PRELIMINARY DRAFT

South Metro Mississippi River
Total Suspended Solids
Total Maximum Daily Load

October 2010

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United States Environmental Protection Agency

Submitted by:

Minnesota Pollution
Control Agency

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<table>
<tr><th colspan="3">TMDL Summary</th></tr>
<tr><th>EPA/MPCA Required Elements</th><th>Summary</th><th>TMDL Page #</th></tr>
<tr><td>Location</td><td>The South Metro Mississippi River extends from Lock and Dam 1 to Lock and Dam 4 on the Mississippi River in southeastern Minnesota. Encompassing Lake Pepin, it is part of the Twin Cities Metropolitan Area and Lower Mississippi River Basin.</td><td>8</td></tr>
<tr><td>303(d) Listing Information</td><td>Mississippi River ID 07010206-501-505 and 0704001-531
Impaired Beneficial Use: Aquatic Life
Impairment/TMDL Pollutant(s) of Concern: Turbidity / Total Suspended Solids
Priority ranking of the waterbody: Scheduled for TMDL completion in 2009
Original listing year: 1998</td><td>8</td></tr>
<tr><td>Applicable Water Quality Standards/ Numeric Targets</td><td>A site-specific standard of 32 mg/L TSS summer average is to be achieved in half or more years over a 10-year period based on combined monitoring data at Lock and Dams 2 and 3.</td><td>28-29</td></tr>
<tr><td>Loading Capacity (expressed as daily load)</td><td>The loading capacity for the South Metro Mississippi River is calculated for five flow regimes as follows.<table>
<tr><th>Flow at Lock and Dam 2</th><th>Metric Tons/Day TSS</th></tr>
<tr><td>Very High</td><td>2,455</td></tr>
<tr><td>High</td><td>1,679</td></tr>
<tr><td>Moderate</td><td>1,563</td></tr>
<tr><td>Low</td><td>1,139</td></tr>
<tr><td>Very Low</td><td>725</td></tr>
</table></td><td>38-40</td></tr>
<tr><td>Waste Load Allocation</td><td>Individual WLAs are established for wastewater treatment facilities whose effluent concentration exceeds 32 mg/L TSS. An aggregate WLA is established for the stormwater discharge of MS4 communities.</td><td>40-43
App. A</td></tr>
<tr><td>Load Allocation</td><td><table>
<tr><th rowspan="2">Source</th><th colspan="2">Moderate Flow Conditions</th></tr>
<tr><th>Load Allocation (metric tons/ year)</th><th>Daily Load (metric tons)</th></tr>
<tr><td>Minor Tributaries</td><td>11,022</td><td>30</td></tr>
<tr><td>Metroshed</td><td>49,759</td><td>136</td></tr>
<tr><td>Upper Mississippi River</td><td>109,795</td><td>301</td></tr>
<tr><td>Minnesota River</td><td>353,154</td><td>968</td></tr>
<tr><td>St. Croix River</td><td>24,877</td><td>68</td></tr>
<tr><td>Cannon River</td><td>30,063</td><td>82</td></tr>
<tr><td>Total Loading Capacity</td><td>578,670</td><td>1,585</td></tr>
</table></td><td>43-45</td></tr>
</table>

EPA/MPCA Required Elements	Summary	TMDL Page #
Margin of Safety	An explicit MOS of 6 percent has been applied as part of the TMDL by setting the allowable loads to achieve a TSS target of 30 mg/L TSS summer mean rather than 32 mg/L summer mean.	45
Seasonal Variation	Seasonal variation was addressed through the use of continuous modeling over a 22-year period and by identifying load reductions that will achieve water quality standards during all seasons.	45
Reasonable Assurance	Reasonable assurance that the load allocation will be achieved is provided by: 1) availability of unprecedented funding from the Minnesota Clean Water Fund; 2) research and GIS that will allow targeting of high-contributing sediment sites for remediation; 3) use of existing state authorities regarding agricultural shoreland protection, drainage ditch buffers, and identifiable non-point sources of pollution.	59
Monitoring	A detailed monitoring plan has not been developed as part of this TMDL; however, general recommendations are made for continuing existing monitoring efforts and collecting new data regarding internal sources and the local tributaries.	61
Implementation	The following potential implementation activities are described: ▪ Water level management and island-building in the South Metro Mississippi River. ▪ Ravine erosion control through grade stabilization and drop structures for tile outlets. ▪ Riparian buffer strips and other agricultural Best Management Practices. ▪ Landscape storage of water to moderate stream hydrology. A detailed implementation plan will be developed within one year of TMDL approval.	45-57
Public Participation	A 45-member Stakeholder Advisory Committee has met at least 12 times since 2004 to oversee the development of the TSS site-specific standard and TMDL. A Science Advisory Panel chaired by the University of Minnesota Water Resources Center has reviewed the UMR-LP model, endorsed the site-specific TSS standard used for the TMDL, and recommended proceeding with the TMDL. *(Add information about public notice period after its completion)*	61-62

EXECUTIVE SUMMARY

The Clean Water Act of 1972 provides a framework for assessing water quality impairments in a comprehensive fashion. Called the Total Maximum Daily Load (TMDL), this process calls for monitoring surface water, identifying waterbodies that exceed state standards as being impaired, and then determining the maximum loads of point and nonpoint sources of pollution that can be allowed without exceeding water quality standards. The MPCA is committed to following this process as a means of working toward achievement of water quality standards and, as feasible, broader improvements to aquatic ecosystems.

The South Metro Mississippi River Turbidity/Total Suspended Solids (TSS) TMDL has been under development since 2004 as a companion project to the Lake Pepin eutrophication TMDL initiated the same year. A river model extending from Lock and Dam 1 to Lock and Dam 4 was developed to allow analysis of both turbidity and eutrophication impairments, and interactions between the two. After the model was completed in 2008, the MPCA put the issues of turbidity and eutrophication on separate tracks, starting with the development of site-specific standards and proceeding to the writing of TMDL documents. The MPCA sent the U.S. EPA a proposed site-specific TSS standard for the South Metro Mississippi in 2010, replacing the statewide turbidity standard for these reaches and providing the basis for the South Metro Mississippi TSS TMDL, pending EPA final approval.

The TMDL process as summarized above is narrowly focused on the attainment of water quality standards. As the current TMDL project developed, stakeholders advised, and the MPCA agreed, that the basic framework needed some augmentation to meet its large dimensions. The watershed to the South Metro Mississippi encompasses half the state of Minnesota and part of south-central Wisconsin. Within Minnesota, it includes 33 major (8-digit HUC) watersheds contributing suspended solids to the Mississippi. The MPCA and local partners are conducting turbidity TMDLs upstream on the Minnesota River and its tributaries, which contribute on average 74 percent of the TSS load to the South Metro Mississippi. The MPCA funded three major research projects to determine which areas and landscape features within the Minnesota River Basin are contributing the most sediment. Early results point to a steady shift from farm field- to non-field sources of sediment since the 1940s, with important implications for implementation planning.

The Mississippi River is in a league all its own in terms of size (the largest in the state) and structure. In particular, the construction of Lock and Dams 2 and 3 in the 1930s resulted in the permanent inundation of a floodplain that previously had shifted from wet to dry on a seasonal basis. The new floodplain provides ideal conditions of water depth for submersed aquatic vegetation (SAV), a keystone species group that supports migratory waterfowl, mussels and fish while maintaining water clarity. However, the turbidity impairment prevents sufficient sunlight from penetrating to the river bed to allow the growth and maintenance of SAV. In a project called the Mississippi Makeover, the MPCA joined the Minnesota Department of Natural Resources and local citizens to relate the Mississippi TSS TMDL to ecosystem goals relevant to today’s river. As a result, the Mississippi TSS TMDL will set the stage for reducing internal loads of sediment caused by wind and wave action through island-building and other river management practices undertaken by state and federal partners working to restore the ecosystem of the Upper Mississippi River.

The main finding of the Mississippi TSS TMDL study is that TSS loads from the Minnesota River Basin and other heavy-loading watersheds will need to decrease by 50 to 60 percent to meet the site specific standard for turbidity in the South Metro Mississippi River. Loads from other tributaries will need to decrease by 20 percent. The steepest reductions are focused on watersheds where 80 percent of the sediment originates. These reductions will need to occur in years of medium and higher flows with sufficient frequency to meet a summer mean of 32 mg/L TSS in half or more of all summers over a 10-

year period. If these conditions are met, the river should respond with a flourish of growth in submersed aquatic vegetation and a significant improvement in general ecosystem health.

To make this project feasible, the MPCA plans a phased approach. The TMDL lays out a general implementation plan based on:

- Existing state and federal programs, resources and authorities;
- MPCA's watershed approach; and
- adaptive management.

The MPCA is striving to provide a balance of rigor and flexibility with the expectation that new knowledge will lead to adjustments in this large-scale and complex project.

1.0 INTRODUCTION

Section 303(d) of the Clean Water Act provides authority for completing Total Maximum Daily Loads (TMDLs) to achieve state water quality standards and/or designated uses. A TMDL is a calculation of the maximum amount of pollutant that a water body can receive and still meet water quality standards and/or designated uses. It is the sum of the allowable loads of a single pollutant from all contributing point and nonpoint sources. The U.S. Environmental Protection Agency (EPA) bases its approval of TMDLs on states:

- Designing TMDLs to implement applicable water quality criteria;
- Including load and waste load allocations;
- Considering the impacts of background pollutant contributions;
- Considering critical environmental conditions;
- Considering seasonal environmental variations;
- Including a margin of safety;
- Providing opportunity for public participation; and
- Providing reasonable assurance that TMDLs can be met.

In general, the TMDL is developed according to the following relationship:

TMDL = WLA + LA + MOS + RC

Where:

WLA = wasteload allocation; the portion of the TMDL allocated to existing or future point sources of the relevant pollutant;

LA = load allocation, or the portion of the TMDL allocated to existing or future nonpoint sources of the relevant pollutant. The load allocation may also encompass "natural background" contributions;

MOS = margin of safety, or an accounting of uncertainty about the relationship between pollutant loads and receiving water quality. The Margin of Safety can be provided implicitly through analytical assumptions or explicitly by reserving a portion of loading capacity; and

RC = reserve capacity, an allocation for future growth. This is an MPCA-required element, if applicable, for TMDLs.

This TMDL report applies to five contiguous reaches that are impaired for turbidity between Lock and Dam 1 and Lock and Dam 4 on the Mississippi River (Table 1below). Impairments in this report are currently on the 2008 (final) and 2010 (draft) 303(d) list of impaired waters.

Table 1. South Metro Mississippi River Turbidity Impairments				
Reach and Navigation Pool	**Assessment Unit ID**	**Year of 303d Listing**	**Affected Use**	**Pollutant or Stressor**
Mississippi River, Minnesota River to Metro Wastewater Treatment Plant (River Mile 844 to 835; Pool 2)	07010206-505	1998	Aquatic life	Turbidity
Mississippi River, Metro Wastewater Treatment Plant to Rock Island Railroad Bridge (River Mile 835 to 830; Pool 2)	07010206-504	1998	Aquatic life	Turbidity
Mississippi River, Rock Island Railroad Bridge to Lock and Dam 2 (River Mile 830 to 815.2; Pool 2)	07010206-502	1998	Aquatic life	Turbidity
Mississippi River, Lock and Dam 2 to St. Croix River (River Mile 815.2 to 811.3; Upper Pool 3)	07010206-501	1998	Aquatic life	Turbidity
Mississippi River, St. Croix River through Lake Pepin to the Chippewa River, Wis. (River Mile 811.3 to 764.5; Pools 3- 4)	07040001-531	1998	Aquatic life	Turbidity

1.1 Priority Ranking

The MPCA is conducting the South Metro Mississippi TSS TMDL in conjunction with a TMDL for eutrophication impairment of Lake Pepin, which is a natural impoundment of the Mississippi River from River Mile 785 to River Mile 765 (from Red Wing to Wabasha). The Agency started both TMDLs as a combined project in 2004 because they deal with interacting problems that need to be evaluated together. Turbidity, a measure of light refraction, affects photosynthesis in the water column. Eutrophication produces suspended organic solids that affect turbidity.

The project received priority attention by the MPCA because of it unprecedented size and scope, and because of legal reasons. With the watershed covering half of Minnesota’s land area, the TMDL for eutrophication, in particular, has implications for hundreds of point source dischargers. These implications became especially poignant when the Minnesota Center for Environmental Advocacy challenged an MPCA decision to permit a new discharge of phosphorus proposed by the cities of Annandale and Maple Lake. The legal challenge cited a provision of the Clean Water Act [(40 CFR 122.4(i) and 122.44(d)(1)(i))] that prohibits permitting of new discharges to impaired waters before a TMDL has produced waste load allocations applicable to such discharges. The Minnesota Supreme Court eventually upheld the Agency’s permitting decisions but the Agency developed guidance to better address these requirements. Because the TSS TMDL was being conducted in conjunction with the Lake Pepin TMDL, it received the same high priority in scheduling with a start date of 2005 and a completion date of 2009.

From the start of the TMDL project, the Agency intended to develop a site-specific standard for Lake Pepin eutrophication. However, well into the TMDL study the Agency learned that algae concentrations in Lake Pepin are strongly influenced by eutrophication activity upstream of the lake, in the Mississippi

River and several major tributaries. Therefore, in 2009 the MPCA decided to incorporate the Lake Pepin site-specific standard into the development of nutrient standards for the Mississippi River and its tributaries, as part of the MPCA's triennial review of river water quality standards. Henceforth, the Agency has pursued water quality goals and TMDL developments for eutrophication and turbidity on separate paths, with a site-specific standard for TSS replacing the statewide turbidity standard for the South Metro Mississippi River (pages 28-29).

2.0 WATERBODY DESCRIPTION

The South Metro Mississippi River extends from Lock and Dam 1 to Lock and Dam 4 (river miles 848 to 753), as shown in Figure 1. The turbidity-impaired portion of concern within this stretch extends from the confluence with the Minnesota River to upper Lake Pepin (river miles 844 to 775). In its upper reach before the confluence with the Minnesota River, the Mississippi runs through a deep gorge. After four miles, it joins the Minnesota River and cuts through a broad floodplain cut by the Glacial River Warren about 12,000 years ago. In the 1930s, the federal government built locks and dams at river miles 848 (Ford Dam), 815 (Lock and Dam 2 at Hastings), 797 (Lock and Dam 3 near Red Wing) and 753 (Lock and Dam 4 downstream of Wabasha). The locks and dams drastically altered the meanders and backwater wetlands of the Mississippi River and permanently inundated the floodplain behind each lock and dam. These floodplain areas, primarily from the St. Paul Barge Terminal to upper Lake Pepin, have a high potential to support emergent and submersed aquatic vegetation.

South Metro Mississippi River:
Locks and Dams, Assessment Unit Identification Numbers

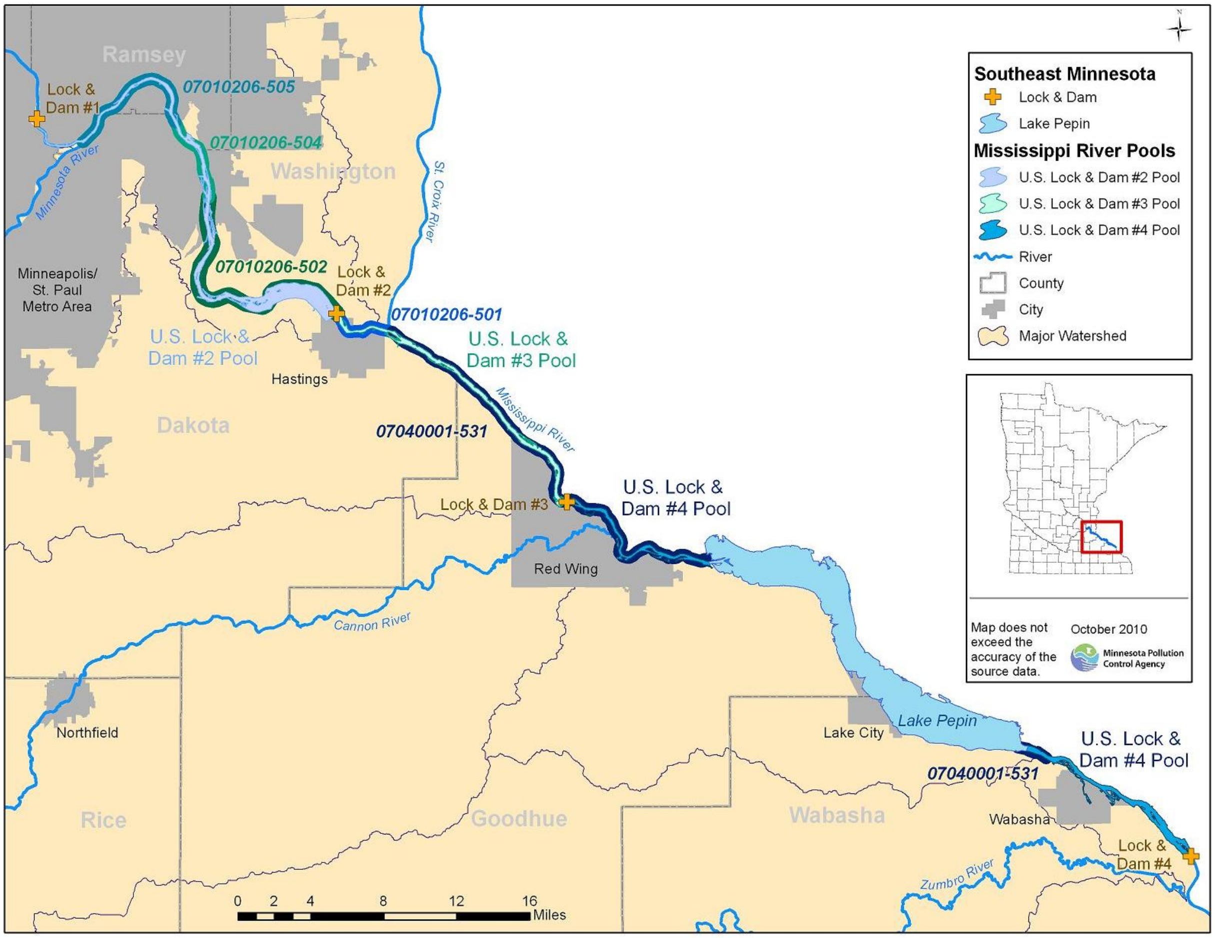


Figure 1. The South Metro Mississippi is impaired by turbidity from the Minnesota River at St. Paul through Lake Pepin, which is roughly from Lock and Dam 1 to Lock and Dam 4. (MPCA map)

Water clarity is good in the uppermost segment of the South Metro Mississippi. At the confluence with the Minnesota River, the shape and condition of the Mississippi River change drastically. The river occupies a narrow channel flanked by a broad flood plain carved by the Glacial River Warren. The river becomes suddenly turbid as it absorbs the heavy sediment load of the Minnesota River. The U.S. Army Corps of Engineers maintains a 9 foot deep (300-600 foot-wide) navigation channel for barge traffic through periodic dredging. In the highly urbanized portion of the river channel, limited opportunities for habitat restoration exist. However, from the St. Paul Barge Terminal on south, such opportunities exist in the shallower areas of the main channel, side-channels and backwaters.

In 1988 the federal government designated a 72-mile stretch of the Mississippi to be a national park. The Mississippi National River and Recreation Area (MNRRA) overlaps with the South Metro Mississippi River for 45 miles between River Mile 848 (Lock and Dam 1) and River Mile 803 between Hastings and Red Wing. The National Park Service manages the park with the goal of "preserving unimpaired" the natural and cultural resources and values of the MNRRA.

Water quality in the South Metro Mississippi is a reflection of the climate, soils, vegetation and land uses within its extensive watershed (Figure 2). Considerable variation exists across the watershed, as shown in the ecoregion map (Figure 3). Land uses vary from heavily forested to the north and east, to mainly agricultural in the south and west, to highly developed in the metropolitan region immediately upstream of Lake Pepin.

Major River Basins of the South Metro Mississippi Watershed

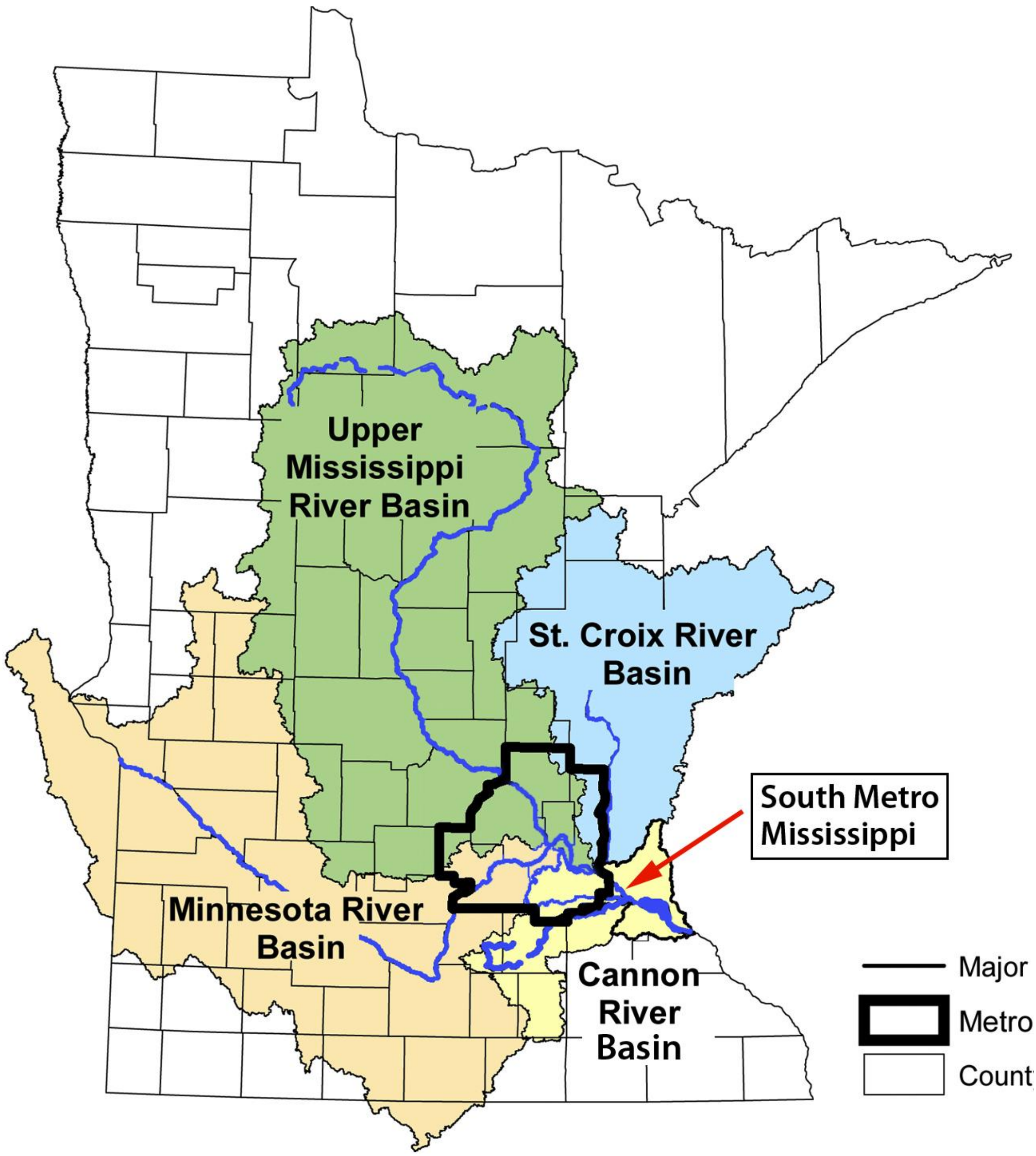


Figure 2. The South Metro Mississippi has an immense watershed, comprising of 48 percent of Minnesota land mass. (MPCA graphic)

Ecoregions of South Metro Mississippi Watershed

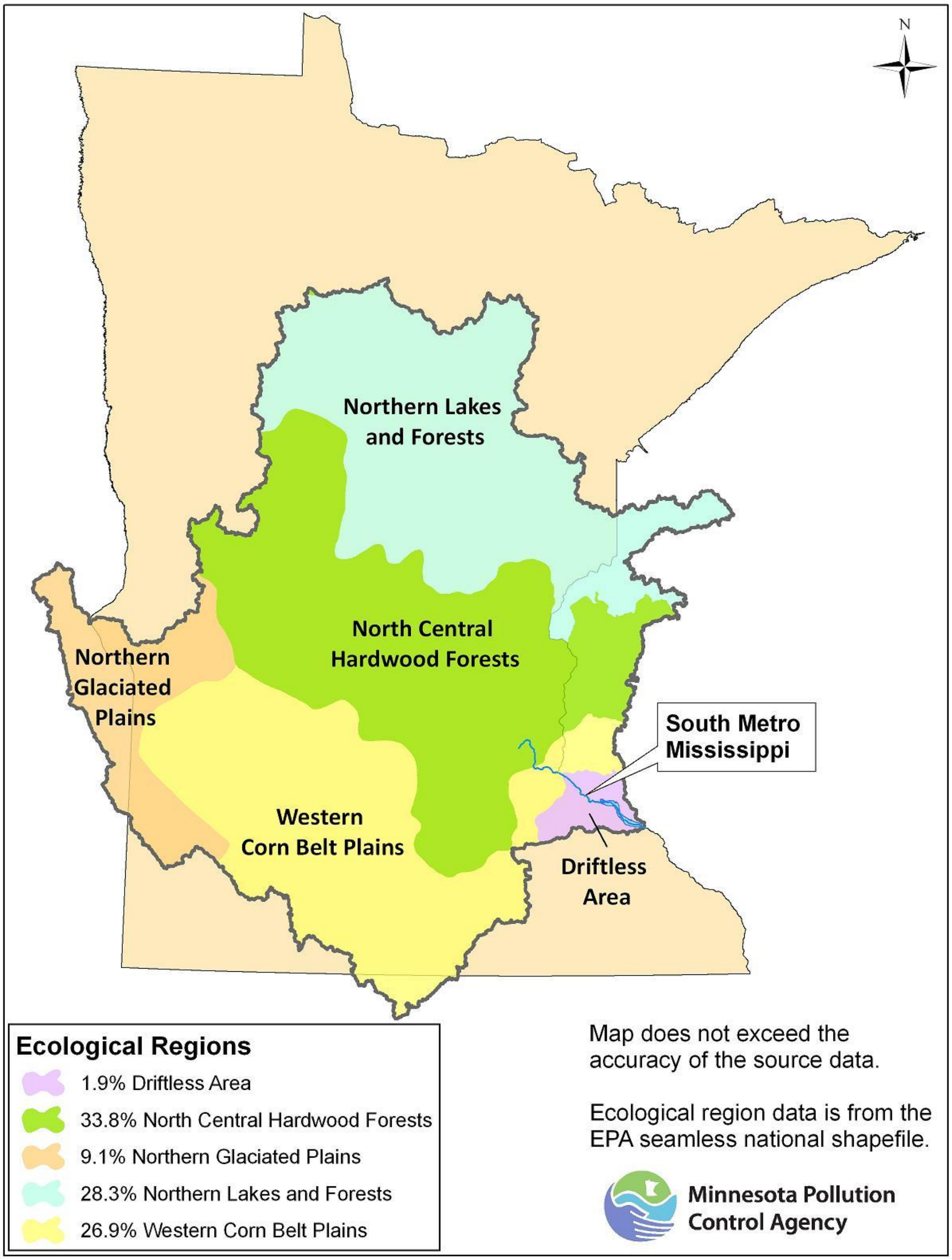


Figure 3. The South Metro Mississippi watershed consists of several different ecoregions. (MPCA graphic)

2.1 Water Quality History

Historical accounts of water quality by early explorers indicate a clear river with healthy beds of aquatic vegetation growing in shallower areas.

