Minnesota's Nonpoint Source Management Program Plan 2013

Minnesota 2013-2017 Nonpoint Source Management Program Plan

In memory of, and with much thanks to, the leadership of:

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Acknowledgments

Minnesota's Nonpoint Source Management Program Plan (NPSMPP) is a result of outstanding commitment, expertise and skills of technical committee chairs, co-chairs, committee members and others who contributed to the development of the chapters and strategies of this Plan.

Each technical committee was chaired or co-chaired by a representative of the University of Minnesota, Minnesota Board of Water and Soil Resources, Minnesota Department Agriculture, Minnesota Department of Natural Resources, or Minnesota Pollution Control Agency. The Minnesota Pollution Control Agency coordinated overall development of the NPSMPP.

Many individuals, agencies and organizations contributed to this document. In particular, representatives of:

- Project Coordination Team
- Association of MN Counties
- Individual Counties, Soil and Water Conservation Districts, Municipalities, Watershed Districts, businesses and public and private organizations.
- University of Minnesota
- Southeast MN Water Resources Board
- Metropolitan Council – Environmental Services
- MN Waters (Formerly Clean Lakes Association and Rivers Council of MN)
- MN Association of Soil and Water Conservation Districts.
- MN Association of Townships
- MN Board of Water and Soil Resources
- MN Department of Agriculture
- MN Department of Health
- MN Department Natural Resources
- MN Department of Transportation
- MN Geological Survey
- MN Pollution Control Agency
- U.S. Corps of Army Engineers
- U.S. Department of Agriculture
- U.S. Department of the Interior
- U.S. Geological Survey

Each technical committee developed one of the 14 chapters/strategies of this Plan. Collectively, they were comprised of more than 200 members representing over 50 federal, state and local governmental organizations and public and private organizations.

Minnesota Nonpoint Source Management Program Plan (NPSMPP)

The United States Congress enacted Section 319 of the Clean Water Act (CWA) in 1987, establishing a national program to control nonpoint sources (NPS) of water pollution.

Rainfall or snowmelt moving over and through the ground carrying natural and human-made pollutants into lakes, rivers, streams, wetlands and ground water causes nonpoint source pollution. Atmospheric deposition and hydrologic modification are also sources of nonpoint sources of pollution.

The State of Minnesota Nonpoint Source Management Program Plan (NPSMPP) is a requirement for Minnesota to remain eligible to receive NPS funding from the US Environmental Protection Agency (USEPA) under Section 319 of the CWA. However, the NPSMPP is intended to reach beyond this purpose by setting Minnesota's Statewide NPS goals and laying out a statewide multi-year approach for addressing water quality problems from NPS pollution. Also, the NPSMPP provides guidance on NPS issues for consideration by federal, state and local governmental units in other NPS planning efforts.

Nonpoint source water pollution control proposals must be cited in this document to be considered for Section 319 funding.

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Executive Summary

Minnesota Pollution Control Agency's (MPCA) Mission: Working to protect and improve our environment and enhance human health.

The MPCA monitors environmental quality, offers technical and financial assistance, and enforces environmental regulations. The MPCA finds and cleans up spills or leaks that can affect our health and environment. Staff develop statewide policy, and support environmental education. The MPCA works with many partners — citizens, communities, businesses, all levels of government, environmental groups and educators — to prevent pollution and conserve resources.

Everyone knows Minnesota is the "Land of 10,000 Lakes." But actually, Minnesota has 11,842 lakes of 10 acres or larger. Add smaller lakes and the total is above 14,000. Minnesota also has more than a trillion gallons of ground water used as drinking water for an estimated 70 percent of Minnesotans and 92,000 miles of streams and rivers. Three continental basins originate in the state, sending water:

- north to Canada's Hudson Bay by the Red River of the North and the Rainy River
- east to the Atlantic Ocean through Lake Superior
- south to the Gulf of Mexico via the Mississippi River

Water is the dominant feature of Minnesota's landscape. Ask any Minnesotan about the top environmental concern and the likely response is, "clean water." The MPCA administers three important financial assistance programs for watershed management of nonpoint source water pollution: 1) Minnesota's Clean Water Partnership (CWP) grant, 2) loan programs and 3) Federal Clean Water Act Section 319 program. Combined, these programs have provided over $147 million in grants and loans to local units of government and other resource management for the protection and restoration of waters in Minnesota.

Minnesota's Nonpoint Source Management Program Plan (NPSMPP)

The MPCA administers three important financial assistance programs for watershed management of nonpoint source water pollution: 1) Minnesota's Clean Water Partnership grant, 2) loan programs and the 3) federal Clean Water Act (CWA) Section 319 grant.

The U.S. Environmental Protection Agency (USEPA) provides federal Section 319 grant program funds for nonpoint source water pollution control implementation projects. The primary goal for this grant program is to protect and improve the quality of Minnesota's water resources by implementing nonpoint source pollution control measures that have been identified in the state NPSMPP. State investigations must identify nonpoint sources of pollution that contribute to water quality problems, as well as waters or stream segments unlikely to meet water quality standards without additional nonpoint source controls. As a minimum, Minnesota's NPSMPP was prepared to satisfy federal CWA requirements, as well as to satisfy Minn. Stat. § 103F.751 for the development of a state nonpoint source pollution control plan.

Section 319 requires that states:

- identify the nonpoint source controls necessary
- specify the programs that will apply the controls
- certify that the state has adequate authorities to implement these measures
- establish a schedule for implementation

The Minnesota NPSMPP is intended to reach beyond this purpose by setting Minnesota's statewide Nonpoint Source (NPS) goals, and laying out a statewide, approach for addressing water quality problems from NPS pollution. The NPSMPP provides guidance on NPS issues for consideration by federal, state and local governmental units in other NPS planning efforts as well as:

- Sets Minnesota Statewide NPS Goals to address NPS pollution.
- Provides assistance to Interagency Teams with prioritizing future Section 319 grant awards.
- Assesses emerging NPS issues and re-evaluates/updates recommendations of the previous NPSMPP.
- Addresses new legislation, programs, rules, studies, initiatives and knowledge regarding NPS water pollution since the previous NPSMPP.
- Provides a forum for officials from federal, state and local units of government, and private and public organizations to discuss nonpoint issues.
- Presents opportunities to representatives of federal, state, local and private organizations to develop Action Plans recommending their priorities for the future.
- Includes NPS activities that officials of other NPS funding programs can use to prioritize NPS funding activities.
- Provides recommendations for consideration by federal, state and local governmental units in their NPS planning efforts.
- Details NPS policies, laws, regulations, programs and knowledge to help guide policy and decision making on NPS water pollution issues in the coming years.

Minnesota's Tiered Approach for 2013-2017 NPSMPP Revisions

For development of the 2013-2017 NPSMPP, MPCA is using a "Tiered "approach. Chapter 3 Watershed Approach, Strategies 4.1 Groundwater, 4.2 Lakes, 4.3 Rivers and Streams, and 4.4 Wetlands and Chapter 5 Monitoring have updated text and Needs, Priorities and Milestones Tables updated in this Plan. For the remaining Chapters only the Needs, Priorities and Milestone Tables have been updated. Text for the remaining chapters will be updated in subsequent years.

As in the past, applicants must cite the Action Step(s) in the Needs, Priorities and Milestone Tables in their Section 319 application in order to be considered eligible for Section 319 grant funding. Applications that do not cite an Action Step(s) in the Needs, Priorities and Milestone Tables will not be approved for Section 319 funding.

Impacts of Development on the Environment

How exactly does our use of the land connect with the health of our environment? One clear connection is soil erosion. Erosion removes irreplaceable soils, and carries pesticides, organic (oxygen-consuming) materials and excess nutrients into surface waters, where they cause harm. Erosion is strongly influenced by surface cover – the kinds of plants and soil tillage patterns most common in the area.

Agricultural drainage (tile lines and constructed ditches) can improve crop yields by drying fields faster and preventing water from pooling on the land. The environmental tradeoffs are declines in water quality and undesirable changes in water quantity, such as increased frequency and intensity of flooding. Development can have many consequences in watersheds as well. More roads, roofs and parking lots accelerate runoff, which gathers contaminants along its way into our waters. Without proper management of urban runoff, nutrients, toxic chemicals and organic materials pollute nearby waters.

The clear trend in Minnesota's major cities and in many smaller communities is growth. The U.S. Department of Agriculture (USDA) estimates that 62,000 acres per year – equal to 170 acres per day – were developed from 1992 through 1997, more than double the rate of the previous decade. If present rates continue, Minnesota will double its current area of developed land in less than 40 years.

Numerous toxic pollutants affect Minnesota's waters, for example mercury, which eventually finds its way into the tissues of fish. Consumption advisories for some game fish remain in effect due to mercury in numerous Minnesota lakes. Health officials issue the advisories to inform anglers how much fish of certain types and sizes can be safely eaten. Minnesota continues to monitor fish contamination trends while working hard to reduce atmospheric deposition of mercury, the main avenue of contamination.

Ground Water – Two-thirds of us draw our drinking water from the ground, and we are increasingly tapping ground water aquifers for other uses. Nitrate, a pollutant of concern for very young children, is found frequently in Minnesota's ground water. While some nitrate occurs naturally, higher-than-normal concentrations come from activities on or near the surface, such as use of fertilizers containing nitrogen and failing septic systems. The heavy fertilization and irrigation used for some crops can put chemically enriched water directly into shallow aquifers.

Lakes – Minnesota lakes face an uncertain future. Shoreland and watershed development, expanding uses and users, the spread of exotic species and water pollution all threaten lakes. Too much phosphorus and nitrogen, which act as fertilizer to algae and weeds, are reaching lakes, carried in soil erosion and runoff from roads, yards, farms and septic systems.

Lakes are Minnesota's most visible and valuable natural resource – the cornerstone of the recreation and tourism industry and a significant portion of many local economies. Painful experience has taught that once a lake declines, recovery is costly and can take many years. Full recovery may not be possible. Prevention is the key. What happens to Minnesota lakes and their watersheds – how well we handle all the converging pressures – will essentially determine the quality of those lakes for the next 100 years. Hundreds of crucial decisions about lakeshore development, nearby development and land use will face citizens, developers and government.

Rivers and Streams – The best long-term data about Minnesota streams comes from measuring six key pollutants at 80 stream locations over the past four decades. On average, they show significant reductions in ammonia, biochemical oxygen demand, phosphorus, total suspended solids and fecal coliform bacteria. However, nitrogen has increased over the same period. It is important to keep in mind that some streams that show overall improvement still do not meet standards designed to protect human health, aquatic life and wildlife. Further, it is not currently possible to measure conditions of all 92,000 miles of streams.

Wetlands – The status of wetlands – which naturally filter pollutants from water, reduce flood damage and provide wildlife habitat – has also changed. According to the Minnesota Board of Water and Soil Resources (BWSR), more than 5.5 million acres of Minnesota wetlands have been lost since the early 1900s. In the early to mid-1900s, with government encouragement, landowners drained thousands of acres of wetland. In contrast, during the 1980s and 1990s, more wetland acres were lost through urban development than through agriculture, according to U.S. Department of Agriculture (USDA) figures. The loss rate has declined. However, significant losses still occur from actions that do not require approvals or permits, according to the state Wetland Conservation Act report.

Sources of NPS Pollution

The 1998 national 305(b) report, titled "National Water Quality Inventory, 1998 Report to Congress" lists sources of impairment for rivers and streams. Nationwide, they are in order

1. Agriculture
2. Hydromodification
3. Urban Runoff/Storm Sewers
4. Municipal Point Sources
5. Resource Extraction
6. Forestry
7. Land Disposal
8. Habitat Modification

Nationwide, sources of impairment for lakes are in order

1. Agriculture
2. Hydromodification
3. Urban Runoff/Storm Sewers
4. Municipal Point Sources
5. Atmospheric Deposition
6. Industrial Point Sources
7. Habitat Modification
8. Land Disposal

Minnesota's Watershed Approach

When a water body fails to meet water quality standards because of one or more pollutants, it is considered impaired water. The 2010 list (303d) of Minnesota's impaired waters shows 1756 impairments that require Total Maximum Daily Load (TMDL) Studies. About 40 percent of those assessed against impairment criteria are impaired; rates comparable with what other states are finding. This list of impaired waters will expand as assessments continue throughout the state. The MPCA anticipates that impaired waters will be located in nearly every watershed in the state, once it assesses all the state's waters.

The watershed approach is a 10-year cycle for addressing waters of the state on the level of Minnesota's major watersheds. The primary feature of the watershed approach is that it provides a unifying focus on the water resource as the starting point for water quality assessment, planning, and results measures. This approach may be modified to meet local conditions, based on factors such as watershed size, landscape diversity and geographic complexity (e.g.,Twin Cities metro area).

The overlapping steps of the Watershed Approach are as follows, with the goal of completing Steps 1 through 3 within four years of initiation in each watershed and Step 4 starting in the fifth year:

Step 1 – Monitor and gather data and information

Step 2 – Assess the data based on results of intensive watershed monitoring in step one

Step 3 – Establish implementation strategies to meet standards. Based on the watershed assessment, a TMDL study and/or protection strategy is completed

Step 4 – Implement water quality activities

Stormwater Manual

The Minnesota Stormwater Manual is a valuable tool for stormwater managers; it helps professionals and newcomers manage stormwater in a way that conserves, enhances, and restores high-quality water in our lakes, rivers, streams, wetlands, and ground water, ensuring a high quality of life for all Minnesotans. The MPCA has replaced the Minnesota Stormwater Manual with a powerful online version that uses a wiki platform. Wiki is a Hawaiian word that means "quick." Released April 2,2013, this online manual offers quick ways to search for information, provide feedback to the MPCA, and update the contents. The revised manual can be found at:

http://www.pca.state.mn.us/index.php/water/water-types-and-programs/stormwater/stormwater-management/minnesotas-stormwater-manual.html

Minnesota's Water Quality Monitoring Strategy 2004-2014

To be effective in conducting monitoring that will meet Minnesotan's needs for information, Minnesota needs to have an overall guiding strategy for its monitoring. This report is intended to pull together and document all of the elements of MPCA's monitoring program strategy for both surface and ground water and for all monitoring types. While intended to satisfy the requirement of the USEPA for preparing a monitoring program strategy, its greatest benefit will be in guiding monitoring programs for the future.

Environmental Data Access (EDA)

The MPCA developed the EDA system to improve access to environmental data. The initial focus was to make statewide surface water monitoring data more accessible to water resource planners and managers, and the public. This portion of the system has been available since July 2003.

http://www.pca.state.mn.us/index.php/data/eda-surface-water-searches/eda-surface-water-data.html. Funding for the EDA system was provided by the Minnesota Legislature in 2001 to address deficiencies in the availability of the state's surface water quality data.

eLINK

Dating back as early as 1986, BWSR has required reports from local units of government (LGU)s that indicate progress made in protecting the state's resources. Throughout the years, the method to complete this reporting has changed, first from paper reports (1986-1996), to floppy disk submission (1997-2002) and finally to the online eLINK database (2003-2012).

Based on feedback and assistance from local government partners, BWSR is now leading development of a new web-based system to track statewide conservation projects and activities. The new system will retain its current name, eLINK, and will include a publicly-accessible page of information from the system.

With eLINK,

1. **State agencies can:** evaluate effectiveness of programs, compile data on county, watershed, or individual-project basis calculate estimated pollution reduction benefits from conservation practices and easements track cumulative grant funding over a period of years map locations of projects
2. **Local governments can:** plan and track conservation projects and grants prioritize and target financial assistance programs evaluate the cost and benefits of conservation practices track projects for long-term monitoring
3. **Front-line field staff technicians can:** use the system's on-line aerial photography to identify and map problem areas plan and budget Best Management Practices (BMP) using menu-driven templates manage landowner contact information quickly assemble a customized package of materials for individual landowners to consider in conservation planning general reporting data that funding organizations require

Nonpoint Source Funding and Results

In 1987 US CWA amendments attempted to deal with a source of pollution that had not been addressed in previous CWA amendments: polluted runoff from farm fields, roads, and other diffuse sources. As point sources of pollution came under greater control, the proportion of adverse environmental conditions attributed to these nonpoint sources of pollution grew.

The Federal Section 319 grant program offers funds for nonpoint source water pollution control implementation projects. The goals of this grant program is to protect and improve the quality of Minnesota's water resources by implementing nonpoint source pollution control measures that have been identified in the state Nonpoint Source Management Program Plan. The USEPA provides the grant funds for the program. A snapshot of Section 319 and Minnesota's (CWP) program activities is provided below.

Estimates of soil loss, sediment and phosphorus reductions through Section 319 and Minnesota CWP programs are provided in the following table.

Section 319 Project Totals:		
Number of Projects		Section 319 Grant Awards
496		$55,985,339
CWP Grant Totals:		
Number of Projects		CWP Grant Awards
270		$39,333,613.19
CWP Loan Totals:		
Number of Projects		
265		$ 51,927,067.38
Totals 1,031		$147,246,020

Section 319 and Minnesota CWP Projects: 1997 - May, 2012

Pollution Reduction Type	# of BMPs	Estimated Soil Loss Reduction (tons/yr)	Estimated Sediment Reduction (tons/yr)	Estimated Phosphorous Reduction (pounds/yr)	Estimated Nitrogen Reduction (pounds/yr)
Feedlot	334	0	0	44,999	89,998
Groundwater quality	1,008	0	0	5,895	11,790
Multiple benefit project	226	18,276	3,113	4,075	8,150
Other conservation projects	995	17,881	3,298	135,969	271,938
Water erosion	4,898	236,520	111,909	126,984	253,968
Wind Erosion	87	2,258	44	632	1,263
Total	**7,548**	**274,935**	**118,364**	**318,554**	**637,107**

Minnesota Clean Water Legacy Act – Leveraging Resources

A series of citizen forums on the environment showed clean water as a top priority in all areas of the state. In addition, in a statewide citizen telephone survey, respondents were read a list of four reasons for protecting the environment and then asked how important they thought each reason was. The responses showed the public believes preserving the environment for future generations is the most important reason for protecting the environment. Other reasons given were health concerns, plants and animals, and recreational opportunities.

In addition to the positive environmental benefits of protecting our waters, clean water also impacts the state's economy. According to earlier data from the Minnesota Department of Employment and Economic Development, tourism greatly contributes to the state's economy. Water provides jobs, drives quality of life, supports fish and wildlife, and is the cornerstone of a multi-billion dollar a year tourism industry.

Minnesotans place a high value on their water resources. Each year, over 1.5 million anglers fish Minnesota waters, representing a tremendous pool of customers for Minnesota businesses. Ninety-eight percent of Minnesota's resorts, 80 percent of campgrounds, and 24 percent of hotels/motels are on a lake and/or river. Fishing licenses sold in 2009 equaled 1,371,106 and sport fishing expenditures in Minnesota is $1.5 billion. Boating, canoeing and kayaking watercraft operator's permits from 1975-2009 totaled 189,000.

The Clean Water Legacy Act (CWLA) was signed into law June 2, 2006 and provided a new operational framework, tools and first-year start-up funding that helped ensure Minnesota's famed legacy of clean water passed intact to future generations. Enactment of this law placed Minnesota in a position of national leadership in developing a collaborative and innovative approach towards implementing the Clean Water Act.

The Clean Water Council was created through the CWLA. The Council's role is to advise on the administration and implementation of the CWLA, including:

- Fostering coordination among public agencies and private entities to ensure cooperation with relevant plans and programs.
- Prioritization strategies for TMDLs, restoration and protection activities.
- Development of appropriate processes for expert scientific review.
- Development of education and participation strategies for citizens and stakeholders

Since 2007, the MPCA and its partners have been implementing the watershed-base management approach, as recommended by the Clean Water Council and directed by the Minnesota Legislature. On November 4, 2008, Minnesota voters approved the Clean Water, Land and Legacy Amendment (Clean Water Legacy Act) to the constitution to protect drinking water sources; to protect, enhance, and restore wetlands, prairies, forests, and fish, game, and wildlife habitat; to preserve arts and cultural heritage; to support parks and trails; and to protect, enhance, and restore lakes, rivers, streams, and groundwater.

The amendment increases the sales and use tax rate by three-eighths of one percent on taxable sales, starting July 1, 2009, continuing through 2034. Of those funds, approximately 33 percent are dedicated to a Clean Water Fund to protect, enhance, and restore water quality in lakes, rivers, streams, and groundwater, with at least five percent of the fund targeted to protect drinking water sources.

Emerging Future Efforts

Because of water's trans-border nature, we must use collaborative approaches to be fully successful in addressing water quality issues. Where water quality is concerned, Minnesota is placing a greater emphasis on collaboration and cooperation between multiple stakeholders, particularly within the agriculture community.

Agricultural land practices that are meant to provide beneficial outcomes with bigger and better crops can at times result in unintended consequences. For instance, nutrients used for growing crops can pollute our waters if agricultural runoff enters nearby surface waters. Some current agriculturally focused collaborative water quality efforts in Minnesota include:

- Development of a state-level Nutrient Reduction Strategy
- Establishment of water quality standards for nitrate nitrogen and total nitrogen
- Creation of the Agriculture Water Quality Certification Program

Minnesota is working to complete a statewide Nutrient Reduction Strategy by the end of 2013, along with other states in the Mississippi-Atchafalaya River Basin (the third largest basin in the world.) A Basin-wide Action Plan is in place that includes creation of individual state nutrient reduction strategy plans to help reduce the size of the hypoxic zone in the Gulf of Mexico. Insufficient oxygen – hypoxia – harms fish and other aquatic life. By reducing the amount of nitrogen and phosphorus (nutrients) that wash into the Mississippi River, less algae will be produced, which in turn will mean a healthier concentration of oxygen in the Gulf waters, thousands of miles downstream.

A compliment to the nitrogen component of this excess nutrient project, the 2010 Minnesota Legislature directed the establishment of water quality standards for nitrate nitrogen and total nitrogen. The characterization of total nitrogen to Minnesota's surface waters will assist in the development of the Nutrient Reduction Strategy and will instruct the actions we can all take to improve water from Minnesota to the Gulf of Mexico. For more information, please visit http://www.legacy.leg.mn/projects/nitrogenbudget - assessment-determine-nitrogen-loadings sources-and-pathways-to-Minnesota-water.

Additionally, a new state-federal partnership was announced January 2012 to collaboratively and cooperatively bring about additional farming conservation practices. Through the Minnesota Agriculture Water Quality Certification Program (http://www.mda.state.mn.us/awqcprogram.aspx), farmers will be able to volunteer to implement scientifically developed conservation practices tailored to their land. The program, which is currently being developed, will provide cost-share funds to help farmers with the expense of certain conservation practices. In exchange, they will receive assurance from regulatory agencies that they will not be required to implement additional water quality measures during the designated certification period. This can provide farmers with greater "certainty" about expectations for addressing water quality.

Chapter 1 Updated NPS Assessment

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Introduction

The Nonpoint Source (NPS) Assessment is an ongoing NPS problem identification process which was initiated in 1987 to meet the requirements of Section 319 of the Clean Water Act Amendments of 1987, as well as to evaluate the state's long term assessment and planning needs.

