557	2513
313	5745	5756	5839	5745	5745	5848	5745

Table A-1. Scenario Average Annual Flow Rates (Acre-Foot per Year) by Subwatershed, 1996–2015 (Page 5 of 6)

ReachID	Base	S1	S2	S3A	S3B	S4	S5
315	2539	2539	2566	2539	2539	2566	2539
316	2199	2199	2231	2214	2021	2241	2199
318	5377	5379	5444	5392	5198	5456	5377
319	9662	9689	9812	9678	9484	9845	9662
321	982	982	1000	982	982	1000	982
323	18828	18885	19155	18843	18649	19214	18828
330	217072	217520	218780	219509	208083	221466	217072
331	2318	2318	2318	2347	2168	2347	2318
333	3300	3300	3300	3336	3031	3336	3300
335	6655	6655	6680	6720	6235	6745	6655
336	8136	8136	8195	8202	7716	8260	8136
337	8798	8798	8857	8864	8378	8922	8798
350	229963	230411	231730	232591	220303	234607	229963
352	932	932	932	953	849	953	932
353	933	933	933	953	849	953	933
354	2058	2058	2058	2100	1889	2100	2058
355	2431	2431	2431	2480	2246	2480	2431
357	3590	3590	3590	3663	3302	3663	3590
359	1295	1295	1295	1321	1184	1321	1295
362	1495	1495	1495	1526	1373	1526	1495
363	2711	2711	2711	2770	2480	2770	2711
365	1679	1679	1679	1708	1560	1708	1679
367	1128	1128	1128	1154	1042	1154	1128

Table A-1. Scenario Average Annual Flow Rates (Acre-Foot per Year) by Subwatershed, 1996–2015 (Page 6 of 6)

ReachID	Base	S1	S2	S3A	S3B	S4	S5
368	2177	2177	2177	2233	2004	2233	2177
369	2807	2807	2807	2888	2576	2888	2807
370	243085	243533	244852	246012	232358	248028	243085
371	1279	1279	1279	1304	1201	1304	1279
390	246386	246834	248153	249393	235423	251409	246386
391	7616	7679	7616	7787	7063	7840	7616
394	529	529	529	541	502	541	529
395	2433	2433	2433	2502	2282	2502	2433
410	257466	257976	259233	260752	245715	262821	257466
411	1598	1607	1629	1620	1467	1653	1598
413	8196	8254	8227	8363	7585	8438	8196
415	3040	3040	3040	3105	2852	3105	3040
417	1542	1542	1542	1583	1445	1583	1542
419	15324	15383	15356	15666	14254	15742	15324
430	274138	274707	275937	277813	261239	279957	274138
431	1211	1211	1211	1234	1122	1234	1211
433	5753	5753	5753	5895	5327	5895	5753
434	185	185	185	185	185	185	185
436	218	218	218	218	218	218	218
438	161	161	161	166	149	166	161
439	162	162	162	166	149	166	162
441	7036	7036	7036	7189	6502	7189	7036
443	14152	14152	14152	14476	13091	14476	14152
450	292658	293227	294457	296762	278524	298906	292658

Table A-2. Scenario Average Annual Total Suspended Solids Loads (tons/yr) Subwatershed, 1996–2015 (Page 1 of 7)

ReachID	Base	S1	S2	S3A	S3B	S4	S5
2	0.47	0.47	0.47	0.62	0.43	0.62	0.46
3	0.50	0.50	0.50	0.65	0.46	0.65	0.49
4	0.41	0.41	0.41	0.57	0.38	0.57	0.41
5	11.25	11.25	11.25	14.13	10.72	14.13	11.18
8	15.04	15.48	15.04	16.18	14.21	16.64	14.81
9	22.82	23.28	22.82	23.97	21.95	24.45	22.57
11	14.50	14.50	14.50	14.50	14.50	14.50	12.69
13	66.00	66.00	66.00	66.00	66.00	66.00	57.63
15	35.56	35.96	35.56	35.56	35.56	35.96	33.35
17	84.03	85.59	84.03	97.33	80.55	98.72	79.85
19	32.17	32.17	32.17	45.21	30.01	45.21	30.56
23	26.78	26.78	26.78	31.45	24.35	31.45	24.72
25	23.29	23.29	23.29	28.12	21.03	28.12	21.93
27	59.43	60.36	59.43	69.92	54.57	70.70	55.40
28	0.46	0.46	0.46	0.46	0.46	0.46	0.42
29	25.81	26.07	25.81	32.01	23.93	32.23	23.59
31	20.78	21.21	20.78	24.86	19.08	25.22	19.70
33	55.71	56.62	55.71	65.83	51.33	66.60	52.47
35	87.79	89.42	87.79	93.76	77.49	95.15	78.75
38	0.65	0.65	0.65	0.65	0.65	0.65	0.63
42	5.32	5.32	5.32	5.32	5.32	5.32	5.07

Table A-2. Scenario Average Annual Total Suspended Solids Loads (tons/yr) Subwatershed, 1996–2015 (Page 2 of 7)