"From St Croix to St. Peter's (Minnesota River) … The water is clear as crystal, and its bosom is generally covered with water-fowl, from the graceful snow-white swan to the mallard and wood duck…the water is clear, and very deep; and it yields the very best fish in great abundance," wrote Charles Lanman in July 1846 (Lanman 1847).

In the late 1920s, a federal government report indicates that where the Mississippi River broadens out to form Lake Pepin, "the shallow north end and east side of the south end have developed some of the finest areas of duck food plants in this entire region. Here wild celery, sago pondweed, clasping leaved pondweed, or red-head grass, leafy pondweed, bushy pondweed and Elodea or water-weed, which are six of the best submerged duck foods, together with numerous others, are abundant" (Uhler, 1929).

Between the time of publication of these two reports – 1845 and the late 1920s – aquatic life appeared to remain healthy upstream of Lake Pepin despite sedimentation rates increasing by a factor of three to four times, as measured by sediment core dating techniques (Engstrom et al., 2009). Apparently, turbidity levels had yet to cross the threshold of having a significant, enduring impact on rooted aquatic vegetation.

The subsequent history of water quality in the South Metro Mississippi River is closely tied to population growth in the Twin Cities Metropolitan Area and intensified farming of the Minnesota River Basin. By 1926, untreated sewage had created a public health nuisance and very poor fish habitat in the Mississippi River. These conditions led to the development of guidelines for water quality and the construction of the Metropolitan Wastewater Treatment Plant in 1938, which resulted in major water quality improvements in the succeeding years (U.S. Environmental Protection Agency, 2000; Metropolitan Council Environmental Services, 2010).

As the urban population steadily increased, along with industry, the Clean Water Act of 1972 established new water quality standards, and pressures for improved water quality increased (Metropolitan Council Environmental Services 2010). In the 1980s, the Metropolitan Council initiated an industrial pre-treatment program for heavy metals, initiated advanced secondary treatment at the Metro Plant, and began the separation of combined sanitary sewers and storm sewers. By the late 1980s and early 1990s, mayflies had returned to the Mississippi downstream of the Metro Plant, signifying improved water quality (Fremling, 2005).

Since the early 1990s, through biological removal technology, phosphorus effluent has decreased from Metropolitan Council wastewater facilities by about 90 percent. In addition, the severity of algae blooms in Lake Pepin appears to be significantly reduced in lower flow years. In the drought years 1987-1989, high levels of algae reduced light penetration into the Mississippi, thereby contributing to the die-off of submersed aquatic vegetation (Wiener et al., 2010). Phosphorus load reductions since that time likely have contributed to reduced frequency and severity of algae blooms, reducing the probability of high TSS levels at low-flow conditions.

From the 1930s to 1960s, the amount of sediment flowing into the South Metro Mississippi and Lake Pepin more than doubled, from 300,000 to 700,000 metric tons per year, as measured by sediment cores in Lake Pepin (Engstrom et al., 2009). This rapid sedimentation rate has stabilized in recent decades. Figure 4 shows the increase in sediment loads over the past 500 years. Note that European settlement of Minnesota started in the early 1800s.

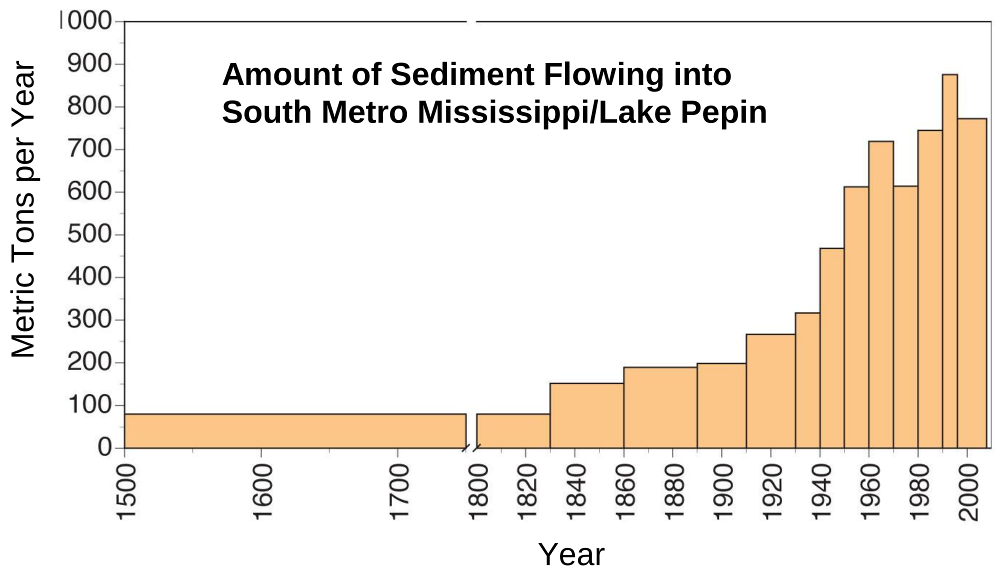


Figure 4. The amount of sediment, called "loads," to the South Metro Mississippi and Lake Pepin greatly increased in the middle part of the 1900s and have stabilized in recent decades, according to Lake Pepin sediment core analysis by the St. Croix Watershed Research Station of the Science Museum of Minnesota. Strata from core samples taken in 1996 and 2008 were dated to estimate historical rates of sediment accumulation.

The 1930s to 1960s coincides with a time of major land-use changes, including:

- Significant land drainage through ditch construction and wetland loss;
- Full mechanization of farming (Tietz,1982);
- Increased specialization in cropping; and
- Conversion of hay and grassland to row crops.

Since the 1960-1970 decade, sediment loads to the Mississippi River, largely from the Minnesota River Basin, have remained fairly constant. However, while total sediment loads have tended to level off, the sources of sediment that comprise the total load have undergone a dramatic shift between 1940 and 2010. In 1940, farm fields accounted for the majority – 65 percent – of the sediment entering water ways leading to the South Metro Mississippi and Lake Pepin (Engstrom and Schottler, 2010). The other 35 percent came from ravines, bluffs and stream banks. Now the sediment sources are the opposite, with 35 percent coming from farm fields and 65 percent coming from ravines, bluffs and stream banks (Engstrom and Schottler, 2010).

This shift coincides with large increases in flow in the Minnesota River. River flow at Jordan has doubled since 1940 (Figure 5), as river flow volume as a percentage of rainfall has increased from 7 percent to 20 percent (Barr Engineering Company, 2004).

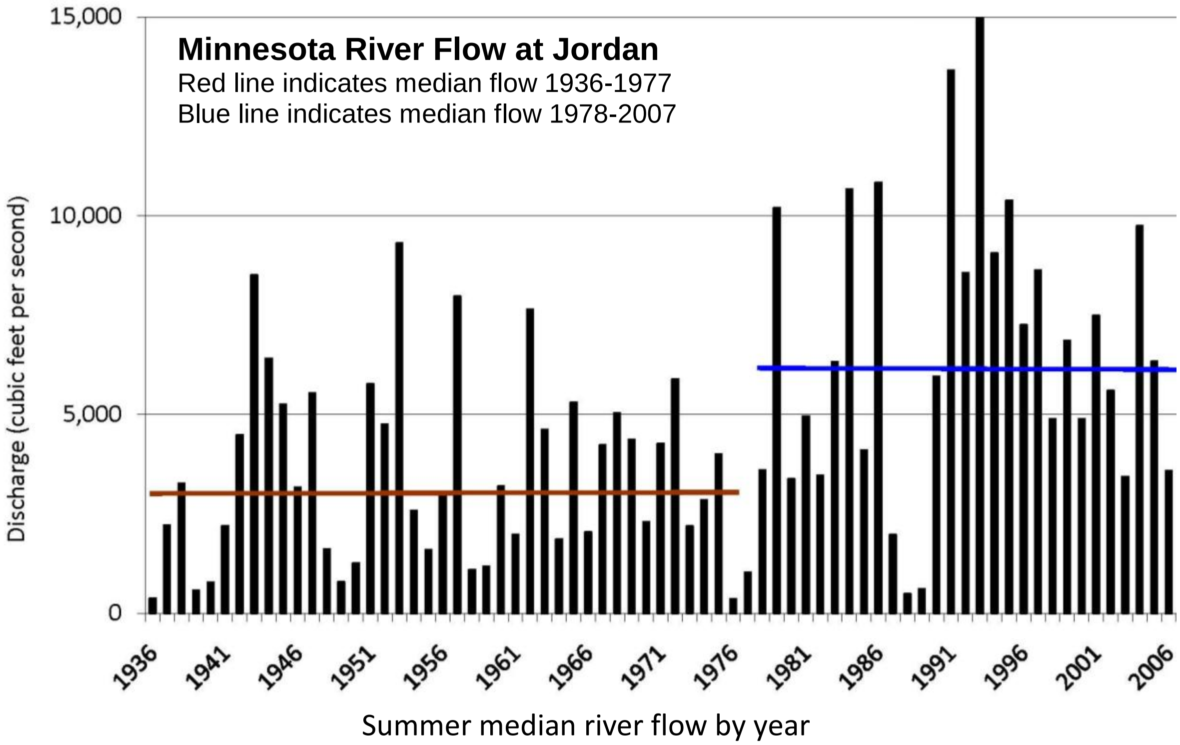


Figure 5. Summer median Minnesota River flows, from June to September, have more than doubled, as measured by the U.S. Geological Survey at Jordan, Minn. Increased median flow is correlated with sustained high sediment loads to the South Metro Mississippi and a declining proportion of field sediment The red line, at left, shows the 1937-1977 median flow of 3,057 cubic feet per second; the blue line, at right shows the 1978-2007 median flow of 6,136 cubic feet per second. (MPCA graphic)

Although the major source of sediment has shifted from fields to non-field sources, stormwater runoff from farm fields significantly affects ravines, bluffs and stream banks as sources of sediment. Field runoff contributes to increased ravine erosion as well as higher stream flows that increase shear stress on stream banks and erode the toe of bluffs, triggering increased sediment loss from these sources (Wilcock, 2009; Blann et al, 2009). Recent studies indicate that sediment concentrations have decreased in the Minnesota River over the past several decades (Minnesota State University, 2009; Johnson et al., 2008). There is also evidence that conservation practices have significantly reduced stream sediment from field erosion compared to what would have been the case without improvements such as residue management and conservation easements (USDA, 2010). However, increased flows have served to hold TSS loads discharged from the main stem fairly constant (Figure 8).

Some stakeholders have proposed climate change as a main driver of increased sediment accumulation rates over the past 180 years. Historical precipitation data for Minnesota indicate that this is unlikely to be the case. The Minnesota State Climatology Office (http://climate.umn.edu/climateChange/climateChangeObservedNu.htm, last viewed July 12, 2010) reports that Minnesota aerial average precipitation has varied considerably since 1890, with an upward trend since the decade of the 1930s evident. However, no trend is perceptible over the entire period of record. The period 1895-1905 had roughly similar precipitation levels as the decade 1990-2000. Notably, rates of sedimentation in the early 1900s were only one-fifth as much as late 1900s, as measured by Lake Pepin sediment cores (Figure 4).

Some stakeholders have also suggested that precipitation events have grown more intense in recent decades, packing more erosive force than events of the past. State Climatologist Jim Zandlo answers the question as follows in the web site shown above: "…the amount of precipitation occurring as large events has been increasing for decades but about 100 years ago that fraction was similar to or even higher than what it is today." Thus, neither average precipitation or precipitation intensity are much different in recent years compared to a century ago.

Sediment levels have become five times higher in recent decades than in the 1895-1905 decade. The most likely reason lies in extensive land-use changes in largely rural parts of the Minnesota River Basin that are "primed to erode" by geology (Wilcock, 2009). In combination, the clearing and draining of land for agricultural crop production over time alters the natural hydrology of watersheds through reductions in wetland storage and evapotranspiration, especially during spring and early summer when crop growth and ground cover are minimal, and precipitation levels typically high (Blann et al., 2009, page 924). Increases in stream flow, in turn, increases erosive pressure on stream banks and bluffs (Wilcock, 2009).

High sediment loads have led to elevated turbidity levels in the South Metro Mississippi since the flood year of 1993, resulting in sparse submersed aquatic vegetation because poor light penetration has hampered plant growth (Sullivan et al., 2009). An exception is a resurgence of vegetative growth in 2009 following several years of low flows during which turbidity levels remained suppressed (Figure 6). These facts underscore the empirical relationship among turbidity, TSS and aquatic vegetation. They also provide reasons for hope that the Mississippi River will achieve full support of aquatic life if the 32 mg/L TSS criterion can be met in median and higher flow years in addition to lower flow years.

Level of Total Suspended Solids and Frequency of Vegetation
In Upper Pool 4 (Lake Pepin) of the Mississippi River
TSS: Total suspended solids
SAV: Submersed Aquatic Vegetation

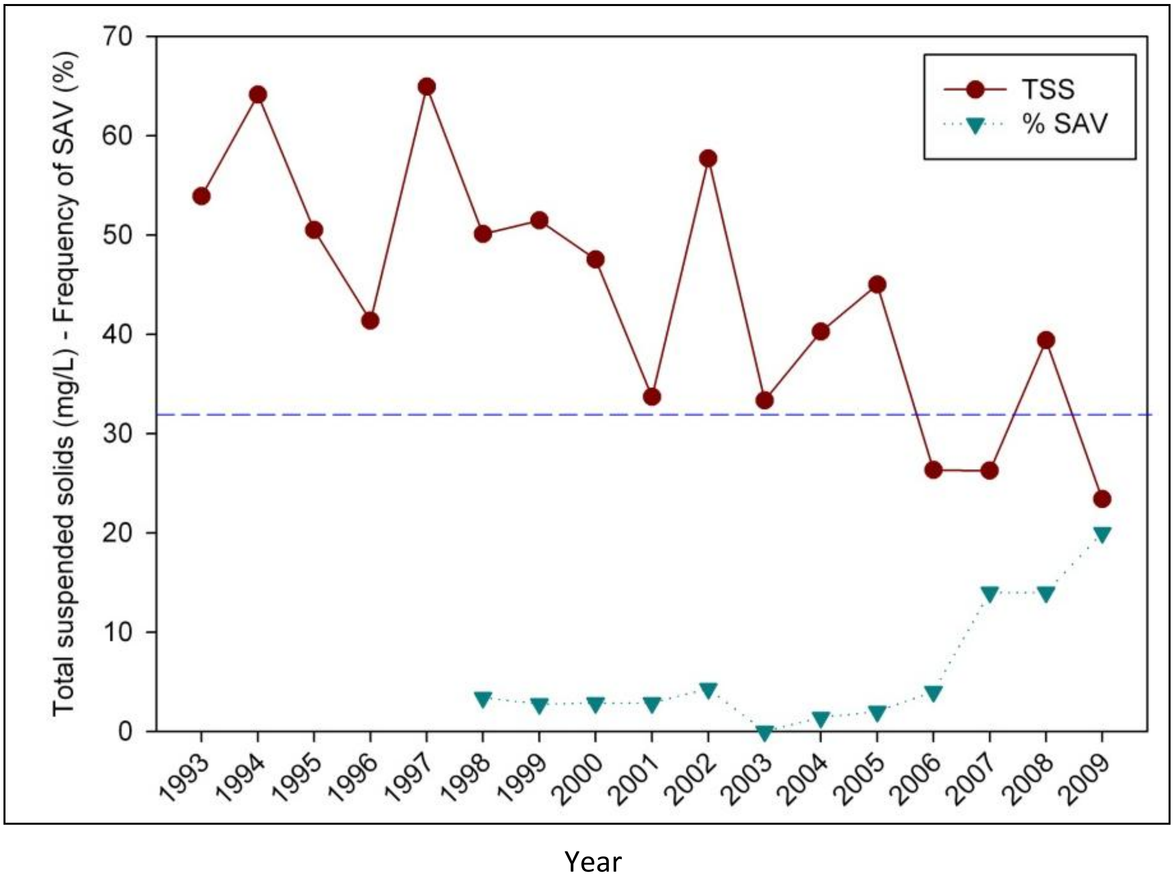


Figure 6. Monitoring shows that vegetation growth increased in frequency when TSS levels fall below 32 parts per million (mg/L), the proposed standard as indicated by the dashed line, in the South Metro Mississippi. (Long-Term Resource Monitoring Program of the USGS)

In addition to causing aquatic life impairments in the Mississippi, high sediment loads have accelerated the sedimentation of Lake Pepin, an issue of concern to local residents, river scientists and environmental groups. A continuation of current rates of sedimentation would result in the in-filling of the upper third of Lake Pepin, above Frontenac, by the end of the present century, and of the entire lake within an additional 250 years (Engstrom et al., 2009). The disappearance of Lake Pepin as a sediment basin would adversely affect the Mississippi River downstream, allowing Minnesota River sediment to be carried down river as far as the Minnesota-Iowa border and beyond. This would seriously impair this portion of the Mississippi, which currently sustains high-quality water to support a relatively healthy ecosystem, including extensive beds of submersed aquatic vegetation.

2.1.1 Pollutant of Concern

In relatively shallow areas of the main channel border, side-channels and especially in backwaters of the permanently inundated floodplain, SAV flourished immediately following construction of the locks and dams. However, in recent decades, this plant life has been scarce because of high levels of turbidity, or cloudiness, preventing sunlight from penetrating deeply enough into the water column to support and maintain photosynthetic activity. High turbidity also reduces populations of site-feeding fish species. Plus it harms the larvae of sensitive native mussel species such as the Higgins Eye (Mike Davis, Minnesota Department of Natural Resources, 2010). As a result, the state of Minnesota placed four reaches within the South Metro Mississippi River on the 303(d) list of impaired waters in 1998 for turbidity.

High levels of suspended solids impair the Mississippi River by shading the sunlight and reducing the potential for photosynthesis in shallower portions of the river: main channel border, side-channels, and especially connected backwaters on the floodplain. The problem of turbidity, caused by TSS, is the pollutant of concern for this TMDL. TSS includes both inorganic, geologically derived particles, and organic particles from algae, detritus and other sources. These two components are distinguished as non-volatile and volatile suspended solids in the water quality model used to develop the TMDL (pp. 30-31, and Limno-Tech 2009, pp. 70-73).

3.0 SEDIMENT SOURCES

"Sediment is created by the weathering of host rock and delivered to stream channels through various erosional processes, including sheet wash, gully and rill erosion, wind, landslides, dry ravel, and human excavation. In addition, sediments are often produced as a result of stream channel and bank erosion and channel disturbance,"(U.S. Environmental Protection Agency, 1999). The science of sediment detachment and transport to and through stream channels and networks is complex, influenced by a multitude of interacting factors such as climate and geology, gravity and friction overlain with human disturbances to the land surface, drainage pathways and stream channels (Leopold et al., 1995:151-197).

Some sediment sources originate within the river channel. These sources include stream banks, streambeds, and possibly floodplains and bluffs, all of which are potential sediment suppliers to a river. Algal growth and decay could be considered internal processes even though the phosphorus that drives algal production is usually from external sources such as upland areas or wastewater treatment plants.

A small portion of TSS is contributed by the resuspension of sediments deposited on the river bed, side-channels and backwater areas such as lower Pool 2. The problem is episodic, triggered by wind and wave action, and limited to areas with vast expanses of shallow, open water. Scientists have identified sediment from the wave action of boat traffic as a potential problem, particularly in Pool 3, where wave action from the wake of recreational boats may cause or magnify stream bank erosion (Johnson, 1994; Johnson 2003). However, in the context of total sediment loads, these "internal" sources of sediment are relatively minor (Limno-Tech, Inc. 2009).

Other sources are external to the channel and originate from the contributing watershed area. These components are, at times, transported to the channel through a variety of mechanisms. The major sources of sediment are external to the South Metro Mississippi River. This TMDL Report will first describe sediment sources with reference to tributary basin or watershed of origin, and then by rural and urban sources, and finally by landscape feature.

3.1 Tributary Basins and Watersheds

The volume of flow of the Mississippi almost doubles at the confluence with the Minnesota River in St. Paul, at which point it ceases to meet the state water quality standard for turbidity. Not until the majority of the sediment load from the Minnesota River has settled out in upper Lake Pepin does the Mississippi River once again meet the state turbidity standard. Runoff from an immense and varied watershed, spanning half of Minnesota and a small part of west-central Wisconsin, including the entire Twin Cities Metropolitan Area, affects this stretch of the Mississippi River.

However, the majority of sediment that contributes to high turbidity originates in the Minnesota River Basin, which on average contributes 74 percent of the TSS load to the South Metro Mississippi River (Figure 7). Although average sediment loads to the Mississippi River vary considerably from year to year (Figure 8), the Minnesota River is invariably the greatest single source.