The first NPS Assessment Report was completed in 1988 and was designed to be a companion document to the 1988 NPS Management Program. To ensure that the assessment information more directly drives the management program milestones, both documents were combined in the 1994 Nonpoint Source Management Program Plan (NPSMPP).

The 1994 report and the 2001 and 2008 NPSMPP are referred to only as the NPS Management Program, with the understanding that the assessment report is an integral part.

Assessment Requirements

The United States Clean Water Act requires the NPS Assessment to use all available information to describe, on a watershed basis, the nature, causes, extent and effect of NPS pollutants on state waters. Specific requirements based on USEPA guidance for the Section 319 program include the following:

- Identification of waters within the state which, without additional action to control nonpoint sources of pollution, cannot reasonably be expected to obtain or maintain applicable water quality standards (WQS) or support their designated uses.
- Identification of categories and subcategories of nonpoint sources or, where appropriate, particular nonpoint sources which add significant pollution to each portion of a navigable water in amounts which contribute to such portion(s) not meeting WQS.

Minnesota Pollution Control Agency's (MPCA) Basin Planning and Management

Since 1995 MPCA has organized delivery of its water programs geographically according to the state's major drainage basins. The MPCA's 1998 Continuing Planning Process Report's description of the goals of this action is still relevant:

- increase environmental outcomes by maximizing limited resources
- clearly identify water quality goals and priorities
- integrate point and nonpoint source pollutant reduction strategies
- develop more effective partnerships with MPCA customers, including local governments, environmental groups and permittees

The basin approach looks at the "resource" as a whole. The basin approach proposes solutions which, collectively, improve the condition of the basin. The basin approach links all the jurisdictions in the basin, extending the capacity of local, state and federal governments so that water quality problems can be addressed both ecologically and politically. Starting in 2003, MPCA's Basin Coordinators reviewed the role, goals and focus of basin management and basin planning given the Agency's new impaired waters priority.

External basin teams have been established and function in eight basins of the state. These teams are composed of more than 200 separate state and federal agencies, local governmental units, organizations and non-public constituencies. External basin teams meet monthly in the Lake Superior, Minnesota, Lower Mississippi and Cedar, Upper Mississippi, and Red River basins, and quarterly in the Rainy and St. Croix basins. The names of these teams differ from basin to basin, but the teams each include representatives of federal, state, regional and local government, industry, citizen and special interest groups. Members are actively recruited. Each team has an open door policy, inviting in anyone who wants to participate.

These six groups of more than 200 stakeholders meet routinely and are considered their basin's "go-to" group for water quality. They serve as the stakeholders for development of impaired waters plans. They review and recommend projects for Section 319 funding. The establishment and coordination of these teams brings form and substance to the situational alliances we need to achieve water quality goals. Basin planning has produced two sets of documents for the state's major drainage basins. These documents are:

1. Basin information documents, which summarize conditions and resources of the basin, assesses pollution control status, lists ongoing research and identifies major issues.
2. Basin water quality plans, which provide specific goals to measure water quality improvements.

Minnesota's Agreement with the United States Environmental Protection Agency (USEPA)

In the last report, waterbody assessments for streams and lakes were completed for 305(b) reporting and the 2000 305(b) Report (Report) reflected the Minnesota Pollution Control Agency's third reporting cycle during the transition into the basin management process. This was in lieu of the previous statewide 305(b) biennial reports required by the 1972 CWA. It was also in fulfillment of the 1995 agreement between the USEPA and the MPCA, which stated MPCA's 305(b) reporting commitments. These commitments were to update waterbody assessments at least annually and to prepare a comprehensive statewide 305(b) report after waterbody assessments for each basin had been developed through the basin management process. This agreement was also reflected in the 1999 Environmental Partnership Performance Agreement (EnPPA).

Today these commitments are still in place but because sections 305b and 303d of the federal CWA both call for states to report on their waters to help measure progress toward the national goals of fishable and swimmable waters, the MPCA is now using the USEPA Consolidated Assessment and Listing Methodology (CALM).

CALM integrates the 305(b) Report with the 303(d) Impaired Waters List. It provides a framework for states and other jurisdictions to document how they collect and use water quality data and information for environmental decision making. The primary purposes of these data analyses are to determine the extent that all waters are attaining water quality standards, to identify waters that are impaired and need to be added to the 303(d) list, and to identify waters that can be removed from the list because they are attaining standards.

The CALM requires states to create several new requirements or approaches to enable the Report and List to be blended:

- delineation of water quality assessment units (AUs) based on the National Hydrography Dataset (NHD)
- status of and progress toward achieving comprehensive assessments of all waters
- water quality standard attainment status for every AU
- basis for the water quality standard attainment determinations for every AU

- additional monitoring that may be needed to determine water quality standard attainment status and, if necessary, to support development of Total Maximum Daily Loads (TMDLs) for each pollutant/AU combination
- schedules for additional monitoring planned for AUs
- pollutant/AU combinations still requiring TMDLs
- TMDL development schedules reflecting the priority ranking of each pollutant/AU combination

One significant aspect is categorizing water bodies, which Minnesota began to do in the 2004 reporting cycle and is continuing for 2007.

Initially there were five categories in CALM with category 4 having three subcategories. The categories are as follows:

Category 1: all designated uses are meeting water quality standards
Category 2: some uses are meeting water quality standards and there are insufficient data to assess other uses
Category 3: there are insufficient data to assess any uses
Category 4: at least one use is impaired, but a TMDL is not required
Category 5: at least one use is impaired and a TMDL is required, these become the List of Impaired Waters

Minnesota will use this current categorization scheme to report assessments in 2006, which will place a water body segment in one and only one category. This will mean, for example, that if a segment is impaired for a use but other uses are being met, and a TMDL is required, that segment would be placed in Category 5. Furthermore, if the segment is impaired for more than one pollutant, the segment must stay in Category 5 until all pollutants have USEPA-approved TMDL plans or are de-listed.

Minnesota's Basin Planning and Management Timeline

The MPCA began to implement basin management in 1995. Work in the basins has been staggered and phased in over several years. The MPCA's goal has been to establish an ongoing planning and management cycle and complete basin plans for each of Minnesota's ten basins.

Rivers and Streams Assessment Development

Implementing the monitoring and assessment strategy, considerable has been made incorporating additional data and information from other local, regional, state and federal monitoring and management entities. The MPCA actively seeks both narrative and numeric data from all sources utilizing appropriate Quality Assurance/ Quality Control (QA/QC).

Criteria used to determine whether to use data from other sources are outlined in the document "Guidance Manual for Assessing the Quality of Minnesota Surface Waters for the Determination of Impairment, 305(b) Report and 303(d) List" developed and revised concurrently with each assessment cycle by MPCA staff. Data from the Citizen Lake Monitoring and Stream Monitoring Programs are used as part of assessing lakes and streams. Important outside sources of numeric data include the Metropolitan Council Environmental Services, United States Geological Survey, Long Term Resource Monitoring Program on the Mississippi River at Onalaska, Wisconsin, Wisconsin DNR, Western Lake Superior Sanitary District, the National Forest Service, and many other local partners. Data is used from Clean Water Partnership (CWP) projects that meet the criteria. CWP projects are funded by the MPCA and monitoring is done by local governments. Staff from other agencies contributing monitoring data have also participated in the professional judgment group process.

The major limiting factor in making use of data from external sources has been inaccessibility of some data due to diverse storage formats; lack of information on how data was collected; and difficulty of interpreting measures that lack established WQS, but have intuitive or practical value for local programs.

Two major goals of the CWA, "fishable and swimmable" waters, are assessed here in terms of aquatic life use support (AQL), aquatic recreation use support (AQR), and aquatic consumption use support (AQC).

Rivers and Streams Use Support Assessment Methodology

A. Water quality (WQ) standards consist of two parts: beneficial uses for a waterbody and WQ criteria to protect and support those uses.
   1. Beneficial uses are the desirable uses that WQ should support, legally defined in Minn. R. ch. 7050, to include domestic consumption, aquatic life, recreation (swimming), agriculture and wildlife, industrial consumption, and aesthetics. The level of 'use support' describes the quality of the waterbody with respect to its designated uses. A 'use impairment' occurs when a waterbody cannot support its designated uses fully. Existing and threatened use impairments are considered WQ problems and may require corrective or preventive action.
   2. Numeric WQ criteria establish the minimum chemical and physical parameters required to support a beneficial use. Physical and chemical numeric criteria may set maximum concentrations of pollutants, acceptable ranges of physical parameters, and minimum concentrations of parameters such as dissolved oxygen (DO).

B. Waterbody Delineation
   Assessments of use support in Minnesota are made on individual waterbodies. The waterbody unit used for river system assessments is the river reach or "assessment reach". A river reach extends from one significant tributary river to another and is typically less than 20 miles in length. The reach may be further divided into two or more assessment reaches when there is a change in the use classification (as defined in Minn. R. ch. 7050), or when there is a significant morphological feature such as a dam, or a lake within the reach. In the past, Minnesota used USEPA's Reach File 1 to define reaches. Many of our current assessment reaches are Reach File 1 reaches, or subsegments of Reach File 1 reaches. MPCA is now using the National Hydrography Data Set to identify stream segment locations for Geographical Information Services purposes because it provides a much more complete accounting of all the streams in the State. All of our assessment reaches will be indexed to the National Hydrographic Data set (NHD). Each waterbody is identified by a unique waterbody identifier code, comprised of the US Geological Survey (USGS) eight digit hydrologic unit code plus the three digit assessment reach. It is for these specific reaches that the data are evaluated for potential use impairment. The MPCA consults with border states during the assessment process and documents reasons for any discrepancies in assessment determination between Minnesota and the specific border state.

Typically, the listing of impaired waters is by individual NHD reach. The major exception to this is the listing of river reaches for contaminants in fish tissue. Over the time it takes fish, particularly game fish, to grow to "catchable" size and accumulate pollutants to unacceptable levels there is a good chance some have moved considerable distance from the site where they were sampled. The impaired reach is defined by the location of significant barriers to fish movement such as dams upstream and downstream of the sampled reach. Thus, the impaired reaches often include several NHD reaches.

Aquatic Life Use Support:

Assessments of AQL are conducted to determine if the waters are of a quality to support the aquatic life that would be found in the stream under the most natural conditions. Two types of data are used in the assessments: water chemistry data and biological and habitat information. Table I-1 includes this information.

The following guidelines were used to evaluate each of the data sources for a reach, and to combine them when more than one type of information was available.

A. Water Chemistry Data

To evaluate chemical and physical parameters of WQ, the MPCA uses data and sampling site information that are stored in the USEPA's WQ data storage and retrieval system (STORET) by the MPCA and others. Ten years of data are used where available, based on water year, believing that the time period is sufficient in most cases to pick up impairments under a variety of climatic and flow conditions. Samples are evaluated against WQS set forth in Minn. R. ch. 7050, as minimum requirements needed to support aquatic life. Determinations of use support are based on the 'frequency of exceedance' of the "chronic" standards applicable for a given water class.

1. Conventional parameters include DO, pH, turbidity measured directly, and turbidity estimated from total suspended solids (TSS) measurements or corroborated transparency tube (TT) readings. At least ten independent observations (twenty for turbidity, TSS, or TT) from a reach are needed during the ten-year time frame for a parameter to be evaluated. For each parameter evaluated, levels of support are then defined as:
   - Fully supporting - fewer than 10 percent of samples exceed the standard.
   - Partially supporting - 10 to 25 percent of the samples exceed the standard.
   - Not supporting - more than 25 percent of samples exceed the standard.
2. Toxicants include un-ionized ammonia, chloride, arsenic, cadmium, chromium, copper, lead, nickel, selenium, and zinc. At least five samples are needed for a given toxicant to be evaluated. For each toxicant evaluated, levels of support are then defined, according to USEPA guidance, as:
   - Fully supporting - not more than 2.8 percent of samples exceed the standard (not more than one violation in three years of monthly sampling).
   - Not supporting - more than 2.8 percent of observations exceed the standard.
3. Nonpoint Source Indicators

   In addition, total phosphorus (TP), nitrate/nitrite, TSS, and biochemical oxygen demand (BOD) are evaluated as indicators of NPS pollution. They do not affect use-support status. In contrast to the support parameters described above, Minnesota has not established legal standards for the NPS indicators. However, the MPCA has developed ecoregion expectations for them from data collected at a small set of least impacted sites. At least ten observations are needed for an indicator to be evaluated, and a reach is identified if more than ten percent of the observations of an indicator exceed the ecoregion expectation.
4. Preliminary assessment based on physical/chemical parameters of WQ. For each reach, the evaluations described above are combined into a preliminary assessment of the waterbody's ability to support aquatic life. The level of support is assumed to be no greater than the support provided by the weakest of the elements measured. Therefore, the preliminary assessments are defined as follows:
   - not supporting - At least one of the conventional or toxicants parameters indicates nonsupport
   - partially supporting - the worst parameter indicates partial support
   - fully Supporting - all measures show full support
   - .

Table 1-1. Water Quality Criteria: Aquatic Life Use Support in Rivers and Streams

Physical/chemical parameters - evaluated against state Water Quality Standards (Minn. R. ch. 7050)

Conventional: Dissolved oxygen, pH n $\geq$ 10 observations for each parameter

Turbidity, TSS, or TT n $\geq$ 20 observations

Use Support	Criteria for each parameter evaluated
Fully Supporting	The standard is exceeded in fewer than 10% of the observations.
Partially Supporting	The standard is exceeded 10% to 25% of the time
Not Supporting	The standard is exceeded in more than 25% of the observations.

Table 1-1 (Cont.) Water Quality Criteria: Aquatic Life Use Support in Rivers and Streams

Toxicants: Ammonia, Chloride, Arsenic, Cadmium, Chromium, Copper, Lead, Nickel, Selenium, Zinc n ≥ 5 observations for each parameter

Use Support	Criteria for each parameter evaluated
Full Supporting	The standard is exceeded in fewer then 2.8% of the measurements. (Not more than 1 violation in 3 years of monthly sampling.)
Not Supporting	The standard is exceeded in 2.8% or more of the measurements.

NPS: Total phosphorus, Nitrite/nitrate, Total suspended solids, Biochemical oxygen demand (n ≥ 10)

Evaluated against least impacted sites in the ecoregion

Not Used for Use Support	Criteria for each parameter evaluated (nonpoint source pollution indicators)
No Impace	The ecoregion expectation is exceeded in fewer than 20% of the observations.
Ecoregion Criteria Exceeded	The ecoregion expectation is exceeded in 10% or more of the observations.

Preliminary Assessment, based on physical and chemical parameters of water quality:

Aquatic Life Use Support	Criteria for each waterbody (river reach)
Fully Supporting (Good)	Parameters measured against WQ Standards are Fully Supporting
Partially Supporting (Fair)	The worst parameter measured against WQ Standards is Partially Supporting.
Not Supporting (Poor)	At least 1 of the parameters measured against WQ Standards is Not Supporting

Sampling by MPCA and cooperators. Data stored in the USEPA's STORET data system.

Index of Biotic Integrity (IBI):

Aquatic Life Use Support	Criteria (evaluated against regional expectations)
Fully Supporting (S)	The biological community is in fair or better condition, not significantly altered from what would be expected for the regional under natural conditions. IBI score of 30 or above
Not Supporting (NS)	Indications of a poor or very poor biological community severely modified from what would be expected under natural conditions. IBI score less than 30.
Partially Supporting (PS)	Disparate levels of support between different portions of a larger reach..

Determination of Use Support, based on hierarchy of data sources:

Aquatic Life Use Support	Criteria for each waterbody (river reach)
Full Support	IBI shows support for aquatic life (Biology = S).
Partially Supporting	Partial support based on mixed Index of Biotic Integrity findings PS. Partial support based on physical/chemical parameters PS.
Not Supporting	IBI shows nonsupport NS. If no IBI, physical/chemical parameters show NS.

Alternative methods of data analysis may be used based on the size of the data set and on a professional judgment review of the data. Such methods are outlined in "Guidance Manual for Assessing the Quality of Minnesota Surface Waters For Determination of Impairment: 305(b) Report and 303(d) List," Minnesota Pollution Control Agency (January 2004) and subsequent revisions.

B. Biological/Habitat Data

The MPCA uses fish and invertebrate community data to assess the quality of streams for the 305(b) and 303(d) assessment process. The basis for assessing the biological community for impairment is the narrative water quality standards and assessment factors in rule (Minn. R. pt. 7050.0150). The data is assessed every two years.

From 1996-2005, over 1000 streams sites have been sampled in Minnesota. The sampling occurs in a rotating basin sequence with roughly 50 percent of the sites randomly chosen to determine the overall condition of the basin and 50 percent of the sites used to calibrate the IBI. Field investigations and IBI development are conducted in cooperation with numerous federal and state agencies including the USEPA, USGS, Minnesota Department of Natural Resources (MDNR), and the North Dakota Department of Health. The index period for sampling fish communities is during normal to low flows in the summer (mid-June through September) and early fall for the invertebrates. The period of record is the most recent decade of data and information. Impairment decisions based on biological assessment data can be based on a single biological monitoring event on a given reach. The IBI relies on multiple attributes of the aquatic community, called "metrics", to evaluate a complex biological system. Each metric is based upon a structural (e.g., species composition) or functional (e.g., feeding habits) aspect of the aquatic community that changes in a predictable way in response to human disturbance. Each of nine metrics are assigned a score of 0, 2, 5, 7, or 10. Metric scores are then summed and normalized so that the maximum (i.e. best) score possible is 100 (range 0 to 100). Table I-2 on page 1-12, provides an example of the scoring criteria for the nine metrics used to calculate IBI scores for small streams.

Site impairment is determined by comparing the IBI score for a site against a threshold IBI score that is based on the distribution of IBI scores at reference sites. Land use characteristics and the physical characteristics of the sites are used to help guide the reference site selection process. In the process of locating reference sites an attempt is made to meet as many of the following criteria in the sampling site as possible.

Land within the watershed is primarily in a natural state (forest, wetlands, meadow).

- Stream morphology (i.e., riffles, runs, pool sequence) in the stream reach and upstream watershed is in a natural condition (e.g., the stream has not been channelized or dredged).
- Continuous riparian area within the upstream watershed and along the reach (e.g., land use is consistent laterally, soils and vegetation are undisturbed).
- Stream fish community has not been altered through stocking of forage or game fish species or chemically treated to remove rough fish.
- No point source discharges, ditches or drainage canals within the watershed and sampling site.
- Stream morphological characteristics in stream reach representative of upstream and downstream reaches.
- No stream habitat "improvements" within the stream reach (i.e., wing dams, rip rap, etc.)
- Reach has not been snagged (e.g., removal of woody debris to promote drainage)
- No dams or diversions upstream or downstream, or if present not within two replications of major morphological units (i.e., riffles, runs, pool sequence)
- No bridges upstream of the reach, or if present within the watershed not within two meander cycles or two replications of major morphological units.

Table 1-2. Example of Scoring Criteria for the Nine Metrics Used to Calculate IBI Scores for Small Streams in the St. Croix River Basin of Minnesota.

Metric For Fish Communities	Numeric Score Assigned to Conditions:				
	10	**7**	**5**	**2**	**0**
Species Richness and Composition Metrics					
Total number of species	15 or more	12-14	9-11	6-8	0-5
Number of intolerant species	4 or more	3	2	1	0
Number of minnow species	6 or more	5	3-4	2	0-1
Percent tolerant species	0-40	41-55	56-70	71-85	86-100
Percent dominant two species	0-44	45-58	59-72	73-86	87-100
Trophic Composition and Reproductive Metrics					
Number of benthic insectivore species	4	3	2	1	0
Percent simple lithophils (gravel spawners)	49-100	37-48	24-36	13-24	0-12
Abundance and Condition Metrics					
Number of fish per 100 meters	11 or more				0-10
Percent anomalies	0-1		2-3		< 3

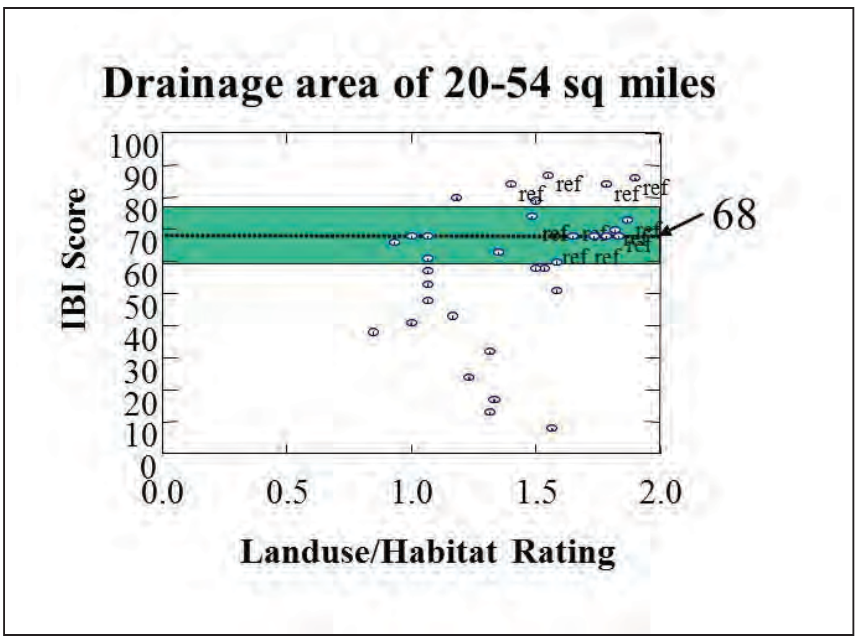


Figure 1: Index of biological integrity scores for small streams (20-54 mi² drainage area) in the St. Croix River basin of Minnesota plotted against a land use/habitat rating. The land use/habitat rating is used as an indicator of site condition. The letters “ref” are used to denote reference sites. The horizontal dashed line represents an impairment threshold that is derived using the lower bounds of the range of IBI values for reference sites. The shaded area represents a margin of error around the impairment threshold.

Scores above the threshold are considered to be not impaired. Scores below are considered to be impaired. A margin of error is calculated using data from repeated visits to the same site. Within the margin of error additional physical and chemical data from within the reach and the watershed are used to help corroborate whether a site is or is not impaired. See example in Figure 1.

At this time, IBIs have been used to determine stream impairment in the St. Croix, Upper Mississippi, Minnesota, and Red River basins. Detailed information can be found at the MPCA's TMDL Website: *www.pca.state.mn.us/water/tmdl/index.html*

C. How we combined the information sources: Some waterbodies had more than one category of data available for assessing use support. When this occurred, the judgment was based on the strongest information possible.
   Biology was considered to be the strongest indicator of a waterbody's ability to support aquatic life, therefore IBI evaluations took precedence over any other preliminary assessments for a reach.
   In the absence of biological measures, support levels were based on physical and chemical parameters of WQ, where available.

Aquatic Recreation Use Support

Assessments for AQR use support are conducted to determine whether the waters are of a quality to support primary body contact. AQR use was determined based on in-stream monitoring of fecal coliform bacteria.