ReachID	Base	S1	S2	S3A	S3B	S4	S5
43	5.56	5.56	5.56	5.56	5.56	5.56	5.31
45	12.17	12.17	12.17	12.17	12.17	12.17	11.67
48	7.04	7.38	7.04	7.04	7.04	7.38	7.01
49	8.33	8.70	8.33	8.33	8.33	8.70	8.30
60	309.28	319.43	309.28	354.19	251.94	364.01	301.60
70	316.77	326.98	316.77	361.81	259.14	371.68	309.10
72	0.92	0.92	0.92	0.92	0.92	0.92	0.90
80	327.66	338.20	327.66	379.83	269.57	389.98	319.42
90	350.48	361.18	350.48	403.06	291.52	413.36	342.25
100	334.90	345.29	334.90	385.90	277.87	395.91	326.57
110	363.53	373.96	363.53	414.60	306.26	424.63	355.16
120	450.02	463.72	450.02	515.43	385.01	528.24	438.75
121	82.48	84.30	82.48	82.48	82.48	84.30	75.63
130	876.16	891.93	876.16	942.45	809.21	957.29	841.06
131	113.69	113.69	113.69	113.69	113.69	113.69	110.78
133	273.61	273.61	273.61	273.61	273.61	273.61	266.93
135	414.98	414.98	414.98	414.98	414.98	414.98	406.58
150	1438.06	1453.77	1438.06	1504.21	1371.27	1519.00	1392.33
151	48.95	48.95	48.95	48.95	48.95	48.95	48.55
170	1677.75	1693.27	1728.36	1743.10	1612.12	1808.32	1627.76
171	31.22	31.22	41.90	31.22	31.22	41.90	29.99
173	154.37	154.37	154.37	154.37	154.37	154.37	149.54

Table A-2. Scenario Average Annual Total Suspended Solids Loads (tons/yr) Subwatershed, 1996–2015 (Page 3 of 7)

ReachID	Base	S1	S2	S3A	S3B	S4	S5
175	402.60	402.60	462.21	402.60	402.60	462.21	393.43
177	79.97	79.97	106.03	91.63	72.36	113.78	76.82
190	2240.87	2256.38	2399.64	2317.50	2167.72	2486.98	2175.23
191	40.99	40.99	52.81	45.69	37.10	55.74	39.49
193	72.28	72.28	90.02	79.16	64.59	94.23	67.50
210	2436.94	2452.40	2638.06	2541.94	2346.47	2747.39	2359.46
211	90.13	90.13	109.46	101.91	81.82	118.35	86.04
213	57.56	57.56	66.40	61.03	51.17	68.54	51.64
215	156.32	156.32	184.57	172.39	140.62	196.40	145.70
217	157.55	157.55	190.00	167.78	140.96	195.37	146.06
219	132.89	132.89	143.32	129.52	115.78	138.38	112.68
221	154.19	154.19	164.62	151.80	134.70	160.67	131.12
223	71.16	71.16	71.16	78.77	64.08	78.77	63.50
230	3172.80	3188.19	3446.08	3321.25	2997.83	3588.10	3015.48
231	95.42	95.42	95.42	95.42	95.42	95.42	90.71
233	136.29	136.29	136.29	136.29	136.29	136.29	126.45
235	249.94	249.94	249.94	249.94	249.94	249.94	230.62
237	398.97	398.97	398.97	398.97	398.97	398.97	377.32
239	685.09	685.09	685.09	685.09	685.09	685.09	641.99
241	15.75	15.75	15.75	18.82	14.34	18.82	14.94
243	94.01	94.01	117.55	105.47	84.50	125.49	87.87
245	1058.58	1058.58	1121.75	1084.28	1021.36	1137.98	983.89

Table A-2. Scenario Average Annual TSS Loads (tons/yr) Subwatershed, 1996–2015 (Page 4 of 7)

ReachID	Base	S1	S2	S3A	S3B	S4	S5
249	163.86	163.86	163.86	173.12	145.04	173.12	143.79
251	294.23	294.23	330.31	302.37	259.23	333.04	261.50
253	605.44	605.44	642.44	630.13	533.55	661.57	541.10
255	108.71	108.71	108.71	112.00	96.61	112.00	96.35
257	2024.36	2024.36	2125.54	2094.51	1876.73	2180.52	1847.11
259	157.83	157.83	157.83	160.07	137.12	160.07	137.89
261	2370.89	2370.89	2473.07	2460.24	2188.68	2547.10	2164.70
263	119.14	119.48	119.14	133.20	113.70	133.49	113.28
265	143.07	143.07	143.07	148.81	127.56	148.81	124.68
270	5917.25	5932.92	6295.43	6176.38	5517.11	6532.76	5524.58
272	71.89	71.89	71.89	80.28	60.92	80.28	68.30
274	79.42	79.42	79.42	88.70	66.45	88.70	75.43
276	109.84	110.16	109.84	121.58	92.49	121.86	103.60
277	160.39	161.00	160.39	173.75	137.59	174.28	149.22
279	28.67	28.67	28.67	29.03	25.73	29.03	25.67
281	86.95	86.95	86.95	87.17	76.81	87.17	75.23
283	56.47	56.47	56.47	56.47	56.47	56.47	48.81
284	119.86	119.86	119.86	124.83	101.81	124.83	106.22
285	139.95	139.95	139.95	146.28	119.65	146.28	124.45
287	38.49	38.49	38.49	38.49	38.49	38.49	33.54
290	6367.28	6383.62	6747.10	6644.58	5904.15	7003.03	5934.33
291	54.82	54.82	64.99	57.05	49.08	65.70	48.67