Sources of Sediment, by Major River Basin, to the South Metro Mississippi River

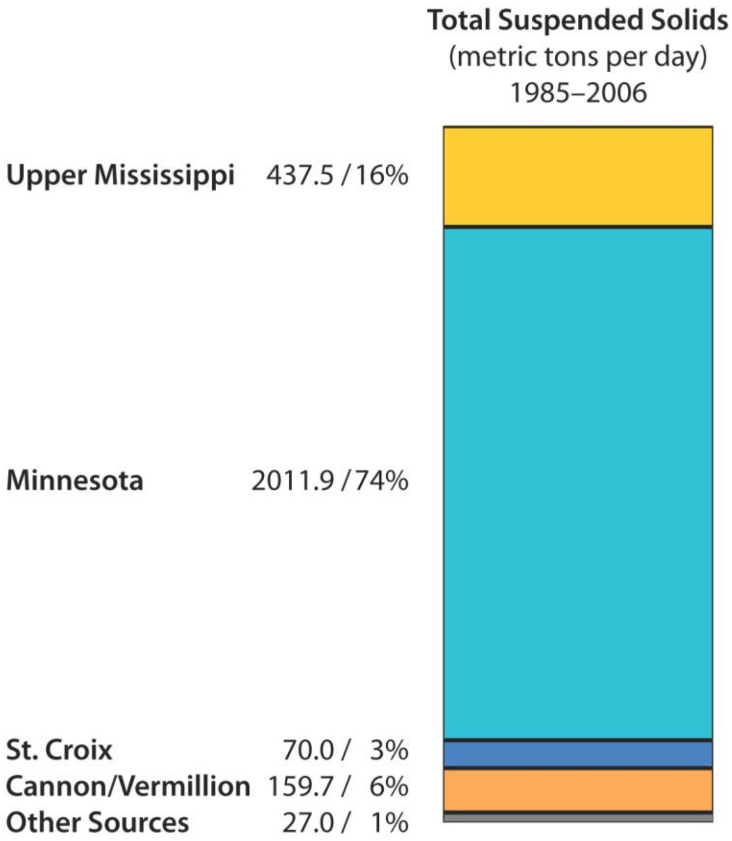


Figure 7. The majority of sediment – 74 percent – in the South Metro Mississippi derives from the Minnesota River, based on river monitoring data from 1985 to 2006. (MPCA graphic)

River Flow at Lock and Dam 2 at Prescott, Wis., and Total Suspended Solids by Basin and Metro Wastewater

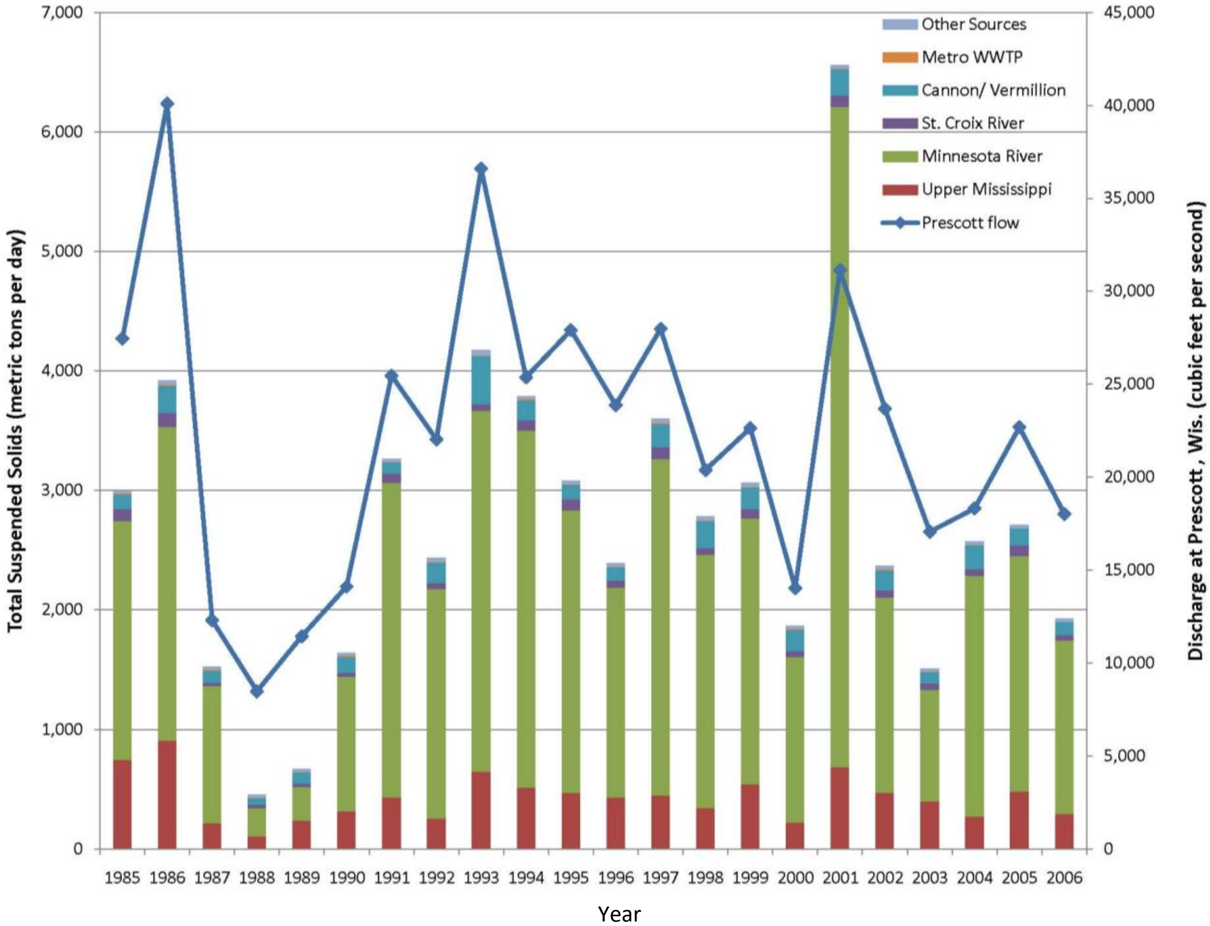


Figure 8. While stream flow varies considerably from year to year, as measured by the river's discharge at Lock and Dam 2 at Prescott, Wis., the majority of sediment consistently derives from the Minnesota River Basin (Limno-Tech, Inc, 2009).

Watersheds in the eastern part of the Minnesota River Basin contribute the majority of sediment to this river system. Factors contributing to the sediment loads include (Wilcox, 2009):

- High precipitation;
- Land form and land-use combinations susceptible to erosion;
- Extensive drainage that affects stream flows; and
- Increasing flows that erode stream banks, bluffs and ravines.

Within the Minnesota River Basin, the majority of TSS load comes from two major watersheds, the Le Sueur and Blue Earth River watersheds, which discharge to the main stem in Mankato (Minnesota State University, Mankato, Water Resources Center 2004, 2009). Smaller direct tributaries in the eastern basin also contribute relatively high levels of sediment per acre (Figure 9; Minnesota State University, Mankato Water Resources Center, 2004).

Major Sources of Total Suspended Solids in the Minnesota River Basin

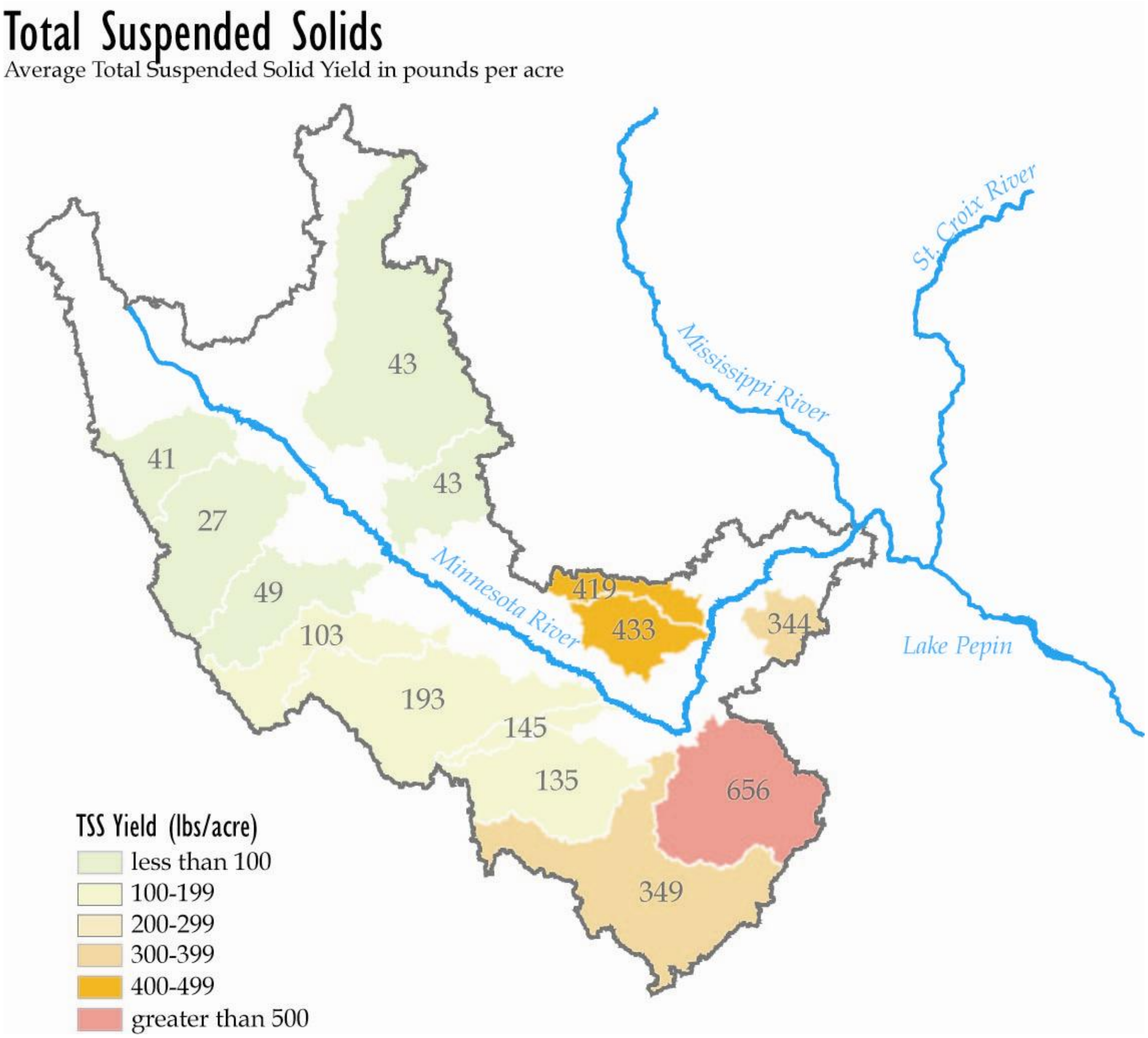


Figure 9. Within the Minnesota River Basin, researchers have identified watersheds that contribute relatively high loads of total suspended solids, as indicated by the darker colors. (Minnesota State University-Mankato, Water Resources Center)

3.1.1 Urban and Rural Sources

Compared to rural areas, urban land uses typically have more persistent vegetative cover on pervious surfaces, such as lawns and parks, which helps reduce sediment loading. During construction, however, sediment aerial loading can exceed that of row crop agriculture. Also, increases in the amount of impervious surface through the construction of roads, parking lots, and buildings significantly alters site hydrology by decreasing infiltration, increasing surface runoff, and decreasing travel times such that peak and total flow volumes substantially increase. The altered hydrology can also impact stream morphology, leading to unstable streams, bank and channel erosion, siltation, and habitat modification. Urbanization also tends to lead to a loss of riparian corridor vegetation, which can increase stream temperatures, reduce filtering capacity and destabilize stream banks.

The South Metro Mississippi watershed is predominantly rural with a low percentage of acres in impervious surfaces and municipal areas, as outlined in Table 2 below. The South Metro Mississippi watershed includes 204 Municipal Separate Storm Sewer Systems (MS4) where the National Pollutant Discharge Elimination System (NPDES) permit process regulates urban runoff. The MS4 area represents the total developed area within regulated MS4 boundaries, based on calculations using 2001 National Land Cover Data (NLCD).

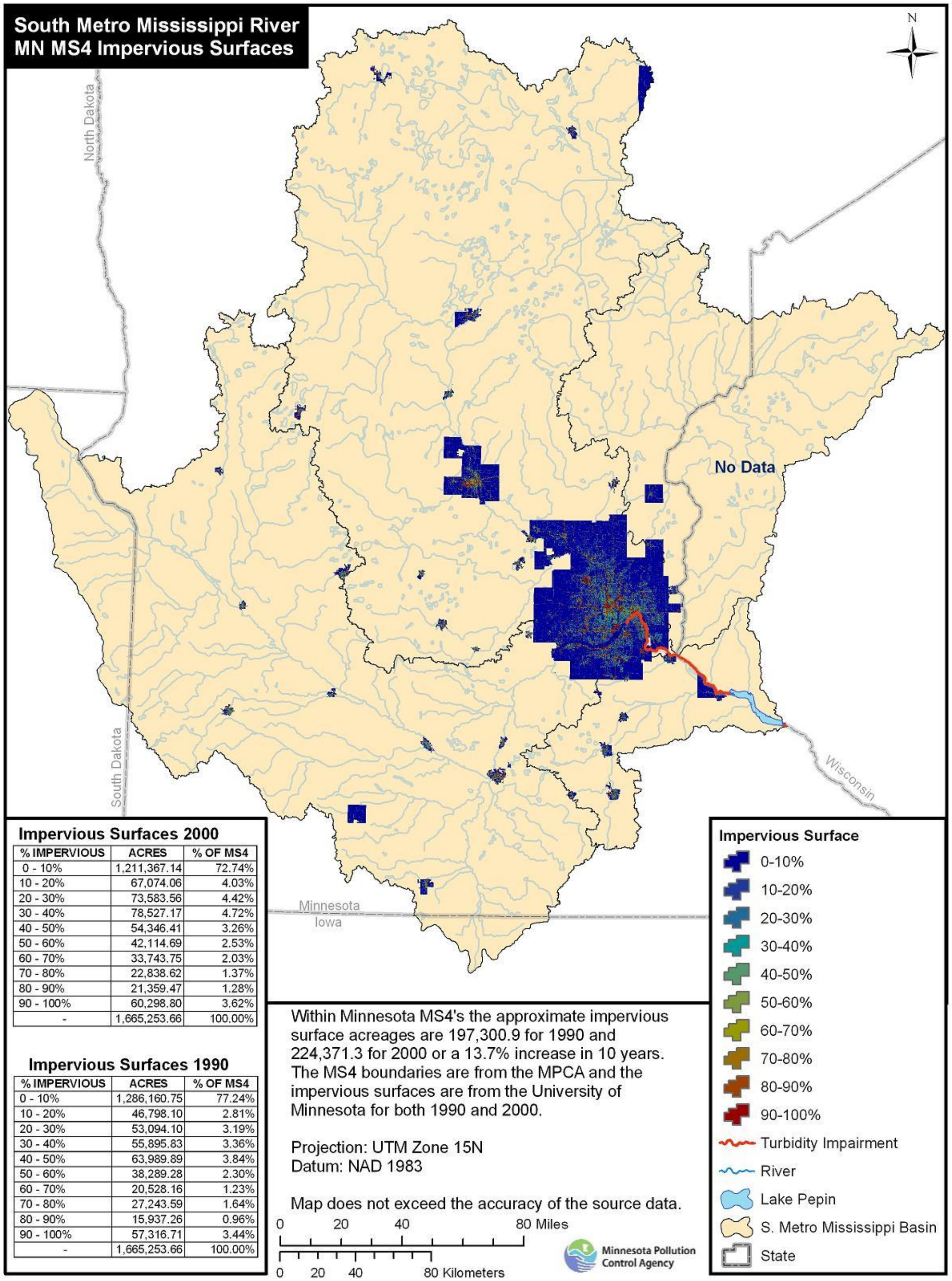
Table 2. Impervious Surfaces and Municipal Areas in the South Metro Mississippi Watershed

Area	Acres	Percentage of Whole Watershed
South Metro Mississippi Watershed in Minnesota	26,036,433	100.00%
Total Impervious Surfaces	624,490	2.40%
(MS4) Impervious Surfaces	224,371	.86%
Total MS4 Area	1,665,254	6.40%
Total Municipal Areas	1,806,146	6.90%

* MS4: Municipal Separate Storm Sewer System, a permit program administered by the MPCA to better manage stormwater across the state and meet the requirements of the federal Clean Water Act.

Source: MPCA and University of Minnesota

Figure 10 on the next page shows the impervious surfaces within the MS4 areas. Some areas of the watershed are experiencing increases in developed areas. The MPCA has included a margin of safety in this TMDL to address future increases in urban stormwater, as explained in Section 5.4.1.



Impervious Surfaces 2000

% IMPERVIOUS	ACRES	% OF MS4
0 - 10%	1,211,367.14	72.74%
10 - 20%	67,074.06	4.03%
20 - 30%	73,583.56	4.42%
30 - 40%	78,527.17	4.72%
40 - 50%	54,346.41	3.26%
50 - 60%	42,114.69	2.53%
60 - 70%	33,743.75	2.03%
70 - 80%	22,838.62	1.37%
80 - 90%	21,359.47	1.28%
90 - 100%	60,298.80	3.62%
-	1,665,253.66	100.00%

Impervious Surfaces 1990

% IMPERVIOUS	ACRES	% OF MS4
0 - 10%	1,286,160.75	77.24%
10 - 20%	46,798.10	2.81%
20 - 30%	53,094.10	3.19%
30 - 40%	55,895.83	3.36%
40 - 50%	63,989.89	3.84%
50 - 60%	38,289.28	2.30%
60 - 70%	20,528.16	1.23%
70 - 80%	27,243.59	1.64%
80 - 90%	15,937.26	0.96%
90 - 100%	57,316.71	3.44%
-	1,665,253.66	100.00%

Figure 10. While municipalities in the watershed include areas of concentrated impervious surfaces, the vast majority of the South Metro Mississippi remains rural. Some municipal areas are experiencing increases in development, which the MPCA addresses in this TMDL with a margin of safety for future increases in urban stormwater. (Source: MPCA).

While urban stormwater is a source of sediment in streams and rivers in the South Metro Mississippi watershed, the majority of the watershed is rural and the majority of sediment derives from rural areas. This conclusion is confirmed by water quality monitoring by several state and federal agencies over many years.

For example, research shows that agricultural areas tend to yield more sediment per acre than urban areas in the southeastern Minnesota River watershed. “Yield” refers to the amount per acre of sediment eroded from the land surface by runoff and delivered to a stream system. In subwatersheds with a majority of land in agricultural use, the TSS yield averaged from 233 to 687 pounds per acre a year, compared to 144 to 185 pounds per acre for subwatersheds with a majority of land in urban use. Figure 11 on the next page shows the TSS yield for major tributaries draining to the southeastern portion of the Minnesota River.

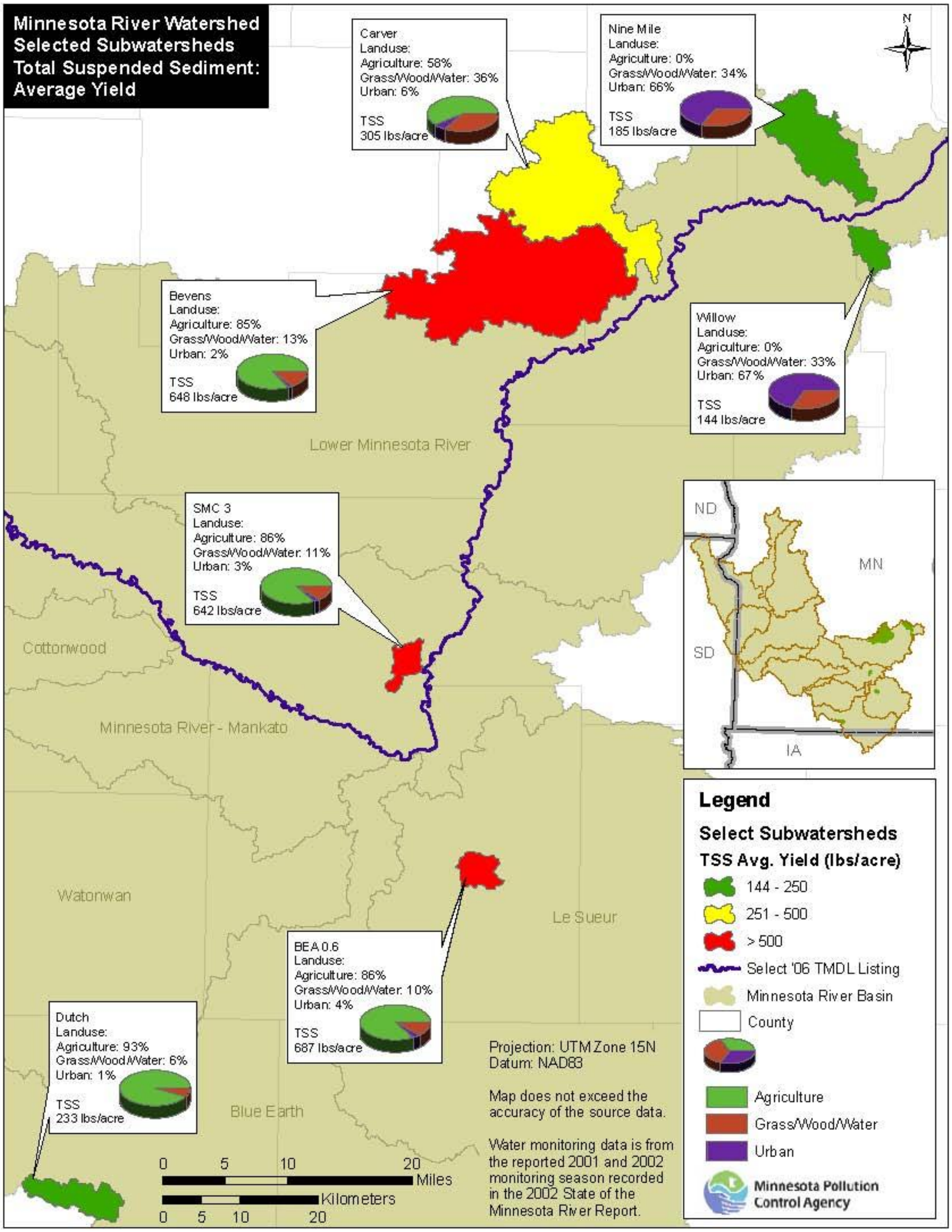


Figure 11. This figure shows the average annual TSS loads per acre (yield) to the Minnesota River system from major tributaries in the eastern part of the basin. Subwatersheds with a majority of land in agricultural use had the highest yields. (MPCA graphic)

3.1.2 Sediment Sources by Landscape Feature

Lake Pepin serves as a depositional basin where sediments from the South Metro Mississippi River watershed have accumulated over many centuries. Sediment cores from Lake Pepin have been analyzed to estimate historical rates of sediment deposition, as well as recent changes in sources of sediment. Sediment dating techniques show that sediment accumulation rates have increased by about a factor of 10 since European settlement (Figure 4). An estimated 80 percent of the sediment load is from the Minnesota River and several small Mississippi River tributaries. Recent estimates of sediment loads based on Lake Pepin core analysis correspond closely to monitored river data (Engstrom et al., 2009).

The St. Croix Watershed Research Station of the Science Museum of Minnesota has conducted several studies to determine what percentage of Lake Pepin sediment is derived from erosion of agricultural fields, how much is from non-field sources, and how these proportions have changed over time. The studies used two radioisotopes to fingerprint and apportion sources of sediment in Lake Pepin and its tributary watersheds. These studies have found that, at present, an estimated 35 percent of the total sediment load to Lake Pepin, as measured by sediment core samples, originates from farm field erosion (Schottler et al., 2010). This proportion has shifted from an estimated 65 percent field/35 percent non-field in 1940, in response to increased erosion from non-field sources. The proportions vary greatly among watersheds depending on topography, stream gradient, land use and precipitation. Non-field sources include ravines, stream bluffs and stream banks.

Drastic land-use changes to a river basin that is geologically predisposed to high erosion rates appear to be largely responsible for the dramatic increase in sediment loads from the Minnesota River over time. The sudden and extremely rapid drainage of Glacial Lake Agassiz though the River Warren channel some 11,500 years ago carved out a wide, deep valley through which the Minnesota River runs today. Since that event the tributary streams have been steadily down-cutting in their lower reaches to adjust to the new lower base level. The creation of steep valley walls around the Minnesota River main stem and the lower reaches of its tributaries “primed” the landscape to erode sediment (Wilcock, 2009). Land clearing, the tripling of acreage in row crop production, and increased flows in the Minnesota River since 1940, combined with the landscape’s inherent potential for sediment loss, led to progressively greater sediment loads.

Within the Minnesota River basin, the proportions of sediment originating from stream banks, bluffs and ravines vary widely by major watershed, as well as by year. Bluff erosion appears to be significant in the Blue Earth River and Le Sueur River watersheds, the highest contributors of sediment in the Minnesota River Basin (Sekely et al.,2002; Thoma et al., 2005). The main driver of bluff erosion in the long run is erosion at the toe of the bluff (Wilcock, 2009). Net stream bank erosion also appears to be a significant source of sediment in the Le Sueur watershed, as indicated by historical widening of the stream channel in response to elevated river flows (Stephanie Day, National Center for Earth Surface Dynamics, University of Minnesota, Minneapolis, personal communication).

Erosion of ravines is driven by the volume and rate of water discharged to the ravine, which is often increased by discharge from the upland drainage system (Wilcock, 2009). Ravine erosion is most prominent in the catchments of deeply incised tributaries, often found on the descent down the Minnesota River escarpment. It is especially prominent in wetter years with high levels of surface runoff and tile line discharge (Patrick Baskfield, MPCA, Mankato, personal communication).

4.0 WATER QUALITY STANDARDS AND REVIEW OF AVAILABLE DATA

4.1 Water Quality Standards

Minnesota adopted its first statewide water quality standards in 1967. The state has updated these standards by adding new standards and regulations periodically. The comprehensive Clean Water Act amendments of 1972 require states to adopt water quality standards that meet the minimum requirements of the federal Clean Water Act. Minnesota's water quality standards meet or exceed the federal requirements.

Under the Clean Water Act, every state must adopt water quality standards to protect, maintain, and improve the quality of the nation's surface waters. These standards represent a level of water quality that will support the Act's goal of "fishable and swimmable" waters. Water quality standards consist of three components: beneficial uses, numeric or narrative standards, and a non-degradation policy. Minnesota's water quality standards are summarized in Table 3 and explained in greater detail below.

Table 3. Minnesota Water Quality Standards

Component	Description
Beneficial use	Beneficial uses are the uses that states decide to make of their water resources. The process of determining beneficial uses is spelled out in the federal rules implementing the Clean Water Act.
Numeric standards	Numeric water quality standards represent safe concentrations in water that protect a specific beneficial use. If the standard is not exceeded, the use should be protected.
Narrative standards	Narrative water quality standards are statements that prohibit unacceptable conditions in or on the water, such as floating solids, scums, visible oil film, or nuisance algae blooms. Narrative standards are sometimes called "free froms" because they help keep surface waters free from basic types of water pollution.
Nondegradation	Nondegradation is equivalent to the federal term "antidegradation." The fundamental concept of nondegradation is that lakes, rivers, and streams whose water quality is better than the applicable standards should be maintained at that high level of quality and not allowed to degrade to the level of applicable standards.

Water quality standards and related provisions can be found in several Minnesota rules, but the primary rule for statewide water quality standards is Minnesota Rules Chapter 7050. Included in this rule are the following:

- A classification system of beneficial uses for both surface and groundwaters;
- Numeric and narrative water quality standards;
- Nondegradation provisions;
- Provisions for the protection of wetlands;
- Treatment requirements and effluent limits for wastewater discharges; and
- Other provisions related to protecting Minnesota's water resources from pollution.