Data are aggregated by individual month over the most recent ten-year time period that begins in October and ends in September. There must be a minimum total of 10 observations for a water to be assessed. There must be a minimum of five observations for a month (all years combined) to determine a geometric mean for that month. The standard applies from April 1 to October 31. Substitute appropriate water quality standard for support determination for each use classification.

Fecal Coliform Water Quality Standards		
Class 2A	200 orgs/100 ml	Not to exceed as geometric mean of 5 or more samples/calendar month **OR**
	400 orgs/100 ml	No more than 10% of samples/calendar month can individually exceed.
Class 2Bd, 2B, 2C, 2D	200 orgs/100 ml	Not to exceed as geometric mean of 5 or more samples/calendar month **OR**
	2,000 orgs/100 ml	No more than 10% of samples/calendar month can individually exceed.

Full Support: If the geometric mean for each month (all years combined) does not exceed 200 orgs/100 ml and if; less than 10 percent of all individual observations for the ten-year period exceed 2,000 orgs/100 ml.

Partial Support: If the geometric mean for one or two months (all years combined) exceeds 200 orgs/100 ml or if 10-25 percent of all individual observations for the ten-year period exceed 2,000 orgs/100 ml.

Nonsupport: If the geometric mean for three or more months (all years combined) exceeds 200 orgs/100 ml or if more than 25 percent of all individual observations for the ten-year period exceed 2,000 orgs/100 ml.

Aquatic Consumption Use

Assessments of AQC are assessments of fish for human consumption based on fish contaminant data. The data used in the MPCA assessments are the same data used by the Minnesota Department of Health (MDH) to issue the Fish Consumption Advisories.

Of the bioaccumulative pollutants that have been monitored in fish, mercury and polychlorinated biphenyls (PCB) are the primary contaminants found at levels of concern to human consumers of fish. The Minnesota Fish Consumption Advisory (MFCA) and the MPCA fish contaminant assessments deal just with these two pollutants. Fish from some waterbodies may contain both mercury and PCBs. The consumption advice, and the determination of an impaired condition consider both pollutants. About 40 percent of the river advisories reflect both mercury and PCB contamination; the rest are due mainly to mercury. Fish contaminant data are also used by the MPCA to determine where site-specific studies are needed, to help identify sources of pollutants, and to look for trends in fish tissue levels.

The basis for assessing the contaminants in fish tissue is the narrative water quality standards and assessment factors in Minn. R. pt. 7050.0150, subp. 7 which is quoted below:

Subp. 7. ***Impairment of waters relating to fish for human consumption.***

In evaluating whether the narrative standards in subpart 3, which prevent harmful pesticide or other residues in aquatic flora or fauna, are being met, the commissioner will use the residue levels in fish muscle tissue established by the Minnesota Department of Health to identify surface waters supporting fish for which the Minnesota Department of Health recommends a reduced frequency of fish consumption for the protection of public health. A water body will be considered impaired when the recommended consumption frequency is less than one meal per week, such as one meal per month, for any member of the population. That is, a water body will not be considered impaired if the recommended consumption frequency is one meal per week, or any less restrictive recommendation such as two meals per week, for all members of the population. The impaired condition must be supported with measured data on the contaminant levels in the indigenous fish.

The MDH has established concentrations of mercury and total PCBs in fish tissue that corresponds to meal frequency recommendations. These concentrations are derived using health-based estimates of exposure to mercury and PCBs, through fish consumption that are likely to be without appreciable risk of harmful effects on humans (assuming the advice is followed). The mercury advice of interest to 303(d) listing targets the most sensitive individuals in the population, including but not limited to children, pregnant women and their fetuses.

It is not necessarily protective of hypersensitive individuals. The advice is derived using the best peer-reviewed science available.

The fish tissue mercury and PCB concentrations and corresponding MDH advice categories are shown in Table I-3. It is coincidental that the one meal-per-week threshold is 0.2 ppm for both mercury and PCBs. Mercury concentrations in Table I-4 are for consumption by the more sensitive sub-population of young children and women of child-bearing age. The concentrations for PCBs apply to all humans.

A. Mercury

Minnesota has two human health-based Class 2 water quality standards for total mercury, the statewide standard in Minn. R. ch. 7050 and the standard applicable to just the waters of the Lake Superior basin in Minn. R. ch. 7052. These standards are shown below:

- 6.9 ng/L. chronic standard, Minn. R. pt. 7050.0222
- 1.3 ng/L. chronic standard, Minn. R. pt. 7052.0100 (ng/L = nanogram per liter, or parts per trillion)

Relevant to the assessment of mercury in fish is the issuance by USEPA of a revised human health-based water quality criterion for methylmercury (USEPA 2001). This new criterion is unique among all USEPA (Clean Water Act section 304(a)) criteria in that the medium for the acceptable mercury concentration is fish tissue rather than water. A fish tissue criterion for mercury is logical because it is fish that are the main source of methylmercury exposure to both humans and wildlife. Also, a tissue-based criterion eliminates the need for a bioaccumulation factor in the criterion calculation which can be a significant source of uncertainty. The new USEPA criterion is 0.3 mg/kg (ppm) methylmercury in fish muscle tissue. Since nearly 100 percent of the mercury in fish muscle is methyl mercury, the criterion can be assumed to be a total mercury criterion.

In the determination of the 0.3 ppm criterion, USEPA assumes people eat 17.5 grams of fish per day (g/d), as mentioned above. If the USEPA criterion is re-calculated assuming people eat 30 g/day, the criterion becomes 0.17 ppm. This USEPA criterion and the MFCA are both based on the same USEPA-derived reference dose of 0.1 µg/kg/day. The difference between the MDH value of 0.2 ppm from Table I-3 and the re-calculated USEPA criterion of 0.17 ppm, both of which assume a single half pound meal of fish per week, has to do with how the consumption of marine fish is taken into account. The MFCA is advice about eating fish from any source, sport-caught, store-bought, marine or freshwater. The USEPA aquatic life criteria (applicable in Minnesota) apply only to freshwater habitats. But, in the calculation of freshwater criteria, USEPA assumes people eat a certain amount of marine fish in addition to the 17.5 g/d of freshwater fish.

As a result, the freshwater criterion is lowered to allow for this "outside" source of mercury (this is standard procedure in USEPA criteria and MPCA standard calculations). Thus, the re-calculated mercury criterion ends up at 0.17 rather than 0.2 ppm. Considering the points listed below, the MPCA believes that the use of 0.2, rather than 0.17 ppm as the basis for impairment decisions is appropriate.

- USEPA rounded the reference dose of 0.1 µg/kg/day to one
- significant figure; thus, 0.17 and 0.2 ppm could be considered essentially the same number
- the use by MPCA of the more protective fish consumption amount (30 g/d
- the use of safety factors in the criterion calculation (again, standard procedure)
- uncertainties inherent in criteria development
- the importance of maintaining consistency in the MPCA/MDH approaches

Table I-3. Fish Tissue Concentrations (in ppm) for Levels of Consumption Advice Established by MDH for Mercury and Total PCBs.

Mercury	**Mercury Concentration in Fish, ppm**				
	< 0.05	0.05 - 0.2	0.2 - 1.0		> 1.0
Consumption Advice*	Unlimited	1 meal/week	1 meal/month		Do not eat
Total PCBs	**Total PCBs Concentration in Fish, ppm**				
	< 0.05	0.05 - 0.2	0.2 - 1.0	1.0 - 1.9	> 1.9
Consumption Advice	Unlimited	1 meal/week	1 meal/month	1 meal/2 months	Do not eat

*Consumption advice for young children and women of child-bearing age. Shaded cells indicate consumption advice that corresponds to non-support and an impaired condition.

Table I-4. Summary of Data Requirements and Fish Contaminant Thresholds for Assessment of Fish for Human Consumption.

Impairment Assessment For	Period of Record*	Minimum No. of Data Points*	Fish Contaminant Levels for Mercury and PCBs. Fish Consumption Advice	
		Fish Contaminant Levels → Advice to Eat a Fish Meal→	≤ 0.2 ppm Once a week, or more frequent	> 0.2 ppm. Less frequent than once a week
305(b) Report	Hg: not limit. PCBs: 10 years	One	Information	Information
303(d) List (TMDL)	Hg: no limit. PCBs: 10 years	One	Not Listed	Listed

*Available data averaged by waterbody by species by size class over a five-year period that includes most recent data.

B. Polychlorinated Biphenyls

Since the manufacture and sale of PCB were banned in 1976, measured concentrations in fish tissue have decreased by 90 percent in some fish species in the Mississippi River and by 75 percent in Lake Superior lake trout. It is anticipated that, with time, natural volatilization and sedimentation processes in lakes and streams will further reduce fish exposure to PCBs in the environment at most locations. The total PCB concentrations in Lake Superior water dropped from about 2.4 ng/L in 1980 to 0.18 ng/L in 1992, mostly due to volatilization (Jeremiason et al. 1994). The fish tissue concentration thresholds for PCB consumption advice are shown in Table I-4.

C. Data Requirements and Determination of Impaired Condition

The one exception to the overall practice of using the latest 10 years of data for the 305(b) and 303(d) assessments is for the analysis of mercury fish tissue data. The complete mercury fish tissue data record will be used; that is, at present, there is no age limit for mercury fish tissue data. The reason for this departure from the 10-year period of record in this case is rather simple. A state-wide trend analysis of mercury fish tissue concentrations measured over the last 10 – 15 years indicates a very slight average rate of decline – about one percent per year (MPCA 2002). This is not a large enough downward trend to justify using only the latest 10 years of data. Also, there have been no significant changes in sampling or analytical procedures, associated with the fish tissue data that would invalidate the older data. It would not be justifiable to remove a waterbody from the 303(d) list simply because the mercury fish tissue data for that waterbody were collected more than 10 years ago.

Only the most recent 10 years of data are used in the assessment of fish tissue data for PCBs. As noted previously, significant downward trends in PCB concentrations have been documented. Thus, older data is not likely to be a valid indicator of current conditions.

The MDNR coordinates the fish tissue sampling program with input from the MPCA and MDH on where to collect fish. Each year some waterbodies are sampled for the first time and some waterbodies are re-sampled. Sample locations are determined by:

- Where MDNR personnel will be conducting population surveys,
- Waterways where fishing pressure is relatively high,
- Where previous collections are becoming outdated, or
- Where information is needed for special studies or trend analysis.

The edible portion, which is a skin-on fillet, is prepared in the MPCA fish processing lab. Currently, fish samples are analyzed by the Department of Agriculture analytical lab. Since fish bioaccumulate these pollutants, concentrations below method detection limits are not usually an issue. When they do occur, one half of the method detection limit (less-than value) is used in the assessments. The data for each lake or river reach are separated by species and by individual size classes: 5-15, 15-20, 20-25, 25-30 and 30 + inches.

Data collected in the five-year period that includes the most recent sampling is averaged. That is, the assessment program identifies the most recent data point, then searches back five years for additional data from the same waterbody, same species, same size class, and averages them. The entire mercury database will be searched, but only the most recent 10 years for PCB data. Waterbodies will be considered impaired if the arithmetic average concentration for any fish species in any size class exceeds 0.2 ppm for either mercury or PCBs. Only waterbodies with measured data in excess of this threshold will be listed in Table I-4.

Fish can be very mobile and difficult to attribute to a discrete portion of a lake or river reach. For the 305(b) and the 303(d) assessments, all fish tissue information from a lake are aggregated unless there is evidence to show that fish from certain parts of a lake are isolated and may be exposed to different levels of contamination. For rivers, fish are collected with nets or electrofishing gear in a range of river miles generally not more than five miles apart. Sampled sections of a river are associated with river reaches in the USGS hydrologic unit code system. However, fish tissue data from one or more sampling station may be considered representative of more than just the reach from which they were collected. Adjacent river reaches may be listed as well as the reach from which the fish were collected based on general information about the home range of the species, location of upstream or downstream fish barriers such as falls and dams, and significant river tributaries.

Lakes Assessment Process and Development: 2006 Assessment

Thirty four years of data (1970-2004) from USEPA's STORET database was the primary basis for this assessment. The focus of this assessment is on trophic state and its relation to support and nonsupport of designated uses, specifically aquatic recreation uses, which includes swimming, wading, aesthetics and other related uses. The parameters used to assess trophic state and aquatic recreational use were epilimnetic TP, chlorophyll-a (chl-a) and Secchi Disk (SD) transparency.

In addition to this assessment raw water quality data are available to the public on the Environmental Data Access Web site: *www.pca.state.mn.us/data/edaWater/index.cfm*

This Web site allows for a text or map-based search for lake and stream data. This allows the user to do their own analysis of the data and double-check assessments that were made.

Monitored Data

Lakes with summer data (defined as the time period from June through September) collected between calendar years 1995-2004 were considered monitored. Summer data are preferred for assessments to better represent the maximum productivity of a lake and yield the best agreement among trophic variables. This time period also reflects the primary season when the resource is used for aquatic recreation. Summer-means were calculated for each variable and used in the assessment. In addition the number of observations (N), standard error (SE) of the mean, maximum (max) and minimum (min) values were calculated as well. These additional statistics can be used to place the mean values in perspective and improve the ability to make comparisons of values among lakes.

Evaluated Data

Lakes without data meeting monitored criteria, but with TP, chl-a or SD transparency measurements collected from 1970-1994 were treated as evaluated. Summer data were used for calculating mean chl-a and SD transparency. All available TP data were used to calculate mean TP. Expanding the season for TP allows for inclusion of a larger number of lakes in northern Minnesota. These lakes were often sampled only during spring or fall turnover as part of the MPCA Acid Rain Lake Monitoring Program in the early 1980's.

Data Quality

Assessing the "quality" of data used in the assessment is a new feature of the 305(b) assessment. Since the data used in these assessments was derived from STORET we assume that certain "quality control" thresholds were already established for the data. Hence our definition of "quality" will focus on the relative amount of information available for the assessment. In the case of our aquatic recreational use assessments TP is the primary variable used so we place the greatest emphasis on the amount of TP data available for the assessment. The "quality" terms used in Table I-5, were drawn from USEPA guidance. In general we feel that assessments based on multiple measurements are more reliable than those based on only a few measurements. The rationale for assigning the respective "quality" definitions corresponds roughly to typical lake-monitoring regimens (e.g. monthly sampling during the summer season), whereby four TP samples often represent one summer; eight samples two summers and 12 samples two-three summers. In the case of 303(d) assessments 12 or more TP, chlorophyll-a and Secchi measurements are required to determine if a lake should be placed on the 303(d) list and was considered "excellent" quality data for assessment. In general the thresholds were similar for the "monitored" (recent) and the "evaluated" (old) data with the exception that there would be no "excellent" evaluated data as these data are more that ten years old.

A. Trophic Status Assessment

Trophic Status was determined for each lake using Carlson's Trophic State Index (TSI). This index was developed using the relationship among summer Secchi transparency, epilimnetic concentrations of chlorophyll-a, and TP (Figure 2).

The TSI values are calculated as follows:

* *Secchi disk* (SD) TSI (TSIS) = 60 - 14.41 natural log (ln) SD;
* *Total phosphorus* (TP) TSI (TSIP) = 14.42 ln TP + 4.15;
* *Chlorophyll-a* (chl-a) TSI (TSIC) = 9.81 ln chl-a+30.6; (chl-a and TP in micrograms per liter (µg/L) and SD transparency in meters).

The index ranges from 0 to 100 with higher values indicating more eutrophic conditions. The TSI values were calculated for each variable; however trophic status will be based on total phosphorus when data are available. If no TP data are available for a lake, the Secchi TSI value will be used to estimate trophic status. Ideally, chlorophyll-a would be used for this purpose; however chlorophyll-a (corrected) is measured much less frequently than Secchi or TP so we chose to focus on TP. The following breakpoints were used to define the trophic status of the lake: TSI ≤40 "oligotrophic (O)", ≥41 TSI <50 "mesotrophic (M)", ≥50 TSI ≤70 "eutrophic (E), and TSI ≥70 "hypereutrophic (H). This index and the inter-relationships among TP, chlorophyll-a, and Secchi figure prominently in definition of use-support categories to be addressed later.

Table I-5. Data quality characterizations for 305(b) and 303(d) assessments.

Quality	"Monitored Data"	"Evaluated Data"
Poor	< 4 TP measurements	< 4 TP measurements
Fair	4 ≤ TP < 8, some chl-a & Secchi	4 ≤ TP < 8, some chl-a & Secchi
Good	8 < TP < 12, some chl-a & Secchi	8 < TP < 12, some chl-a & Secchi
Excellent	12 TP, 12 chlorophyll-a & 12 Secchi	NA

B. Aquatic Recreation Use Assessment

Assessing whether lakes "support" or "do not support" aquatic recreation is required as a part of Section 305(b) of the Clean Water Act. Minnesota has long used an ecoregion-based approach for these assessments. Previously developed ecoregion-based phosphorus (TP) criteria (Table I-6) have long been used in conjunction with Carlson's TSI scale (Figure 2) to establish use support thresholds (Table I-7). These thresholds are described in more detail in MPCA's "Guidance Manual for Assessing the Quality of Minnesota Surface Water" that may be found at: *www.pca.state.mn.us/water/tmdl/index.html#publications*

These thresholds provide a basis for determining nutrient-impaired waters for the 2002, 2004 and 2006 303(d) lists and help guide the 305(b) assessments as well. The phosphorus "criteria" we refer to were originally derived based on an analysis of reference lake data Table I-8 and various ecoregion-specific considerations such as lakemorphometry, attainability and lake user perceptions (Heiskary and Wilson, 1988). Determining use support by ecoregion provides a more reflective picture of the condition of Minnesota lakes, as opposed to assessing all lakes by a single scale that ignores important regional differences such as lake morphometry and lake user perceptions.

The MPCA is in the process of developing ecoregion-based total phosphorus, chlorophyll-a and Secchi criteria as a part of the water quality standards revision process and draft criteria are presented in Table I-9. The thresholds used for 305(b) were modified slightly (from previous assessments) so they were more consistent with use support definitions developed for 303(d) assessment (Table I-7). For 305(b) purposes we employ three "levels" of support: full, partial, and non support. In general, full support thresholds for the Northern Lakes and Forests (NLF) and North Central Hardwood Forests (CHF) ecoregions are the same as in previous 305(b) assessments (30 and 40 µg/L respectively); while those for the Western Corn Belt Plains (WCP) and Northern Glaciated Plains (NGP) are somewhat less restrictive (70 µg/L). Differences in lake-user perceptions of "impaired swimming" and what constitutes nuisance algal blooms, along with differences in lake-morphometry and attainability are primary reasons for the regional differences. As with assessment of trophic status, TP was used as the basis for assessing use support. If TP data was not available Secchi (based on TSI thresholds described below) was used.

The NLF and CHF ecoregions phosphorus criteria levels, 30 µg/L and 40 µg/L, respectively, serve as the upper thresholds for full support of aquatic recreational use. Those concentrations correspond to Carlson's TSI values of 53 and 57, respectively. Phosphorus concentrations above criteria levels would result in greater frequencies of nuisance algal blooms and increased frequencies of "impaired swimming." The upper threshold for partial support of aquatic recreational use was set at 56 and 59 Carlson's TSI units, respectively, for these two regions. As phosphorus concentrations increase from about 30 µg/L to 60 µg/L, summer-mean chlorophyll-a concentrations increase from about ten µg/L to 30 µg/L, and Secchi transparency decreases from about 2.5 meters to 1.5 meters (Table I-8). Over this range, the frequency of nuisance algal blooms (greater than 20 µg/L chl-a) increases from about five percent of the summer to about 70 percent of the summer (Table I-9 on page 1-28). The increased frequency of nuisance algal blooms and reduced Secchi transparency results in a high percentage of the summer (26-50 percent) perceived as "impaired swimming." For the NLF ecoregion summer-mean TP concentrations above 35 µg/L were associated with nonsupport of aquatic recreational use. At TP concentrations above 35 µg/L, mild algal blooms (greater than

10 µg/L chl-a) may occur over 50 percent of the summer and nuisance blooms (> 20 µg/L chl-a) about 15 percent of the summer. Secchi transparency will typically average 1.6 m or less. The combination of frequent blooms and reduced transparency will result in a high frequency of impaired swimming (perhaps 50 percent of summer) and greater than 25 percent as "no swimming."

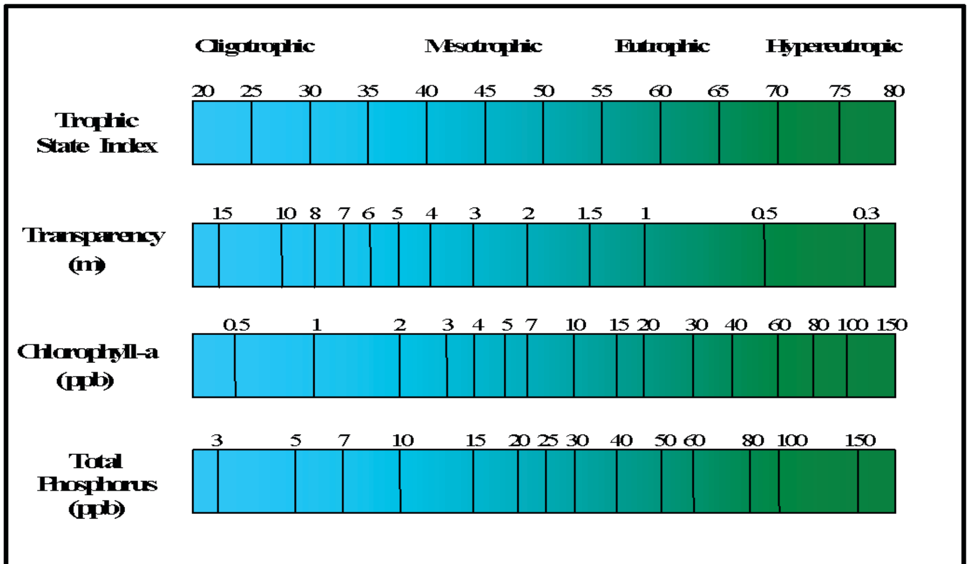
Table I-6. Minnesota Lakes Total Phosphorus Criteria
(Heiskary and Wilson (1988).

Ecoregion	Use and Level of Support	TP Criterion
Northern Lakes and Forests	Cold water fishery Full support	< 15 µg/liter
Northern Lakes and Forests	Primary-contact recreation and aesthetics Full support	< 30 µg/liter
North Central Hardwood Forests	Primary-contact recreation and aesthetics Full support	< 40 µg/liter

Figure 2. Carlson's Trophic State Index

Carlson's Trophic State Index
RE Carlson

TSI <30	Classic Oligotrophy: Clear water, oxygen throughout the year in the hypolimnion, salmonid fisheries in deep lakes.
TSI 30 - 40	Deeper lakes still exhibit classical oligotrophy, but some shallower lakes will become anoxic in the hypolimnion during the summer.
TSI 40 - 50	Water moderately clear, but increasing probability of anoxia in hypolimnion during summer.
TSI 50 - 60	Lower boundary of classical eutrophy: Decreased transparency, anoxic hypolimnia during the summer, macrophyte problems evident, warm-water fisheries only.
TSI 60 - 70	Dominance of blue-green algae, algal scums probable, extensive macrophyte problems.
TSI 70 - 80	Heavy algal blooms possible throughout the summer, dense macrophyte beds, but extent limited by light penetration. Often would be classified as hypereutrophic.
TSI >80	Algal scums, summer fish kills, few macrophytes, dominance of rough fish.