Table A-2. Scenario Average Annual TSS Loads (tons/yr) Subwatershed, 1996–2015 (Page 5 of 7)

ReachID	Base	S1	S2	S3A	S3B	S4	S5
293	45.85	45.85	45.85	49.97	41.70	49.97	41.17
310	6542.96	6559.26	6934.85	6822.14	6061.97	7190.88	6097.46
311	86.92	87.16	94.22	86.92	86.92	94.42	75.05
313	221.64	221.86	242.99	221.64	221.64	243.18	192.17
315	72.83	72.83	78.93	72.83	72.83	78.93	64.27
316	71.44	71.44	77.37	71.20	57.52	76.23	64.69
318	154.86	154.99	166.76	154.89	140.74	166.11	140.13
319	322.59	323.33	353.01	322.67	308.22	352.94	286.14
321	41.54	41.54	45.17	41.54	41.54	45.17	35.20
323	654.65	656.17	723.82	654.75	640.25	724.43	575.82
330	7250.03	7267.88	7711.71	7527.31	6751.90	7966.38	6722.40
331	79.65	79.65	79.65	80.40	71.56	80.40	71.01
333	140.81	140.81	140.81	137.73	123.86	137.73	121.71
335	255.08	255.08	260.27	252.72	229.67	257.91	223.26
336	171.45	171.45	179.37	170.97	147.57	178.91	154.35
337	190.75	190.75	198.68	190.29	166.74	198.24	171.95
350	7690.96	7708.88	8161.37	7996.56	7153.76	8444.43	7128.34
352	19.90	19.90	19.90	21.02	15.44	21.02	17.99
353	20.12	20.12	20.12	21.24	15.63	21.24	18.21
354	51.95	51.95	51.95	55.38	41.00	55.38	47.50
355	75.59	75.59	75.59	80.62	64.08	80.62	70.18
357	130.81	130.81	130.81	137.91	113.32	137.91	119.05

Table A-2. Scenario Average Annual TSS Loads (tons/yr) Subwatershed, 1996–2015 (Page 6 of 7)

ReachID	Base	S1	S2	S3A	S3B	S4	S5
359	50.83	50.83	50.83	50.78	44.82	50.78	43.88
362	47.87	47.87	47.87	49.53	39.13	49.53	42.77
363	98.32	98.32	98.32	102.36	83.95	102.36	87.07
365	85.13	85.13	85.13	90.00	78.44	90.00	76.49
367	37.17	37.17	37.17	39.01	33.36	39.01	33.04
368	69.39	69.39	69.39	74.83	57.10	74.83	63.76
369	88.50	88.50	88.50	97.01	74.53	97.01	81.47
370	8213.32	8231.30	8684.33	8546.39	7610.77	8994.91	7600.87
371	29.04	29.04	29.04	30.77	26.57	30.77	27.23
390	8320.77	8338.79	8792.24	8660.60	7708.24	9109.61	7702.64
391	209.96	211.47	209.96	223.39	189.44	224.68	196.61
394	0.74	0.74	0.74	0.85	0.66	0.85	0.72
395	59.16	59.16	59.16	66.26	55.73	66.26	57.04
410	8627.40	8646.97	9099.17	8991.37	7986.81	9441.99	7992.13
411	62.19	62.42	69.37	61.20	54.73	67.47	53.55
413	265.40	266.63	272.47	278.97	240.06	285.98	240.45
415	71.82	71.82	71.82	78.53	66.74	78.53	69.11
417	39.66	39.66	39.66	43.83	37.18	43.83	38.10
419	455.26	456.53	462.37	487.06	416.28	494.13	422.05
430	9129.89	9150.74	9608.89	9532.17	8448.33	9990.01	8461.08
431	25.05	25.05	25.05	26.68	22.31	26.68	23.51
433	127.17	127.17	127.17	140.03	114.72	140.03	121.84

Table A-2. Scenario Average Annual Total Suspended Solids Loads (tons/yr) Subwatershed, 1996–2015 (Page 7 of 7)

ReachID	Base	S1	S2	S3A	S3B	S4	S5
434	3.14	3.14	3.14	3.14	3.14	3.14	2.84
436	1.39	1.39	1.39	1.39	1.39	1.39	1.29
438	1.60	1.60	1.60	1.70	1.37	1.70	1.44
439	1.60	1.60	1.60	1.70	1.37	1.70	1.44
441	160.25	160.25	160.25	171.61	144.07	171.61	150.77
443	316.22	316.22	316.22	342.87	284.63	342.87	299.92
450	9651.09	9671.99	10130.27	10095.63	8932.43	10553.70	8965.20

Table A-3. Scenario Average Annual Total Phosphorus Loads (Pounds per Year) by Subwatershed, 1996–2015 (Page 1 of 7)