All waters of Minnesota are assigned classes based on their suitability for the following beneficial uses:

1. Domestic consumption
2. Aquatic life and recreation
3. Industrial consumption
4. Agriculture and wildlife
5. Aesthetic enjoyment and navigation
6. Other uses
7. Limited resource value

Beneficial uses of the turbidity-impaired reaches of the South Metro Mississippi River are as follows:

- Mississippi River, Metro WWTP to Rock Island Railroad Bridge: 2C, 3B, 3C, 3D, 4, 5 and 6
- All other water bodies in Table 1 (page 8) are classified as follows: 2B, 3B, 4A, 4B, 5 and 6

For conventional pollutants such as turbidity, river reaches are listed as impaired if 10 percent or more of samples taken over the assessment period exceed the water quality standard. Based on this criterion, the Mississippi River from its confluence with the Minnesota River to the Lake Pepin inlet is shown to be impaired, while the lower part of the lake is shown to be in full support of the turbidity standard of 25 nephelometric turbidity units (NTU). The MPCA used more than 1,000 water quality samples from a 10-year period in the assessment.

4.1.1 Water Quality Standard and Numeric Target

Minnesota's numeric turbidity standard is defined as 25 NTU. The state listed five contiguous segments of the South Metro Mississippi River as impaired by turbidity in 1998, based on analysis of the 10-year period of monitoring from 1986 to 1996, which showed that 10 percent or more of the samples taken exceeded the state standard of 25 NTU. Tellingly, the Mississippi River above the confluence with the Minnesota River, and below Lake Pepin, was not listed as impaired (Figure 12). This points to the overwhelming influence of the Minnesota River as a sediment source, and the role of Lake Pepin as a sediment sink, for this portion of the Mississippi River.

In the course of conducting a TMDL study for these river reaches in conjunction with Lake Pepin, the MPCA confronted a confusing situation with several types of turbidity meters, each giving a different reading, used in monitoring the river over the past two decades. In 2008 the MPCA decided on a specific type of turbidity meter, used by Metropolitan Council Environmental Services at the Lock and Dam 2 monitoring site for years, as a reference point for the 25 NTU turbidity standard. The MPCA then evaluated the meter with reference to aquatic life use support and found it wanting. No SAV was found to have grown in the Mississippi at the TSS-equivalent of the turbidity standard, which is 64 mg/L TSS. At this point, the Agency decided it was necessary to develop a site-specific standard for the South Metro Mississippi River.

In summer 2010, in close cooperation with the Wisconsin Department of Natural Resources and Mississippi River scientists, and with public review, the MPCA developed a site-specific standard of 32 mg/L TSS summer mean (June 1-September 30) for the Mississippi River from Lock and Dam 1 to Lock and Dam 4.The site-specific standard was developed after MPCA staff and the Science Advisory Panel came to realize that the statewide 25 NTU standard failed to adequately protect aquatic life in the South Metro Mississippi. After a technical paper was developed by a team of research scientists (Sullivan et al., 2009), the MPCA developed a proposed site-specific standard. Following public notice, it was presented to the MPCA Citizens Board in June 2010. Following Board approval, it was sent to the EPA for its review and approval.

The site-specific standard replaces the turbidity standard for this reach of the Mississippi, and is based on combined bi-weekly monitoring samples at Lock and Dams 2 and 3. The criterion of 32 mg/L TSS is well below the equivalent value for the state turbidity standard of 25 NTU, which corresponds to 64 mg/L TSS in this part of the Mississippi River. The standard specifies that a mean value of 32 mg/L or less must be attained in half or more of summers over a long-term period of at least 10 years. Secondary monitoring targets associated with the standard include:

- Not exceeding 44 mg/L TSS at the 90^{th} percentile of individual monitoring values over the assessment period; and
- Attaining a SAV monitoring survey frequency of 21 percent using the U.S. EPA's Environmental Mapping and Assessment Program protocol.

The portion of the Mississippi River in this TMDL forms a boundary between Minnesota and Wisconsin from the confluence with the St. Croix River to the confluence with the Chippewa River. Wisconsin does not have numeric river standards for turbidity or TSS, but lists this reach of the Mississippi as impaired by suspended sediment that is suppressing the growth of submersed aquatic vegetation and filling in Lake Pepin at an accelerated pace. Wisconsin is using Minnesota's proposed TSS standard and the 21 percent frequency SAV target as numeric translators of this narrative standard until such time as it develops its own TSS standards for rivers.

Figure 12. Data from the Metropolitan Council Environmental Services and Long-Term Resource Monitoring Program show that the Mississippi River at Lock and Dam 1 – above the confluence with the Minnesota River –meets the proposed TSS standard of 32 mg/L, as does the river at Lock and Dam 4 – below Lake Pepin. The impaired reach greatly exceeds the standard, as measured at Locks and Dams 2 and 3. The bars in the chart measure the median of annual average values over the 1985-2006 period of record to correspond generally to how the site-specific standard will be used. (MPCA graphic)

5.0 MODELING APPROACH AND RESULTS

5.1 Water quality models used

The complex nature of the Upper Mississippi River-Lake Pepin system requires a model that is complex in terms of process resolution and in terms of spatial and temporal resolution. The system stretches for about 90 miles and consists of three morphometrically and hydraulically distinct pools, separated by lock and dam control structures. There is considerable variability both laterally and longitudinally of the system bathymetry, including channels, shoals, deltas, and impoundments. In addition, several islands throughout the system complicate the hydraulics.

A linked hydrodynamic-sediment transport-water quality model was developed for the Upper Mississippi River from Lock and Dam 1 through Lock and Dam below Lake Pepin. The model, called the Upper Mississippi River - Lake Pepin Water Quality Model (UMR-LP model), was developed to support TMDLs for turbidity and nutrient-chlorophyll *a* impairments in Pools 2, 3, and 4 (River Miles 848 to 765) of the Upper Mississippi River.

A hydrodynamic water quality model developed by Hydra-Qual, Inc., in the 1990s was adapted and upgraded by Limno-Tech, Inc. for use in the Mississippi River turbidity and Lake Pepin eutrophication TMDLs. The ECOMSED-RCA model was successfully calibrated and then used to evaluate the effect of specific load and flow reductions on TMDL endpoints including turbidity, phosphorus, chlorophyll, and Secchi transparency. The model was developed in close consultation with the Lake Pepin TMDL Science Advisory Panel and MPCA, and is central to the development of the turbidity and eutrophication TMDLs. The main processes characterized in the model include:

- The growth and decay of algae in response to alternative nutrient inputs, temperature, flow and light conditions; and
- The level of turbidity, TSS, and Secchi transparency in the river as affected by loadings and resuspension of sediment and by growth cycles of algae.

Details of the model, its data set and calibration can be found in Limno-Tech, Inc.'s modeling report (2009).

The overall project approach followed EPA's Draft Guidance on the Development, Evaluation, and Application of Regulatory Environmental Models (EPA 2003). Based on this guidance, the general approach to model development and application adhered to the following steps in the regulatory environmental modeling process:

1) Problem specification;
2) Model framework selection and formulation;
3) Model development;
4) Model evaluation; and
5) Model application.

An important component of this project was the adherence to an open modeling process throughout the project that involved continual interaction with all stakeholders at each step in the process. Another important part of the open modeling approach was ongoing model peer review of the entire modeling process by a Science Advisory Panel (SAP) consisting of academic and government scientists and MPCA staff familiar with the system under study.

The UMR-LP modeling framework consists of modified versions of two public domain models:

- The ECOMSED hydrodynamic/sediment transport model; and
- The Row-Column AESOP (RCA) water quality model.

The two models operate on the same computational grid, and hydrodynamic and sediment transport predictions from the ECOMSED model are linked directly to the RCA model to inform the water quality simulation. The "ECOM" component of the ECOMSED modeling framework is used to simulate three-dimensional and time-dependent hydrodynamic behavior in the Upper Mississippi River from Lock and Dam 1 to Lock and Dam 4. As a complementary module to the "ECOM" hydrodynamic module, the "SED" component of the overall ECOMSED framework is used to simulate the transport and fate of cohesive and non-cohesive sediments, which together constitute non-volatile suspended solids. Advective/dispersive transport and deposition and resuspension processes are simulated for cohesive sediments, which represent clays, fine and medium silts, and associated organic material. Likewise, transport and deposition/resuspension is simulated for a non-cohesive sediment class, which typically represents medium to coarse sands.

The basic RCA framework includes a suite of state variables to represent carbon, nitrogen, phosphorus, silica, oxygen and algal dynamics, and it is configured to interface directly with the ECOMSED model, including linkage of hydrodynamic, water temperature, and sediment transport results. The RCA framework includes a simulation of water column processes affecting water quality. It also includes a coupled sediment diagenesis sub-model that simulates the cycling of detrital material and nutrients in the surface sediments and subsequent impacts on near-bed sediment oxygen demand and release of dissolved nutrients, including dissolved inorganic phosphorus.

The MPCA made every effort to incorporate all available data for the Upper Mississippi River (UMR) system during the model development and calibration/confirmation process. The UMR system has a long history of abundant water quality and biological data collected over the past 22 years by federal, state and local government agencies. Within Pools 2 and 3, the Metropolitan Council of Environmental Services (MCES) has collected a majority of the monitoring data, while the USGS through its LTRMP has collected a majority of the data in Pool 4. Other agencies that regularly collect data within the UMR system include the U.S. Army Corps of Engineers (USACE), MPCA, Minnesota Department of Natural Resources (MDNR), and the Wisconsin Department of Natural Resources (WDNR).

With 22 years of data available for the UMR-Lake Pepin system, the MPCA decided to use half of the data for model calibration and half for confirmation. The model was calibrated using monitoring data for 1996-2006, and the monitoring data from 1985-1995 was used as a confirmation dataset. Both the calibration and confirmation data sets included a low flow and a high flow year. The calibration period included the:

- Intense low-flow monitoring program conducted in 2006 (10th percentile summer, from June to September) flow at Lock and Dam 2 at Prescott, Wis.; and
- The 86th percentile annual high flow at Lock and Dam 2 at Prescott, Wis. in 2002.

The earlier confirmation period included the 1 percent summer flow in 1988 and the highest annual flow on record in 1993. It was important to test the model's ability to simulate the system response over the full range of flow conditions because high flows represent the critical conditions for turbidity, while low flows represent the critical conditions for nutrient-stimulated phytoplankton growth.

Results of this iterative calibration/confirmation process included:

- Complete listings of calibration parameters;
- Graphical presentations of the calibrated model;

- Comparison with system data along with a presentation of model-data comparisons for the confirmation period;
- Metrics used to quantitatively evaluate the model calibration/confirmation; and
- Diagnostic analyses of the modeling results with regard to important features of the system behavior.

The MPCA and the project Science Advisory Panel found the overall model performance for the calibration period and confirmation periods to be quite good, especially given the complexity of the model framework and the extent of the model domain.

Once achieving the best possible model parameterization, Limno-Tech, Inc. conducted a suite of model application runs to provide a computation of the sediment and nutrient load-response relationships to support the TMDL process. Limno-Tech developed a Management Analysis Tool (MAT) to help the MPCA and stakeholders to visualize and compare the results of 21 different load reduction scenarios in relation to TMDL targets for chlorophyll *a*, total phosphorus, Secchi depth, and turbidity.

The simulation and accounting of sediment bed properties is a critical component of the SED sediment transport module. ECOMSED requires the specification of sediment type, such as cohesive or non-cohesive, and other physical properties, including particle size distribution and deposition- and erosion-related process coefficients. Exchange between the water column and the underlying sediment bed may occur through settling/deposition and resuspension processes. A detailed treatment of these sediment transport processes is provided in the HQI user's manual for ECOMSED version 1.3 (HydroQual 2002). The rate of mass deposition to the bed for cohesive and non-cohesive suspended solids is dictated by a particle settling rate, the local water column suspended sediment concentration, and a probability of deposition term. Resuspension of cohesive or non-cohesive material from the sediment bed to the overlying water column may result from elevated shear stresses caused by either elevated near-bed velocities during high-flow events and/or wind-generated waves. The sediment type assigned to each horizontal model grid was consistent with the original model developed by HQI.

The UMR-LP model responds to inputs from upstream watersheds and direct discharges from wastewater treatment facilities to the Mississippi (Figure 13). The MPCA assembled water quality monitoring data from 1985 to 2006 to serve as inputs to the model.

Inputs to the South Metro Mississippi

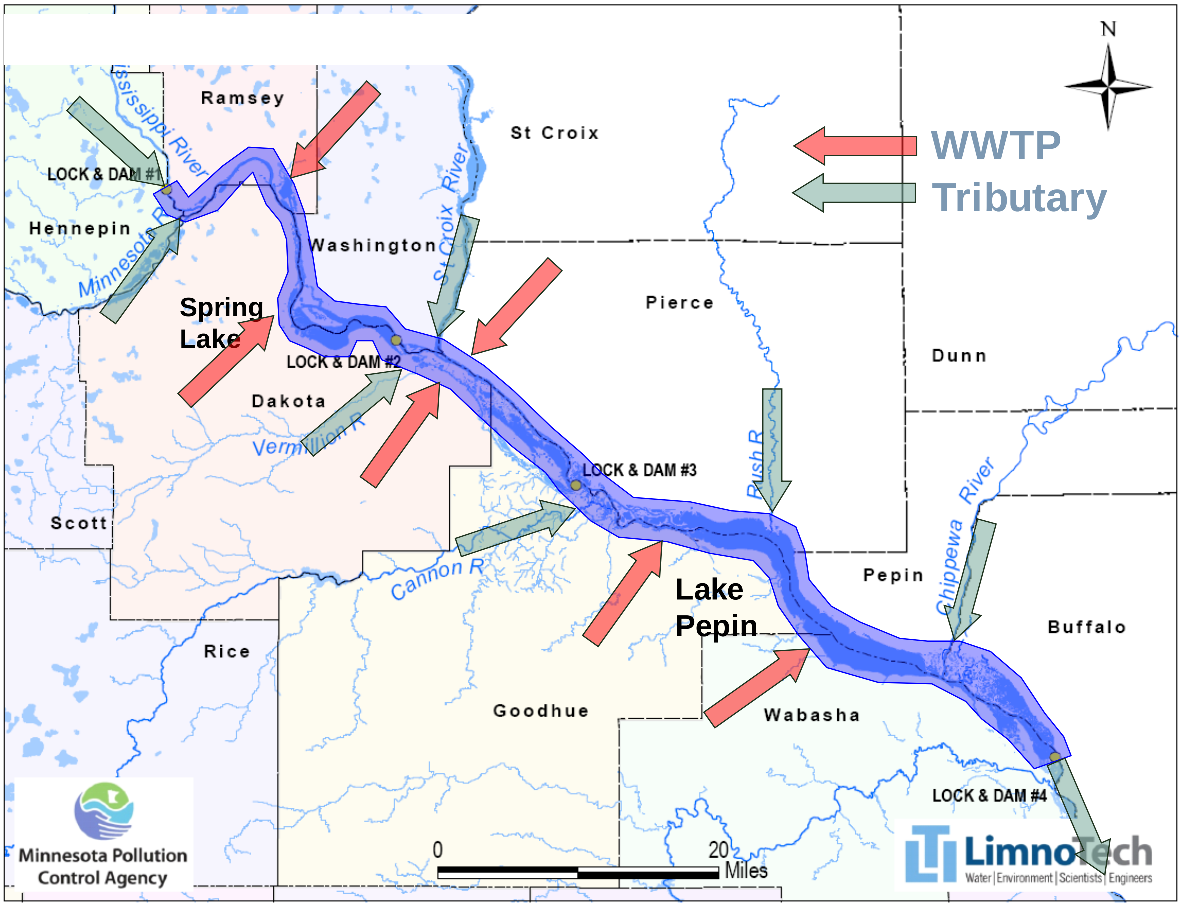


Figure 13. The Upper Mississippi River –Lake Pepin model used inputs from the several tributary and direct wastewater inputs to the system. (Limno-Tech Inc. graphic)

5.1.1 Load reduction scenarios

In order to attain the site specific standard of 32 mg/L, Limno-Tech Inc. ran 21 scenarios to represent a wide range of conditions ranging from historical baseline to moderate reductions to extreme reductions approximating pre-settlement conditions (90-percent load reductions from tributaries with zero direct wastewater discharges). Table 4 on the next page lists the scenarios. The results of the modeling scenarios are described by Limno-Tech Inc. (2009).

Table 4.

TSS Load Reduction Scenarios Evaluated by UMR-LP Model

Reductions in TP and TSS ranging from 10 to 90 percent from historical baseline were evaluated for each major tributary and source area. Each scenario is defined by which cells are filled with an “x.” For example, Scenario 17 includes a 20-percent TSS reduction in the Upper Mississippi, St. Croix and other tributary rivers; 50-percent reduction in the Minnesota and Cannon rivers; reductions in TSS from wastewater treatment plants.

Scenario No.	Load Reduction Scenario	UMR / MR Load Reductions	Upper Miss. River				Minnesota River					St. Croix		Cannon		Other Tribs		WWTPs			
			Hist	20%	50%	90%	Hist	20%	50%	80%	90%	Hist	20%	Hist	50%	Hist	20%	Hist	Permit	Red.	Rem.
1	Historical Tributary & WWTP Loads	(none)	x				x					x		x		x		x			
2	Tributary Load Reductions with Permitted WWTP Loads	(none)	x				x					x		x		x			x		
3		20% / 20%		x				x					x		x		x		x		
4		20% / 50%		x					x				x		x		x		x		
5		20% / 80%		x						x			x		x		x		x		
6		50% / 20%			x			x					x		x		x		x		
7		50% / 50%			x				x				x		x		x		x		
8		50% / 80%			x					x			x		x		x		x		
9	Tributary Load Reductions with Reduced WWTP Loads	(none)	x				x					x		x		x				x	
10		20% / 20%		x				x					x		x		x			x	
11		20% / 50%		x					x				x		x		x			x	
12		20% / 80%		x						x			x		x		x			x	
13		50% / 20%			x			x					x		x		x			x	
14		50% / 50%			x				x				x		x		x			x	
15		50% / 80%			x					x			x		x		x			x	
16	"Natural Background" Case	90% / 90%				x					x		x		x		x				x
17	Tributary Load Reductions with Reduced Pool 2 Resuspension	20% / 50%		x					x				x		x		x			x	
18		50% / 80%			x					x			x		x		x			x	
19		90% / 90%				x					x		x		x		x				x
20	Minnesota River TSS Reductions Based on HSPF "Scenario 4"	20% / ~50%		x			**HSPF "Scenario 4" + CE-QUAL-W2**						x		x		x		x		
21		20% / ~50%		x									x		x		x			x	

6.0 TMDL DEVELOPMENT AND DETERMINATION OF ALLOCATIONS

The TSS TMDL for the South Metro Mississippi River watershed is presented in this section of the report. The MPCA used the calibrated UMR-LP model to determine the allocations necessary to achieve the TMDL target. The modeling period was based on the same weather and hydrologic conditions as the calibration period, Jan. 1, 1995 to Dec. 31, 2006, with the following locations used as assessment points:

- Mississippi River at Lock and Dam 2 (River Mile 815 near Hastings)
- Mississippi River at Lock and Dam 3 (River Mile 797 near Red Wing)

Scenario 17 showed that TSS load reductions of 50 percent from the Minnesota and Cannon Rivers, combined with 20 percent reductions from other major tributaries could achieve a long-term summer average of 32 mg/L TSS. Since the modeling analysis was conducted, the Agency has further refined the site-specific standard to apply to a moving 10-year period of data as an averaging period, and evaluated how to meet the standard under the most critical, high-flow conditions. The MPCA made two main adjustments to Scenario 17 to serve as a basis for the TMDL allocations:

- First, for the St. Croix River, the Agency will require no TSS load reduction from current levels because its TSS concentration remains well below the site-specific standard of 32 mg/L. Thus, the St. Croix River helps to dilute – not increase – the TSS concentration of the Mississippi River. The vast majority of sediment in the St. Croix River settles out in Lake St. Croix before discharging to the Mississippi River.

- Second, the Agency will require additional TSS load reductions from the Minnesota River – 60 percent instead of 50 percent – during higher flows in non-winter months in order to meet the water quality standard in each of the 10-year periods evaluated from 1985-2006. Only additional reductions from the Minnesota River were effective in meeting the standard during the most challenging decades of high water flows when TSS concentrations are at their peak.

The MPCA also delineated a region called the Metroshed for the seven-county metropolitan area, with county boundaries adjusted to coincide with watershed boundaries, in order to clearly distinguish metro-area loads from the other major tributary inputs to the model domain: the Minnesota River; Cannon River; St. Croix River, Upper Mississippi River; and minor direct tributaries downstream of the metro region (Figure 14).

Metroshed: Seven-County Metro Area

Figure 14. The Metroshed, highlighted in dark green, distinguishes metro-area loads of the Minneapolis-St. Paul area from other major tributary inputs. (MPCA graphic)

In summary, the TMDL calls for the following set of TSS load reductions:

- 60 percent from the Minnesota River Basin at high and very high flows; 50 percent at median and lower flows;
- 50 percent from the Cannon River Basin;
- 20 percent from the Upper Mississippi River Basin;
- 0 percent from the St. Croix River Basin;
- 0 percent from all tributaries from December to February
- 25 percent from regulated MS4 communities;
- 50 percent from internal sources such as wind-induced resuspension; and
- 33 percent from local tributary loads.

Table 5 on the next page shows how these reductions are applied to TSS loads by source for average river flows in order to achieve the total loading capacity for the South Metro Mississippi River.

MS4 reductions are 25 percent, regardless their locating in the South Metro Mississippi watershed.

Loads from wastewater treatment facilities discharging at a concentration greater than 30 mg/L are extremely small in relation to the total TSS load. Thus, the Agency will require no load reductions and these facilities will receive allocations equal to current permitted discharge.

The numbers in Table 6 also reflect the need to allow for projected growth in urban areas, additional NPDES stormwater permittees, and increased wastewater discharge from facilities with permitted effluent limits in excess of 30 mg/L TSS. According to the state demographer's office, the metropolitan population of Minnesota and western Wisconsin is projected to increase by 22 percent from 2005 to 2035 (www.demography.state.mn.us/documents/MinnesotaPopulationProjections20052035.pdf).

The TMDL will allow for future growth in metropolitan population as it is likely to impact urban stormwater and urban wastewater volume. The TMDL also accounts for MS4s that become regulated after this TMDL is approved. Thirty percent of the total MS4 waste load allocation (WLA) is provided for future growth and future regulated MS4s, with Best Management Practices (BMPs) reflecting the TMDL applied in accordance with stormwater NPDES permits. Fifty percent of the existing sum of WLAs for wastewater treatment facilities, or 1,311 metric tons per year, was added to provide for growing and new facilities with permitted effluent limits in excess of 30 mg/L TSS.

Table 5. Annual Allocations of TSS for Average Flow Conditions of the South Metro Mississippi

Category	Minor Tributaries	Metroshed	Upper Mississippi	Minnesota	St. Croix	Cannon	Total
	Metric tons/year						
Stormwater * (Construction/ Industrial)							**1,841**
Stormwater (MS4s)	875	34,935	7,410	2,485	1,381	1,335	**48,420**
WWTPs**			1,247	1,124	228	23	**2,622**
WWTPs (reserve capacity)			624	562	114	12	**1,311**
Natural Background	790	1,580	9,480	59,250	3,160	4,740	**79,000**
Load Allocation	9,357	13,244	89,194	289,733	19,994	23,953	**445,475**
Total Loading Capacity	**11,022**	**49,759**	**107,954**	**353,154**	**24,877**	**30,063**	**578,670**

* The MPCA manages stormwater across the state with permitting programs for industrial and construction stormwater.
**WWTP: Wastewater Treatment Plants

Table 6 on the next page shows the TSS load allocations for the same source categories and areas as in Table 5 above, but adds five categories of river flow. Allocations by flow regime, from very high to very low, are based on historical monitoring data at Lock and Dam 2 on the Mississippi River. Allocations were developed using the UMR-LP model, with modifications to Scenario 17 as discussed previously (page 35).

The table outlines WLAs for MS4 communities, construction and industrial stormwater, wastewater treatment facilities, natural background, load allocation (LA), and total loading capacity. These TMDL components are defined for six pollutant input categories and an aggregated total.