After Moore, 1. And K. Thornton, [Ed.] 1988. Lake and Reservoir Restoration Guidance Manual. USEPA>EPA 440/5-88-002.

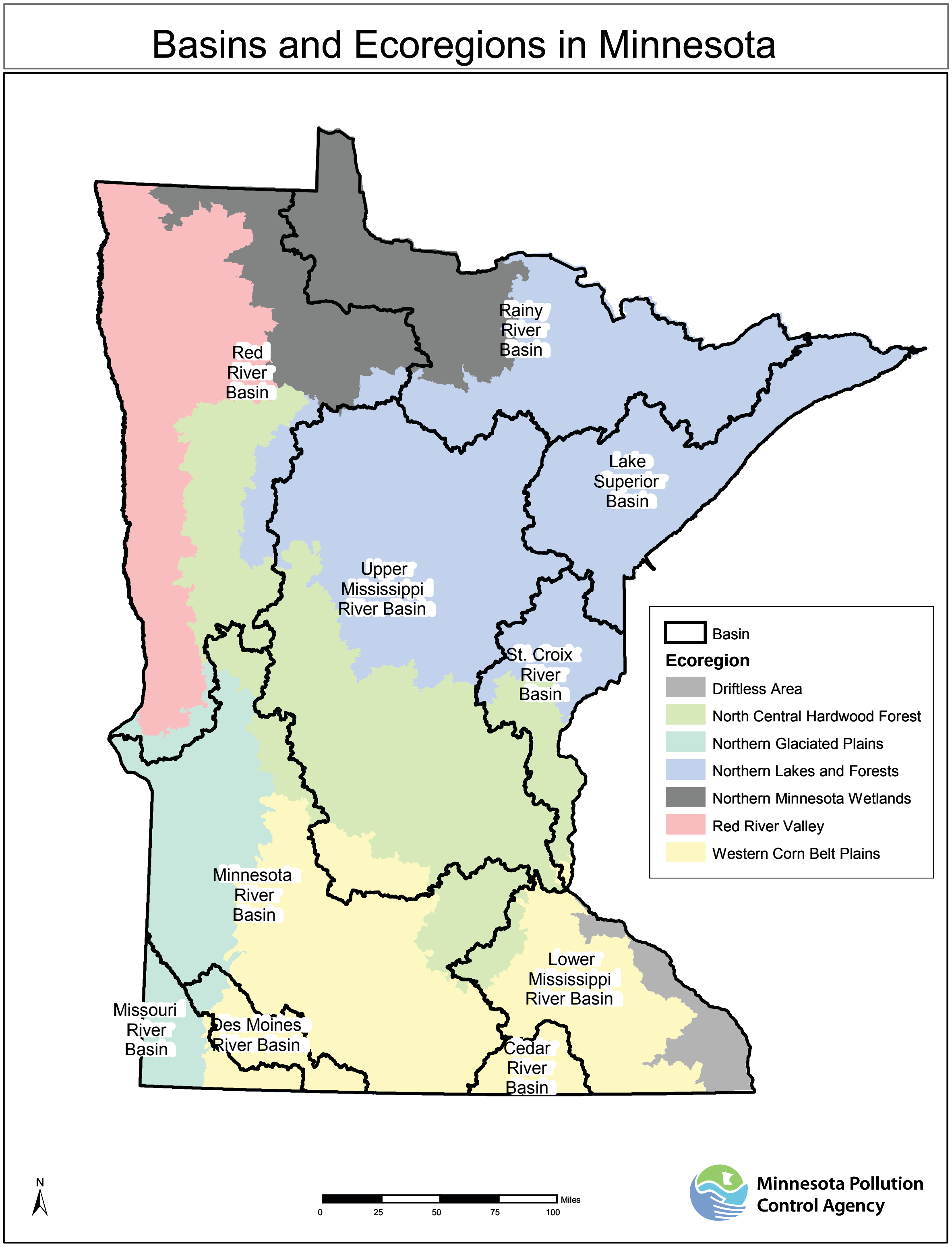
Ecoregion	Use and Level of Support	TP Criterion
Western Corn Belt Plains and Northern Glaciated Pains	Primary-contact recreation, Full support	< 40 µg/liter
Western Corn Belt Plains and Northern Glaciated Pains	Primary-contact recreation, Partial support	< 90 µg/liter

Table I-7. Trophic Status Thresholds for Determination of Use Support For Lakes: Comparison of 305(B) and 303(D). (Carlson's TSI noted for each threshold.)

Ecoregion (TSI)	**TP ppb**	**Chl ppb**	**Secchi m**	**TP Range ppb**	**TP ppb**	**Chl ppb**	**Secchi m**
305(b)	**Full Support**			Partial Support		Non-Support	
303(d)	**Not Listed**			**Review**	**Listed**		
NLF	**<3 0**	**< 10**	**≥ 1.6**	**30-35**	**> 35**	**> 12**	**< 1.4**
(TSI)	(< 53)	(< 53)	(< 53)	(53-56)	(>56)	(> 55)	(>55)
CHF	**< 40**	**< 15**	**≥ 1.2**	**40 - 45**	**> 45**	**> 18**	**< 1.1**
(TSI)	(< 57)	(< 57)	(< 57)	(57-59)	(> 59)	(> 59)	(> 59)
WCP & NGP	**< 70**	**< 24**	**> 1.0**	**70 - 90**	**> 90**	**> 32**	**< 0.7**
(TSI)	(< 66)	(< 61)	(< 61)	(66—69)	(> 65)	(> 65)	(> 65)

TSI = Carlson trophic state index; Chl = Chlorophyll-a; ppb = parts per billion or µg/L, m = meters

Figure 3. Minnesota's Ecoregions and Major Drainage Basins.



For the CHF ecoregion summer-mean TP concentrations above 45 µg/L were associated with nonsupport of aquatic recreational use. At TP concentrations above about 45 µg/L mild blooms occur over 80 percent of the summer, nuisance blooms about 40 percent of the summer, and severe nuisance blooms about 15 percent of the summer. Secchi transparency typically averages 1.1 m or less over this range of TP. Transparencies less than 1.4 m are typically associated with impaired swimming, while those less than 1.1 m are typically associated with no swimming (Heiskary and Wilson, 1988).

For the WCB Plains and NGP the upper TP thresholds for fully supporting is 70 µg/L, which is consistent with the level used for 303(d) assessment (Table I-7). This corresponds to a TSI of 66. At a TP concentration of 70 µg/L, summer mean chlorophyll-a averages about 24 µg/L and Secchi transparency is about 0.8 meter.

Nuisance algal blooms (greater than 30 µg/L chl-a for these regions) would occur for approximately 50 percent of the summer. Few lakes in these two ecoregions have TP concentrations of 70 µg/L or less. Partial support, which corresponds to a TP concentration of 70 - 90 µg/L (Carlson's TSI = 69), is again consistent with the 303(d) assessment (Table I-7). Total phosphorus concentrations greater than 90 µg/L are considered not supporting of aquatic recreational use. At TP concentrations greater than 90 µg/L, Secchi transparency averages 0.5 meters or less and nuisance algal blooms may occur over 75 percent of the summer.

Lakes in the Red River Valley (RRV) and Northern Minnesota Wetlands (NMW) ecoregions were assessed using the North Central Hardwood Forests and Northern Lakes and Forests criteria, respectively. This is because there were too few lakes to establish reference conditions in the Red River Valley or Northern Minnesota Wetlands ecoregions.

Once promulgated into water quality standards the draft nutrient criteria (Table I-9) will be the basis for 305(b) and 303(d) lake assessments. These criteria should allow for a more comprehensive assessment of lake water quality and use support. Two features of the draft criteria is that they allow for the differentiation between deep and shallow lakes and also consider fishery requirements more fully. A detailed report (Heiskary and Wilson, 2005) on the development of the criteria is available at: *www.pca.state.mn.us/water/lakequality.html#reports*

Table I-8. Ecoregion Reference Lake Data Summary. Based on the Interquartile (25th - 75th percentile) Range for Reference Lakes. Also referred to as "typical range."

Parameter	Northern Lakes and Forests	North Central Hardwood Forests	Western Corn Belt Plains	Northern Glaciated Plains
# of reference lakes	30	35	12	10
Total Phosphorus (µg/L)	14 - 27	23 - 50	65 - 150	122 - 160
Chlorophyll mean (µg/l)	4 - 10	5 - 22	30 - 80	36 - 61
Chlorophyll max. (µg/L)	< 15	7 - 37	60 - 140	66 - 88
Secchi Disk (feet) (meters)	8 - 15 (2.4 - 4.6)	4.9 - 10.5 (1.5 - 3.2)	1.6 - 3.3 (0.5 - 1.0)	1.3 – 2.6 (0.4 – 0.8)
Total Kjeldahl N (mg/l)	0.4 – 0.75	< 0.60 - 1.2	1.3 - 2.7	1.8 - 2.3
Nitrite + Nitrate-N (mg/l)	<0.01	<0.01	0.01 - 0.02	0.01 - 0.1
Alkalinity (mg/l)	40 – 140	75 - 150	125 - 165	160 - 260
Color (Pt-Co Units)	10 – 35	10 - 20	15 - 25	20 - 30
pH (SU)	7.2 - 8.3	8.6 - 8.8	8.2 - 9.0	8.3 - 8.6
Chloride (mg/l)	0.6 – 1.2	4 - 10	13 - 22	11 - 18
Total Sus. Solids (mg/l)	< 1 – 2	2 - 6	7 - 18	10 - 30
Total Suspended Inorganic Solids (mg/l)	< 1 – 2	1 - 2	3 - 9	5 - 15
Turbidity (NTU)	< 2	1 - 2	3 - 8	6 - 17
Conductivity (umhos/cm)	50 – 250	300 - 400	300 - 650	640 - 900
TN:TP ratio	25:1 - 35:1	25:1 - 35:1	17:1 - 27:1	7:1 - 18:1

Table I-9. Draft Eutrophication Criteria by Ecoregion and Lake Type
(Heiskary and Wilson, 2005).

Ecoregion	TP	Chl-a	Secchi
	ppb	ppb	meters
NLF – Lake trout (Class 2A)	< 12	< 3	> 4.8
NLF – Stream trout (Class 2A)	< 20	< 6	> 2.5
NLF – Aquatic Rec. Use (Class 2B)	< 30	< 9	> 2.0
CHF – Stream trout (Class 2a)	< 20	< 6	> 2.5
CHF – Aquatic Rec. Use (Class 2b)	< 40	< 14	> 1.4
CHF – Aquatic Rec. Use (Class 2b) Shallow lakes	< 60	< 20	> 1.0
WCP & NGP – Aquatic Rec. Use (Class 2B)	< 65	< 22	> 0.9
WCP & NGP – Aquatic Rec. Use (Class 2b) Shallow lakes	< 90	< 30	> 0.7

Wetlands

Wetlands have not been assessed through the 2006 reporting cycle, but there will be assessments for aquatic life use in some wetlands for the 2008 reporting cycle.

Total Maximum Daily Loads (TMDLs) and Minnesota's Waterways

The currently emphasized approach to help solve the problem of water pollution is developing TMDLs. Waterbody assessments form the basis for identifying a waterbody as needing a TMDL study.

For each pollutant that causes a water body to fail to meet state water quality standards, the Federal Clean Water Act requires the MPCA to conduct a TMDL study. A TMDL study identifies both point and nonpoint sources of each pollutant that causes a waterbody to fail to meet water quality standards. Numerous TMDL studies are underway. Existing and future TMDL Studies can be viewed at: *www.pca.state.mn.us/water/tmdl/tmdl-projects.html*

Water quality sampling and computer modeling determine how much each pollutant source must reduce its contribution to assure the water quality standard is met. Rivers and streams may have several TMDLs, each one determining the limit for a different pollutant.

The Clean Water Act requires states to publish, every two years, an updated list of streams and lakes that are not meeting their designated uses because of excess pollutants. The list, known as the 303(d) list, is based on violations of water quality standards and is organized by river basin.

The final 2006 303(d) list of impaired waters in Minnesota can be viewed at: *www.pca.state.mn.us/water/tmdl/tmdl-303dlist.html*

Some of the waterbody assessments mapped in this chapter are based on screening level data, that is either the quality or the quantity of the data is less than that required for TMDL listing. On the other hand, there are waterbodies on the TMDL list for localized toxicants concerns, high temperature in trout streams, and mercury in the water column. Because statewide assessments are not done for these conditions, those waterbodies are not included in the assessments mapped in this chapter.

The list that Minnesota submitted to USEPA in 2004 included streams throughout the state. By establishing TMDLs in these areas, the MPCA will be able to take steps to regain designated uses in these waters.

Pollutant Trends for Minnesota Rivers and Streams

The best available information on pollutant trends in rivers and streams comes from Minnesota Milestone sites. These are a series of 80 monitoring sites across the state with good, long-term data. While the sites are not necessarily representative of Minnesota's rivers and streams as a whole, they do provide a valuable historical record for many of the state's waters. Monitoring results over the period of record, which in some cases goes back to the 1950s, show significant reductions across the state for biochemical oxygen demand, total suspended solids, phosphorus, ammonia and fecal coliform bacteria. These results reflect the considerable progress made during that time in controlling municipal and industrial point sources of pollution. At most locations, it is simply known that municipal and industrial wastewater treatment improved during this time period.

At some locations, such as the Rainy River, St. Louis Bay and Metro area Mississippi, specific studies were done which relate wastewater treatment improvements with improvement in stream conditions. Nitrite/ nitrate levels, on the other hand, show increases at many of the Minnesota Milestone sites, perhaps reflecting continuing NPS problems. Table I-10 on the following pages. and the six maps following this table, provide further detail.

Table I-10. Pollutant Trends at Minnesota Milestone Sites

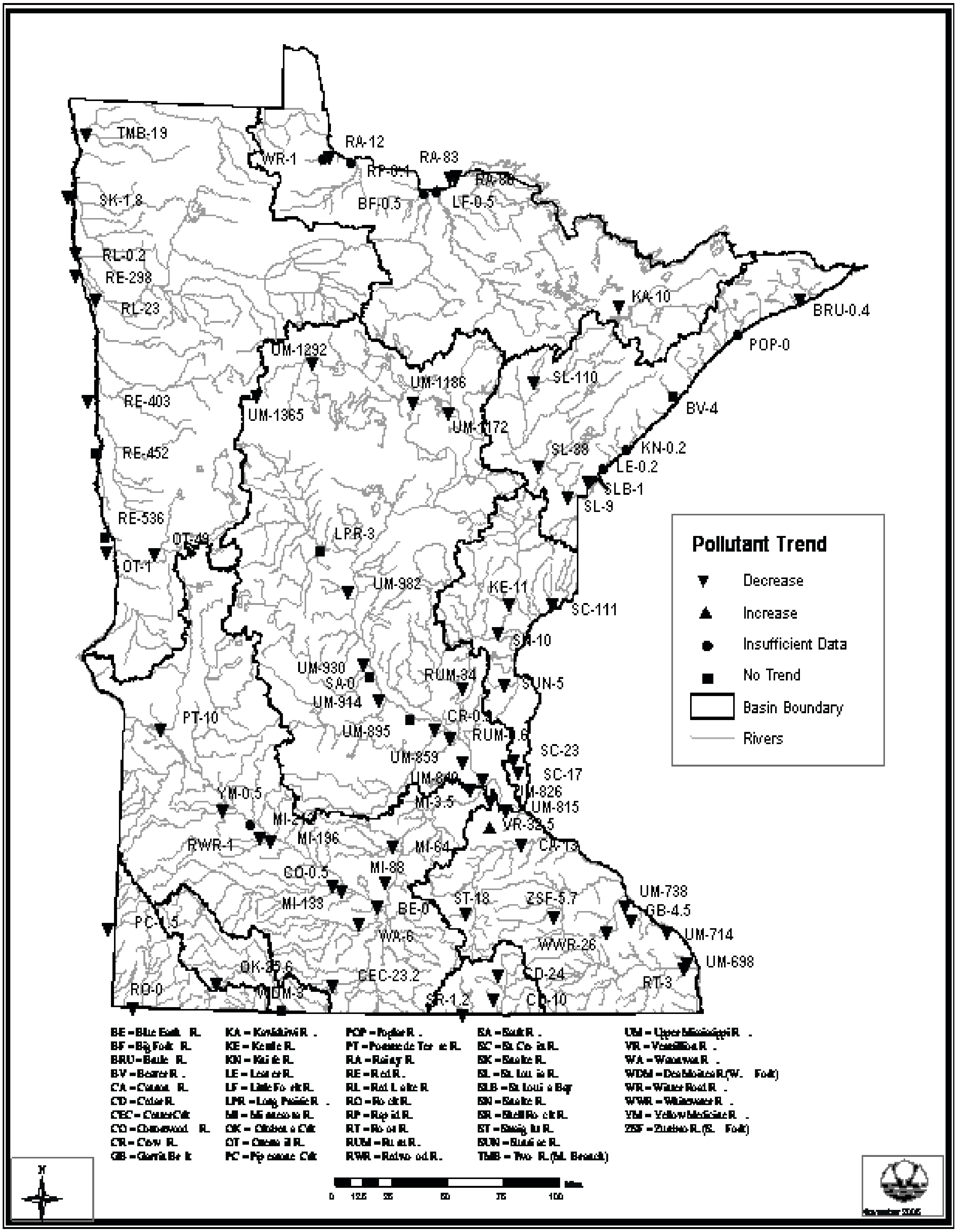
Basin	Station	Length of Record	Biochemical Oxygen Demand	Total Suspended Solids	Total Phosphorus	Nitrite/ Nitrate	Unionized Ammonia	Fecal Coliform
Big Sioux	PC-1.5	1963 - 2000	decrease	no trend	decrease	increase	decrease	decrease
Cedar – Des Moines	CD-10	1967 - 2000	decrease	no trend	decrease	increase	decrease	decrease
	CD-24	1967 - 2000	decrease	no trend	decrease	no trend	decrease	no trend
	OK-25.6	1973 - 2000	decrease	insuf data	increase	increase	decrease	insuf data
	SR-1.2	1961 - 2000	decrease	decrease	no trend	increase	decrease	no trend
	WDM-3	1967 - 2000	no trend	no trend	decrease	increase	decrease	decrease
Lake Superior	BRU-0.4	1973 - 2000	decrease	insuf data	decrease	insuf data	insuf data	insuf data
	BV-4	1973 - 2000	no trend	decrease	decrease	no trend	increase	decrease
	KN-0.2	1973 - 2000	insuf data	decrease	decrease	increase	insuf data	decrease
	LE-0.2	1973 - 2000	insuf data	decrease	decrease	insuf data	insuf data	decrease
	POP-0	1973 - 2000	insuf data	insuf data	decrease	insuf data	increase	insuf data
	SLB-1	1974 - 2000	decrease	decrease	decrease	decrease	no trend	decrease
	SL-9	1953 - 2000	decrease	decrease	decrease	no trend	decrease	decrease
	SL-38	1953 - 2000	decrease	no trend	decrease	no trend	decrease	decrease
	SL-110	1967 - 2000	decrease	no trend	decrease	no trend	no trend	decrease

Basin	Station	Length of Record	Biochemical Oxygen Demand	Total Suspended Solids	Total Phosphorus	Nitrite/ Nitrate	Unionized Ammonia	Fecal Coliform
Minnesota	BE-0	1967 - 2000	decrease	no trend	decrease	increase	decrease	decrease
	CEC-23.2	1974 - 2000	decrease	no trend	decrease	increase	decrease	decrease
	CO-0.5	1967 - 2000	decrease	no trend	no trend	increase	decrease	decrease
	MI-3.5	1974 - 2000	decrease	no trend	no trend	no trend	decrease	no trend
	MI-64	1955 - 2000	decrease	no trend	decrease	no trend	decrease	decrease
	MI-88	1955 - 2000	decrease	no trend	decrease	no trend	decrease	decrease
	MI-133	1957 - 2000	decrease	no trend	decrease	increase	decrease	decrease
	MI-196	1967 - 2000	decrease	no trend	decrease	increase	decrease	decrease
	MI-212	1957 - 2000	insuf data	insuf data	insuf data	increase	decrease	insuf data
	PT-10	1971 - 2000	decrease	decrease	decrease	increase	decrease	decrease
	RWR-1	1974 - 2000	decrease	no trend	decrease	increase	decrease	no trend
	WA-6	1968 - 2000	decrease	no trend	decrease	increase	decrease	decrease
	YM-0.5	1967 - 2000	decrease	no trend	no trend	increase	decrease	decrease
Missouri	RO-0	1962 - 2000	decrease	no trend	decrease	increase	decrease	no trend
Rainy	BF-0.5	1971 - 2000	insuf data	decrease	decrease	increase	insuf data	decrease
	KA-10	1967 - 2000	decrease	decrease	decrease	no trend	no trend	decrease
	LF-0.5	1971 - 2000	insuf data	insuf data	insuf data	increase	insuf data	decrease
	RA-12	1958 - 2000	decrease	decrease	decrease	increase	no trend	decrease
	RA-83	1953 - 2000	decrease	decrease	decrease	increase	no trend	decrease
	RA-86	1974 - 2000	decrease	decrease	decrease	increase	insuf data	insuf data
	RP-0.1	1971 - 2000	insuf data	decrease	decrease	increase	decrease	insuf data
	WR-1	1958 - 2000	insuf data	insuf data	decrease	increase	decrease	insuf data
Red	OT-1	1953 - 2000	decrease	no trend	decrease	increase	decrease	decrease
	OT-49	1967 - 2000	decrease	decrease	decrease	insuf data	decrease	decrease
	RE-298	1995 - 2000	decrease	no trend	no trend	increase	decrease	decrease
	RE-403	1967 - 2000	decrease	no trend	no trend	increase	no trend	decrease