ReachID	Base	S1	S2	S3A	S3B	S4	S5
2	43.6	43.6	43.6	46.6	41.8	46.6	43.2
3	43.3	43.3	43.3	46.2	41.5	46.2	42.9
4	75.6	75.6	75.6	80.5	73.0	80.5	75.4
5	199.7	199.7	199.7	217.9	195.1	217.9	198.5
8	371.6	379.6	371.6	383.8	365.4	391.8	366.5
9	432.9	440.9	432.9	444.9	426.8	453.0	427.5
11	232.2	232.2	232.2	232.2	232.2	232.2	197.1
13	694.7	694.7	694.7	694.7	694.7	694.7	584.9
15	386.6	394.1	386.6	386.6	386.6	394.1	359.6
17	876.2	903.5	876.2	934.7	849.8	958.7	826.2
19	329.1	329.1	329.1	363.0	309.8	363.0	309.6
23	297.5	297.5	297.5	308.8	275.5	308.8	271.5
25	282.2	282.2	282.2	302.4	269.3	302.4	263.8
27	660.7	676.9	660.7	693.2	618.1	707.0	608.3
28	33.9	33.9	33.9	33.9	33.9	33.9	32.0
29	298.7	303.5	298.7	304.2	278.0	308.1	269.5
31	270.1	277.7	270.1	290.3	259.4	296.7	255.5
33	603.0	618.2	603.0	638.5	570.2	651.4	562.8
35	445.3	450.6	445.3	433.0	401.1	437.6	386.1
38	54.9	54.9	54.9	54.9	54.9	54.9	53.8
42	135.7	135.7	135.7	135.7	135.7	135.7	130.2
43	134.5	134.5	134.5	134.5	134.5	134.5	129.1

Table A-3. Scenario Average Annual Total Phosphorus Loads (Pounds per Year) by Subwatershed, 1996–2015 (Page 2 of 7)

ReachID	Base	S1	S2	S3A	S3B	S4	S5
45	237.5	237.5	237.5	237.5	237.5	237.5	228.8
48	114.8	119.3	114.8	114.8	114.8	119.3	114.1
49	113.9	118.4	113.9	113.9	113.9	118.4	113.2
60	4820.8	4865.4	4820.8	4934.8	4643.1	4974.6	4713.3
70	4817.1	4861.7	4817.1	4931.1	4639.5	4970.8	4709.8
72	18.1	18.1	18.1	18.1	18.1	18.1	17.7
80	5172.0	5225.1	5172.0	5318.4	4986.4	5365.3	5059.5
90	5159.7	5212.8	5159.7	5305.9	4974.2	5352.8	5047.4
100	5242.7	5293.6	5242.7	5381.9	5058.8	5427.1	5131.4
110	5316.3	5367.2	5316.3	5455.3	5132.9	5500.2	5205.1
120	5535.9	5594.8	5535.9	5695.2	5334.8	5746.9	5412.8
121	389.3	395.1	389.3	389.3	389.3	395.1	345.8
130	10105.2	10169.5	10105.2	10263.8	9904.1	10321.5	9824.3
131	434.2	434.2	434.2	434.2	434.2	434.2	416.5
133	1066.8	1066.8	1066.8	1066.8	1066.8	1066.8	1026.0
135	1633.7	1633.7	1633.7	1633.7	1633.7	1633.7	1582.0
150	12451.6	12516.4	12451.6	12610.0	12250.9	12667.8	12097.7
151	186.6	186.6	186.6	186.6	186.6	186.6	183.7
170	13278.0	13340.0	13768.1	13433.2	13075.0	13979.5	12898.0
171	353.0	353.0	495.1	353.0	353.0	495.1	337.1
173	757.3	757.3	757.3	757.3	757.3	757.3	720.2
175	1791.0	1791.0	2345.2	1791.0	1791.0	2345.2	1723.6

Table A-3. Scenario Average Annual Total Phosphorus Loads (Pounds per Year) by Subwatershed, 1996–2015 (Page 3 of 7)

ReachID	Base	S1	S2	S3A	S3B	S4	S5
177	860.9	860.9	1211.2	902.8	798.2	1200.8	818.7
190	16245.6	16307.3	17922.0	16441.3	15983.1	18121.6	15721.7
191	472.9	472.9	631.4	484.9	436.3	619.8	453.1
193	826.7	826.7	1066.4	830.7	749.9	1034.5	762.4
210	19690.1	19753.1	21908.5	19887.0	19242.8	22023.3	19020.5
211	891.3	891.3	1144.2	894.8	809.2	1109.4	838.3
213	679.4	679.4	798.5	654.5	606.7	755.7	600.9
215	1602.7	1602.7	1970.5	1577.2	1440.0	1889.6	1466.4
217	1611.3	1611.3	2033.5	1601.4	1455.3	1960.2	1464.3
219	1203.4	1203.4	1305.4	1116.7	1055.9	1203.4	1010.6
221	1383.6	1383.6	1485.4	1283.9	1214.2	1370.5	1163.7
223	1133.3	1133.3	1133.3	1092.7	1047.8	1092.7	1032.9
230	24819.8	24871.8	27772.3	24718.7	23665.7	27475.8	23393.1
231	606.1	606.1	606.1	606.1	606.1	606.1	572.9
233	900.4	900.4	900.4	900.4	900.4	900.4	830.2
235	1550.5	1550.5	1550.5	1550.5	1550.5	1550.5	1415.8
237	2539.5	2539.5	2539.5	2539.5	2539.5	2539.5	2386.8
239	4071.7	4071.7	4071.7	4071.7	4071.7	4071.7	3774.6
241	196.1	196.1	196.1	212.7	184.8	212.7	185.1
243	1107.0	1107.0	1419.6	1144.3	1018.7	1410.0	1025.0
245	7019.2	7019.2	7687.5	6983.1	6722.6	7552.9	6431.7
249	1345.0	1345.0	1345.0	1288.0	1191.5	1288.0	1161.5