Table 6. Annual Allocations of TSS for a Range of Flow Conditions of the South Metro Mississippi

Category	Flow Condition	Minor Tributaries	Metroshed	Upper Mississippi	Minnesota	St. Croix	Cannon	Total
		Metric tons/year						
Stormwater* (Industrial / Construction)	Very high							2,945
	High							2,301
	Moderate							1,841
	Low							1,381
	Very low							922
Stormwater (MS4s)	Very high	1,427	56,659	12,012	4,051	2,210	2,163	78,522
	High	1,105	44,185	9,343	3,130	1,703	1,703	61,170
	Moderate	875	34,935	7,410	2,485	1,381	1,335	48,420
	Low	691	26,833	5,661	1,933	1,058	1,013	37,189
	Very low	461	18,503	3,912	1,335	736	691	25,637
WWTP**	Very high			1,247	1,124	228	23	2,622
	High			1,247	1,124	228	23	2,622
	Moderate			1,247	1,124	228	23	2,622
	Low			1,247	1,124	228	23	2,622
	Very low			1,247	1,124	228	23	2,622
WWTP (reserve capacity)	Very high			624	562	114	12	1,311
	High			624	562	114	12	1,311
	Moderate			624	562	114	12	1,311
	Low			624	562	114	12	1,311
	Very low			624	562	114	12	1,311
Natural Background	Very high	1,426	2,853	17,117	106,982	5,706	8,559	142,643
	High	939	1,879	11,272	70,453	3,757	5,636	93,937
	Moderate	790	1,580	9,480	59,250	3,160	4,740	79,000
	Low	563	1,127	6,761	42,254	2,254	3,380	56,338
	Very low	272	544	3,266	20,411	1,089	1,633	27,215

* The MPCA manages stormwater across the state with permitting programs for industrial and construction stormwater.
**WWTP: Wastewater Treatment Plants

Continued on next page

Category	Flow Condition	Minor Tributaries	Metroshed	Upper Mississippi	Minnesota	St. Croix	Cannon	Total
	Metric tons/year							
Load Allocation	Very high	10,380	16,740	162,351	415,133	24,941	38,506	668,050
	High	8,978	13,460	107,591	266,041	25,620	29,626	451,316
	Moderate	9,357	13,244	89,194	289,733	19,994	23,953	445,475
	Low	7,847	11,435	62,883	200,207	13,479	20,994	316,845
	Very low	5,104	9,849	38,205	132,691	8,224	12,663	206,735
Total Loading Capacity	Very high	13,233	76,251	193,351	527,852	33,199	49,262	896,093
	High	11,022	59,524	130,077	341,310	31,423	37,000	612,658
	Moderate	11,022	49,759	107,954	353,154	24,877	30,063	578,670
	Low	9,101	39,395	77,175	246,079	17,133	25,422	415,686
	Very low	5,837	28,896	47,253	156,123	10,390	15,022	264,443

TMDL components are based on the information in Tables 5 and 6. In summary:

- Wastewater Treatment Facilities: The total allocation for WWTPs is 3,933 metric tons/year. Individual WLAs for 173 NPDES facilities are listed in Appendix A.
- Municipal Separate Storm Sewer Systems (MS4s) covered under a NPDES permit are assigned an aggregate WLA of 48,420 metric tons per year for average flow conditions. WLAs for additional flow categories are listed under the Total column in Table 6. The 204 currently permitted MS4s in the South Metro Mississippi watershed are listed in Appendix B. As discussed above, future regulated MS4s are accounted for in the WLA.
- LAs are defined for the six contributing areas under each of the five flow regimes shown in Table 6. Natural background may be defined technically as part of the LA. The LAs as defined here are maximum anthropogenic loads of TSS per year consistent with achieving the TMDL over a full range of river flows.

The TMDL components are discussed furiesher in the sections below.

6.1 Wasteload Allocations (WLA) and Load Allocations (LA)

The WLAs for individual wastewater facilities and for the aggregate runoff from Municipal Separate Storm Sewer Systems (MS4s) are provided in the following sections.

6.2 Wastewater Treatment Facilities

A total of 568 permitted wastewater treatment facilities discharge in the South Metro Mississippi River watershed. Of these, 395 have effluent limits of 30 mg/L TSS. Because this concentration is less than the water quality standard of 32 mg/L, discharge from these facilities does not cause or contribute to a TSS-related water quality impairment in the South Metro Mississippi River. The MPCA and EPA are discussing the most appropriate way of developing WLAs for these facilities.

A total 173 permitted wastewater treatment facilities discharge with effluent limits exceeding 32 mg/L TSS in the watershed. Most of these are stabilization ponds that discharge twice a year, during a spring and fall discharge window. Most of these facilities have an effluent limit of 45 mg/L TSS. The combined permitted TSS load of all such facilities is 2,622 metric tons per year, which amounts to 0.45 percent of the total TSS load at average flow, as shown in Figure 15 below. Although their combined impact is minimal, their effluent concentration exceeds the 32 mg/L TSS water quality standard, and so they are assigned individual WLAs equal to their permitted flow times permitted TSS effluent concentration. As discussed above, 1,311 metric tons/year is added to the total waste load allocation to allow for growth of existing and new facilities, bringing the total aggregate WLA for wastewater treatment facilities to 3,933 metric tons. These facilities are listed in Appendix A along with their permit numbers, locations and individual WLAs.

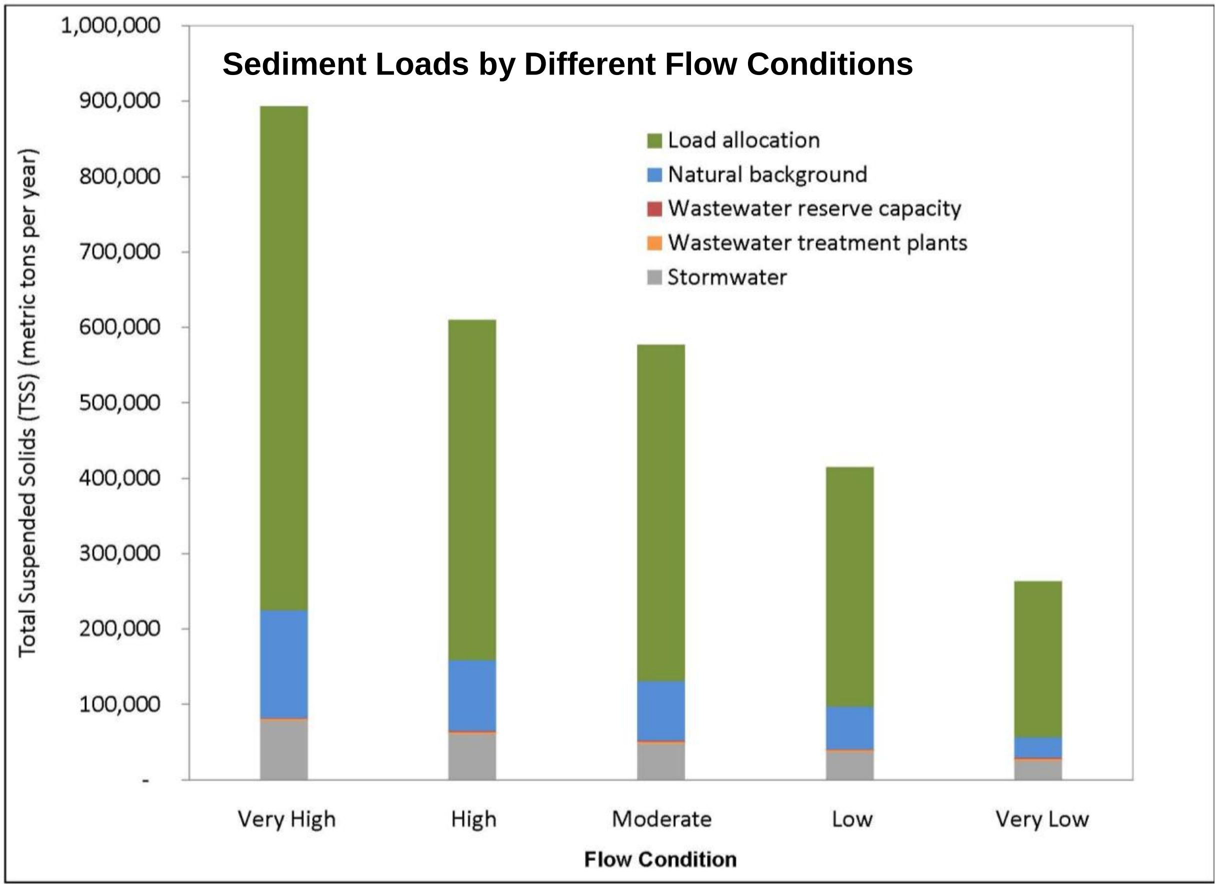


Figure 15. The combined permitted TSS load of all Wastewater Treatment Plant facilities discharging at greater than 30 mg/L is 2,622 metric tons per year, which amounts to 0.45 percent of the total TSS load at average flow. (MPCA graphic)

Individual permittees with WLAs (see Appendix A) are distributed geographically throughout the South Metro Mississippi watershed, as indicated in Table 7.

Table 7. Waste Load Allocations by Tributary in the South Metro Mississippi Watershed

Subwatershed	Number of Permits	Design Flow (million gallons per day)	Permitted TSS Load (Kg/y)
Cannon	7	0.375	23,328
Metroshed	7	7.013	558,703
Minnesota	88	12.755	797,044
St. Croix	16	3.669	228,072
Upper Mississippi	55	16.344	1,016,084
Total	**173**	**40.156**	**2,623,231**

6.3 Municipal Separate Storm Sewer Systems

The MPCA consulted a number of information sources to determine the estimated sediment export from the built-up portion of MS4 communities. These include:

- "Review of Published Export Coefficient and Event Mean Concentration (EMC) Data," by the Environmental Laboratory of the U.S. Army Corps of Engineers. This summary report provides an extensive list of references. The MPCA went to each of the references and extracted the data (http://el.erdc.usace.army.mil/elpubs/pdf/tnwrap04-3.pdf).
- Non-degradation reports for 30 MS4s in Minnesota. Each developed its own export coefficients.
- Data from the Capitol Region Watershed District, which measures discharges at outfalls in St. Paul.

Based on these data sources, the MPCA estimates that the built-up urban areas export an annual average of 225 lbs/acre of TSS to receiving surface water, or a total of 64,000 metric tons, which accounts for 6.4 percent of the average annual TSS load to the South Metro Mississippi River. Under EPA's NPDES stormwater program, the MPCA has developed rules to prevent stormwater from washing harmful pollutants into surface waters. At present, 204 cities, townships and other public entities that own and operate Municipal Separate Storm Sewer Systems (MS4s) within the South Metro Mississippi River watershed are required to obtain NPDES permits to discharge stormwater.

Permitted MS4s are assigned an aggregate MS4 WLA for average flow of 48,420 metric tons/year. Stormwater WLAs for the full range of flows are included in Table 6.

MS4 permittees will be deemed to be achieving their WLA if they are in compliance with their NPDES permit. The MPCA will develop a set of BMPs which, if incorporated into the MS4 permit, will meet the WLAs by achieving an estimated 25 percent reduction from pre-BMP loads within municipal areas that are already built up and 50 percent in municipal areas that are planned for urban development. If MS4s choose to implement other management strategies, they are required to demonstrate that their Storm Water Pollution Prevention Program is meeting the WLA.

In addition to stormwater discharges from MS4s, NPDES permits are required for certain construction and industrial activities that generate stormwater discharges. WLAs for construction and industrial stormwater were each set at 0.1 percent of the TMDL. Construction stormwater activities are considered in compliance with provisions of the TMDL if:

- They obtain a Construction General Permit under the NPDES program;
- Properly select, install and maintain all BMPs required under the permit, including any applicable additional BMPs required in Appendix A of the Construction General Permit for discharges to impaired waters; or
- Meet local construction stormwater requirements if they are more restrictive than requirements of the State General Permit.

Industrial stormwater activities are considered in compliance with provisions of the TMDL if they:

- Obtain an industrial stormwater general permit; or
- Obtain a General Sand and Gravel general permit (MNG49) under the NPDES program; and
- Properly select, install and maintain all BMPs required under the permit.

6.4 Load Allocations and Natural Background

The TMDL specifies load allocations for anthropogenic sources that are not subject to NPDES permit requirements as well as "natural background" sources. Both point and nonpoint sources are identified for each of the areas receiving TMDL allocations in Figure 16. The load allocation is by far the largest source of TSS, especially in the Minnesota River. Load allocations include anthropogenic or human-induced runoff from non-regulated areas such farmland, rural residential and other non-urban surfaces (including non-MS4 towns).

Natural background, based on estimates of pre-European settlement loads of sediment to Lake Pepin (Engstrom et al., 2009), is consistent with definitions of natural background cited in state rule (7050.0150, subp4): "'Natural causes' means the multiplicity of factors that determine the physical, chemical or biological conditions that would exist in the absence of measurable impacts from human activity or influence." Also, the Clean Water Legacy Act (114D.10, subd. 10) defines natural background as "characteristics of the water body resulting from the multiplicity of factors in nature, including climate and ecosystem dynamics that affect the physical, chemical or biological conditions in a water body, but does not include measurable and distinguishable pollution that is attributable to human activity or influence."

The date 1830 is used as a reference point for measuring the beginning of anthropogenic effects on TSS loads to the Mississippi River as estimated from Lake Pepin sediment cores (Figure 4). This period is prior to European settlement, which introduced dramatic changes to the landscape discussed on pages 13-18. These changes – primarily converting more than 90 percent of native prairie and wetlands to agriculture through tillage and artificial drainage and the introduction of annual row crops – altered a landscape that was geologically predisposed to high erosion rates. As Schottler explains, the land form that creates the potential for high erosion rates is natural, but today's high rates of erosion and sediment concentration are not natural:

> "Because of geologic history, non-field sources such as bluffs and large ravines are natural and prevalent features in some watersheds. Consequently these watersheds are predisposed to high erosion rates. However, it would be highly inaccurate to label this phenomenon as natural. Post-settlement increases in sediment accumulation rates in Lake Pepin, the Redwood Reservoir…and numerous lakes in agricultural watersheds …clearly show that rates of sediment erosion have increased

substantially over the past 150 years. Coupling these observations with the non-field sediment yields determined in this study, demonstrates that the rate of non-field erosion must also have increased. The features and potential for non-field erosion may be natural, but the rate is not.“ (Schottler et al., 2010, page 32)

Starting with the finding that historical, natural background levels of sedimentation in Lake Pepin are almost 10 times less than current rates, the MPCA apportioned this total natural background load among basins in proportion to their relative contributions of sediment to Lake Pepin:

- 75 percent to the Minnesota River;
- 13 percent to the Upper Mississippi River;
- 6 percent to the Cannon River;
- 4 percent to the St. Croix River; and
- 2 percent to minor tributaries and urban areas.

The LA exceeds natural background at all flow intervals. The MPCA made no attempt to divide the LA into subcomponents such as field, ravine, bluff and stream bank, as more research is needed to determine these components with accuracy, a task properly undertaken at the 8-digit major watershed scale or smaller. Field studies are underway that will generate information for use in TSS TMDLs at these hydrologic scales.

Sediment Loads by River Basin and Metroshed

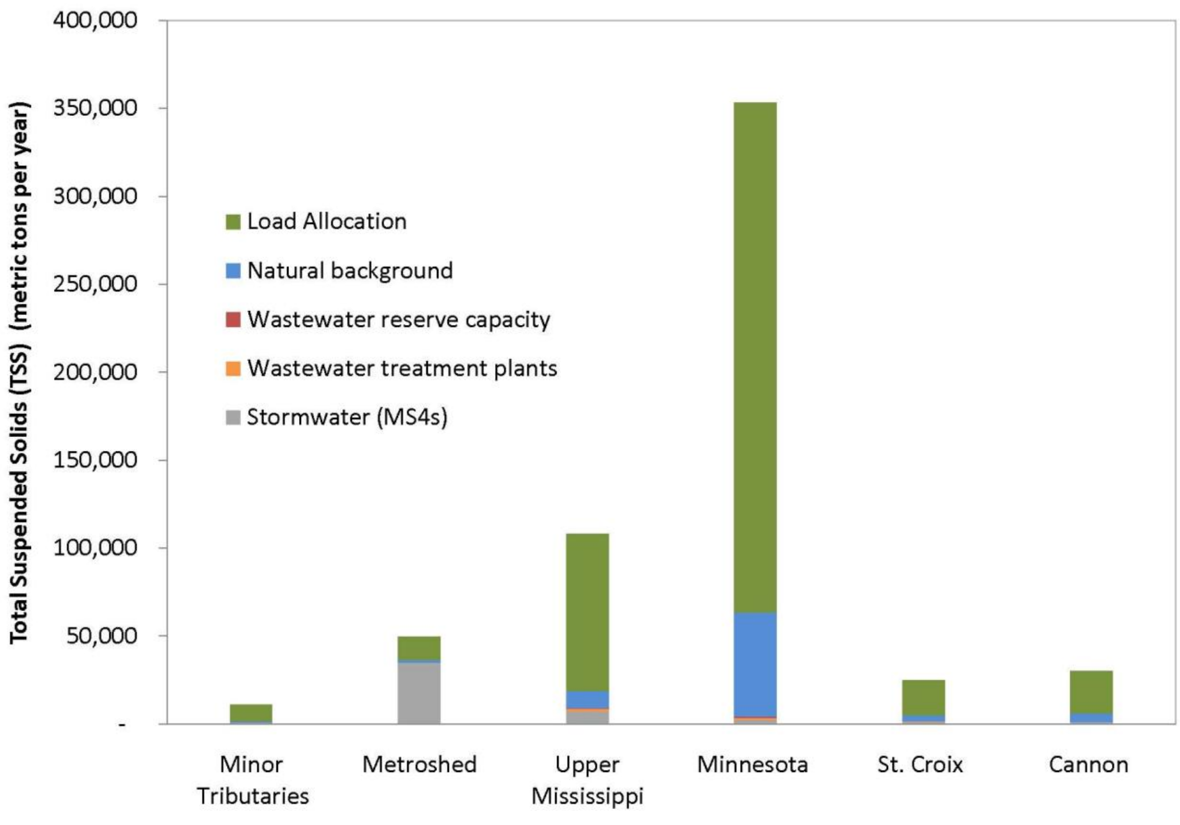


Figure 16. The nonpoint source pollution categories of load allocation and natural background dominate the TMDL allocations for TSS in all areas except the Metroshed, where urban stormwater is prominent. (MPCA graphic)

6.4.1 Margin of Safety

The Clean Water Act requires that a TMDL include a margin of safety (MOS) to account for any lack of knowledge concerning the relationship between load and wasteload allocations and water quality. U.S. EPA guidance explains that the MOS may be implicit, such as incorporated into the TMDL through conservative assumptions in the analysis, or explicit, such as expressed in the TMDL as loadings set aside for the MOS.

An explicit MOS is provided for this TMDL by setting 30 mg/L TSS as the TMDL end point, 6 percent below the water quality standard of 32 mg/L TSS. The more stringent target is based on the TSS criterion proposed for the Mississippi River downstream of Lake Pepin in Navigation Pools 5-9. The Upper Mississippi River Conservation Committee has proposed 30 mg/L TSS as a target to establish and sustain SAV in this reach, which benefits from the natural sediment trapping of Lake Pepin (Sullivan et al., 2009). Because the restoration potential of this reach is naturally higher, a more stringent TSS criterion has been proposed. Adoption of this more stringent water quality target for the Mississippi River upstream of Lake Pepin will provide additional assurance that load allocations specified in the TMDL will result in the restoration of aquatic life, especially SAV (see Critical Conditions in 6.5 below).

The MOS can also be expressed as the increase in TSS load reduction required of the Minnesota River Basin, from 50 to 60 percent of historic baseline, at high and very high flows. This increased increment of reduction was subtracted from the LA for the Minnesota River in order to meet the target of 30 mg/L TSS summer mean under the most critical condition (see 6.5 below.)

6.5 Critical Conditions and Seasonality

The standard governing the TMDL is a summer mean concentration of 32 mg/L TSS, to be attained in half or more years over a 10-year period of record. A critical period for the attainment of this standard is a prolonged continuous number of wet, high-flow years during which attainment of the 32 mg/L TSS summer mean will be more difficult than usual. Such a period occurred during the 1990s. The UMR-LP model allows evaluation of how alternative load-reduction scenarios would have affected each of these years. A critical test for the TMDL is attainment of a 32 mg/L in half or more years over the wettest 10-year period of record for which water quality data are available. The period 1993-2002 results in the highest 10-year median flow. Modeling for the TMDL indicates that the load allocations will achieve the TSS criterion of 32 mg/L during and leading up to the SAV growing season.

Submersed aquatic vegetation in the Mississippi River is subjected to variable light conditions throughout any growing season or series of growing seasons. Monitoring data show that SAV can withstand limited durations of high turbidity, but that prolonged turbid conditions, especially over two or more consecutive years, can impair growth and survival (Sullivan et al., 2009. The site-specific TSS standard is designed to allow vegetation to flourish even though turbidity may be periodically higher than 32 mg/L TSS. Turbidity and SAV suppression occur at moderate and higher river flows. The critical period of SAV growth is June to September. The site-specific TSS standard is designed to protect SAV from high-turbidity conditions during this period. Measures taken to achieve nonpoint source reductions called for in the load allocations will also reduce TSS levels in the April to May period, which tend to be high-runoff months.

7.0 GENERAL IMPLEMENTATION STRATEGY

Restoring the South Metro Mississippi River will require the efforts of residents, businesses and landowners from throughout its vast watershed. The challenge will be to work with urban areas as well as communities and partners in the Minnesota River Basin to reduce the amount of sediment in both the Minnesota and Mississippi rivers. Table 8 lists the current sediment loading by subwatershed and the reductions needed to achieve the turbidity standard.

Table 8. Sediment Loading by Subwatershed in the South Metro Mississippi Watershed			
Sediment Source by Major Inputs	**Current Sediment Loading** metric tons per year (% of total load)	**Load to Meet the TMDL** metric tons per year (% of total load)	**Reduction in Sediment Load** (%)
Cannon	54,000 5.0%	28,000 5.0%	52.0
Metro Wastewater Treatment Plants	900 0.1%	900 0.1%	0*
Minnesota River at Fort Snelling	733,000 74.0%	337,000 64.0%	54.0
Rush/Vermillion	8,000 1.0%	6,000 1.0%	25.0
Other sources	11,000 1.0%	11 2.0%	0
Upper Mississippi River at Lock and Dam 1	157,000 16.0%	127,000 24.0 %	19.0
St.Croix River	24,000 2.0%	24,000 5.0%	0
* Must maintain current load as population increases			

Implementation strategies will address both source and nonpoint source pollution.

- Point source:
  - Communities that require Municipal Separate Storm Sewer (MS4) permits will need to reduce TSS in stormwater by 25 percent in built-up areas and by 50 percent in newly developed areas, compared to baseline data.
  - The MPCA will also address TSS in construction and industrial stormwater through permits.
  - Wastewater treatment facilities with a permitted effluent concentration exceeding 30 mg/L TSS will be assigned individual WLAs equal to their current permitted discharge (concentration times flow).

- Nonpoint source:
  - Implementation strategies will focus on nonpoint source pollution because it contributes nearly all sediment to the South Metro Mississippi.
  - Implementation will focus on the Minnesota River Basin in particular because it contributes the majority of sediment to the South Metro Mississippi. In fact, success of the TMDL will depend on achieving significant reductions in TSS from a few major subwatersheds in the Minnesota River Basin.

In addition, the MPCA will work with several partners, such as the Minnesota Dept. of Natural Resources and the U.S. Army Corps of Engineers, to decrease internal loading from wind and wave resuspension by 50 percent by building islands and other work in the river.

7.1 MPCA Implementation Approach

The TSS-reduction goals needed to achieve this TMDL will only be achieved if undertaken in a gradual but determined manner, using the appropriate combination of economic incentives, education and regulation needed to meet progressively steeper load-reduction interim targets specified in the TMDL implementation plan, on the way to achieving full attainment with the TSS water quality standard. This approach is sometimes referred to as a three-legged stool that requires an appropriate balance of incentives, education and regulation (Soil and Water Conservation Society, Minnesota Chapter, 1995).

The challenges to achieving nonpoint source TSS reductions are many. Most nonpoint source reduction programs rely on incentives for voluntary compliance. Today, a buoyant feed grain economy has raised net farm income from crop production (Food and Agricultural Policy Research Institute, 2010), increasing disposable private funds available for conservation investments. However, increased profitability has led to inflated crop land values, thereby increasing the direct cost of conservation easements for wetland and prairie restorations and raising the opportunity cost of alternative, conserving land uses, such as perennial land cover.

However, the level of public and private investment funding availability is not the only, or even the main, requirement for effective reduction of nonpoint sources of TSS. Targeting of funds to the most cost-effective TSS reduction sites is equally important. Recently completed and ongoing research on sediment sources can help to target private dollars in addition to a new source of money, the Clean Water Fund, to implement solutions to field runoff, gully erosion and other sources of sediment.

This section describes how the MPCA, working in partnership with federal, state and local units of government, as well as non-government organizations, will attempt to meet challenges and maximize opportunities to achieve water quality standards over time. The implementation approach consists of four parts:

1. **Geographic Scale Linkages:** The MPCA will connect the TMDL goals and implementation strategies to both the South Metro Mississippi watershed scale and the subwatersheds at the 8-digit hydrologic unit scale (HUC). In general, the smaller the hydrologic scale, the greater the detail specified for point and nonpoint source pollutant load allocations and implementation measures.

2. **Nonpoint Source Control Strategies:** Key features of the nonpoint source control strategy include –

    - Careful targeting of implementation measures;
    - Appropriate use of existing nonpoint source control authorities; and
    - Tracking of land use and water quality in a phased mode of implementation.

3. **Point Source Control Strategies:** The MPCA will implement aggregate waste load allocations (WLAs) at the basin scale through agency programs for MS4s, construction stormwater and industrial stormwater. MS4 permits will include a standard set of BMPs to achieve a 25-percent decrease in TSS in urban runoff from baseline conditions. Regarding urban expansion, the Agency will implement criteria to achieve a 50-percent decrease in TSS from pre-development conditions. The WLAs of wastewater permittees will be implemented through NPDES permits, which must be consistent with the assumptions and requirements of the WLAs. Reserve capacity equal to 50 percent of the sum of all wastewater facility WLAs is set aside for new and expanding dischargers with effluent concentration exceeding 30 mg/L.