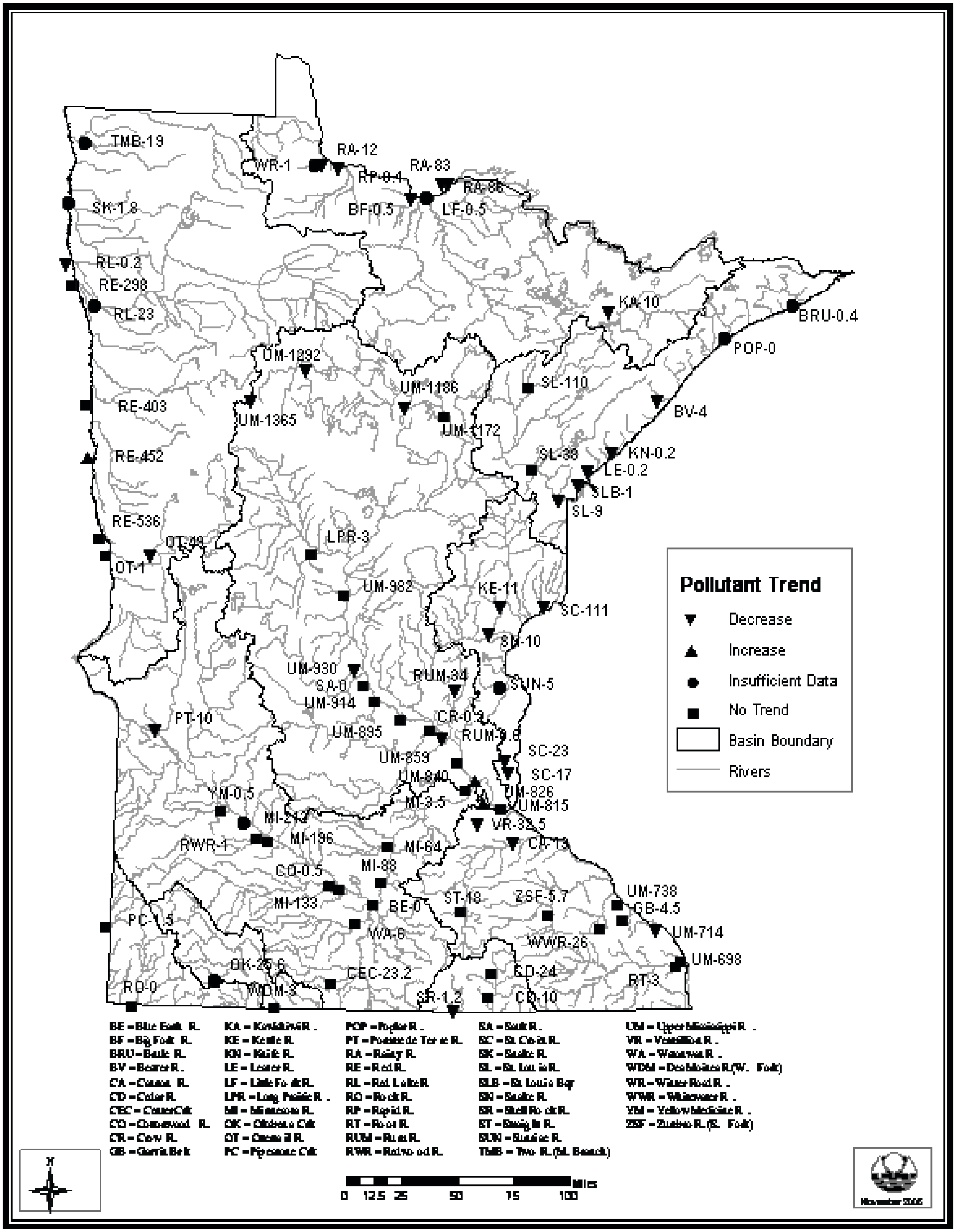
Basin	Station	Length of Record	Biochemical Oxygen Demand	Total Suspended Solids	Total Phosphorus	Nitrite/ Nitrate	Unionized Ammonia	Fecal Coliform
	RE-452	1971 - 2000	no trend	increase	no trend	increase	decrease	decrease
	RE-536	1953 - 2000	no trend	no trend	no trend	increase	decrease	decrease
	RL-0.2	1953 - 2000	decrease	decrease	decrease	no trend	decrease	decrease
	RL-23	1955 - 2000	decrease	insuf data	decrease	insuf data	decrease	decrease
	SK-1.8	1971 - 2000	decrease	insuf data	insuf data	insuf data	decrease	insuf data
	TMB-19	1971 - 2000	decrease	insuf data	decrease	insuf data	decrease	decrease
St. Croix	KE-11	1967 - 2000	decrease	decrease	decrease	no trend	decrease	decrease
	SC-17	1967 - 2000	decrease	decrease	decrease	increase	no trend	decrease
	SC-23	1953 - 2000	decrease	decrease	decrease	insuf data	insuf data	decrease
	SC-111	1957 - 2000	decrease	decrease	decrease	no trend	no trend	decrease
	SN-10	1971 - 2000	decrease	decrease	decrease	insuf data	insuf data	decrease
	SUN-5	1974 - 2000	decrease	insuf data	insuf data	insuf data	increase	insuf data
Upper Miss -- Lower Portion	CA-13	1953 - 2000	decrease	decrease	decrease	no trend	decrease	decrease
	GB-4.5	1981 - 2000	decrease	no trend	no trend	increase	decrease	no trend
	RT-3	1958 - 2000	decrease	no trend	decrease	increase	decrease	decrease
	ST-18	1955 - 2000	decrease	no trend	decrease	no trend	decrease	decrease
	UM-698	1958 - 2000	decrease	no trend	decrease	increase	decrease	no trend
	UM-714	1962 - 2000	decrease	decrease	decrease	no trend	decrease	decrease
	UM-738	1974 - 2000	decrease	no trend	decrease	increase	decrease	no trend
	UM-815	1958 - 2000	decrease	no trend	decrease	increase	decrease	decrease
	UM-826	1975 - 2000	decrease	increase	decrease	increase	decrease	decrease
	UM-840	1973 - 2000	decrease	increase	no trend	increase	decrease	decrease
	VR-32.5	1981 - 2000	increase	decrease	no trend	increase	decrease	no trend
	WWR-26	1974 - 2000	decrease	no trend	no trend	increase	decrease	no trend
	ZSF-5.7	1973 - 2000	decrease	no trend	decrease	increase	decrease	no trend

Basin	Station	Length of Record	Biochemical Oxygen Demand	Total Suspended Solids	Total Phosphorus	Nitrite/ Nitrate	Unionized Ammonia	Fecal Coliform
Upper Miss – Upper Portion	CR-0.2	1953 - 2000	decrease	no trend	no trend	increase	decrease	decrease
	LPR-3	1974 - 2000	no trend	no trend	no trend	increase	decrease	decrease
	RUM-0.6	1953 - 2000	decrease	decrease	decrease	insuf data	insuf data	decrease
	RUM-34	1955 - 2000	decrease	decrease	decrease	increase	decrease	decrease
	SA-0	1953 - 2000	no trend	no trend	no trend	no trend	decrease	decrease
	UM-859	1953 - 2000	decrease	no trend	decrease	increase	decrease	decrease
	UM-895	1976 - 2000	no trend	no trend	decrease	increase	decrease	no trend
	UM-914	1967 - 2000	decrease	no trend	no trend	increase	no trend	decrease
	UM-930	1953 - 2000	decrease	decrease	decrease	increase	decrease	no trend
	UM-982	1967 - 2000	decrease	no trend	decrease	increase	decrease	decrease
	UM-1172	1974 - 2000	decrease	no trend	decrease	increase	decrease	decrease
	UM-1186	1967 - 2000	decrease	decrease	decrease	increase	decrease	decrease
	UM-1292	1967 - 2000	decrease	decrease	decrease	increase	decrease	decrease
	UM-1365	1965 - 2000	decrease	decrease	decrease	increase	decrease	decrease

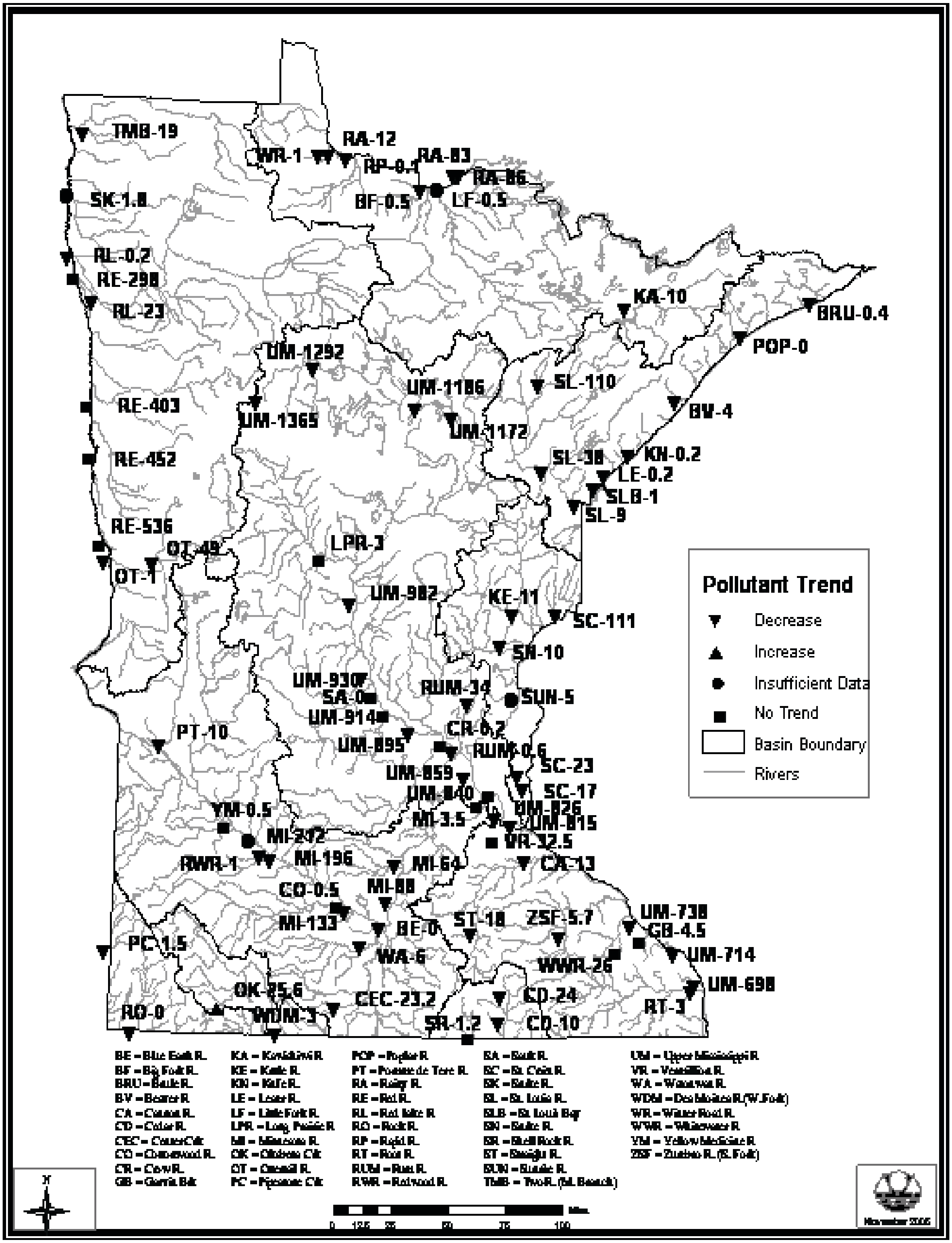
Trends at Minnesota Milestone Sites - Biochemical Oxygen Demand



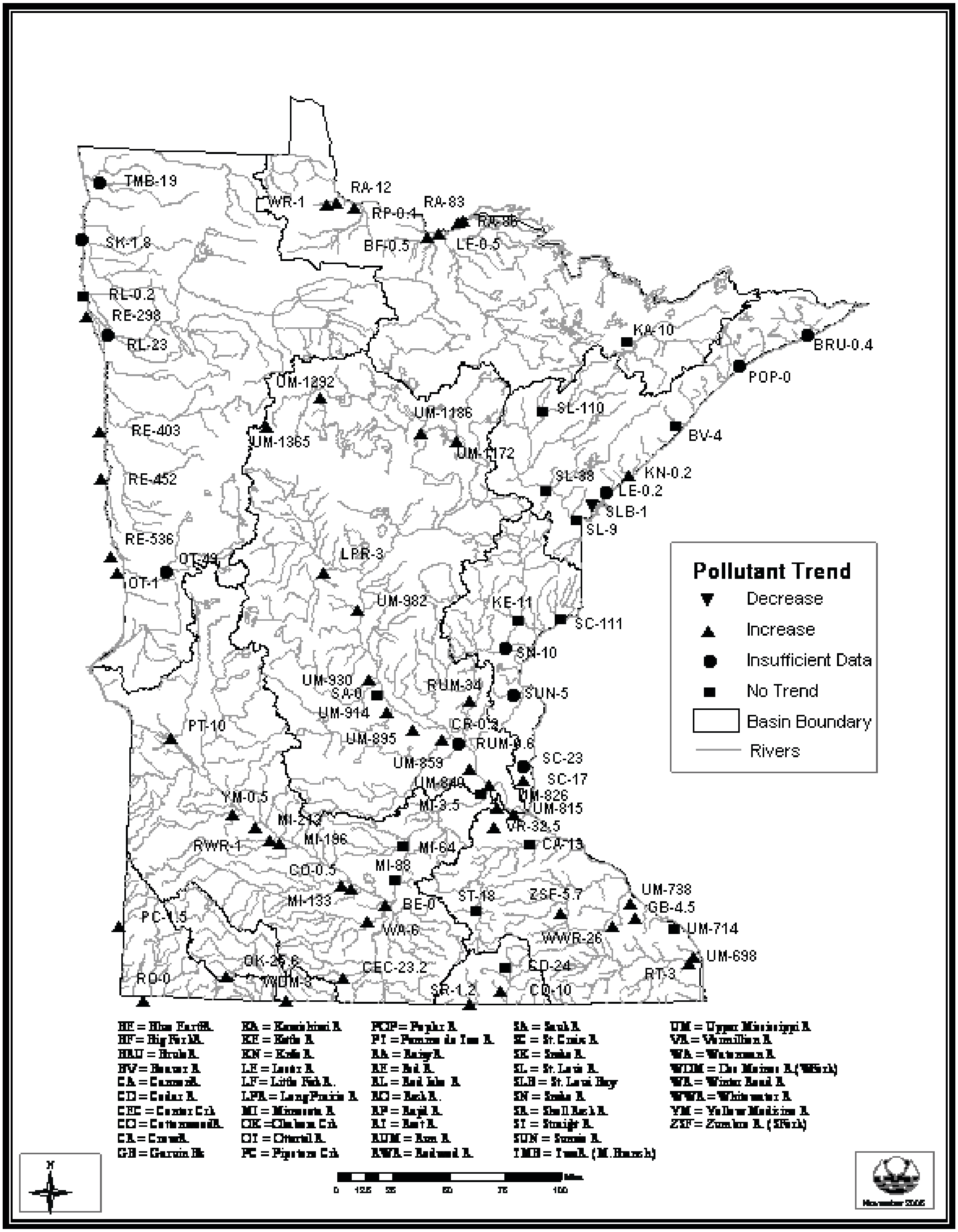
Trends at Minnesota Milestone Sites - Total Suspended Solids



Trends at Minnesota Milestone Sites - Total Phosphorus

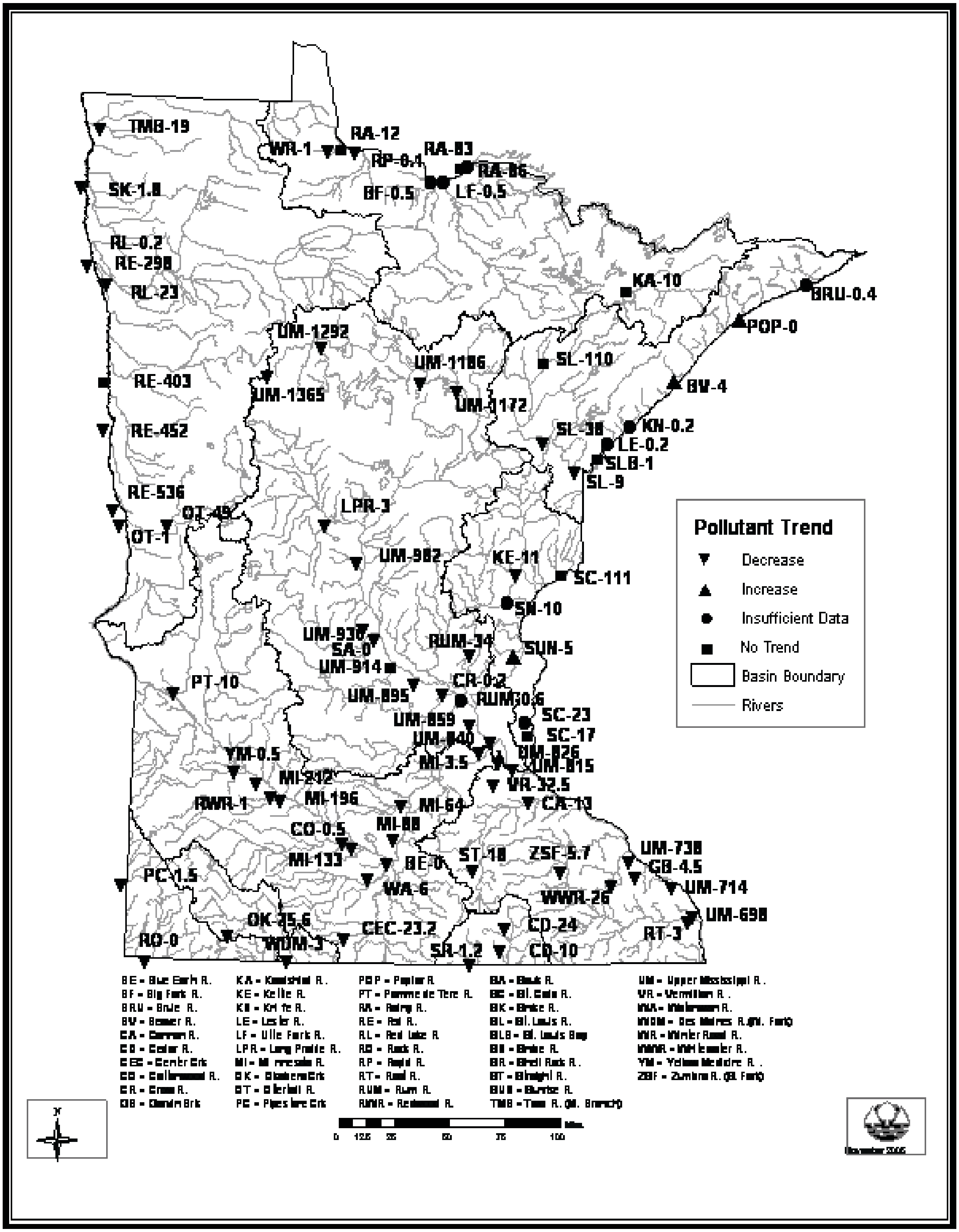


Trends at Minnesota Milestone Sites - Nitrite/Nitrate



Minnesota Pollution Control Agency

Trends at Minnesota Milestone Sites - Unionized Ammonia



Trends at Minnesota Milestone Sites - Fecal Coliform

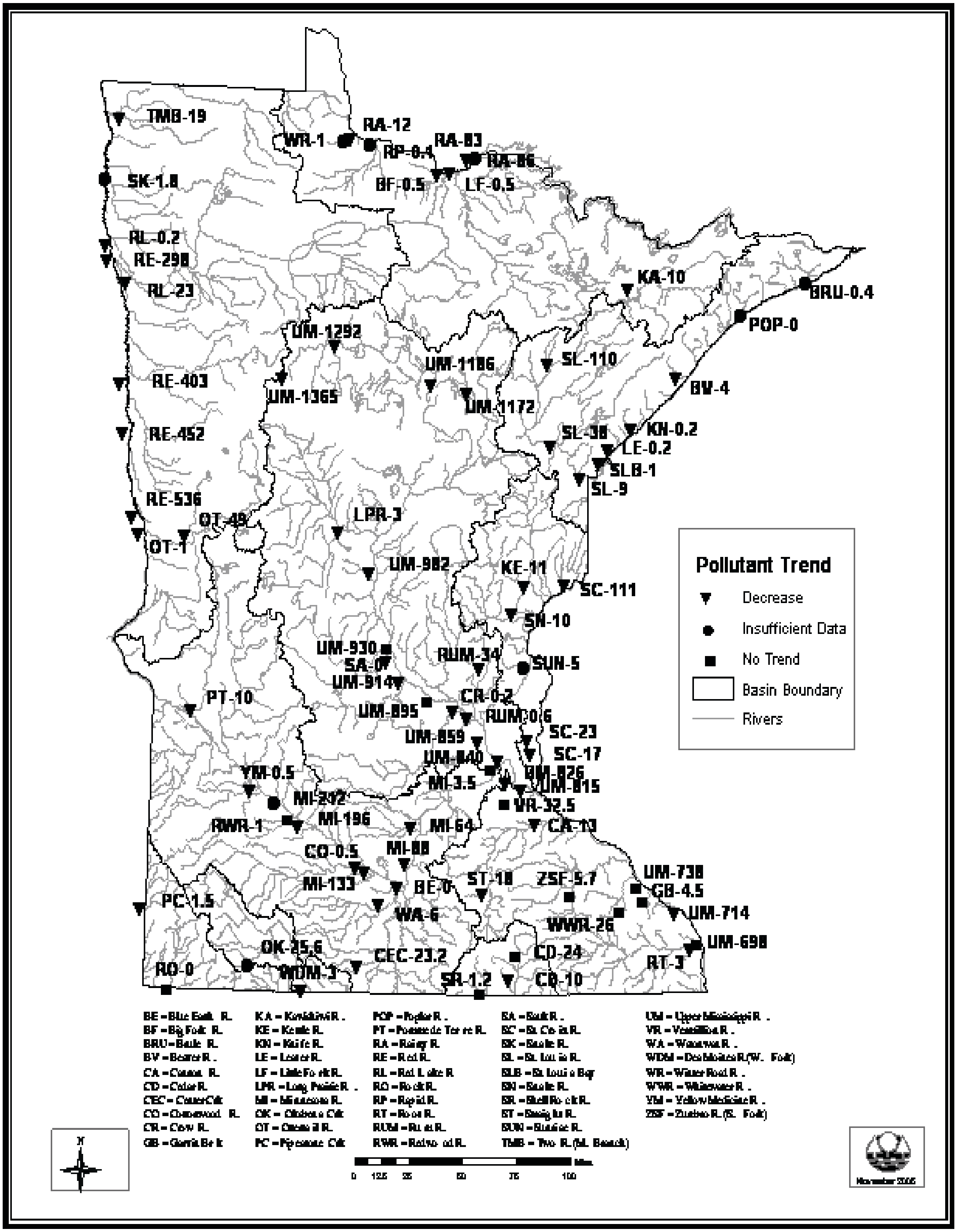


Table I-10. Pollutant Trends at Minnesota Milestone Sites (Cont.)