Table A-3. Scenario Average Annual Total Phosphorus Loads (Pounds per Year) by Subwatershed, 1996–2015 (Page 4 of 7)

ReachID	Base	S1	S2	S3A	S3B	S4	S5
251	2105.5	2105.5	2434.5	1989.5	1853.7	2267.8	1820.1
253	3772.0	3772.0	4085.8	3561.2	3293.1	3826.5	3248.1
255	920.3	920.3	920.3	869.5	817.5	869.5	805.6
257	12342.0	12342.0	13294.8	11934.7	11280.3	12744.8	10936.7
259	1219.0	1219.0	1219.0	1129.2	1075.6	1129.2	1030.6
261	13418.3	13418.3	14348.9	12899.2	12162.2	13686.8	11812.8
263	952.9	956.5	952.9	949.4	907.6	952.5	893.6
265	1183.3	1183.3	1183.3	1124.1	1052.6	1124.1	1011.4
270	37472.3	37520.7	41168.9	36775.8	34952.3	40139.5	34355.0
272	422.3	422.3	422.3	443.6	377.7	443.6	381.0
274	444.1	444.1	444.1	465.4	394.2	465.4	399.0
276	618.4	620.8	618.4	627.4	546.3	629.3	551.8
277	1048.5	1054.0	1048.5	1050.6	937.5	1055.2	931.7
279	262.2	262.2	262.2	256.6	239.8	256.6	232.0
281	791.3	791.3	791.3	751.5	705.9	751.5	674.1
283	612.9	612.9	612.9	612.9	612.9	612.9	524.2
284	905.4	905.4	905.4	857.1	787.1	857.1	762.8
285	1013.8	1013.8	1013.8	965.4	886.4	965.4	861.5
287	410.4	410.4	410.4	410.4	410.4	410.4	354.0
290	38296.7	38349.3	41852.3	37535.7	35563.4	40765.0	34916.7
291	604.6	604.6	726.0	596.6	550.4	699.9	531.9
293	458.0	458.0	458.0	452.3	418.1	452.3	404.1

Table A-3. Scenario Average Annual Total Phosphorus Loads (Pounds per Year) by Subwatershed, 1996–2015 (Page 5 of 7)

ReachID	Base	S1	S2	S3A	S3B	S4	S5
310	38421.0	38468.6	42022.4	37639.2	35639.9	40910.5	34969.4
311	909.6	915.2	992.7	909.6	909.6	997.5	794.8
313	2002.6	2007.7	2200.0	2002.6	2002.6	2204.6	1783.8
315	854.5	854.5	938.9	854.5	854.5	938.9	742.7
316	667.1	667.1	734.4	631.3	577.7	688.6	575.6
318	1527.6	1528.4	1670.9	1496.9	1443.7	1634.0	1322.7
319	3038.8	3049.4	3382.1	3010.0	2961.0	3356.8	2612.7
321	468.5	468.5	510.8	468.5	468.5	510.8	395.8
323	5425.7	5446.5	6111.9	5402.0	5356.9	6100.2	4709.7
330	43668.4	43737.7	47930.1	42864.3	40830.5	46808.0	39497.8
331	881.7	881.7	881.7	854.0	806.3	854.0	787.0
333	1312.5	1312.5	1312.5	1229.2	1160.2	1229.2	1114.2
335	2423.4	2423.4	2484.4	2313.9	2199.0	2374.6	2096.4
336	1925.8	1925.8	1985.5	1776.2	1672.4	1957.8	1617.3
337	2107.5	2107.5	2165.7	1959.4	1856.3	2139.4	1781.7
350	56528.2	56598.4	60815.2	55526.4	53311.5	59619.0	51886.1
352	248.3	248.3	248.3	227.5	197.2	227.5	197.6
353	247.1	247.1	247.1	226.2	196.0	226.2	196.5
354	461.3	461.3	461.3	448.7	400.3	448.7	403.1
355	566.3	566.3	566.3	568.7	518.8	568.7	535.9
357	966.0	966.0	966.0	943.8	870.8	943.8	869.2
359	535.4	535.4	535.4	512.9	478.8	512.9	458.1

Table A-3. Scenario Average Annual Total Phosphorus Loads (Pounds per Year) by Subwatershed, 1996–2015 (Page 6 of 7)