4. **Complementary Mississippi Restoration Activities:** The MPCA has engaged federal, state and local partners in planning restoration activities for the Mississippi River Navigation Pools 2, 3 and 4 to complement upstream load reductions. These activities are mainly concerned with re-

establishment of submersed aquatic vegetation in shallow littoral areas of the Mississippi and reducing sediment re-suspension.

The next section expands on these four implementation approaches.

7.1.1 Geographic Scale Linkages:

The South Metro Mississippi watershed includes 33 major (8 digit HUC)contributing watersheds. These upstream watersheds include streams with turbidity impairments. The MPCA and local partners are developing TMDLs to address the majority of these upstream impairments.

The MPCA is implementing a framework to integrate its water quality management programs on a major watershed scale, a process that includes:

- Intensive watershed monitoring;
- Assessment of watershed health;
- Development of watershed restoration (TMDL) and protection plans; and
- Management of National Pollutant Discharge Elimination System (NPDES) and other regulatory and assistance programs.

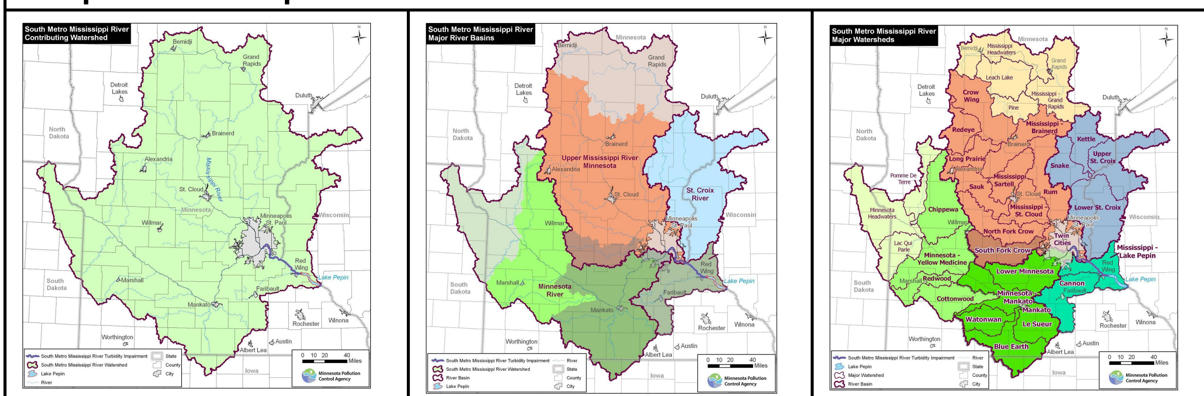
This framework will result in detailed load and waste load allocations for the basin as a whole and the major watersheds within the basin.

The present TMDL defines aggregate load allocations of TSS for the following river basins:

- Minnesota River (at Jordan);
- Upper Mississippi River (at Anoka);
- Cannon River (at Welch);
- Metroshed (seven-county metropolitan area around Minneapolis-St. Paul); and
- Direct tributaries downstream of the Metroshed, excluding the Cannon River.

The implementation plan will describe how programmatic resources, authorities and funding will be deployed at the three operative scales – South Metro Mississippi River Watershed, Tributary Basin, and 8-digit HUC Major Watershed – to ensure that these load allocations are achieved in an accountable and timely fashion. Figure 17 below shows the three scales of implementation

Comparison of implementation scales



Whole watershed scale	Major basin scale	Major watershed scale

Figure 17. The MPCA will implement changes to the South Metro Mississippi Watershed on three scales to achieve the proposed TSS standard of 32 mg/L.

Particular emphasis will be placed on linking TSS load-reductions strategies for the TMDL to implementation planning in major watersheds contributing high sediment loads, such as those shown in Figure18.

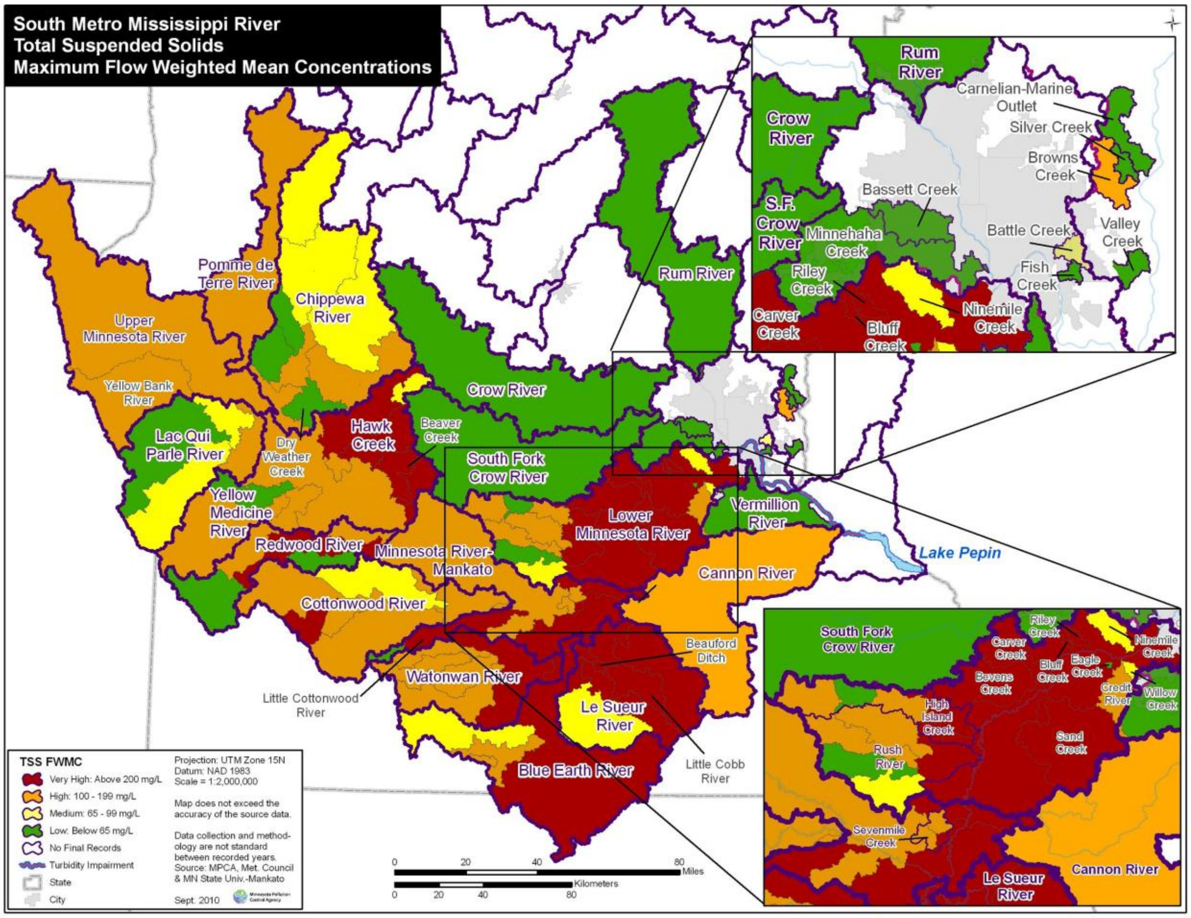


Figure 18. Watersheds are ranked by their potential for high TSS yields, based on maximum TSS annual flow-weighted mean concentrations recorded during 1999 to 2008. Not all monitoring sites had continuous records. The highest potential for TSS yield is focused in the eastern portion of the Minnesota River Basin. Maximum values are listed in Table 9 below. (MPCA graphic)

Further analysis will be conducted before determining priority watersheds. However, to illustrate how a prioritization system would likely work in practice, suppose that watersheds identified as "very high" contributors of sediment in Table 9 are singled out for emphasis in the 10-year major watershed cycle. Those shaded red in Figure 18 are those with the highest maximum annual TSS yields (Table 9). It could be argued that these watersheds, under the right conditions of precipitation and land cover, have the highest potential to contribute sediment to the Mississippi River. The MPCA would review the major watershed plans developed for such high-contributing areas to ensure they are taking into account the sediment-reduction needs of the South Metro Mississippi, and are factoring in the needs of downstream turbidity impairments in their planning and scheduling of BMP implementation.

Table 9. Maximum Flow-Weighted Mean concentrations of TSS for Watersheds of the South Metro Mississippi River Basin Data are basis for Figure 18			
Watershed	**Max TSS FWMC (mg/L)**	**Watershed**	**Max TSS FWMC (mg/L)**
South Fork Crow River	45	Nine Mile Creek	96
Crow River	60	Carnelian-Marine Outlet	3
Rum River	28	Silver Creek	42
Bassett Creek	37	Browns Creek	153
Minnehaha Creek	12	Valley Creek	11
Fish Creek	20	Chippewa River	83
Vermillion River	45	Dry Weather Creek	53
Cannon River	160	Hawk Creek	324
Beauford Ditch	258	Beaver Creek	300
Little Cobb River	239	High Island Creek	1223
Le Sueur River	918	Rush River	792
Blue Earth River	362	Seven Mile Creek	331
Sand Creek	837	Watonwan River	208
Bevens Creek	429	Little Cottonwood River	265
Carver Creek	298	Cottonwood River	804
Bluff Creek	472	Redwood River	354
Riley Creek	531	Yellow Medicine River	130
Eagle Creek	9	Lac Qui Parle River	79
Credit River	137	Yellow Bank River	154
Willow Creek	837		

7.1.1.1 South Metro Mississippi River Watershed Scale

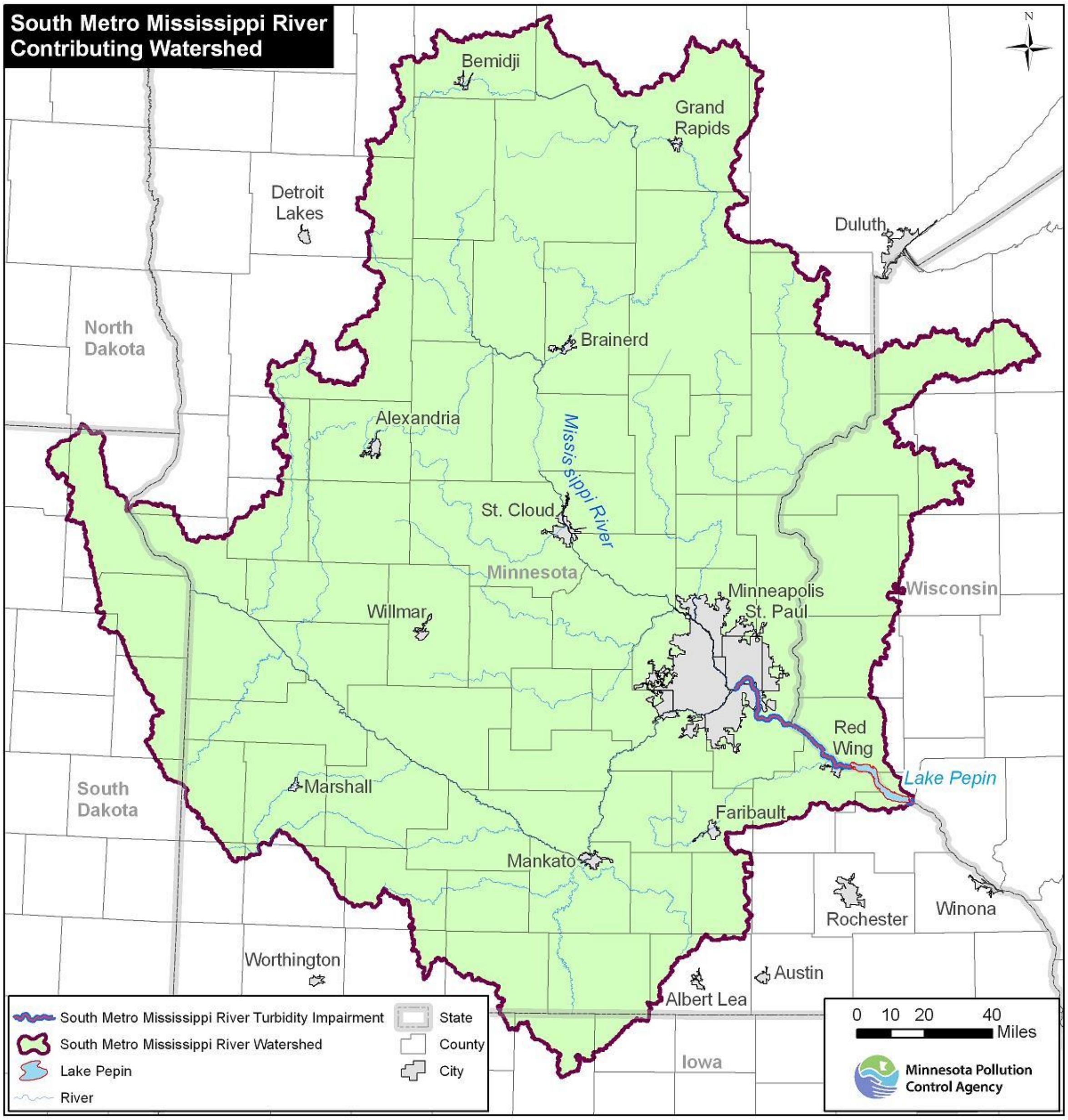


Figure 19. This map represents the entire South Metro Mississippi River watershed scale. (MPCA graphic)

Implementation across the entire watershed will consist of the following elements.

- **Source Identification and Targeting**. The MPCA and local partners will use recent studies and water quality monitoring data (e.g., Nieber et al., 2010) to identify areas that contribute high percentages of sediment to the basin. For example, in Figure 19 above, major watersheds highlighted in red contribute disproportionate volumes of nonpoint source sediment to the South Metro Mississippi River. The Agency, and partners such as the Minnesota River Data Center, will target areas within these watersheds by using information from additional water quality monitoring, studies on sediment sources, LiDAR and small watershed modeling.

- **Phase One Load Reduction Plan:** In coordination with basin strategy development, the MPCA will create a plan to implement a 25 percent reduction in nonpoint source loads of total suspended solids to the South Metro Mississippi. This plan will serve as the nonpoint source component of a Phase I Plan to achieve balanced reductions from point and nonpoint sources by 2021.

- **Gap Analysis:** The MPCA will evaluate existing programmatic, funding, and technical capacity to fully implement basin and watershed strategies. This evaluation will identify gaps in current programs, funding and local capacity to achieve the needed controls. The Agency will commit to systematically fill gaps and build program capacity. The Agency will also agree to meet specific, iterative, short-term (1-2 year) milestones.

- **Adaptive Management:** The MPCA will monitor and report progress at set regular times. It will adjust the implementation plan as necessary, advancing the implementation of any contingency requirements that may be specified in an approved implementation plan if failing to meet milestones after a previously agreed time or after specific actions have been taken. After 10 years, the Agency will evaluate progress in nonpoint source implementation and, if deemed inadequate, undertake a thorough, multi-agency review of existing approaches and recommend modifications in funding, programs and authorities.

- **Hydrology and Water Quality Assessment**: Building on past and current research projects[1], the MPCA will develop a plan to evaluate and modify hydrologic conditions for water quality improvement, with an emphasis on developing land use strategies to reduce rates of stream bank and bluff erosion in areas of high net sediment losses from the stream channel.

- **Economic Analysis:** The costs and benefits of alternative BMPs are site-specific. The cost of the same practice can vary widely among watersheds depending on land values, site characteristics, and BMP design parameters. The MPCA is funding a University of Minnesota study of three small watersheds (Seven Mile Creek, Little Cannon, and West Fork Beaver Creek) to comprehensively evaluate market- and non-market costs and benefits of alternative approaches to meeting sediment targets for the TMDL. In this "full cost accounting" study, the University is using modeling of watershed hydrology, land use, ecosystem services and economics to determine economically optimal solutions. The Agency will share this information with organizations preparing land use management plans in priority watersheds to evaluate cost and benefit tradeoffs.

- **Data Storage and Retrieval System:** There is a need for a central clearinghouse of data and information generated from stream monitoring, watershed modeling and other research pertaining to sediment and phosphorus sources, pathways, and BMPs. The Water Resources Center of Minnesota University-Mankato has a Minnesota River Data Center that could be evaluated as a model for such a system. Data storage and management systems such as EQuIS, eLink and the U.S. Geological Survey LTRM program will continue to be used.

[1] Current research includes two related projects linking tile drainage intensity with stream hydrology and sedimentation rates of Lake Pepin undertaken by the St. Croix Watershed Research Station of the Science Museum of Minnesota in collaboration with the Water Resources Center of Minnesota State University.

7.1.1.2 Basin Scale

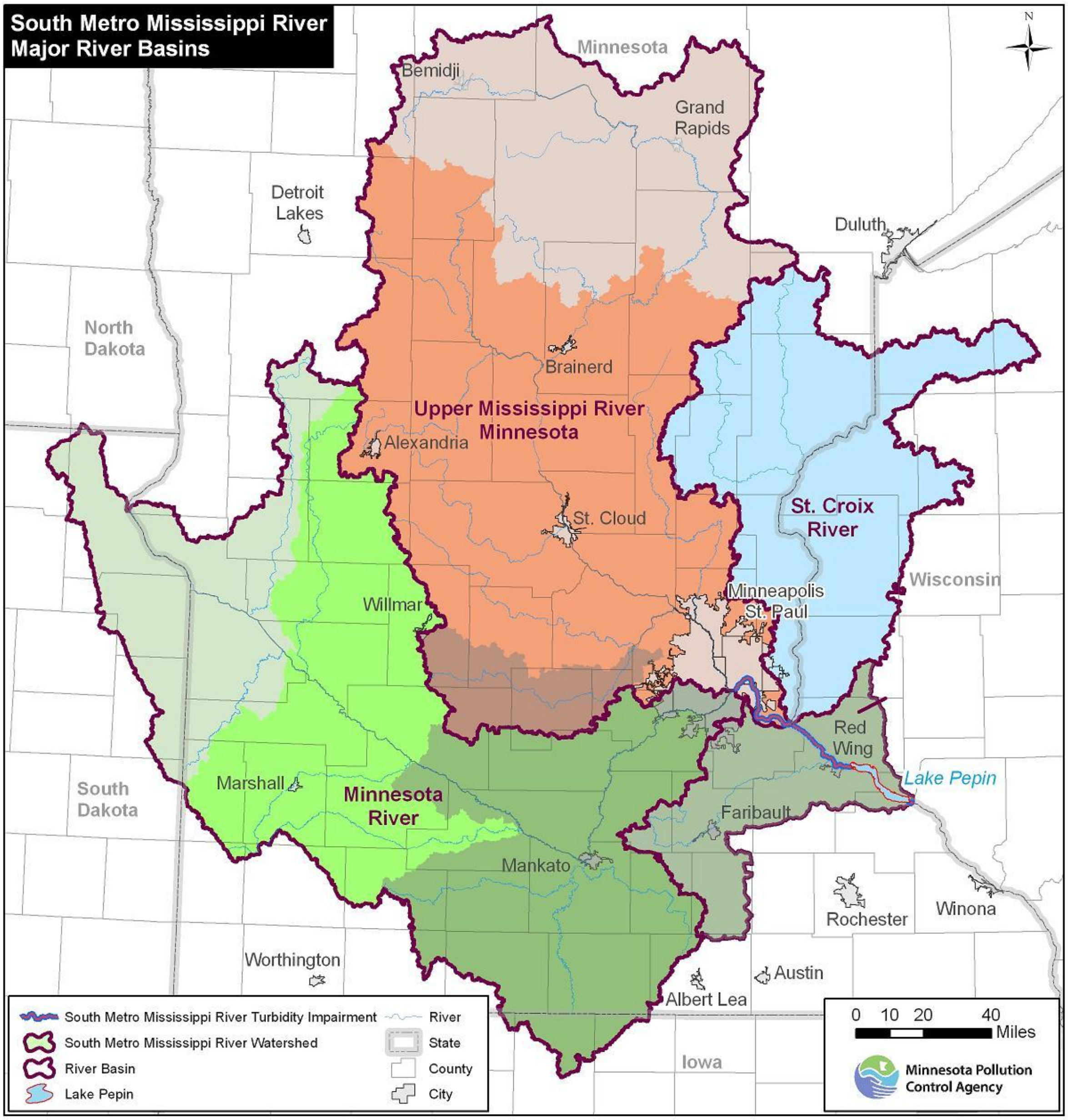


Figure 20. This map represents the basin scale of the South Metro Mississippi River TSS TMDL. (MPCA graphic)

Implementation on the basin level will consist of the following elements.

- **Basin Strategy Development:** The MPCA, in consultation with local partners, will allocate basin load-reduction targets among major watersheds. The Agency will develop load-reduction strategies for the Minnesota River Basin, Cannon River watershed, plus direct watersheds, to meet TMDL allocations according to a phased schedule of implementation. This strategy will include how specific activities will be implemented at the appropriate scale – broad basin-wide initiatives and more specific actions for major watersheds. MPCA basin coordinators will lead this development in accordance with the Agency's watershed approach.

- **BMP Targeting Strategy:** To target BMPs and maximize both funding and sediment reduction, MPCA basin plans will identify the subwatersheds that contribute the highest loads of sediment. Within these subwatersheds, the plans will include priority management zones for nonpoint source BMPs. For example, sediment source research indicates that high levels of ravine, stream bluff and bank erosion tend to occur downstream of the abrupt changes in streambed gradient – called knick points – of Minnesota River tributaries. Basin managers will use Geographical Information Systems (GIS) to identify:
  - Areas downstream of knick points of tributaries;
  - Eroding ravines ranked by catchment area;
  - Stream bluffs ranked by susceptibility to erosion;
  - Riparian corridors of streams and drainage ditches; and
  - Areas identified by the soil erodibility index as high priorities.

- **Water Quality Monitoring and BMP Tracking:** Basin plans will include a section describing water monitoring for sediment and tracking of key land-use changes such as surface crop residue and inventory updates on eroding ravines, bluffs and stream banks. Tracking and monitoring plans will build on existing efforts such as the "State of the Minnesota River Report" and crop residue transect surveys.

7.1.1.3 Major Watershed Scale

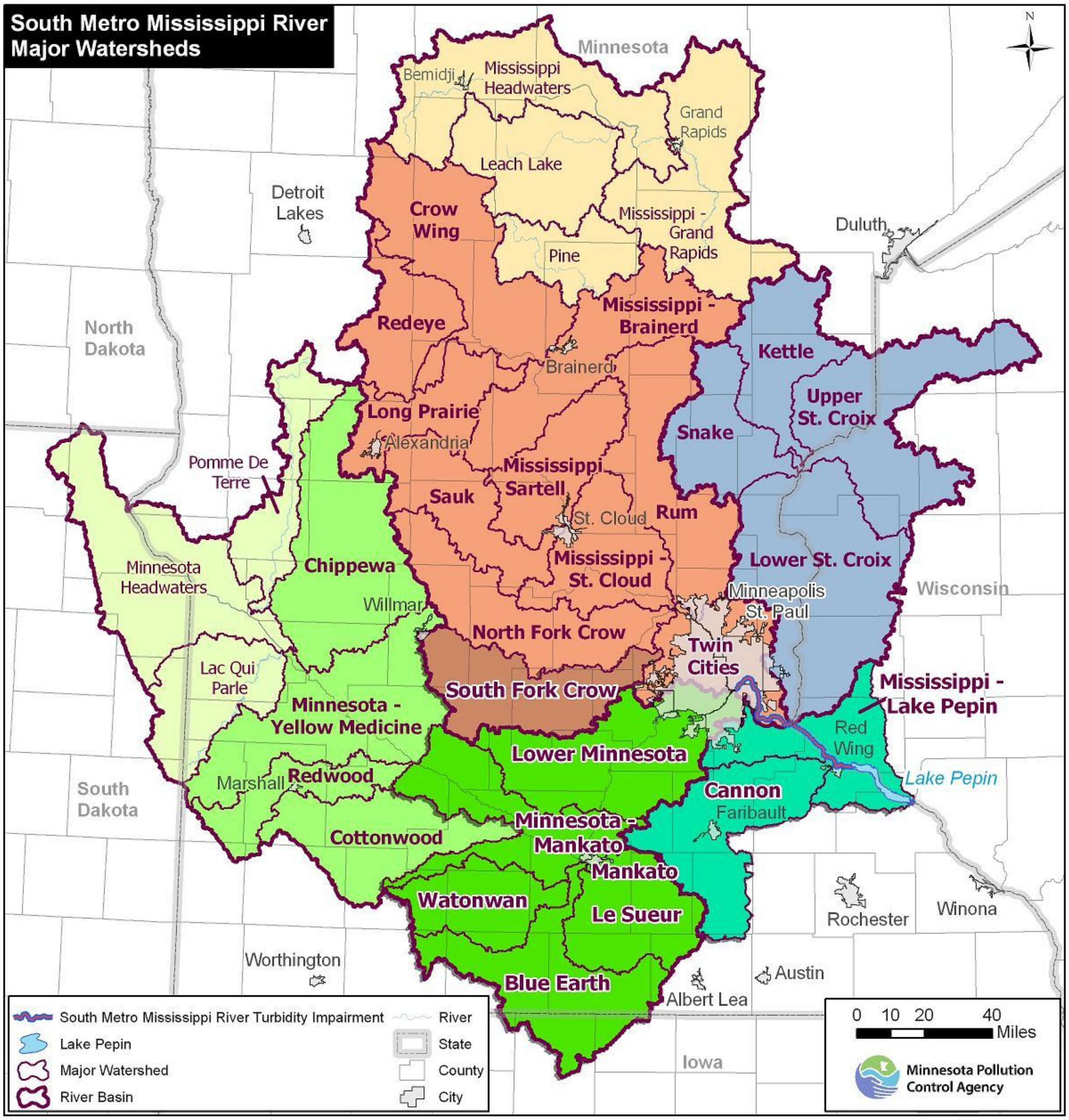


Figure 21. This map represents the major watershed scale of the South Metro Mississippi River TSS TMDL. (MPCA graphic)

The 8-digit hydrologic unit watershed is the scale at which most nonpoint source planning and implementation will occur. The Agency will use plans and databases developed at larger scales, with other input, to assist in and review the development of plans for execution at the major watershed scale. Watershed plans may address additional water quality issues such as TMDLs for impairments in the watershed itself or downstream impairments other than those addressed in the South Metro Mississippi TMDL. These plans many also address protection of threatened water resources.