Milestone sites (having sufficient data) showing:	BOD	TSS	TP	N02/N03	NH_3	F.C.
Decreasing pollutant trend	**89%**	**41%**	**78%**	**1%**	**83%**	**82%**
Increasing pollutant trend	**1%**	**4%**	**1%**	**75%**	**4%**	**0%**
No trend	**10%**	**54%**	**21%**	**23%**	**13%**	**18%**
Milestone sites (out of 80) having insufficient data	8	10	4	11	9	9
(Insufficient data means p > .05 and n < 80)						
((Logs of) TSS, TP, BOD, and fecal coliforms analyzed using Pearson's correlation coefficient and p values; NH_3 and NO_2/NO_3 analyzed using Kendall's Tau B and p values)						

Water Quality Trends for Minnesota Lakes

In addition to characterizing trophic status, detecting changes (trends) in WQ over time is a primary goal for many lake monitoring programs. Detecting trends requires many measurements each summer and several years' worth of data. An ideal database for trend analysis consists of eight or more measurements per summer with eight or more years of data at a consistent site in the lake. One of the best parameters for characterizing the trophic status of a lake and trend detection is Secchi transparency. Secchi transparency is the preferred parameter for many reasons: low cost, it is easily incorporated in volunteer monitoring programs and it allows for the collection of a large number of samples in a given sampling period on many lakes. A variety of statistical tests can be used to perform trend analysis. Kendall's tau-b is a statistical test that has been used in previous MPCA 305(b) reports to Congress (MPCA, 1990 and 1992) for assessing trends in Secchi transparency over time. Kendall's tau-b is a nonparametric test which computes correlation coefficients between variables (Gilbert, 1987) - in this case, summer-mean (June-September) Secchi transparency versus year. The Kendall's tau-b (R_k) ranges from $-1 \leq$ tau-b ≤ 1. The closer the value is to ± 1, the stronger the trend. Our null hypothesis is that there is no change (*i.e.,* no trend) in mean summer Secchi transparency over time. Positive R_k values in our analysis would suggest an increasing trend in transparency. Negative R_k values would conversely suggest a decreasing trend in transparency. A probability level (p) ≤ 0.1 was used as a basis for identifying significant trends in transparency. At this "p" level, there is a 10 percent chance of rejecting the null hypothesis of "no trend" when it is true (*i.e.,* a 10 percent chance of identifying a trend when none exists). Simply stated, the smaller the 32"p" value for our analysis, the more likely the events were not random. When performing trend analysis, it is important to consider the strength of the correlation, "p" level and years of measurement.

Table I-11. Trends in Lake Water Quality

Description	Number of Lakes
Assess for Trends	822
Improving	246
Stable	530
Degrading	46
Fluctuating	–
Trend Unknown	–

Ground Water Assessment

This section addresses NPS pollution of ground water including the following topics

- major sources of ground water contamination
- ground water data needs and progress on making data accessible
- ground water monitoring programs
- results and conclusions from monitoring efforts
- pollutants observed where certain land use activities occur adjacent to particular aquifer types
- examples of how ground water impacts surface water quality
- specific areas known to have an aquifer(s) with pollution that exceeds criteria for use as a drinking water source (special well construction areas)
- wellhead protection efforts
- plans and best management practices for protecting ground water.

Sources of Ground Water Contamination

In contrast to major contamination in surface water bodies, ground water contamination is often limited, even if temporarily, to relatively discrete subsurface areas where it might remain undetected or unquantified for long periods of time. Therefore, to better estimate, describe or understand the nature and extent of ground water contamination statewide, we need information about the potential sources of ground water contamination. A variety of tools are available for locating and reviewing potential sources of ground water contamination in Minnesota. Some of these tools are described below.

Survey of Major Sources of Ground-Water Contamination

Major Sources of Ground Water Contamination (see Table I-11), is presented as background information for this section. Although the information is somewhat dated and is based on opinion as opposed to hard data, it does provide a convenient overview of the relative magnitude of major ground water contamination sources in Minnesota. Please note that, for the purposes of this survey, no distinction was made between point source and non-point source contamination. The information in this table is based on a November 5, 1999, survey of eleven staff from one federal and seven state agencies. Most of the participants were involved in ground water monitoring in Minnesota. The survey indicates that five categories stand out as the most important sources of ground water contamination:

- animal feedlots
- fertilizer applications
- pesticide applications
- septic systems
- urban runoff

An earlier (February 1999) survey with 18 participants indicated Minnesota's major sources of ground water contamination were as follows:

- pesticide application
- septic systems
- fertilizer applications
- irrigation practices
- storage tanks (underground)
- hazardous waste sites
- animal feedlots
- industrial facilities

What's in My Neighborhood? Web Sites

The Minnesota Department of Agriculture (MDA) and the Minnesota Pollution Control Agency (MPCA) have Web sites designed to help make it easier to find potential sources of contamination by geographic location. These are called "What's in My Neighborhood?" Web sites.

The MDA is the lead agency for response to, and cleanup of agricultural chemical contamination in Minnesota. Because of this role, MDA has tracked spills of agricultural chemicals and sites contaminated with agricultural chemicals since the late 1970's. For the purpose of mapping these incidents, MDA has categorized them into three categories 1. Old Emergencies, 2. Small Spills and Investigations, and 3. Investigations Boundaries. The MDA *What's in My Neighborhood?* Agricultural Interactive Mapping Web site, allows you to view known and potential sources of agricultural chemical soil and ground water contamination. On this Web site, you can do the following:

- search for specific site locations
- conduct searches by options such as city, county or zip code
- print maps of site locations

MDA has also made available information relating to any investigations that have been closed with contingencies attached to them. Additional background information can be found at this Web site. The MPCA *What's in My Neighborhood?* Web site is a convenient place to check for a variety of potential contamination sites in Minnesota by geographic location.

Depending on perspective or definition used, many of these sources might be considered point-sources of contamination. Examples of the types of potential contamination sites that can be found include the following:

- CERCLIS Sites (Comprehensive Environmental Response, Compensation and Liability Information System)
- NFRAP Sites (No Further Remedial Action Planned)
- Federal Superfund Sites (Federal Superfund, or National Priority List (NPL), sites)
- State Superfund Sites (State Superfund, or Permanent List of Priorities (PLP), sites)
- Delisted State Superfund Sites (Delisted State Superfund Sites, or Delisted PLP (DPLP), sites)
- Permitted Solid Waste Sites
- State Assessment Sites
- Unpermitted Dumps (Metro Dump Inventory (MDI), the Outstate Dump Inventory (ODI) and the Open Dump Inventory)
- Voluntary Investigation and Cleanup Sites (VIC)
- State Closed Landfill Sites
- Resource Conservation and Recovery Act (RCRA) Facilities
- RCRA Investigation/Cleanup Sites

Minnesota Storage Tank Site Search

It is also possible to search and find basic information about a site where a petroleum product leak has occurred from a storage tank (leak site) and has been reported to the MPCA. To conduct a search using the MPCA Web site, users simply need to fill in the site name, city or county of interest on a web-based form.

Ground Water Data Needs and Access

MPCA ground-water data are not as accessible or as easily used as desired. If data accessibility and usability were improved, more of the data would be used for local and regional ground water quality assessments and wellhead protection efforts. Existing ground water data are also needed for more site-specific purposes such as property assessments for real estate transactions, contaminated site investigations and subsequent cleanup activities, etc. The MPCA has a large amount of ground water related information, but much of it is not easily accessible outside the programs that collect it.

The Nature of Existing Data

MPCA ground-water data have been collected to varying standards of completeness and accuracy and for differing purposes; as a consequence, the data are difficult to compile and compare. Certain desired information, such as accurate locations and the identity of the aquifer are not in some databases. This makes it difficult to map the data and sort it by aquifer, watershed, or hydrogeologic setting.

In addition, much of MPCA's ground water data and other ground water related information are not available in electronic form. Much of it is only available in paper project file folders or reports. The MPCA does have some databases that feature ground water data and some that feature cleanup site and project background information. However, much of the agency's electronic ground water related data are isolated in individual spreadsheets, on CD ROMs, general purpose permitting databases, etc.

Table I-12. Major Sources of Ground Water Contamination

Based on a 2 November 1999 Survey of eleven staff from one federal and seven state agencies

Contaminant Source	Ten Highest-Priority Sources	Factors Considered in Selecting a Contaminant Source[2]	Contaminants[3]
Agricultural Activities			
Agricultural chemical facilities			
Animal feedlots	X	A C D E H	E J L
Drainage wells			
Fertilizer applications	X	A C D E H	E
Irrigation practices	x	A E	E
Pesticide applications	X	A D E F H	A B D
On-farm agricultural mixing and loading procedures			
Land application of manure (unregulated)	x	C D E	E J L
Storage and Treatment Activities			
Land application (regulated or permitted)			
Material stockpiles			
Storage tanks (above ground)			
Storage tanks (underground)	x	A C D E	C D
Surface impoundments			
Waste piles			
Waste tailings			
Disposal Activities			
Deep injection wells			
Landfills	x	A C E	C H J M
Septic systems	X	A C D E H	E J L
Shallow injection wells			
Other			
Hazardous waste generators			
Hazardous waste sites	x	A C E	C D H

Contaminant Source	Ten Highest-Priority Sources	Factors Considered in Selecting a Contaminant Source[2]	Contaminants[3]
Large industrial facilities			
Material transfer operations			
Mining and mine drainage			
Pipelines and sewer lines			
Salt storage and road salting			
Salt water intrusion			
Spills			
Transportation of materials			
Urban runoff	X	A B C D E H	A B D E G H
Small-scale manufacturing and repair shops			
Other sources (please specify)			

The lowercase x's denote sources checked as a top ten source by less than 50% of those surveyed (that still qualified as one of the ten most frequently checked sources for the overall survey group)
See the following page for Key to Letters Used to Represent Contaminant Source Factors
See the Following For Key to Letters Used to Represent Contaminants

Key to Letters Used to Represent Contaminant Source Factors and Contaminants (for Table I-12)

Factor(s) Used to Select each of the Contaminant Sources (3rd column)

A. human health and/or environmental risk (toxicity)
B. size of the population at risk
C. location of the sources relative to drinking water sources
D. number and/or size of contaminant sources
E. hydrogeologic sensitivity
F. state findings, other findings
G. documented from mandatory reporting
H. geographic distribution/occurrence
I. other criteria (please add or describe in the narrative)

Contaminants/Classes of Contaminants Considered to be Associated with Each Source Checked (4th column)

A. inorganic pesticides
B. organic pesticides.
C. halogenated solvents
D. petroleum compounds
E. nitrate
F. fluoride
G. salinity/brine
H. metals
I. radionuclides
J. bacteria
K. protozoa
L. viruses
M. other

There is no single ground water database that contains the majority of the Minnesota Pollution Control Agency's electronic ground water data, and there is no database that contains or directly links together ground water databases from all the state agencies that collect ground water data. However, the County Well Index represents a multi-agency effort and its location, geologic and well construction data are used by numerous state and local organizations.

Environmental Data Access System

The MPCA Environmental Data Access System (EDA) is currently working on developing a system to make more ground-water data available electronically over the Internet through a geographic-based (GIS) interface. Although only a small percentage of historical ground water data are expected to become available, the EDA system is expected to significantly improve access to selected MPCA ground water data. The EDA Web site should allow site visitors to efficiently locate some ground water information by geographic location without waiting for staff assistance.

Accessibility of MPCA Baseline Ground Water Quality Data

Baseline ambient ground water quality data for Minnesota are currently available in Microsoft Excel spreadsheets on the Internet. The data can be viewed or accessed by aquifer, region, and basin.

The MPCA Environmental Data Access Project is working on making MPCA baseline ambient ground water data available on the Internet through a GIS interface. The ground water data are expected to be accessible by autumn 2006.

MPCA baseline ambient ground water quality data are also available in reports that include supporting information. In March 1998, the Ground Water Monitoring and Assessment Program (GWMAP) published "Baseline Water Quality of Minnesota's Principal Aquifers."

This report is based on detailed chemical analysis of ground water samples collected from nearly 1000 wells throughout the state. The interpretation of results includes summary statistics of an extensive list of water-quality parameters that are presented for each of the principal aquifers of the state. To further assist customers around the state, customized versions of the baseline report were prepared for each of the MPCA regions. In these reports, ground water quality summary statistics were presented for that portion of each principal aquifer that falls within the boundaries of the region. Finally, to assist MPCA basin planning efforts, an additional report was prepared that presented the ground water quality information by major surface water basin.

Ground Water Monitoring Programs and Strategies

The state agencies that conduct the most ground water monitoring in Minnesota include the Minnesota Department of Agriculture, Minnesota Pollution Control Agency and Minnesota Department of Health.

In 2004, these agencies agreed on a joint plan for conducting ground water quality monitoring on a statewide basis in Minnesota. The plan outlines the agencies' different purposes, goals and roles in ground water quality monitoring based on their individual state and federal authorities and requirements. The plan identifies how monitoring by the Agencies will be conducted in an integrated fashion providing a comprehensive, statewide assessment of ground water quality resources for the future. The plan also establishes inter-agency cooperation in shared monitoring design, sample collection, sampling location selection, evaluation of sensitive areas, and data management to ensure efficiencies in the system.

Finally, the plan provides for an annual review of the ground water quality monitoring system to allow for modifications, along with a five-year evaluation, at which time this agreement will be updated. For more details about the plan, see the "complete monitoring plan agreement."

Minnesota Department of Agriculture

The Minnesota Department of Agriculture monitors to provide information on the impacts of the routine use of agricultural chemicals (pesticides and fertilizers) on the quality of Minnesota's water resources. The Department's monitoring goals/objectives are as follows:

- to measure the status and trends in occurrence and concentration of pesticides and nutrients (from fertilizer) in water resources of the state
- to evaluate attributes associated with ground water quality conditions that may cause or reduce ground water degradation by pesticides and nutrients
- to provide scientifically and legally defensible information from which the efficacy of pesticide and nutrient management plans and practices may be determined
- to investigate the causes of agricultural chemical contamination and evaluate the effectiveness of Best Management Practices (BMPs) and any necessary Water Resource Protection Requirements (WRPRs).

The Minnesota Department of Agriculture (MDA) is the lead state agency for all aspects of pesticide and fertilizer environmental and regulatory functions. Therefore its role in addressing NPS issues is especially important. This MDA Web site provides a description of its agricultural chemical monitoring and assessment programs and links to numerous information resources including pesticide monitoring reports.

Minnesota Department of Health

The Minnesota Department of Health monitors to ensure all Minnesotans have safe drinking water and to understand current contaminant levels and trends in water quality that may pose significant health concerns for those drinking it. The Department's monitoring goals/objectives are as follows:

- to assess public water supplies to ensure contaminants are below levels that present a human health threat;
- to assess private water supply wells to ensure that new wells meet minimal water quality standards and that the owners of private wells understand the health risks associated with contaminants that are detected in their well water
- to evaluate the risk to human health arising from the presence of human-caused and naturally-occurring contaminants in ground water
- to assist local health departments with addressing the human health impacts related to the contamination of public and private water supply wells

Minnesota Pollution Control Agency

The Minnesota Pollution Control Agency monitors to provide information on the impacts of non-agricultural chemicals on water resources. The Agency's monitoring goals are as follows:

- to assess the status and trends of Minnesota's ground water system for non-agricultural impacts;
- to determine specific causes of impairments and to quantify inputs from sources
- to investigate specific problems, and to design management approaches to protect or improve ground water resources; and
- to evaluate the effectiveness of regulatory or voluntary management actions.

The MPCA "Ambient Ground Water Monitoring and Assessment" Web site provides additional details about monitoring activities, data sets, past projects and publications.

Monitoring Results: NPS Ground Water Pollution

The 1992 - 1996 MPCA study of the 'Baseline Water Quality of Minnesota's Principal Aquifers' provides a good overview of concentrations of chemicals typically found in Minnesota ground water away from known point sources of pollution. But many types of chemicals occur naturally in ground water. And when synthetic chemicals or elevated concentrations of naturally-occurring chemicals are found in ground water, it is not always obvious whether the source is point-source or non-point source pollution. Nonetheless, since this 1992-1996.

MPCA Baseline Study specifically avoided sampling near known point-sources of pollution, the data sets, maps and reports from this study are useful in evaluating potential non-point source pollution.

Additional information about the distribution of chemicals in Minnesota ground water can be found from the results of smaller scale MPCA ambient monitoring studies and in various documents linked to the MDA Monitoring and Assessment for Agricultural Chemicals in the Monitoring and Assessment for Agricultural Chemicals in the Environment Web page.

Please see the subsections immediately below for summary discussions on two more specific subtopics that are particularly relevant to non-point source issues.

Distribution of Ground Water Pollution Based on Aquifer Types and Land-Use Activities

Based on MPCA ambient ground water studies, certain combinations of hydrogeologic settings and land use activities consistently lead to non-point source pollution of ground water that prevents ground water from supporting its designated use. Minnesota ground water has only one designated use classification: drinking water. The outline below identifies several problematic combinations of hydrogeologic settings and land use activities and specifies the contaminant of concern for each in parentheses '( )'. The criteria used here for 'failure to meet the designated use' are as follows:

A. State of Minnesota (standards by rule) Health Risk Limits (HRLs), or when no HRL exists
B. Federal Maximum Contaminant Limits (MCLs), or when no MCL exists
C. Federal Secondary MCLs
   1. Unconfined sand and gravel aquifers as sources of drinking water
      - Irrigated corn or potatoes – almost always (*nitrate*)
      - Small lot, nonsewered land use – occasionally (*nitrate*)
      - Nonirrigated corn – occasionally (*nitrate*)
      - Older urban areas – occasionally (*volatile organic compounds [VOCs]*)
   2. Shallow sand and gravel aquifers as sources of water to streams and rivers
      - Urban areas – often (*chloride*)
   3. Buried sand and gravel aquifers as sources of drinking water
      - Irrigated corn or potatoes – often (*nitrate*)
   4. Fractured unconfined bedrock aquifers used as sources of drinking water
      - Irrigated corn or potatoes – almost always (*nitrate*)
      - Nonirrigated corn – occasionally (*nitrate*)

Pesticides in Ground Water

There is no comprehensive statewide study of the distribution of pesticides in Minnesota ground water, although MDA has conducted considerable sampling statewide. In a 2004 study, MDA found one or more pesticides or pesticide degradates in 15 of 71 drinking water wells from agricultural areas. Studies by Dakota County, the USGS, and MPCA showed detection rates exceeding 50 percent in drinking water wells completed in aquifers considered vulnerable to contamination. Limited sampling of shallow monitoring wells in sand aquifers shows detection frequencies of 80 percent or more. Concentrations, frequency of detection, and number of chemicals detected are greater in shallow monitoring wells than in drinking water wells. However, in both types of wells, concentrations are typically well below water quality standards.

The following MDA reports are available on the MDA's 'Monitoring and Assessment for Agricultural Chemicals in the Environment' Web page:

- Pesticide Monitoring in Water Resources: Annual Data Report, Publication Date: 2/25/2005 (PDF: 2.48 MB / 153 pages)
- Pesticide Monitoring in Water Resources: Sampling Data, Publication Date: 2/25/2005 (PDF: 217 KB / 34 pages)

MPCA pesticide monitoring results are available on their "Ambient Ground Water Monitoring" Web site.

The United States Geological Survey "NAWQA Pesticide National Synthesis Project" Web site includes hypertext links to detailed reports and data about pesticides in ground water and much more.

This Web site features the USGS national assessment of pesticides in the streams, rivers, and ground water of the United States. The Pesticide National Synthesis Project is part of the U. S. Geological Survey's National Water Quality Assessment Program (NAWQA). The program began in 1991 with the purpose of producing a long-term assessment of the status of and trends in the quality of the Nation's water resources.

In Minnesota, Dakota County also has pesticide monitoring data available on their Web site in their March 2003 report of the 'Hastings Area Nitrate Study.' In fact, this report includes detailed discussions about the presence of pesticides, nitrate and other NPS pollutants in Dakota County ground water.

Nitrate in Ground Water

While many parts of the state are blessed with excellent ground water quality, there are potential trouble spots scattered throughout the state. Shallow aquifers underlying sandy soils in central Minnesota, glacial outwash aquifers in the southwest, and the fractured bedrock aquifers in the southeast are highly susceptible to nitrate contamination (excerpt from MDA online brochure: for more details, see the Web-based document *Nitrate Contamination - What is the Cost?).*

The "MDA Water Testing for Nitrate" Web page describes the free "walk-in" style water testing clinics which are conducted with the goal of increasing public awareness of nitrates in rural drinking and livestock water supplies. The Web page also provides the following information about nitrate in Minnesota ground water: *Nitrate is a common contaminant found in many wells throughout Minnesota. Shallow wells, dug wells, and wells with damaged or leaking casings are the most vulnerable to nitrate contamination. Major sources of nitrate contamination can be from fertilizers, animal waste, and human sewage.*

Over the years, the Water Testing for Nitrate program has gained valuable information linking well characteristics and nitrate concentrations. Based on approximately 9700 surveys (1995-98 data), the following observations are worth noting: Sixteen percent of the sand point wells (representing 26 percent of all wells tested) and 40 percent of all dug wells (representing only 3 percent of the total) exceeded the health standard of 10 ppm NO3-N. Drilled wells represented 71 percent of the well construction types and 9 percent of these exceeded the health standard.

Age of the wells was also highly correlated with nitrate levels. The number of wells exceeding the health standard in the age categories of 0-10, 11-20, 21-50, and greater than 50 years old were 6, 9, 13, and 27 percent, respectively (from the MDA Water Testing for Nitrate Web page).

The MDA Web site for Drinking Water Protection in Agricultural Areas includes links to a number of resource materials to assist planners in managing potential agricultural contamination sources:

- Nitrogen Basics for Wellhead Protection Teams
- Nitrate Contamination—What is the Cost?
- The Importance of Crop Selection and Management for Controlling Nitrogen Losses
- Promoting the Right Nitrogen Rate
- Effectiveness of Nitrogen Best Management Practices (BMPs)—Irrigated Sands
- Effectiveness of Nitrogen Best Management Practices (BMPs)—South Central Minnesota
- Nutrient Management Planning Basics
- Nitrogen Fertilizer Best Management Practices

The Minnesota Department of Health Nitrate and Source Water Protection Web page includes links to nitrate probability maps to assist in state and local water quality planning efforts. These maps identify areas of a county with relatively high, moderate, and low probability of having elevated nitrate concentrations in ground water. The goal of nitrate probability mapping is to help protect public and private drinking water supplies and to help prevent further contamination.

The MPCA Ambient Ground Water Monitoring and Assessment Web site includes publications and data sets that include information about nitrate in ground water from a statewide ground water quality baseline study and from more local studies. A statewide map that displays the distribution of nitrate concentrations found in the baseline study can also be found on their Web site. General trends in the distribution of nitrate in Minnesota ground water were discussed above in the section titled *Distribution of Ground Water Pollution Based on Aquifer Types and Land-Use Activities.*

Ground Water Recharge that Improves Surface Water Quality

Ground water base flow is a very important and often overlooked component of flow in streams and rivers. Direct ground water recharge can also make up a large percentage of lake water. In many cases, the water quality of the ground water improves the water quality of the surface water via dilution of surface water contaminants. Examples of surface water quality improvement due to ground water recharge in some specific river basins of Minnesota are presented below.