ReachID	Base	S1	S2	S3A	S3B	S4	S5
362	324.3	324.3	324.3	312.4	282.0	312.4	283.3
363	814.4	814.4	814.4	786.2	720.6	786.2	704.9
365	1191.9	1191.9	1191.9	1155.5	1118.2	1155.5	1088.3
367	377.1	377.1	377.1	372.3	344.5	372.3	331.9
368	427.6	427.6	427.6	426.2	348.1	426.2	350.8
369	588.9	588.9	588.9	595.4	499.7	595.4	498.8
370	60391.2	60462.3	64659.9	59286.8	56742.0	63359.7	55256.4
371	279.2	279.2	279.2	289.0	263.7	289.0	260.4
390	60516.2	60585.8	64763.6	59440.6	56824.7	63492.6	55358.1
391	2030.0	2050.0	2030.0	2067.7	1921.1	2084.0	1917.5
394	40.2	40.2	40.2	42.3	38.1	42.3	39.5
395	451.1	451.1	451.1	476.7	427.8	476.7	429.4
410	62629.9	62717.8	66861.1	61633.0	58798.8	65684.1	57351.7
411	658.3	662.2	741.7	625.5	587.1	698.9	561.9
413	2172.6	2192.4	2246.9	2153.2	1985.1	2233.0	1930.0
415	542.0	542.0	542.0	570.3	514.5	570.3	516.6
417	355.5	355.5	355.5	375.4	341.2	375.4	338.6
419	3369.9	3387.9	3440.5	3411.0	3107.8	3485.5	3063.8
430	65943.1	66048.8	70236.1	65012.2	61849.3	69128.3	60374.2
431	256.9	256.9	256.9	265.3	240.9	265.3	238.9
433	1173.0	1173.0	1173.0	1220.8	1103.9	1220.8	1099.8
434	35.3	35.3	35.3	35.3	35.3	35.3	31.4

Table A-3. Scenario Average Annual Total Phosphorus Loads (Pounds per Year) by Subwatershed, 1996–2015 (Page 7 of 7)

ReachID	Base	S1	S2	S3A	S3B	S4	S5
436	28.2	28.2	28.2	28.2	28.2	28.2	25.8
438	28.0	28.0	28.0	28.0	25.0	28.0	25.2
439	27.9	27.9	27.9	28.0	25.0	28.0	25.1
441	1410.8	1410.8	1410.8	1473.0	1310.9	1473.0	1314.3
443	2794.6	2794.6	2794.6	2912.9	2610.6	2912.9	2609.6
450	68802.7	68910.3	73073.5	68038.3	64522.3	72128.7	63087.3

Table A-4. Scenario Average Annual Total Nitrogen Loads (Pounds per Year) by Subwatershed, 1996–2015 (Page 1 of 7)

ReachID	Base	S1	S2	S3A	S3B	S4	S5
2	1720	1720	1720	1790	1663	1790	1716
3	1714	1714	1714	1783	1657	1783	1710
4	2123	2123	2123	2210	2060	2210	2121
5	5561	5561	5561	5855	5599	5855	5545
8	8307	8444	8307	8488	8211	8626	8249
9	9778	9914	9778	9958	9682	10094	9716
11	3604	3604	3604	3604	3604	3604	3168
13	10500	10500	10500	10500	10500	10500	9164
15	8448	8567	8448	8448	8448	8567	8112
17	20165	20582	20165	21180	20604	21550	19540
19	7596	7596	7596	8205	7856	8205	7354
23	6171	6171	6171	6433	6211	6433	5851
25	6064	6064	6064	6427	6211	6427	5841
27	14057	14304	14057	14721	14212	14931	13419
28	672	672	672	672	672	672	652
29	5910	5984	5910	6087	5916	6149	5554
31	6088	6201	6088	6433	6227	6529	5912
33	13859	14092	13859	14544	14085	14741	13363
35	6101	6168	6101	6109	5942	6167	5512
38	1091	1091	1091	1091	1091	1091	1078
42	3079	3079	3079	3079	3079	3079	3014
43	3056	3056	3056	3056	3056	3056	2991
45	5370	5370	5370	5370	5370	5370	5265
48	3271	3363	3271	3271	3271	3363	3263

Table A-4. Scenario Average Annual Total Nitrogen Loads (Pounds per Year) by Subwatershed, 1996–2015 (Page 2 of 7)

ReachID	Base	S1	S2	S3A	S3B	S4	S5
49	3240	3331	3240	3240	3240	3331	3232
60	72751	73309	72751	74203	70903	74703	71706
70	72683	73240	72683	74134	70836	74633	71639
72	645	645	645	645	645	645	639
80	85583	86294	85583	87656	84027	88290	84451
90	85413	86125	85413	87484	83859	88117	84284
100	97038	97731	97038	99039	95404	99657	95902
110	99099	99791	99099	101096	97468	101712	97963
120	113192	114011	113192	115535	111550	116257	111924
121	6048	6124	6048	6048	6048	6124	5616
130	145461	146352	145461	147796	143819	148594	142626
131	9679	9679	9679	9679	9679	9679	9503
133	23616	23616	23616	23616	23616	23616	23208
135	38473	38473	38473	38473	38473	38473	37939
150	199862	200755	199862	202193	198220	202990	196251
151	4798	4798	4798	4798	4798	4798	4766
170	222923	223792	227622	225221	221256	230703	219013
171	8212	8212	9756	8212	8212	9756	8013
173	15478	15478	15478	15478	15478	15478	15067
175	38936	38936	44297	38936	38936	44297	38182
177	18283	18283	22077	19237	18486	22464	17760
190	292128	292992	309063	295356	290682	312508	286479
191	9687	9687	11405	10057	9709	11519	9440
193	15310	15310	17905	15737	15153	17944	14515