- **Planning Cycle for Priority Watersheds**: For purposes of South Metro Mississippi TMDL, major watersheds of concern are those listed in Table 10, below. Each watershed is scheduled to be addressed through a cyclical sequence of monitoring, assessment and implementation planning that has been established for Minnesota's 81 major watersheds. The sequence shown here is in draft, subject to adjustments.

- **Comprehensive Watershed Plan Development:** Local partners in priority watersheds will work in cooperation with MPCA project managers to develop detailed implementation plans. They will develop a Phase One component first by 2013, using load-reduction goals allocated to the watershed as water quality targets to achieve by 2020. Basin coordinators will work with project managers to ensure that appropriate data sets are made available to local partners, and that broad strategies for load reductions are considered in the development of the watershed plans. They will develop Phase II and subsequent phases in accordance with the watershed approach schedule shown in Table 9, above, to achieve both the full load reductions needed for the South Metro Mississippi TMDL, as well as other TMDLs that may require additional load reductions.

- **Links to Local Government Units:** A critical aspect of major watershed plans will be to link water quality objectives, including those of the South Metro Mississippi TMDL and additional TSS TMDLs nested within the overall watershed, to programs and authorities administered by local government units such as counties, municipalities, watershed districts, soil and water conservation districts (SWCDs), and water management organizations. Local offices of the Natural Resources Conservation Service (NRCS) of the U.S. Department of Agriculture also provide critical technical and financial support for comprehensive resource conservation, which needs to be integrated into local planning efforts, especially with the SWCDs. This is scale where the MPCA and local partners will develop specific plans, including BMP implementation and administration of programs governing feedlots and land-use zoning. Basin plans will define linkages with local units of government within their drainage area, and with the South Metro Mississippi TSS TMDL downstream.

Table 10: Priority Watershed Planning Schedule

Watershed	Monitoring	Planning	Implementation
Le Sueur River	2008	2011	2012-17
Hawk Creek	2010	2013	2014-29
Watonwan River Middle Minnesota River	2013	2016	2017-22
Lower Minnesota River Rush River High Island Creek	2014	2017	2018-23
Redwood River Cottonwood River	2016	2019	2020-25
Blue Earth River	2017	2020	2021-26

7.2 Potential Implementation Activities

This section of the report focuses on potential activities that could reduce sediment loads from internal sources and from major contributing tributaries to the South Metro Mississippi River. Listed activities are taken from Minnesota River watershed modeling, suggestions from stakeholder and non-MPCA scientists, and MPCA staff. In particular, Scenario 4 from a Minnesota River modeling study (Tetra-Tech, 2009) has led the MPCA to focus on targeted perennial vegetation, ravine stabilization, and increased surface water storage as essential to the ultimate attainment of TMDL goals. Through these and additional practices, sediment loads at Jordan, near the mouth of the main stem Minnesota River, were reduced by about half in average flow years. More conventional Best Management Practices, such as riparian buffers and conservation tillage, can help to make further progress in field erosion reduction, but by themselves cannot achieve the TMDL goals.

7.2.1 Internal Load-Reduction Practice

The MPCA will work with several partners, such as the Minnesota DNR, U.S. Army Corps of Engineers and U.S. Fish and Wildlife Service, to reduce in-river loading through building islands and periodic water level drawdowns. Islands in shallower areas with wide expanses of open water, such as lower Pool 2, can reduce wind fetch in order to cut down on sediment re-suspension. Drawdowns of the water level in a navigation pool expose the bottom sediment in shallow floodplains and areas near islands, allowing the sediment to dry and consolidate. Exposure also facilitates the growth of rooted vegetation, which reduces wind and wave erosion. The Mississippi Makeover project is developing detailed plans for this work (Jester 2010).

7.2.2 Agricultural Best Management Practices

Every level of planning will identify BMPs for agricultural land and will target areas that contribute the most sediment. Such practices include:

- Residue management;
- Cover crops;
- Conservation structures;
- Buffers and grade stabilization structures at the field-ravine interface; and
- Stream and drainage ditch buffers.

7.2.2.1 Drainage System Maintenance Practices

Because artificial drainage has changed the hydrology of the South Metro Mississippi Basin and its watersheds, agricultural BMPS will also address practices such as:

- Surface tile intake buffering; and
- Tile outlet protection, including water storage and drop structures.

7.2.2.2 Bluff top stabilization practices

Research shows bluffs are a major contributor of sediment in some of the South Metro Mississippi watersheds. Stabilization practices such as the following will play a critical role:

- Planting deep-rooted perennial vegetation;
- Restricting development and agricultural uses in a bluff impact zone; and
- Artificial drainage to divert shallow groundwater pressure and seeps.

7.2.2.3 Water storage for hydrologic stabilization

Scenario 4 from Tetra-Tech (2009) calls for controlled drainage on crop land with less than 1 percent slope, plus use of practices to store the first one inch of potential storm runoff for at least 24 hours. Water storage in the soil profile, in wetlands, behind ditch banks and road embankments needs to be considered and prioritized. Wetlands restored under the Conservation Reserve Enhancement Program, as well as culvert down-sizing in southwest Minnesota, can serve as models in developing a concerted strategy to reduce storm hydrographs, pollutant concentrations and loads. Measures to protect ravines from erosive tile drainage discharges can be designed to temporarily store and release water. These types of measures will help to moderate the stream flow hydrograph, potentially reducing erosion of stream banks and bluff toes. In-stream treatments are discussed in Nieber et al., 2010.

7.2.2.4 Research Needs

Studies to examine which mechanism or combination of mechanisms is responsible for recent increases in non-field erosion must be continued. Potential mechanisms include artificial drainage, loss of perennial vegetation and precipitation patterns. Simultaneously, research on drainage modifications such as the effect of two-stage ditch configurations on hydrology, should continue. Research on the cost and social acceptability of water-storage practices also is needed. As research generates new information on relationships between land use, precipitation, drainage system design and hydrology, implementation strategies should be refined accordingly.

7.2.3 Urban Stormwater Best Management Practices

The Implementation Plan for this TMDL will contain a list of BMPs that, when implemented, are considered to bring permittees in compliance with the reduction requirement from developed areas. The BMPs will focus on prevention, education and other good housekeeping measures. Specific examples include:

- Improved or enhanced street sweeping;
- Lawn and leaf recycling programs;
- Ordinances designed to reduce waste, such as pet waste ordinances, and ordinances to prevent yard waste from being placed on impervious surfaces; and
- Education efforts focused specifically on reducing pollutant loads of TSS.

Guidance and pollutant reduction credits for these BMPs will be developed in conjunction with the TMDL implementation plan.

In newly developing areas, pollutant loads above natural background must be reduced by 50 percent. This reduction will primarily be accomplished by implementation of structural BMPs. Permittees will be encouraged to implement BMPs that also reduce stormwater runoff volumes. Many of these BMPs are associated with Low Impact Development and Conservation Design.

Rather than implement BMPs included in the TMDL implementation plan, permittees may choose to demonstrate that pollutant loads from their MS4 meet the target load of 169 lbs/acre/year from developed areas and 112.5 lbs/acre/year from newly developed areas. This proof can be accomplished through water quality monitoring or modeling. In the case of modeling, permittees will implement BMPs as necessary to achieve the target concentrations.

The Minnesota Stormwater Manual (http://www.pca.state.mn.us/water/stormwater/stormwater-manual.html) provides information on the design and reported effectiveness of a wide range of BMPs. The manual also includes a discussion of appropriate models for predicting pollutant loads from urban stormwater.

7.2.4 Wastewater Treatment Facility TSS

As explained above, wastewater treatment facilities that discharge at a concentration of 30 mg/L or less, which includes most of the larger facilities, do not cause or contribute to impairment of the South Metro Mississippi River, as they are discharging below the TSS standard of 32 mg/L TSS. The bulk of those facilities that discharge at or above the TSS standard are comprised of stabilization ponds. Most of these are small facilities that discharge twice a year, typically in the March-June time frame and in the September-October time frame. The TMDL sets individual WLAs for these facilities equal to current permitted discharge. This adds up to a total potential wastewater discharge of 2,622 metric tons per year, or about one half of 1 percent of the total TSS load to the South Metro Mississippi River under average flow conditions. Since the total discharge is insignificant, each will receive a WLA equal to its permitted TSS discharge. Thus, no immediate reductions in TSS loads will be required. Over time, as existing facilities grow and new ones are proposed, a reserve capacity of 1,322 metric tons/year will be set aside for those discharging at more than 32 mg/L TSS.

7.3 Reasonable Assurance of Nonpoint Source Controls

A TMDL needs to provide reasonable assurance that water quality targets will be achieved through the specified combination of point and nonpoint source reductions reflected in the LAs and WLAs. "When a TMDL is developed for waters impaired by both point and nonpoint sources, and the WLA is based on an assumption that nonpoint source load reductions will occur ... the TMDL should provide reasonable assurances that nonpoint source control measures will achieve expected load reductions in order for the TMDL to be approvable. This information is necessary for EPA to determine that the TMDL, including the load and wasteload allocations, has been established at a level necessary to implement water quality standards." (U.S. EPA, 1992)

EPA's expectations regarding the reasonable assurance section of a TMDL are described in a four-part test for nonpoint source actions or management measures. They must be:

1. Specific to the pollutant and waterbody for which the TMDL is being established;
2. Implemented as expeditiously as practicable;
3. Accomplished through a reliable delivery system, and
4. Supported by adequate funding.

(EPA 200065 Fed. Reg. 43586 (July 13, 2000).)

In the South Metro Mississippi TSS TMDL, required point source controls will not be effective in improving water quality unless accompanied by considerable reductions in nonpoint sources. Another large TMDL project, for the Chesapeake Bay, has worked with U.S. EPA to define components of reasonable assurance and a framework for implementation (http://executiveorder.chesapeakebay.net/file.axd?file=2009%2f9%2f202(a)+Water+Quality+Draft+Report.pdf) (last viewed 7/16/2010):

- Revise tributary strategies to identify controls needed to meet TMDL allocations;
- Evaluate existing programmatic, funding, and technical capacity to fully implement tributary strategy;
- Identify gaps in current programs and local capacity to achieve the needed controls;
- Commit to systematically fill gaps and build program capacity;
- Agree to meet specific, iterative, short-term (1-2 year) milestones;
- Demonstrate increased implementation and/or pollutant reductions;
- Commit to track/monitor/assess progress at set times – adaptive management; and
- Accept contingency requirements if milestones are not met.

For the South Metro Mississippi TMDL, the MPCA will loosely adopt the Chesapeake Bay Reasonable Assurance framework, with some modifications as follows:

- Develop strategies for the basins of the Minnesota, Upper Mississippi and Cannon Rivers, plus direct watersheds, to meet TMDL allocations according to a phased schedule of implementation. This strategy will include how specific activities will be implemented at the appropriate scale – broad basin-wide initiatives and more specific actions for major watersheds. MPCA basin coordinators will lead these strategies in accordance with the watershed approach.
- Evaluate existing programmatic, funding, and technical capacity to fully implement basin and watershed strategies.
- Identify gaps in current programs, funding and local capacity to achieve the needed controls.
- Commit to systematically fill gaps and build program capacity. Agree to meet specific, iterative, short term milestones. Demonstrate increased implementation and/or pollutant reductions.

- Commit to track/monitor/assess and report progress at set regular times – adaptive management.
- Accept contingency requirements if certain milestones are not on schedule.

Contingency requirements can take the form of:

- Access to funding by local units of government;
- Review of statewide nonpoint source control programs and policies by state agencies, and their implementation by local agencies;
- Requirements or inducements to implement existing nonpoint source authorities, including protected shoreland buffers (MN Statutes 103F.201). For example, Dodge, Olmsted, Winona and Goodhue counties working to achieve county-wide compliance using existing staff.
- Require buffers on public drainage ditches (MN Statutes 103E.021) by a time certain. Six counties in the Minnesota River Basin have ordered a redetermination of benefits on all systems, which results in buffer implementation. These include Martin, Sibley, Freeborn, Steele, Redwood and Faribault. Fourteen other counties are using this process on selected drainage systems.
- Prohibition against excessive soil loss (MN Statutes 103F.415). Fillmore, Olmsted and Mower counties have such an ordinance in place.
- Prohibition of nuisance nonpoint source pollution (MN Rules 7050.0210, Subp.2).
- Other existing regulatory measures that may be identified in the TMDL implementation plan.

Within this framework of implementation, reasonable assurance will be provided with regard to nonpoint sources through commitments of funding, watershed planning, and use of existing regulatory authorities. The Clean Water Legacy Act (2006) provided the MPCA authority and direction for carrying out section 303(d) of the Clean Water Act, in addition to one-time funding to initiate a comprehensive10-year process of assessment and TMDL development in Minnesota. In November 2008, Minnesotans voted in support of the Clean Water, Land and Legacy Amendment to the state constitution. Through this historic vote, about $5.5 billion will be dedicated to the protection of water and land over the next 25 years. One third of the annual proceeds from sales tax revenue, an estimated $80 to $90 million, will be devoted to a Clean Water Fund to protect, enhance and restore water quality of lakes, rivers, streams and groundwater. The Amendment specifies that this funding must supplement and not replace traditional funding. Approximately two-thirds of the annual proceeds will be earmarked for water quality protection and restoration.

In addition, efforts will be made to make more effective use of existing land-use authorities, as the Clean Water Legacy Act (Minn Stat. Ch. 114D.20, Subd 3) enjoins state agencies to "…use existing regulatory authorities to achieve restoration for point and nonpoint sources of pollution where applicable, and promote the development and use of effective nonregulatory measures to address pollution sources for which regulations are not applicable." The MPCA will seek to pursue the following policies with state and local agencies:

- Comply with 50 foot buffer required for the shore impact zone of streams classified as protected waters (MN Statutes 103F.201) for agricultural land uses;
- Comply with requirements to buffer highly erodible land within the 300-foot shoreland district, as described in the state shoreland rule;
- Establish a process and timeline to ensure compliance with the requirement for a 16.5-foot buffer on agricultural drainage ditches as defined in Minn. Stat. 103E.021;
- Review the use of excessive soil loss ordinances by counties (described in MN Statutes 103F.415) and the potential benefits of applying soil loss ordinances specifying a maximum rate of "T" (the tolerable rate of soil erosion which the NRCS defines as the rate at which soil can

replenish itself) to areas contributing high amounts of sediment to the South Metro Mississippi and tributary watersheds; and

- Review the MPCA's authorities on the prohibition of nuisance nonpoint source pollution (MN Rules 7050.0210, Subp.2.

7.4 Water Quality Monitoring Plan

The monitoring plan for the South Metro Mississippi TMDL is drawn from supporting documentation for the TSS site-specific standard (Sullivan et al., 2009).

The site-specific target of 21 percent average SAV frequency of occurrence is based on the Environmental Mapping and Assessment Program (EMAP) sampling design for main channel and side channel borders. A roughly equivalent target for main channel borders of about 12 percent frequency is based on the LTRMP sampling design. These SAV targets are roughly two times existing conditions based on long-term historical estimates (1976-2008) from TSS-derived SAV frequencies. To evaluate attainment of these SAV targets, it is recommended that the initial monitoring frequency be based on a minimum of at least three annual EMAP-based surveys over a 5-year period. To simplify the SAV monitoring design and to make it consistent with the recommended TSS monitoring described below, the attainment of the SAV target should be evaluated by focusing on the river reach extending from Lock and Dam 2 to the Rush River in upper Lake Pepin. Once the target has been consistently achieved, then a re-evaluation of the monitoring frequency can be made.

Achieving the above SAV frequencies for main channel borders can be expected to yield improved SAV frequency of occurrence in other aquatic areas (side channels and backwaters), but these would be considered secondary targets since they were not directly linked with main channel TSS concentrations.

To achieve the above SAV targets, summer average TSS concentrations will need to be reduced about 32 percent (47 to 32 mg/L) from existing conditions based on the combined monitoring data for Locks and Dams 2 and 3. It is suggested that attainment be based on achieving a median and 90th percentile summer average TSS concentrations of 32 and 44 mg/L, respectively, based on combined bi-weekly monitoring at Locks and Dams 2 and 3. The 90th percentile was derived for main channel summer average data (1998-07) for Pool 13, a desirable reference pool that was used to derive the SAV targets. Achieving these TSS criteria will improve the conditions for SAV growth throughout the turbidity impaired reach and result in reduced sediment infilling of Lake Pepin.

The MPCA's major watershed load monitoring program also will be an integral component of an overall monitoring plan for this TMDL.

8.0 PUBLIC PARTICIPATION RECORD

The MPCA built participation by stakeholders, scientists, and the general public into the TMDL process from the start. The MPCA invited a representative group of individuals to the first Stakeholder Advisory Committee in October 2004, and has involved this group in discussions ever since (Appendix C). It engaged the SAC in the development of two successive TMDL work plans – the first one to guide water quality assessment, and the second to guide watershed analysis. The MPCA promptly posted both on its web site. The MPCA has also posted presentations given at SAC meetings on its web site.

The Lake Pepin TMDL Science Advisory Panel (SAP) was established in February 2005, in consultation with the SAC and the University of Minnesota. (Appendix C). The first task undertaken by the SAP was to advise the MPCA on the development of a Request for Proposals for Lake Pepin (including the South Metro Mississippi) TMDL modeling. A sub-group worked on details of the RFP work plan, which the entire SAP reviewed before the draft was finalized. The SAP met subsequently on occasion to review and comment on modeling results, the last such meeting being on Oct. 8, 2008. In addition to attendance at meetings, several SAP members contributed many hours to discussion and analysis of technical issues that arose during the development and application of the Upper Mississippi River-Lake Pepin model.

The MPCA held three sector-specific meetings in summer 2008 with groups representing:

- Agriculture;
- Conservation and environmental protection; and
- Municipal wastewater and stormwater.

As a follow-up to this meeting, an MS4 stakeholder advisory group was formed and met three times with considerable email correspondence. It includes representatives from MS4 communities, their consultants, and the MPCA. About 60 were involved in the kickoff meeting, where 13 members of the advisory group were selected. Meetings typically had eight to 10 people. This group focused on choosing a strategy for linking the permit to the TMDL and setting allocations.

In addition to the SAC and SAP, the MPCA has involved the broader public through annual forums and conferences. The MPCA held three Lake Pepin Forums in Red Wing, Minn., on the Mississippi River, to engage stakeholders and citizens from the immediate vicinity of the impaired waters. Three annual technical conferences on the Lake Pepin TMDL also were held in 2006, 2007 and 2008 – the first two in the Twin Cities, and the third in Mankato, for two days. MPCA staff has made presentations on the Lake Pepin TMDL for many organizations and audiences, including the Minnesota Association of Watershed Districts, Minnesota Association of Soil and Water Conservation Districts, Upper Mississippi River Basin Association, Upper Mississippi River Conservation Committee, and others.

In order to further strengthen local and regional ties to this large, complex TMDL project, the MPCA has contracted with Dakota County and Dakota County SWCD to coordinate “Mississippi Makeover,” a project to coordinate both local land use planning and Mississippi River management with the TMDL. A stakeholder group formed for Mississippi Makeover has developed a list of environmental indicators for the project. A technical committee chaired by Minnesota Dept. of Natural Resources developed metrics, or quantitative targets, for each of these indicators. The result will be an adaptive management approach to integrating the TMDL with river management and local land use planning.

Finally, following development of a Draft TMDL on (date), the MPCA will conduct a public notice involving the following elements:

- Official public notice published in the State Register;
- Open house events held at five locations as follows:
    - Agriculture Sector: Location and co-sponsorships to be determined.
    - Metro Area Point Sources: Dakota Lodge, Thompson Park, West St. Paul, date, co-hosted by Friends of the Mississippi River and the National Park Service.
    - River Restoration Focus: St James Hotel, Red Wing, co-hosted by Lake Pepin Legacy Alliance.

Comments made during the public notice period were addressed in a memorandum from the MPCA, which is included with the TMDL as Appendix 4.

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APPENDIX A: Wastewater Treatment Facility Waste Load Allocations

Name	Permit Number	Sub-Watershed	Major Watershed	HUC-8	Kilograms/ Year
Seneca Foods Corp - Glencoe	MN0001236	Upper Mississippi	Crow River, South Fork	07010205	310,843.13
Northern Metal Recycling	MN0063380	Metroshed	Mississippi River (Twin Cities)	07010206	223,116.29
MA Gedney Co	MN0022446	Metroshed	Minnesota River (Shakopee)	07020012	155,421.56
Bongards' Creameries Inc	MN0002135	Metroshed	Minnesota River (Shakopee)	07020012	115,820.15
Redwood Falls WWTP	MN0020401	Minnesota	Minnesota River (Granite Falls)	07020004	82,124.75
Wells-Easton-Minnesota Lake WWTP	MN0025224	Minnesota	Le Sueur River	07020011	67,639.46
Paynesville WWTP	MN0020168	Upper Mississippi	Crow River - Crow River, North Fork	07010204	55,143.57
Belle Plaine WWTP	MN0022772	Metroshed	Minnesota River (Shakopee)	07020012	52,221.65
Montrose WWTP	MN0024228	Upper Mississippi	Crow River - Crow River, North Fork	07010204	48,553.70
Del Monte Corp - Plant 114	MN0001171	Minnesota	Cottonwood River	07020008	47,745.50
Pine City WWTP	MN0021784	St. Croix	Snake River (St. Croix River)	07030004	46,626.47
Cokato WWTP	MN0049204	Upper Mississippi	Crow River - Crow River, North Fork	07010204	45,134.42
Sleepy Eye WWTP	MNG580041	Minnesota	Cottonwood River	07020008	43,518.04
Milaca WWTP	MN0024147	Upper Mississippi	Rum River	07010207	42,212.50
Serpent Lake WWTP	MN0058122	Upper Mississippi	Mississippi River (Brainerd)	07010104	41,777.32
Isanti WWTP	MNG550008	Upper Mississippi	Rum River	07010207	40,844.79
Gaylord WWTP	MN0051209	Minnesota	Minnesota River (Shakopee)	07020012	34,192.74
Long Prairie WWTP - Industrial	MN0020303	Upper Mississippi	Long Prairie River	07010108	31,737.08
Acme-Ochs Plant	MN0061646	Minnesota	Cottonwood River	07020008	30,773.47
Moose Lake WWTP	MN0020699	St. Croix	Kettle River	07030003	30,773.47
Albany WWTP	MN0020575	Upper Mississippi	Mississippi River (Sartell)	07010201	28,348.89
Mapleton WWTP	MN0021172	Minnesota	Le Sueur River	07020011	25,240.46
Shafer WWTP	MN0030848	St. Croix	St. Croix River (Lower)	07030005	24,867.45
Rush City WWTP	MN0021342	St. Croix	St. Croix River (Lower)	07030005	24,836.37
East Gull Lake WWTP	MN0059871	Upper Mississippi	Crow Wing River	07010106	24,643.64
Browerville WWTP	MN0022926	Upper Mississippi	Long Prairie River	07010108	23,997.09
Sandstone WWTP	MN0056910	St. Croix	Kettle River	07030003	23,810.58
Motley WWTP	MN0024244	Upper Mississippi	Crow Wing River	07010106	23,313.23