Red River Basin

According to the USGS, nitrogen and phosphorus in surface runoff from cropland fertilizers and nitrogen from manure can contribute nutrients to lakes, reservoirs, and streams in the Red River Basin. Some of the more persistent pesticides, such as atrazine, have been detected in the Red River of the North. Although ground water can also become contaminated, it often dilutes contaminants in the basin's surface water. In the Red River Basin, at times of low flow, when water in streams is largely from ground water seepage (base flow), the water quality predominantly reflects the chemistry of the glacial-drift aquifer system. More specifically, the USGS estimated that 60 percent of the flow in the Red River is base flow. More details are available on the Red River of the North National Water Quality Assessment Study Web site.

Minnesota River Basin

The Mount Simon-Hinckley Aquifer and the Franconia-Ironton-Galesville Aquifer discharge into the Minnesota River near the communities of Courtland and Judson, respectively. These discharge areas are illustrated in the Geologic Atlas of Nicollet County, Minnesota published by the Water Resources Center -- Mankato State University in 1991. The city of Mankato utilizes a ground water source which is under the influence of the Blue Earth and Minnesota Rivers.

The Minnesota River near Mankato is frequently near the federal drinking water standard for nitrate-N of 10 mg/l. Details can be found on the USGS Water-Quality Data for Minnesota Web site. Data collected by the Brown Nicollet Cottonwood Counties Clean Water Partnership Groundwater Assessment Project demonstrate that both The Mount Simon-Hinckley Aquifer and the Franconia-Ironton-Galesville Aquifer are anoxic and contain no appreciable nitrate-N (Brown Nicollet Community Health Services, 1992). Thus the base flow contributions of these two aquifers lower the nitrate-N concentration of the Minnesota River near Mankato.

Related background information can be found at the following Web sites:

- The Minnesota River Basin Data Center *mrbdc.mnsu.edu*.
- Middle Minnesota River Major Watershed
- Minnesota River Basin, Middle and Lower Minnesota River Watersheds *www.pca.state.mn.us/water/basins/mnriver/index.html*

Upper Mississippi River Basin

In the Upper Mississippi River Basin, a ground water and surface water interaction study was conducted to determine why Siseebakwet Lake's water transparency was changing so much and why standard lake water-quality monitoring parameters such as phosphorus and chlorophyll-a (an indicator measure for algae) did not correlate well with observed transparency. In this study, it was determined that approximately 43 percent of Siseebakwet Lake's water came from direct ground-water recharge while only 22 percent came from surface water inflow. The geochemistry of the ground water was found to be substantially different than the surface water inflow and the lake was determined to be a marl lake.

At Siseebakwet Lake, even the lake water transparency is believed to be strongly influenced by ground water. Because the lake cannot hold as much calcium carbonate in solution as is delivered to the lake via ground water recharge, calcium carbonate precipitate periodically 'rains' down through the lake's water column. This phenomenon clouds the lake water and causes a temporary worsening of water transparency. On the other hand, phosphorus, the key (limiting) nutrient for algae growth, is known to co-precipitate out of the lake-water column with calcium carbonate. And the abundance of algae is normally the dominant factor in worsening lake-water transparency in this ecoregion. The net result is that, over the long run, calcium carbonate precipitation causes a substantial reduction of phosphorus in the lake water and the reduced phosphorus concentrations limit the growth of algae. In turn, the trophic status and overall health of the lake remains excellent even though the water may appear cloudy at times due to the presence of calcium carbonate precipitate. This study helped Minnesota scientists and lake associations realize that ground water can have a profound effect on lake water transparency and that standard lake water quality monitoring parameters alone may be inadequate or misleading for marl lakes. It is hoped that the results of this study will help encourage investigators to customize lake monitoring programs to the lake type, taking into account the entire hydrologic cycle of the lake.

Ground Water Recharge that Impairs Surface Water Quality

In much of Minnesota, it is common for ground water to recharge surface water bodies. During mid-winter or extended periods of dry weather, many streams are likely to be at a base flow condition where nearly 100 percent of its water comes from direct ground-water recharge. Even during other parts of the year, the percentage of a lake or stream's water that is supplied by direct ground-water recharge can be very substantial; it varies according to many factors including topography, hydrogeology, climate, recent precipitation or snowmelt events, etc. Where *contaminated* ground water recharges a surface water body, its impact on surface water quality can be significant.

Contaminated Ground Water

For examples of where surface water is contaminated by ground water, see the MPCA Web page entitled "Ground Water Discharge to Surface Water at Contamination Sites." These examples feature fairly discrete sources of ground water contamination. However, ground water that has been contaminated by a more dispersed (non-point) source can also have a significant impact on surface water.

For example, although not extensively studied, based on MPCA ambient ground water studies, it appears that non-point source pollution of ground water in urban areas often leads to impairment of adjacent rivers and streams.

The constituent that is most commonly responsible for the impairment is chloride. Although some contaminants might be less persistent in surface water than in ground water, that is not always the case. For example, volatile organic compounds in ground water recharge might be released into the atmosphere rather promptly after reaching a surface water body. On the other hand, elevated concentrations of nitrate in ground-water recharge could create a persistent nutrient problem in the surface water body.

Uncontaminated Ground Water

It is interesting to note that even *uncontaminated* ground water can have naturally low DO concentrations, e.g., less than 1 part per million DO. As surface water recharge, this ground water can cause surface water impairment in stretches where the surface water body is dominated by direct ground water recharge. An example of this situation is found at Walker Brook in north-central Minnesota. For more details on Walker Brook, see the articles on the following Web pages: *MPCA/Red River Reporter* *www.pca.state.mn.us/water/basins/redriver/rrr-newsletter.html* (in Adobe Portable Document Format [PDF] by Molly MacGregor (May 2004) and *Geological Society of America (GSA) Conference Abstract* *www.geosociety.org* of an article by Professor emeritus Robert C. Melchior of Bemidji State University (May 2005).

Special Well Construction Areas

Special well construction areas are designated by the Minnesota Department of Health Well Management Program.

What is a Special Well Construction Area?

A Special Well Construction Area is sometimes also called a well advisory. It is a mechanism which provides for controls on the drilling or alteration of public and private water supply wells, and monitoring wells in an area where ground water contamination has, or may, result in risks to the public health.

The purposes of a Special Well Construction Area are to inform the public of potential health risks in areas of ground water contamination, provide for the construction of safe water supplies, and prevent the spread of contamination due to the improper drilling of wells or borings.

Why are Special Well Construction Areas Important?

The improper location, construction or sealing of a well or boring in an area of ground water contamination may allow contaminants to spread to otherwise protected aquifers. The designation as a special well construction area alerts the public, including property owners, drilling contractors, and local officials, to the occurrence of ground water contamination, and the need to place special controls on the drilling of new wells and the modifications of existing wells. It provides information on the contamination source, contaminants encountered, aquifers affected, and necessary restrictions. It also allows affected parties, including local units of government, to be aware of and to respond to the contamination problem.

Additional Web-based Information Resources

Information about specific, individual Special Well Construction Areas is available on the Minnesota Department of Health Well Management Program Web site. Their Web site also includes a guide for private well owners called "Protecting Your Well" and a series of online fact sheets that address concerns related to a variety of potential contaminants that might affect private wells.

Wellhead Protection Program Progress

The Minnesota Department of Health leads the wellhead protection effort in Minnesota. Wellhead protection is a way to prevent drinking water from becoming polluted by managing potential sources of contamination in the area which supplies water to a public well. Much can be done to prevent pollution, such as the wise use of land and chemicals. Public health is protected and expense of treating polluted water or drilling new wells is avoided though wellhead protection efforts. A summary of the status of wellhead protection efforts in Minnesota is presented below:

- number of community and nontransient systems in the program - 316
- number of systems with approved wellhead plans (Parts 1 and 2) - 124
- number of systems with approved wellhead protection areas (Part 1 approval) - 208
- number of systems that are currently working on wellhead management plans (Part 2) - 124
- number of systems that are currently delineating wellhead protection areas – 108

Plans, BMPs, and Additional Information: The Minnesota Pesticide Management Plan (MDA)

The Pesticide Management Plan (PMP), available on the MDA Web site, is a guidance document for the prevention, evaluation and mitigation of occurrences of pesticides or pesticide breakdown products in the state's ground water and surface water, and is a requirement of the Pesticide Control Law (Minn. Stat. chapter 18B). The PMP must include components promoting prevention, developing appropriate responses to the detection of pesticides or pesticide breakdown products in ground water and surface waters, and providing responses to reduce or eliminate continued pesticide movement to ground water and surface water.

Best Management Practices (BMP)

The MDA is responsible for the development, promotion and evaluation of voluntary BMPs for pesticide use. BMPs are practicable voluntary practices that are capable of preventing and minimizing degradation of ground water and surface water, considering economic factors, availability, technical feasibility, implementability, effectiveness, and environmental effects. This Web site has hypertext links to numerous Pesticide BMPs and related information.

Minnesota Department of Health Pesticides Web Page

On their Pesticides Web page, the MDH explains that pesticides are substances used to prevent, destroy, repel or mitigate any pest ranging from insects, animals and weeds to microorganisms such as fungi, molds, bacteria and viruses. Pesticides may be toxic and harmful to the environment and to people if they are used improperly. At the same time, they help to manage and prevent pests that spread disease, that damage crops, buildings, and other property, and that are a public nuisance. The MDH also provides assistance on "Evaluating Your Pesticide Risk".

NPS Assessment: Recommendations for Improvement — Assessments of Waterbody Condition and Problem Identification

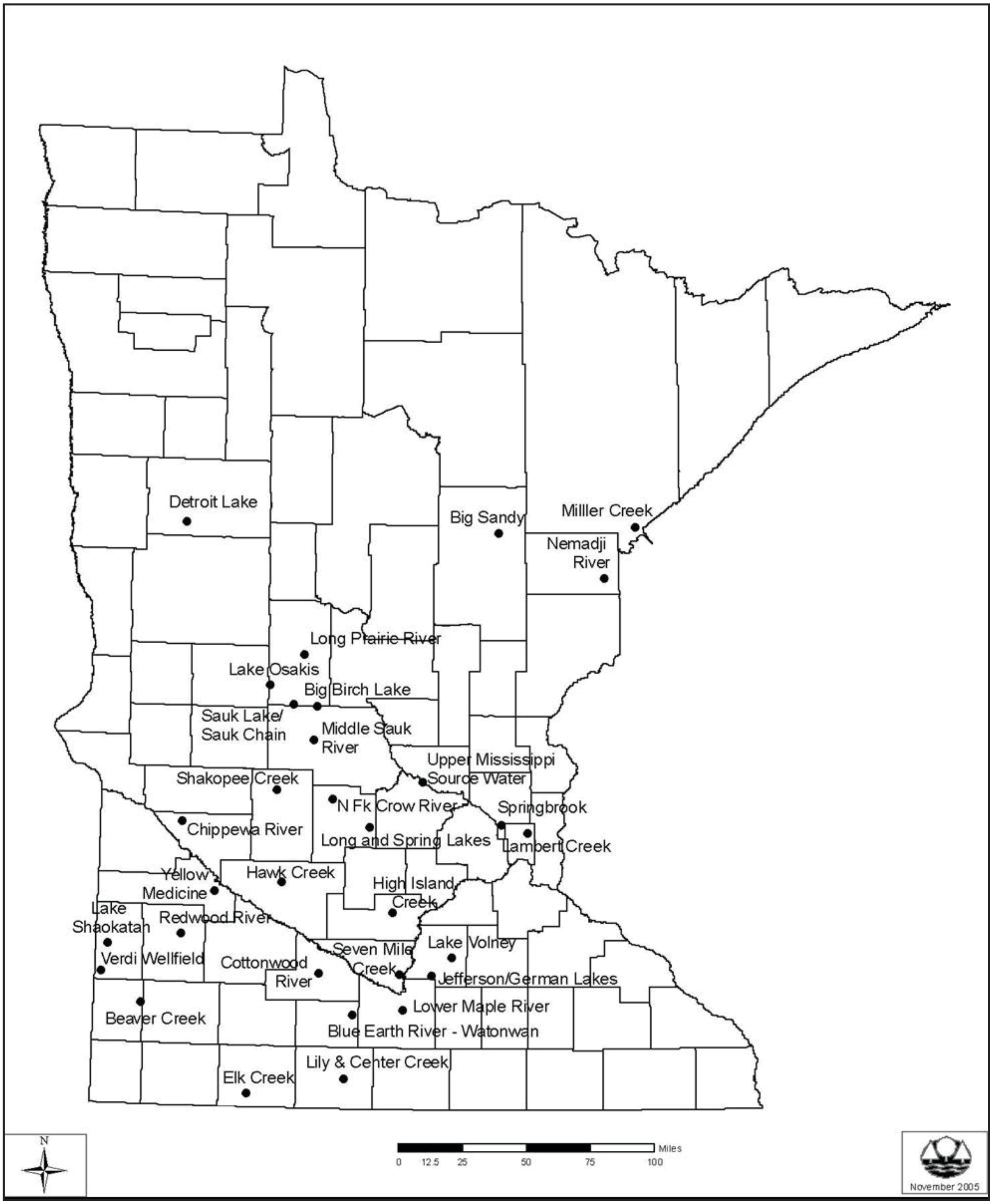
- Establish interagency partnership (led by USGS on federal level and DNR on the state level) to maintain a network of long-term monitoring installations for major river basin-scale NPS pollution load.
- Continue to build and support state-local partnerships to execute minor and major watershed-scale NPS load monitoring where needed to focus implementation.
- MPCA should design and implement a timely report format for citizens and partners with information about current loadings compared with load reduction goals.
- Continue to expand the MPCA basic statewide citizen stream and lake monitoring programs, which provide data management and interpretation.
- Strengthen the linkages between assessment procedures and local water planning.
- Support locally-grown citizen monitoring that is used to inform local resource management decisions. Identify appropriate niches for such information in statewide assessments. Develop resource centers for data management, reporting, and access to technical assistance and training to provide the program continuity necessary for statewide assessments.

- Continue the interagency cooperative work led by MPCA to calibrate biological indices of stream integrity in all the ecoregions of the state.
- For both surface water and ground water, improve Web access to assessments and information.
- Upgrade the NPS Survey.
- Continue to explore, develop and utilize new monitoring technology, equipment and methods to improve the quality and quantity of our NPS assessments.

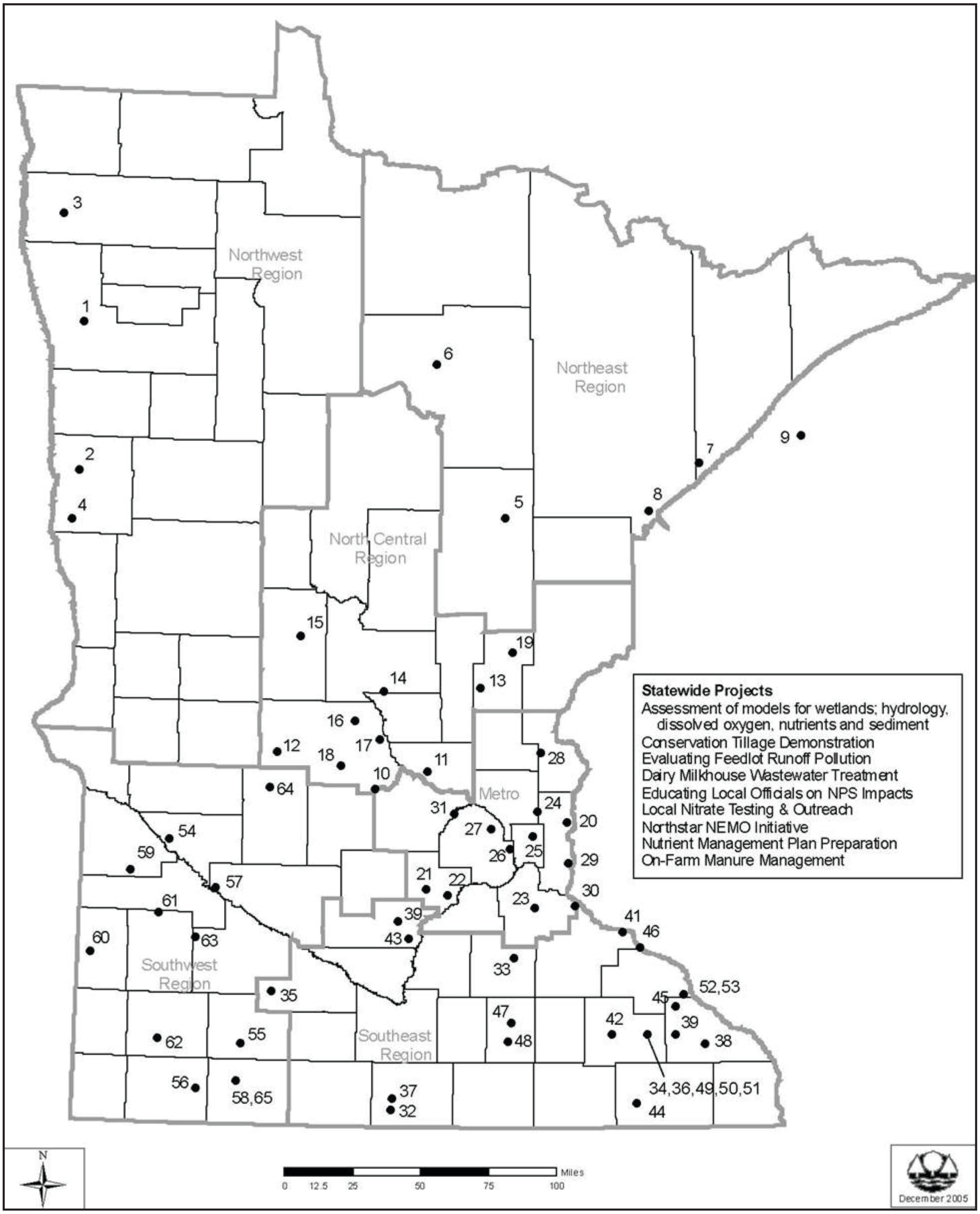
Recommendations for Improvement — Assessment of Effectiveness of BMPs and Improvement to 319 Program

- There is a growing need to develop yardsticks to measure the environmental outcome of NPS projects, chiefly implementation of BMPs and improvements to the 319 program. The MPCA plans to work with partners to discuss the feasibility of developing measures to estimate water quality benefits of NPS activities. These discussions will likely focus on monitoring results, modeling, developing new or revising existing calculations, statistical analysis, conducting site visits and other potential methods for assessing environmental outcomes.