Table A-4. Scenario Average Annual Total Nitrogen Loads (Pounds per Year) by Subwatershed, 1996–2015 (Page 3 of 7)

ReachID	Base	S1	S2	S3A	S3B	S4	S5
210	330075	330943	352912	334239	328266	356363	322573
211	16976	16976	19721	17431	16815	19761	16315
213	11286	11286	12573	11251	10913	12345	10313
215	29174	29174	33159	29588	28610	32974	27471
217	30902	30902	35453	31507	30473	35375	29077
219	16892	16892	17888	16278	15884	17125	14698
221	19413	19413	20406	18709	18258	19553	16910
223	12561	12561	12561	12341	12028	12341	11315
230	423420	424193	454376	426954	418362	455929	406596
231	10820	10820	10820	10820	10820	10820	10468
233	14365	14365	14365	14365	14365	14365	13624
235	25037	25037	25037	25037	25037	25037	23609
237	48695	48695	48695	48695	48695	48695	47077
239	77726	77726	77726	77726	77726	77726	74497
241	4398	4398	4398	4722	4522	4722	4262
243	22330	22330	25743	23378	22474	26280	21314
245	123663	123663	130606	124581	122781	130496	116958
249	20604	20604	20604	20474	19836	20474	18494
251	32382	32382	35610	31828	30939	34562	29070
253	59146	59146	62218	58322	56538	60923	53011
255	13642	13642	13642	13359	13021	13359	12326
257	206837	206837	216575	205934	201450	214213	190515
259	16247	16247	16247	15620	15304	15620	14091
261	224306	224306	233824	222759	217725	230828	205575

Table A-4. Scenario Average Annual Total Nitrogen Loads (Pounds per Year) by Subwatershed, 1996–2015 (Page 4 of 7)

ReachID	Base	S1	S2	S3A	S3B	S4	S5
263	22177	22245	22177	22265	22009	22323	21441
265	18108	18108	18108	17849	17379	17849	16140
270	660547	661324	699511	662235	648613	697853	623282
272	9129	9129	9129	9513	9019	9513	8962
274	10190	10190	10190	10586	10021	10586	10014
276	14617	14662	14617	15198	14373	15239	14294
277	22558	22661	22558	23156	22110	23246	21613
279	5072	5072	5072	5064	4953	5064	4698
281	12925	12925	12925	12652	12355	12652	11467
283	9865	9865	9865	9865	9865	9865	8815
284	17035	17035	17035	17384	16274	17384	16007
285	19272	19272	19272	19639	18475	19639	18086
287	6975	6975	6975	6975	6975	6975	6305
290	696624	697479	734417	699119	683765	733691	656732
291	10696	10696	11955	10764	10464	11834	9841
293	8123	8123	8123	8182	7966	8182	7484
310	706804	707616	745256	709258	693831	744415	665821
311	11958	12042	12673	11958	11958	12746	10732
313	23203	23271	24414	23203	23203	24475	21058
315	15849	15849	16744	15849	15849	16744	14457
316	11658	11658	12314	11364	10562	11917	10391
318	27542	27556	29086	27291	26507	28736	24982
319	53753	53924	57394	53517	52768	57205	48498
321	7290	7290	7732	7290	7290	7732	6427

Table A-4. Scenario Average Annual Total Nitrogen Loads (Pounds per Year) by Subwatershed, 1996–2015 (Page 6 of 7)

ReachID	Base	S1	S2	S3A	S3B	S4	S5
323	89548	89888	96010	89350	88645	96006	81090
330	796338	797492	841050	798558	782462	840167	746748
331	16021	16021	16021	15872	15555	15872	14888
333	21784	21784	21784	21157	20723	21157	19381
335	42837	42837	43475	42073	41315	42709	38864
336	32764	32764	34118	34310	32964	33304	32072
337	36372	36372	37712	37926	36585	36910	35468
350	869403	870558	915222	872891	854941	913275	817047
352	3909	3909	3909	4217	3965	4217	3976
353	3892	3892	3892	4200	3949	4200	3960
354	9425	9425	9425	9415	8652	9415	8746
355	7774	7774	7774	7863	7202	7863	7419
357	14894	14894	14894	14835	14048	14835	13739
359	8837	8837	8837	8728	8515	8728	7915
362	8557	8557	8557	8542	8028	8542	7964
363	16706	16706	16706	16632	15887	16632	15298
365	14939	14939	14939	14681	14446	14681	13723
367	7083	7083	7083	7119	6933	7119	6513
368	9217	9217	9217	9328	9067	9328	9067
369	12631	12631	12631	12893	12519	12893	12303
370	937936	939094	983616	941167	920677	981423	880177
371	6544	6544	6544	6728	6557	6728	6303
390	948393	949537	993915	952092	931108	992205	890176
391	37532	37908	37532	38491	37459	38806	35999