Name	Permit Number	Sub-Watershed	Major Watershed	HUC-8	Kilograms/ Year
Foley WWTP	MN0023451	Upper Mississippi	Mississippi River (St. Cloud)	07010203	23,083.21
Mountain Lake WWTP	MNG580035	Minnesota	Watonwan River	07020010	21,759.02
Winthrop WWTP	MN0051098	Minnesota	Minnesota River (Shakopee)	07020012	21,634.68
Janesville WWTP	MNG580025	Minnesota	Le Sueur River	07020011	21,199.50
Clarkfield WWTP	MN0022306	Minnesota	Minnesota River (Granite Falls)	07020004	20,329.14
Fairfax WWTP	MNG580060	Minnesota	Minnesota River (Mankato)	07020007	19,769.62
Tracy WWTP	MN0021725	Minnesota	Cottonwood River	07020008	18,650.59
Finlayson WWTP	MN0023418	St. Croix	Kettle River	07030003	18,650.59
Osakis WWTP	MN0020028	Upper Mississippi	Sauk River	07010202	18,215.41
Pease WWTP	MNG580167	Upper Mississippi	Rum River	07010207	16,303.72
Minneota WWTP	MNG580033	Minnesota	Minnesota River (Granite Falls)	07020004	14,858.30
Ogilvie WWTP	MN0021997	St. Croix	Snake River (St. Croix River)	07030004	14,298.78
Rich Prairie Sewer Treatment Facility	MN0063657	Upper Mississippi	Mississippi River (Sartell)	07010201	14,273.92
Onamia WWTP	MNG580050	Upper Mississippi	Rum River	07010207	13,055.41
Nicollet WWTP	MNG580037	Minnesota	Minnesota River (Mankato)	07020007	12,931.07
Dairy Farmers of America - Winthrop	MN0003671	Minnesota	Minnesota River (Shakopee)	07020012	12,765.29
Butterfield WWTP	MN0022977	Minnesota	Watonwan River	07020010	12,495.89
Lamberton WWTP	MNG580100	Minnesota	Cottonwood River	07020008	12,433.73
Sebeka WWTP	MN0024856	Upper Mississippi	Redeye River - Leaf River	07010107	12,433.73
Atwater WWTP	MN0022659	Upper Mississippi	Crow River - Crow River, North Fork	07010204	12,433.73
Isle WWTP	MN0023809	Upper Mississippi	Rum River	07010207	12,433.73
Eagle Bend WWTP	MN0023248	Upper Mississippi	Long Prairie River	07010108	12,160.18
Dassel WWTP	MN0054127	Upper Mississippi	Crow River - Crow River, North Fork	07010204	11,687.70
Bird Island WWTP	MN0022829	Minnesota	Minnesota River (Granite Falls)	07020004	11,563.36
Rice WWTP	MN0056481	Upper Mississippi	Mississippi River (Sartell)	07010201	11,501.20
Tyler WWTP	MNG580116	Minnesota	Redwood River	07020006	10,879.51
Royalton WWTP	MN0020460	Upper Mississippi	Mississippi River (Sartell)	07010201	10,755.17
Belgrade WWTP	MN0051381	Upper Mississippi	Crow River - Crow River, North Fork	07010204	10,382.16
Buffalo Lake WWTP	MN0050211	Upper Mississippi	Crow River, South Fork	07010205	10,257.82
Gibbon WWTP	MNG580020	Minnesota	Minnesota River (Shakopee)	07020012	10,009.15
Hoffman WWTP	MNG580134	Minnesota	Chippewa River	07020005	9,884.81
Alden WWTP	MNG580118	Minnesota	Blue Earth River	07020009	9,884.81
Westbrook WWTP	MNG580127	Minnesota	Cottonwood River	07020008	9,325.29
Barnum WWTP	MNG580142	St. Croix	Kettle River	07030003	9,051.75
Hancock WWTP	MN0023582	Minnesota	Chippewa River	07020005	8,890.11

Name	Permit Number	Sub-Watershed	Major Watershed	HUC-8	Kilograms/ Year
Taylors Falls WWTP	MN0053309	St. Croix	St. Croix River (Lower)	07030005	8,765.78
Silver Lake WWTP	MNG580164	Upper Mississippi	Crow River, South Fork	07010205	8,641.44
Cottonwood WWTP	MNG580010	Minnesota	Minnesota River (Granite Falls)	07020004	8,579.27
Cleveland WWTP	MNG580009	Minnesota	Minnesota River (Mankato)	07020007	8,517.10
Brooten WWTP	MN0025909	Upper Mississippi	Crow River - Crow River, North Fork	07010204	8,268.43
Morton WWTP	MNG550018	Minnesota	Minnesota River (Mankato)	07020007	8,206.26
Elysian WWTP	MN0041114	Cannon	Cannon River	07040002	8,081.92
Freeport WWTP	MNG580019	Upper Mississippi	Sauk River	07010202	8,081.92
Elmore WWTP	MN0021920	Minnesota	Blue Earth River	07020009	7,833.25
Balaton WWTP	MN0020559	Minnesota	Cottonwood River	07020008	7,646.74
Wahkon WWTP	MN0047066	St. Croix	Snake River (St. Croix River)	07030004	7,522.40
Harris WWTP	MN0050130	St. Croix	St. Croix River (Lower)	07030005	7,522.40
Belview WWTP	MNG580003	Minnesota	Minnesota River (Granite Falls)	07020004	7,211.56
Franklin WWTP	MNG550004	Minnesota	Minnesota River (Mankato)	07020007	7,149.39
Stewart WWTP	MNG580077	Upper Mississippi	Crow River, South Fork	07010205	7,087.22
Menahga WWTP	MN0056880	Upper Mississippi	Crow Wing River	07010106	6,900.72
Clarissa WWTP	MNG580008	Upper Mississippi	Long Prairie River	07010108	6,341.20
Hampton WWTP	MN0021946	Metroshed	Mississippi River (Red Wing)	07040001	6,279.03
Ellendale WWTP	MNG580014	Cannon	Cannon River	07040002	6,235.51
Evansville WWTP	MN0023329	Minnesota	Chippewa River	07020005	6,216.86
Grey Eagle WWTP	MN0023566	Upper Mississippi	Mississippi River (Brainerd)	07010104	5,781.68
Kiester WWTP	MNG580097	Minnesota	Blue Earth River	07020009	5,595.18
Cosmos WWTP	MNG580056	Upper Mississippi	Crow River, South Fork	07010205	5,595.18
Echo WWTP	MNG580059	Minnesota	Minnesota River (Granite Falls)	07020004	5,377.59
Pennock WWTP	MNG580104	Minnesota	Minnesota River (Granite Falls)	07020004	5,346.50
Russell WWTP	MNG580062	Minnesota	Redwood River	07020006	5,222.16
Raymond WWTP	MN0045446	Minnesota	Minnesota River (Granite Falls)	07020004	5,135.13
Ivanhoe WWTP	MNG580103	Minnesota	Minnesota River (Granite Falls)	07020004	5,097.83
GEM Sanitary District	MN0056863	Upper Mississippi	Sauk River	07010202	5,029.44
Farwell Kensington Sanitary Dist WWTP	MN0065293	Minnesota	Chippewa River	07020005	4,743.47
Pillager WWTP	MN0048909	Upper Mississippi	Crow Wing River	07010106	4,550.74
Chippewa Valley Ethanol Co	MN0062898	Minnesota	Chippewa River	07020005	4,476.14
Jeffers WWTP	MNG580111	Minnesota	Minnesota River (Mankato)	07020007	4,351.80
Geneva WWTP	MN0021008	Cannon	Cannon River	07040002	4,289.64

Name	Permit Number	Sub-Watershed	Major Watershed	HUC-8	Kilograms/ Year
Danube WWTP	MNG580057	Minnesota	Minnesota River (Granite Falls)	07020004	4,165.30
Bricelyn WWTP	MNG580129	Minnesota	Blue Earth River	07020009	4,165.30
Wood Lake WWTP	MNG580107	Minnesota	Minnesota River (Granite Falls)	07020004	4,009.88
Carlos WWTP	MN0023019	Upper Mississippi	Long Prairie River	07010108	3,978.79
Hamburg WWTP	MN0025585	Metroshed	Minnesota River (Shakopee)	07020012	3,916.62
Loretto WWTP	MN0023990	Upper Mississippi	Crow River, South Fork	07010205	3,792.29
Lewisville WWTP	MN0065722	Minnesota	Watonwan River	07020010	3,730.12
Good Thunder WWTP	MN0020851	Minnesota	Le Sueur River	07020011	3,730.12
Vernon Center WWTP	MNG550024	Minnesota	Blue Earth River	07020009	3,649.30
Sanborn WWTP	MNG580115	Minnesota	Cottonwood River	07020008	3,450.36
Lake Lillian WWTP	MN0021954	Upper Mississippi	Crow River, South Fork	07010205	3,326.02
Pemberton WWTP	MNG580075	Minnesota	Le Sueur River	07020011	3,294.94
New Germany WWTP	MN0024295	Upper Mississippi	Crow River, South Fork	07010205	3,232.77
Searles WWTP	MNG580080	Minnesota	Minnesota River (Mankato)	07020007	3,170.60
Ruthton WWTP	MNG580105	Minnesota	Redwood River	07020006	3,139.52
Askov WWTP	MN0022616	St. Croix	St. Croix River (Upper)	07030001	3,133.30
Hanska WWTP	MN0052663	Minnesota	Minnesota River (Mankato)	07020007	3,108.43
Northrop WWTP	MN0024384	Minnesota	Blue Earth River	07020009	3,108.43
Darwin WWTP	MNG580150	Upper Mississippi	Crow River - Crow River, North Fork	07010204	3,108.43
Garfield WWTP	MN0023515	Upper Mississippi	Long Prairie River	07010108	3,046.26
Foreston WWTP	MN0047503	Upper Mississippi	Rum River	07010207	3,040.05
Frost WWTP	MNG580120	Minnesota	Blue Earth River	07020009	2,984.09
Upsala WWTP	MNG580053	Upper Mississippi	Mississippi River (Sartell)	07010201	2,934.36
Lynd WWTP	MNG580030	Minnesota	Redwood River	07020006	2,834.89
Hartland WWTP	MNG580102	Minnesota	Le Sueur River	07020011	2,797.59
Gilman WWTP	MNG580021	Upper Mississippi	Mississippi River (St. Cloud)	07010203	2,797.59
Willow River WWTP	MN0021971	St. Croix	Kettle River	07030003	2,735.42
Murdock WWTP	MNG580086	Minnesota	Chippewa River	07020005	2,642.17
St Martin WWTP	MN0024783	Upper Mississippi	Sauk River	07010202	2,611.08
Blomkest Svea Sewer Board WWTP	MN0069388	Minnesota	Minnesota River (Granite Falls)	07020004	2,486.75
Miltona WWTP	MN0024155	Upper Mississippi	Long Prairie River	07010108	2,486.75
Granada WWTP	MNG580023	Minnesota	Blue Earth River	07020009	2,461.88
Millerville WWTP	MN0054305	Minnesota	Chippewa River	07020005	2,424.58
Grasston WWTP	MN0025691	St. Croix	Snake River (St. Croix River)	07030004	2,362.41
Ghent WWTP	MNG580121	Minnesota	Redwood River	07020006	2,300.24
Vesta WWTP	MNG580043	Minnesota	Redwood River	07020006	2,213.20
Freeborn WWTP	MNG580018	Minnesota	Le Sueur River	07020011	2,213.20
Kettle River WWTP	MNG580183	St. Croix	Kettle River	07030003	2,182.12

Name	Permit Number	Sub-Watershed	Major Watershed	HUC-8	Kilograms/ Year
Storden WWTP	MNG580106	Minnesota	Cottonwood River	07020008	2,174.66
Milroy WWTP	MNG580124	Minnesota	Redwood River	07020006	2,151.03
Hanley Falls WWTP	MNG580122	Minnesota	Minnesota River (Granite Falls)	07020004	2,113.73
Lowry WWTP	MN0024007	Minnesota	Chippewa River	07020005	2,113.73
Deer Creek WWTP	MN0020281	Upper Mississippi	Redeye River - Leaf River	07010107	2,113.73
Hewitt WWTP	MNG580024	Upper Mississippi	Redeye River - Leaf River	07010107	2,113.73
Odin-Ormsby WWTP	MN0069442	Minnesota	Watonwan River	07020010	1,955.20
Dayton Park Properties	MN0041432	Metroshed	Mississippi River (Twin Cities)	07010206	1,927.23
Bowlus WWTP	MN0020923	Upper Mississippi	Mississippi River (Sartell)	07010201	1,865.06
Lucan WWTP	MNG580112	Minnesota	Cottonwood River	07020008	1,715.85
Delavan WWTP	MNG580109	Minnesota	Le Sueur River	07020011	1,715.85
Dennison WWTP	MN0022195	Cannon	Cannon River	07040002	1,556.83
Watson WWTP	MN0022144	Minnesota	Chippewa River	07020005	1,554.22
Clements WWTP	MNG580094	Minnesota	Cottonwood River	07020008	1,554.22
Danvers WWTP	MNG580119	Minnesota	Chippewa River	07020005	1,423.66
Kilkenny WWTP	MNG580084	Cannon	Cannon River	07040002	1,417.44
Garvin WWTP	MNG580101	Minnesota	Cottonwood River	07020008	1,336.63
Taunton WWTP	MNG580090	Minnesota	Minnesota River (Granite Falls)	07020004	1,305.54
Porter WWTP	MNG580128	Minnesota	Minnesota River (Granite Falls)	07020004	1,181.20
Flensburg WWTP	MNG580016	Upper Mississippi	Mississippi River (Brainerd)	07010104	1,150.12
Revere WWTP	MNG580114	Minnesota	Cottonwood River	07020008	1,112.82
Knollwood Mobile Home Park WWTP	MN0030651	Minnesota	Minnesota River (Mankato)	07020007	1,106.60
Saint Leo WWTP	MN0024775	Minnesota	Minnesota River (Granite Falls)	07020004	1,056.87
Sobieski WWTP	MN0041220	Upper Mississippi	Mississippi River (Brainerd)	07010104	1,056.87
Wanda WWTP	MNG580126	Minnesota	Cottonwood River	07020008	1,038.22
Meriden Township WWTP	MN0068713	Cannon	Cannon River	07040002	1,000.91
Sunburg WWTP	MNG580125	Minnesota	Chippewa River	07020005	976.05
Walters WWTP	MN0068756	Minnesota	Blue Earth River	07020009	971.07
Shorewood Park Sanitary District	MN0051390	St. Croix	St. Croix River (Lower)	07030005	932.53
Evan WWTP	MN0066460	Minnesota	Minnesota River (Mankato)	07020007	795.76
Altona Hutterian Brethren WWTP	MN0067610	Minnesota	Minnesota River (Shakopee)	07020012	777.11
MNDOT Straight River Rest Area	MN0049514	Cannon	Cannon River	07040002	746.02
Urbank WWTP	MN0068446	Minnesota	Chippewa River	07020005	683.85
Starland Hutterian Brethren Inc	MN0067334	Minnesota	Minnesota River (Shakopee)	07020012	683.85

Name	Permit Number	Sub-Watershed	Major Watershed	HUC-8	Kilograms/ Year
Cedar Mills WWTP	MN0066605	Upper Mississippi	Crow River, South Fork	07010205	568.84
MDNR Father Hennepin State Park	MN0033723	Upper Mississippi	Rum River	07010207	534.65
Wolf Lake WWTP	MN0069205	Upper Mississippi	Redeye River - Leaf River	07010107	522.22
Neuhof Hutterian Brethren	MNG580113	Minnesota	Watonwan River	07020010	261.11

APPENDIX B: Regulated MS4 List

MS4ID	Name
MS400264	Alexandria City MS4
MS400073	Andover City MS4
MS400001	Anoka City MS4
MS400066	Anoka County MS4
MS400222	Anoka Technical College MS4
MS400223	Anoka-Ramsey Community College MS4
MS400074	Apple Valley City MS4
MS400002	Arden Hills City MS4
MS400231	Baxter City MS4
MS400265	Bemidji City MS4
MS400067	Benton County MS4
MS400249	Big Lake City MS4
MS400234	Big Lake Township MS4
MS400075	Blaine City MS4
MS400005	Bloomington City MS4
MS400266	Brainerd City MS4
MS400068	Brockway Township MS4
MS400006	Brooklyn Center City MS4
MS400007	Brooklyn Park City MS4
MS400238	Buffalo city of MS4
MS400069	Burns Township MS4
MS400076	Burnsville City MS4
MS400250	Cambridge City MS4
MS400206	Capitol Region WD MS4
MS400077	Carver City MS4
MS400070	Carver County MS4
MS400078	Centerville City MS4
MS400171	Century College MS4
MS400008	Champlin City MS4
MS400079	Chanhassen City MS4
MS400080	Chaska City MS4
MS400009	Circle Pines City MS4
MS400010	Columbia Heights City MS4
MS400172	Coon Creek WD MS4
MS400011	Coon Rapids City MS4
MS400081	Corcoran City MS4

MS4ID	Name
MS400082	Cottage Grove City MS4
MS400131	Credit River Township MS4
MS400012	Crystal City MS4
MS400132	Dakota County MS4
MS400254	Dakota County Technical College MS4
MS400083	Dayton City MS4
MS400013	Deephaven City MS4
MS400084	Dellwood City MS4
MS400014	Eagan City MS4
MS400087	East Bethel City MS4
MS400015	Eden Prairie City MS4
MS400016	Edina City MS4
MS400089	Elk River City MS4
MS400237	Elko-New Market City MS4
MS400135	Empire Township MS4
MS400017	Excelsior City MS4
MS400239	Fairmont City MS4
MS400018	Falcon Heights City MS4
MS400233	Faribault City MS4
MS400090	Farmington City MS4
MS400175	Federal Medical Center MS4
MS400268	Fergus Falls City MS4
MS400262	Forest Lake MS4
MS400019	Fridley City MS4
MS400020	Gem Lake City MS4
MS400252	Glencoe City MS4
MS400021	Golden Valley City MS4
MS400269	Grand Rapids City MS4
MS400091	Grant City MS4
MS400022	Greenwood City MS4
MS400092	Ham Lake City MS4
MS400240	Hastings City MS4
MS400136	Haven Township MS4
MS400138	Hennepin County MS4
MS400198	Hennepin Technical College Brooklyn Pk - MS4
MS400199	Hennepin Technical College Eden Prairie MS4
MS400270	Hibbing City MS4

MS4ID	Name
MS400023	Hilltop City MS4
MS400024	Hopkins City MS4
MS400094	Hugo City MS4
MS400248	Hutchinson City MS4
MS400095	Independence City MS4
MS400096	Inver Grove Heights City MS4
MS400224	Inver Hills Community College MS4
MS400140	Jackson Township MS4
MS400098	Lake Elmo City MS4
MS400142	Laketown Township MS4
MS400099	Lakeville City MS4
MS400025	Landfall City MS4
MS400026	Lauderdale City MS4
MS400143	Le Sauk Township MS4
MS400027	Lexington City MS4
MS400028	Lilydale City MS4
MS400100	Lino Lakes City MS4
MS400253	Litchfield City MS4
MS400029	Little Canada City MS4
MS400227	Little Falls City MS4
MS400101	Long Lake City MS4
MS400030	Loretto City MS4
MS400144	Louisville Township MS4
MS400031	Mahtomedi City MS4
MS400226	Mankato City MS4
MS400102	Maple Grove City MS4
MS400103	Maple Plain City MS4
MS400032	Maplewood City MS4
MS400241	Marshall City MS4
MS400104	Medicine Lake City MS4
MS400105	Medina City MS4
MS400033	Mendota City MS4
MS400034	Mendota Heights City MS4
MS400201	Metropolitan State University - MS4
MS400146	Midway Township MS4
MS400147	Minden Township MS4
MN0061018	Minneapolis Municipal Storm Water

MS4ID	Name
MS400182	Minnehaha Creek WD MS4
MS400177	Minnesota Correctional-Lino Lakes MS4
MS400179	Minnesota Correctional-St Cloud MS4
MS400036	Minnetonka Beach City MS4
MS400035	Minnetonka City MS4
MS400106	Minnetrista City MS4
MS400170	MNDOT Metro District MS4
MS400180	MNDOT Outstate District MS4
MS400261	Montevideo City MS4
MS400242	Monticello City MS4
MS400108	Mound City MS4
MS400037	Mounds View City MS4
MS400207	Mpls Community/Technical College MS4
MS400038	New Brighton City MS4
MS400039	New Hope City MS4
MS400228	New Ulm City MS4
MS400040	Newport City MS4
MS400255	Normandale Community College MS4
MS400260	North Branch City MS4
MS400205	North Hennepin Community College - MS4
MS400229	North Mankato City MS4
MS400109	North Oaks City MS4
MS400041	North St Paul City MS4
MS400271	Northfield City MS4
MS400110	Oak Grove City MS4
MS400042	Oakdale City MS4
MS400111	Orono City MS4
MS400043	Osseo City MS4
MS400243	Otsego City MS4
MS400244	Owatonna City MS4
MS400044	Pine Springs City MS4
MS400112	Plymouth City MS4
MS400113	Prior Lake City MS4
MS400189	Prior Lake-Spring Lake WSD MS4
MS400115	Ramsey City MS4
MS400191	Ramsey County Public Works MS4
MS400190	Ramsey-Washington Metro WD MS4

MS4ID	Name
MS400235	Red Wing City MS4
MS400236	Redwood Falls City MS4
MS400193	Rice Creek WD MS4
MS400045	Richfield City MS4
MS400046	Robbinsdale City MS4
MS400117	Rosemount City MS4
MS400047	Roseville City MS4
MS400048	Sartell City MS4
MS400118	Sauk Rapids City MS4
MS400153	Sauk Rapids Township MS4
MS400119	Savage City MS4
MS400154	Scott County MS4
MS400120	Shakopee City MS4
MS400155	Sherburne County MS4
MS400121	Shoreview City MS4
MS400122	Shorewood City MS4
MS400049	South St Paul City MS4
MS400196	South Washington WD MS4
MS400050	Spring Lake Park City MS4
MS400156	Spring Lake Township MS4
MS400123	Spring Park City MS4
MS400051	St Anthony Village MS4
MS400124	St Bonifacius City MS4
MS400052	St Cloud City MS4
MS400197	St Cloud State University MS4
MS400204	St Cloud Technical College - MS4
MS400125	St Joseph City MS4
MS400157	St Joseph Township MS4
MS400053	St Louis Park City MS4
MS400246	St Michael City MS4
MS400202	St Paul Community & Technical College - MS4
MN0061263	St Paul Municipal Storm Water
MS400054	St Paul Park City MS4
MS400245	St Peter City MS4
MS400159	Stearns County MS4
MS400259	Stillwater City MS4
MS400055	Sunfish Lake City MS4

MS4ID	Name
MS400056	Tonka Bay City MS4
MS400212	U of M-Twin Cities Campus MS4
MS400057	Vadnais Heights City MS4
MS400217	Valley Branch WD MS4
MS400126	Victoria City MS4
MS400232	Waconia City MS4
MS400127	Waite Park City MS4
MS400258	Waseca City MS4
MS400160	Washington County MS4
MS400161	Watab Township MS4
MS400058	Wayzata City MS4
MS400162	West Lakeland Township MS4
MS400059	West St Paul City MS4
MS400060	White Bear Lake City MS4
MS400163	White Bear Township MS4
MS400061	Willernie City MS4
MS400272	Willmar City MS4
MS400128	Woodbury City MS4
MS400129	Woodland City MS4

APPENDIX C: Stakeholder Advisory Committee and Science Advisory Panel

Stakeholder Advisory Committee		
Last Name	**First Name**	**Affiliation**
Baumann	Jim	WI DNR
Beckwith	John	NRCS
Blue	Suzanne	Mississippi River Citizen Comm
Boody	George	Land Stewardship Project
Campe	John	Mississippi River Citizen Comm
Commerford	Steve	Minnesota Soybean
Enblom	Jack	MN DNR
Everett	Les	University of Minnesota
Fisher	Loyal	MASWCD
Flood	Rebecca	MPCA
Formo	Warren	MN Corn Growers
Garletz	Annalee	Assn. of Minnesota Counties
Geske	Jeremy	Minnesota Farm Bureau
Grawe	Robin	Mississippi River Citizen Comm
Haake	Barbara	Rice Creek Watershed District
Johnson	Craig	League of MN Cities
Johnson	Scott	MN DNR
Jordahl	Marilyn	MNDOT-O.E.S.
Lane	David	MESERB
Larson	Cathy	Metropolitan Council
Legvold	David	Dakota County farmer
Lutjen	Mark	Lake City Marina
Peterson	Mark	Audubon
Nelson	Dean	MN WW Operators Association
Noren	James	U.S. Army Corps of Engineers
Nyhus	Steve	MESERB
Olson	Craig	Mississippi River Citizen Comm
Peterson	Mark	Audubon Society
Peterson	Thom	MN Farmers Union
Preisler	Dave	MN Pork Producers Association
Rebuffoni	Dean	Sierra Club
Robertson	Mike	MN Chamber of Commerce
Russell	Trevor	Friends of Mississippi River
Scott	Mary Gail	Metropolitan Council Environmental Services
Sigford	Kris	MCEA
Snyder	Doug	Mississippi River WMO
Hokanson	David	Upper Mississippi River Assoc
Tiedeken	Nick	MNDOT-O.E.S.
Trowbridge	Annette	US FWS
Reetz	Gaylen	MPCA
Vagle	James	Builders Association of Twin Cities
Wege	Gary	US FWS

Last Name	First Name	Affiliation
Wills	Craig	Prairie Island Indian Community
Weirens	Dave	MN BWSR
Weller	Lark	
White	Deanna	Clean Water Action Alliance

Science Advisory Panel		
Last Name	**First Name**	**Affiliation**
Sleeper	Faye	UMN Water Resources Center
Arnold	Bill	UMN Civil Engineering
Brooks	Ken	UMN Forest Resources
Burdis	Rob	MN Dept of Natural Resources
Cooper	Pete	NRCS
Engstrom	Dan	SMM-SCWRS
Everett	Les	UMN Water Resources Center
Heiskary	Steve	MN Pollution Control Agency
Hendrickson	Jon	U.S. Army Corps of Engineers
Henningsgaard	Bruce	MPCA
Jennings	Carrie	Minnesota Geological Survey
Kiesling	Richard	U.S. Geological Survey
Knoff	Michael	US Army Corps of Engineers
Larson	Cathy	MCES
Mulla	David	UMN Soil, Water & Climate
Polasky	Steve	UMN Applied Economics
Randall	Gyles	UMN Waseca
Sands	Gary	UMN Biosystems & Agriculture Engineering
Senjem	Norm	MN Pollution Control Agency
Stefan	Heinz	UMN Civil Engineering
Sterner	Bob	UMN Ecology, Evolution & Behavior
Sullivan	John	WI Dept of Natural Resources
Swackhamer	Deb	UMN Water Resources Center
Thorson	Randy	MN Pollution Control Agency
Vondracek	Bruce	USGS Minnesota Cooperative Fish & Wildlife Research Unit
Wilson	Bruce N.	UMN BioAg Engineering
Zimmerman	Bob	City of Moorhead