Table A-4. Scenario Average Annual Total Nitrogen Loads (Pounds per Year) by Subwatershed, 1996–2015 (Page 7 of 7)

ReachID	Base	S1	S2	S3A	S3B	S4	S5
394	1035	1035	1035	1071	996	1071	1027
395	10656	10656	10656	11101	10706	11101	10375
410	995477	996983	1040882	1000789	978212	1041099	935488
411	10869	10930	11726	10656	10415	11426	9721
413	45085	45449	45854	45460	44354	46418	41987
415	14138	14138	14138	14636	14250	14636	13802
417	8112	8112	8112	8441	8212	8441	7898
419	77117	77464	77854	78673	76592	79585	73123
430	1075652	1077501	1121728	1082860	1058021	1124014	1011784
431	6128	6128	6128	6291	6131	6291	5890
433	28169	28169	28169	29079	28339	29079	27202
434	993	993	993	993	993	993	930
436	926	926	926	926	926	926	889
438	711	711	711	721	668	721	670
439	710	710	710	720	668	720	669
441	34387	34387	34387	35547	34334	35547	33114
443	68552	68552	68552	70804	68699	70804	66096
450	1156422	1158278	1202339	1166513	1139197	1207494	1090365

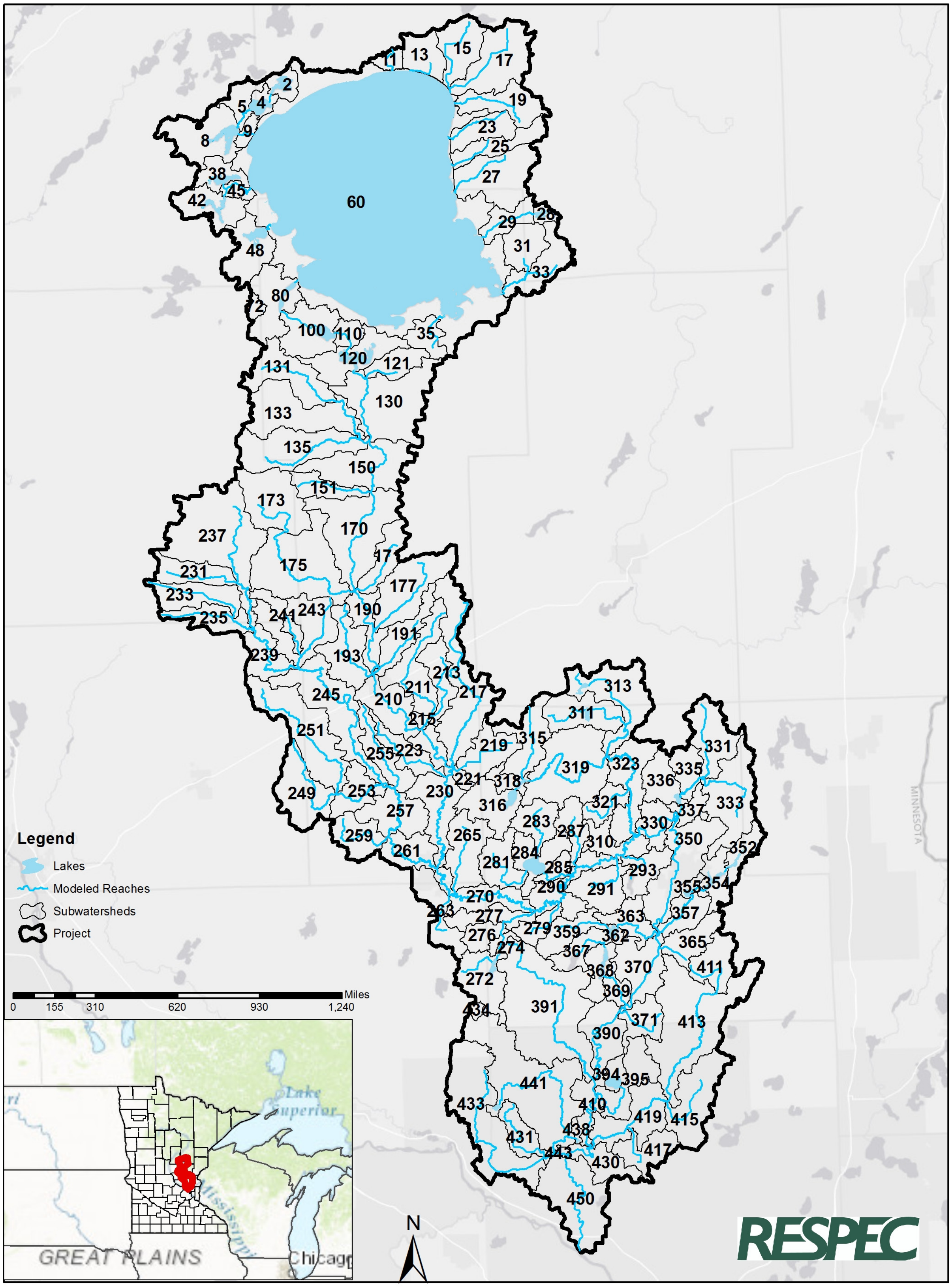

Figure A-1. Subwatershed Key.