Active Clean Water Partnerships in Minnesota



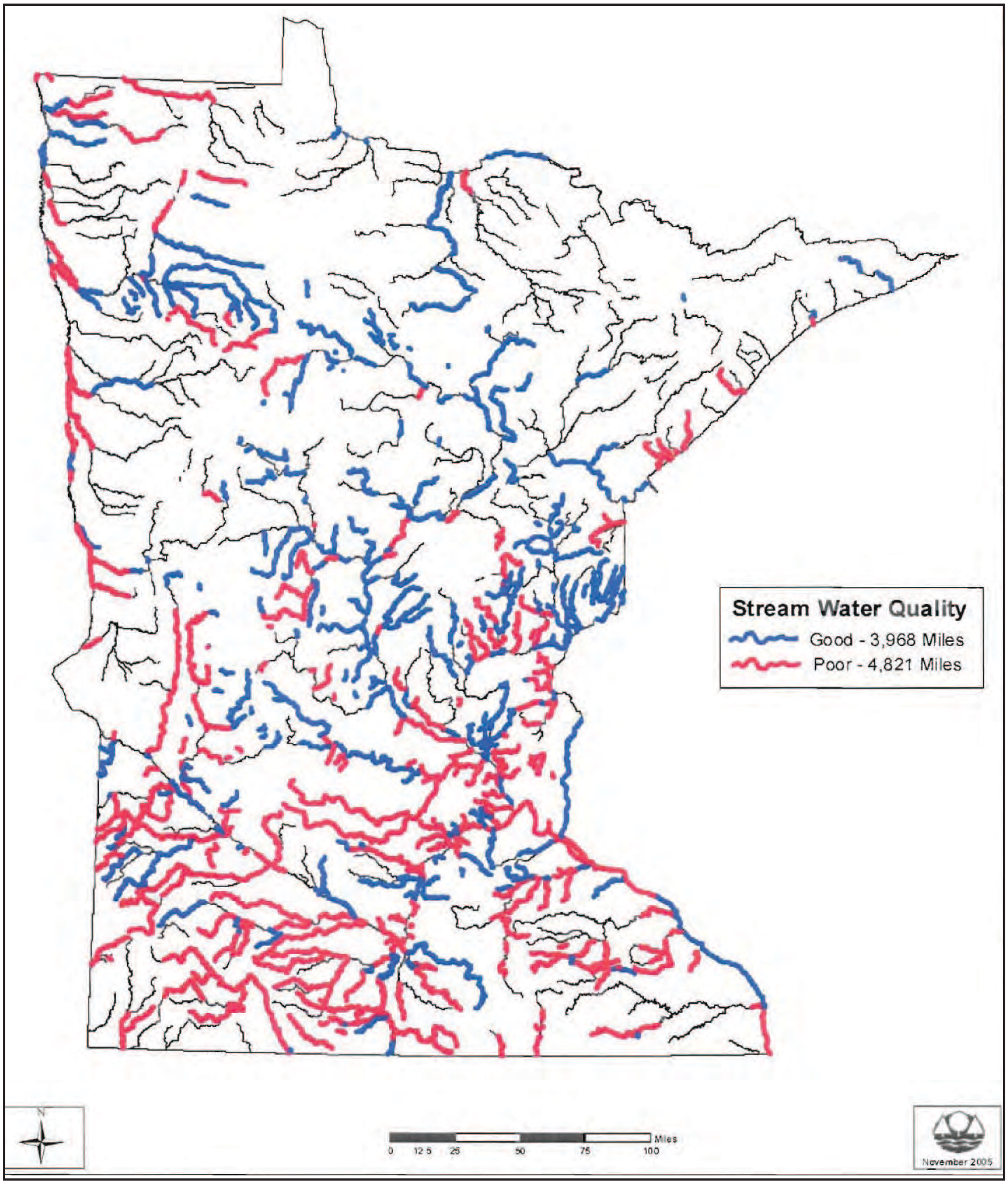
Active 319 Projects in Minnesota



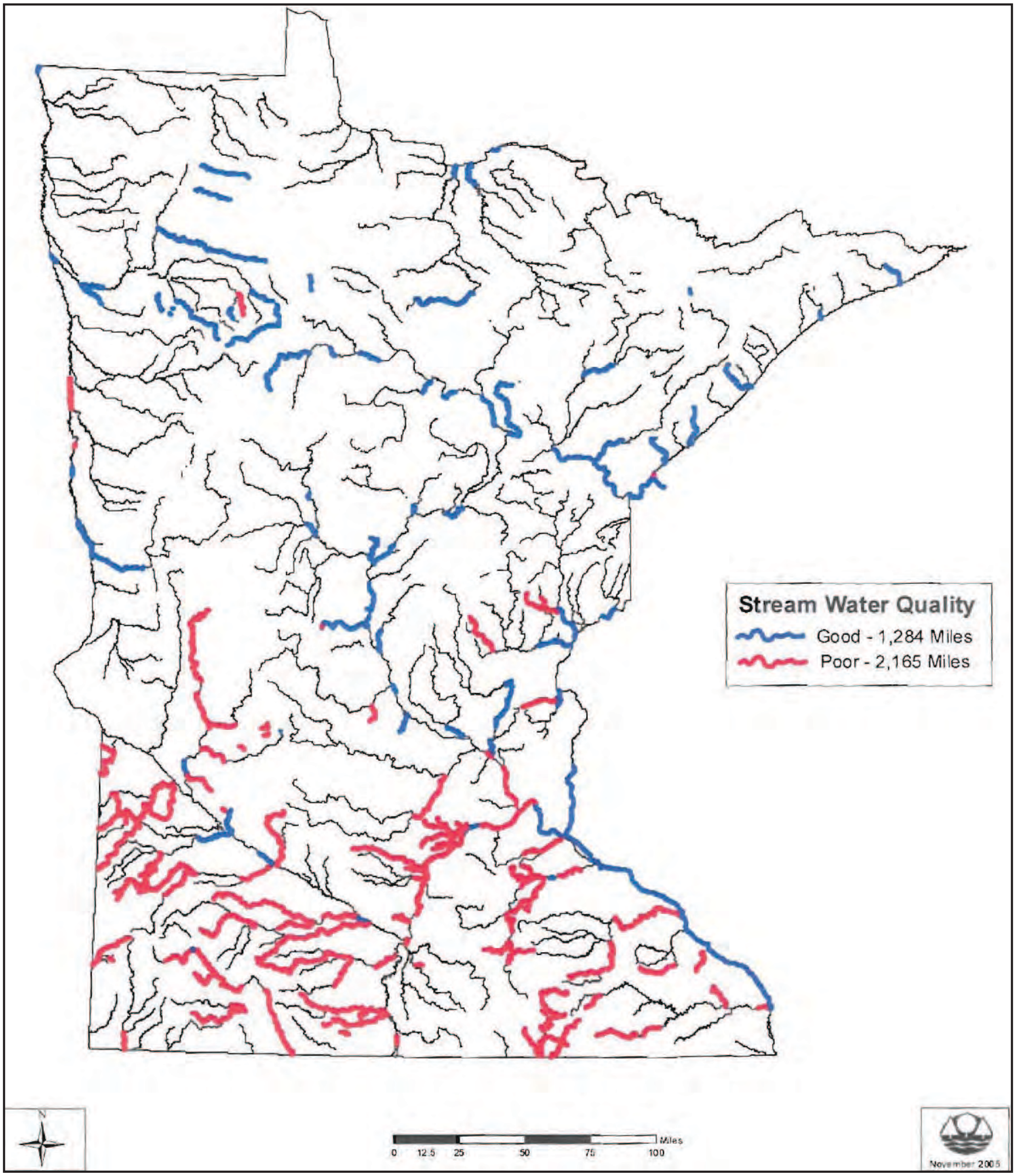
MAP ID#	TITLE
	Northwest Region
1	Red Lake River (Crookston) (Continuation)
2	Red River Basin Buffer Initiative
3	Red River Basin Sediment Reduction Project
4	South Branch Buffalo River Water Quality Monitoring Demonstration Project
	Northeast Region
5	Big Sandy Watershed's Future Implementation Projects
6	Jessie Lake Watershed TMDL Project
7	Knife River
8	Miller Creek TMDL
9	Shared Coastal Zone Engineering Assistance
	North Central Region
10	Clearwater River and Lake Louisa - Phase 2
11	Elk River Watershed Priority Lakes Phosphorus Reduction
12	Feedlot Runoff Pollution Removal by Organic Biofilters Demonstration
13	Groundhouse River TMDL
14	Little Rock Creek TMDL
15	Long Prairie River TMDL Application and Work plan
16	Manure Management within Ecologically Sensitive Areas
17	Sauk River/Greater St. Cloud Area Fecal Coliform TMDL
18	Restoring Water Resources of the Sauk River Chain of Lakes
19	Snake River Watershed Enhancement Project
	Metro Region
20	Best Management Practices Implementation Project
21	Carver and Bevens Creek
22	Carver County Turbidity and Excess Nutrients TMDL
23	Dakota County Nonpoint Source Reduction Project
24	Hardwood Creek TMDL Biota Implementation
25	Lambert Creek Water Quality Improvement Project
26	Pond Sediment Characterization
27	Shingle Creek Lakes TMDL
28	North Branch Sunrise River TMDL
29	Valley Creek Repair and Rehab Program
30	Vermillion River Turbidity Project - Phase 2 and 3
31	Working Together to Improve Water Quality
	Southeast Region
32	BERBI Nonpoint Source Implementation
33	Building (Local) Capacity for Community Solutions to Wastewater Problems
34	Cost-Share Incentives for Small Feedlot Fixes
35	Cottonwood River Watershed Phosphorus Reduction Project
36	Designing Feedlot Improvements in Targeted Areas Under the Open Lot Agreement
37	Expansion of the "Red Top" Farm Demo Concept
38	Grazing Management for Trout Stream Improvement
39	High Island Implementation Project
40	Improved Livestock Management in Riparian Areas

MAP ID#	TITLE
41	Lake Pepin, Spring Lake and 5 Mississippi River reaches and 1 Minnesota River reach
42	Reduction of Fecal Coliform Bacteria From Human Sources (TMDL Implementation Project)
43	Rush River Implementation Project
44	South Branch Root River Watershed Fecal Coliform Bacteria Reduction Project
45	South Branch Whitewater Watershed - Bacteria Reduction Project
46	Southeast MN Milk House Wastewater Treatment Demonstration
47	Steele County Septic System Loan Program
48	Straight River Fecal Coliform Reduction Project
49	Targeted Feedlot Open Lot Implementation Engineering Assistance
50	Targeted Residential Wastewater Treatment Project
51	Volunteer Nitrate Monitoring Network in Targeted Areas - a Pilot Project
52	Whitewater National Monitoring
53	Whitewater Paired Watershed Monitoring
	Southwest Region
54	Chippewa River Watershed Projects
55	Des Moines River Project - Phase 2 and 3
56	Elk Creek Conservation Tillage Incentive
57	Hawk Creek Watershed Projects
58	Heron Lake Watershed District - CWP Project
59	Lac Qui Parle River Mainstem Water Quality Enhancement Project
60	Lake Shaokatan
61	Meeting TMDL Goals with the Minnesota Phosphorus Index
62	MN Restorable Wetland Inventory
63	Redwood River Watershed Phosphorus TMDL Compliance Project
64	Shakopee Creek Headwaters Project
65	TMDL Educational Seminar

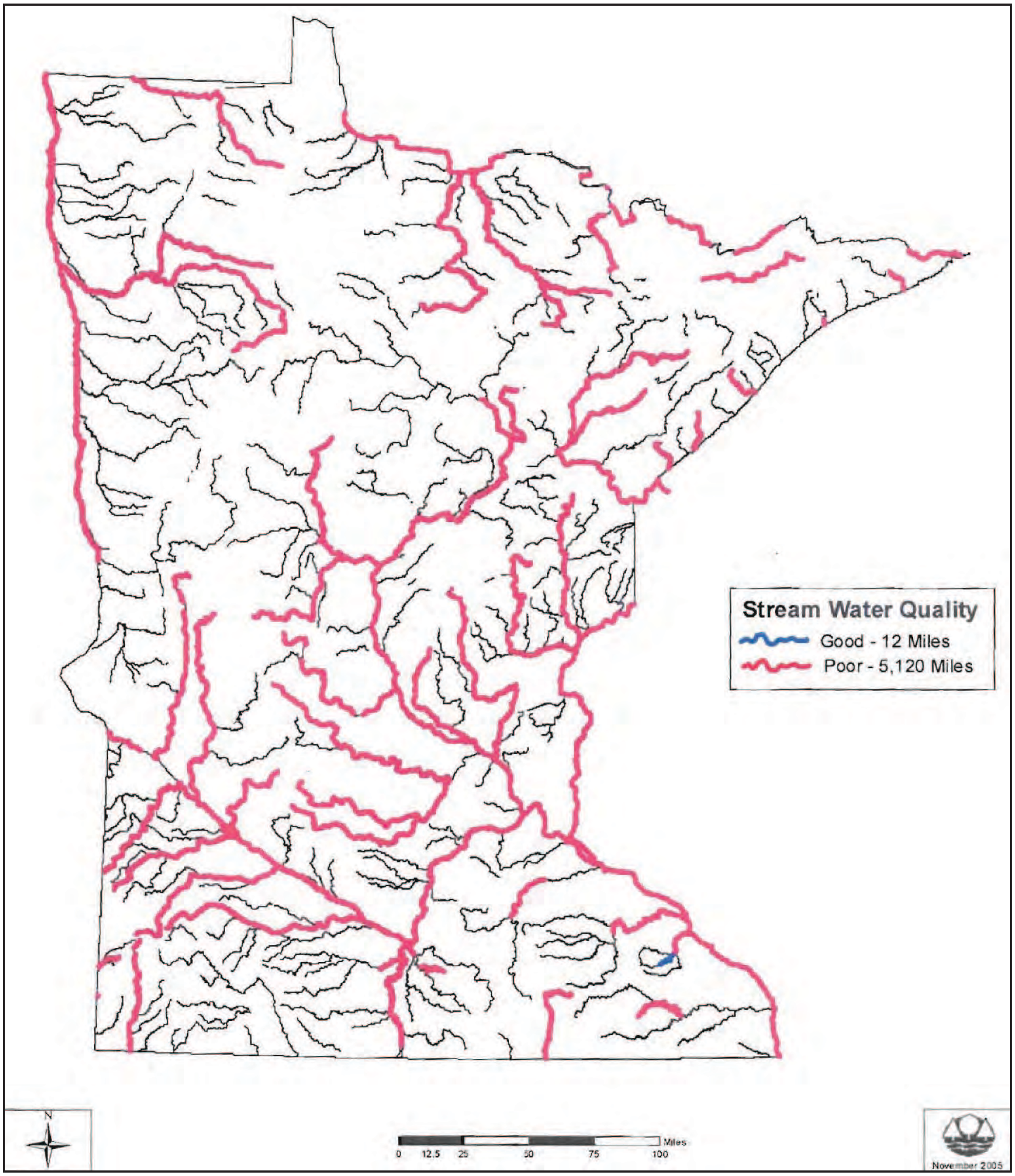
Minnesota 2006 Assessments for Aquatic Life (per Section 305(b) Clean Water Act) Stream Water Quality



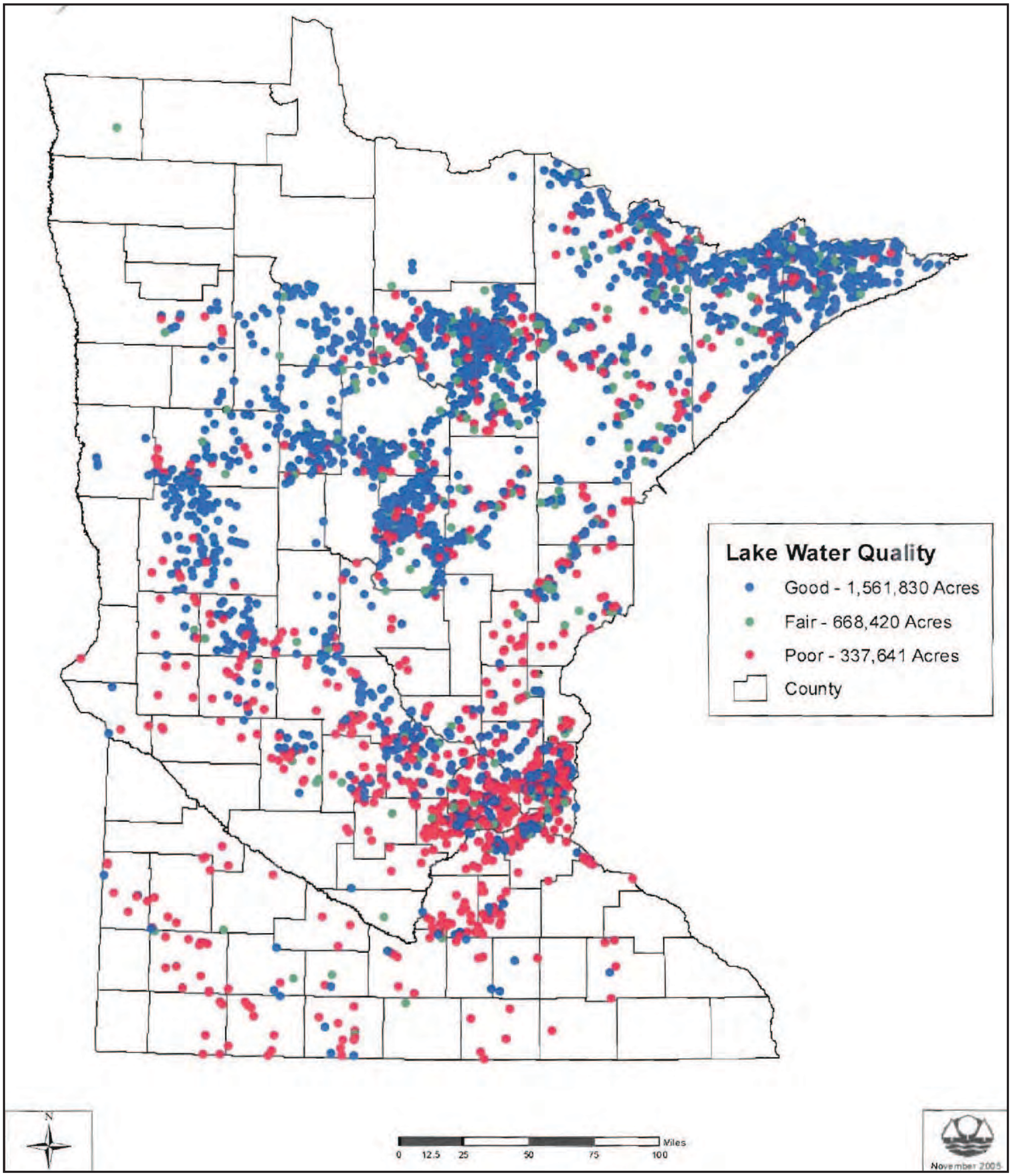
Minnesota 2006 Assessments for Aquatic Recreation (per Section 305 (b) Clean Water Act) Stream Water Quality



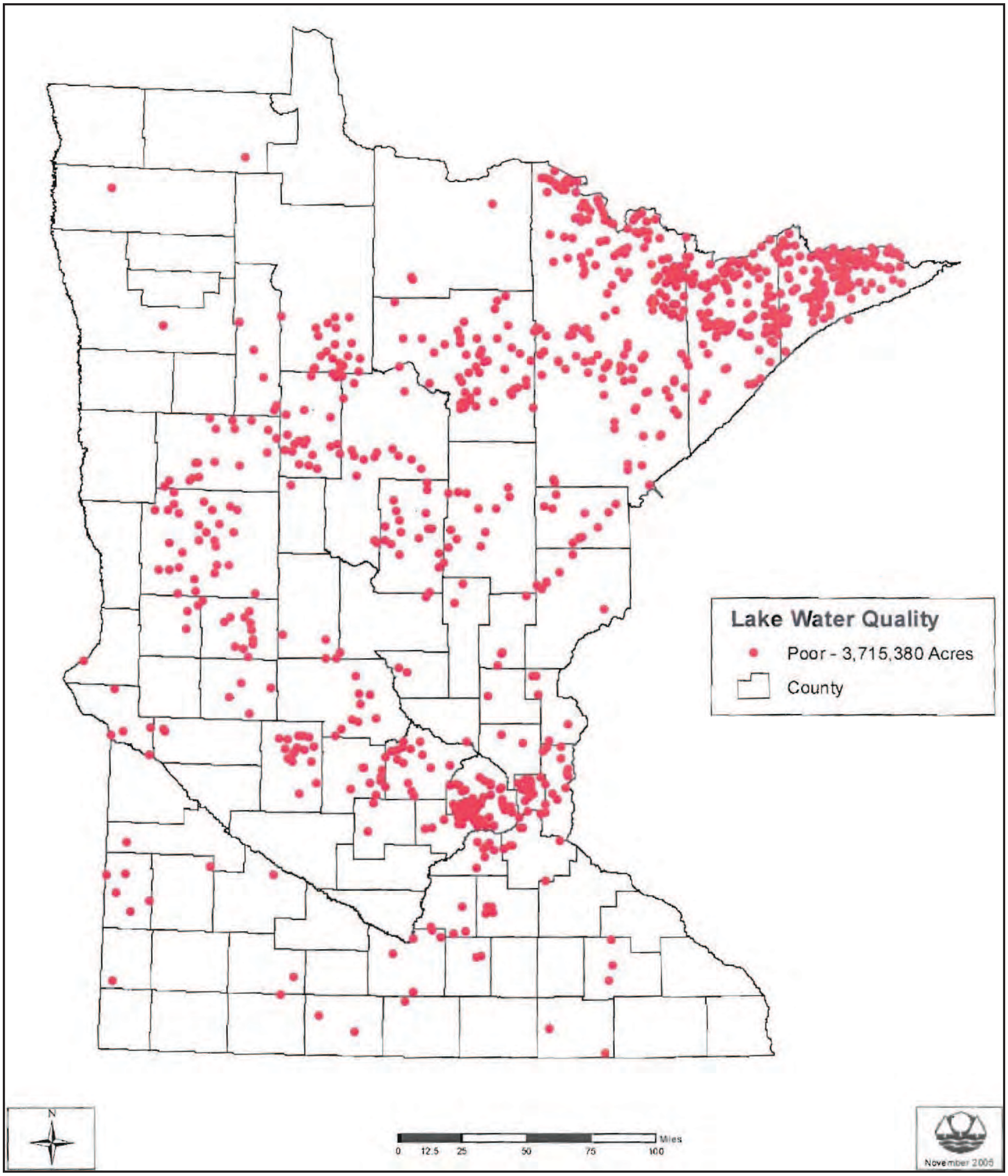
Minnesota 2006 Assessments for Aquatic Consumption (per Section 305(b) Clean Water Act) Stream Water Quality



Minnesota 2006 Assessments for Aquatic Recreation (per Section 305(b) Clean Water Act) Lake Water Quality



Minnesota 2006 Assessments for Aquatic Consumption (per Section 305(b) Clean Water Act) Lake Water Quality



Chapter 2 Programs and Funding for Implementing the Nonpoint Source (NPS) Program

Technical Committee Members

Pete Fastner, Minnesota Pollution Control Agency
Juline Holleran, Minnesota Pollution Control Agency
Sara Johnson, Minnesota Pollution Control Agency

Introduction

In the last twenty years we have better defined the true enormity of the nonpoint source (NPS) pollution problem. The diffuse nature of NPS pollution makes it very expensive to abate. Insufficient funds are the most frequently noted barrier to implementing comprehensive NPS management programs. Amassing enough money to deal with NPS pollution comprehensively even in one small area is a daunting task.

As noted earlier in this document, water quality degradation from point sources has been largely remediated. This remediation was accomplished, however, with substantial financial support over a long period of time. From 1972-1987, the federal government alone invested over $50 billion to help local communities construct secondary wastewater treatment plants to meet Clean Water Act (CWA) requirements. In contrast, the total federal Section 319 appropriation for NPS pollution for the past five federal fiscal years was $1.158 billion.

Historically, both state and federal funding for NPS water pollution has been sporadic and inadequate. In Minnesota, the primary funding sources for NPS activities have been the Federal Section 319 grants, State Revolving Fund (SRF) loan dollars and grant funds dedicated to Clean Water Partnership (CWP) projects. There are state funds allocated to programs that have a secondary benefit to water quality even though they may not focus directly on NPS pollution control. Some of the lake surveys and wildlife management programs administered by the Minnesota Department of Natural Resources (MDNR) also fit into this category. All of these sources of funding will remain critical in the future, and in fact have grown, but full implementation of this NPS Management Program Plan will require significant additional support.

Potential state and federal sources of funding for improving water quality through NPS pollution controls are summarized in Table 1 at the end of this chapter. The primary NPS funding sources; those where significant funding is allocated to activities focused on NPS abatement, are described in more detail below.

Primary Federal Funding Sources

Section 106 Water Pollution Control Program Grants

Section 106 of the CWA authorizes the United States Environmental Protection Agency (USEPA) to provide federal assistance to states (including territories, the District of Columbia, and Indian Tribes) and interstate agencies to establish and implement ongoing water pollution control programs. Prevention and control measures supported by state water quality management programs include permitting, pollution control activities, monitoring, enforcement, training, and assistance to local agencies. Increasingly, USEPA and states are working together to develop basin wide approaches to water quality management. The Section 106 program is helping to foster a watershed protection approach at the state level by looking at states' water quality problems holistically, and targeting the use of limited finances available for effective program management.

Section 104(b) (3) Water Quality Cooperative Agreements

Under authority of Section 104(b) (3) of the CWA, USEPA makes grants to state water pollution control agencies, interstate agencies, and other nonprofit institutions, organizations, and individuals to promote the coordination of environmentally beneficial activities. These activities include storm water control, sludge management, and pretreatment. Among the efforts that are eligible for funding are research, investigations, experiments, training, environmental technology demonstrations, surveys, and studies related to the causes, effects, extent, and prevention of pollution. Minnesota uses a watershed based approach to both point and NPS projects that are funded through this program. In the last two fiscal years Congress has not appropriated any funding for this grant program so the future of this funding source is in doubt.

Section 319 Funding

In 1987, the CWA was amended to include Section 319, a new section which authorized federal assistance for implementing NPS programs. Of the $1.158 billion appropriated by Congress to the USEPA for 319 activities from 2001 through 2005, the state of Minnesota received over $38 million.

USEPA has granted Section 319 funds by first establishing a base funding level for each state to institutionalize the program over the long term. Distribution of funding is done through a national budget formula. The formula is based on population and other factors related to NPS pollution. As an example, in 2005, USEPA Region 5 allocated 19 percent of the total amount they received to Minnesota. Individual states determine how much to spend on their base programs (e.g. staff, etc.) and projects.

From 2001 through 2004, Minnesota received approximately $8 million per year. In 2005 the allocation was decreased to $6.9 million.

National appropriations for each federal fiscal year to date are as follows:

2001 $237.5 million
2002 $237.5 million
2003 $238.5 million
2004 $237.0 million
2005 $207.3 million

Federal project funding is available to all state agencies or local entities that meet USEPA match requirements and USEPA/MPCA funding criteria. Project funds are awarded competitively based upon project merit and consistency with Section 319 program requirements and priorities. A group of representatives from some 20 different state, local, and federal agencies, called the Project Coordination Team (PCT), assists the MPCA in scoring and choosing the projects to be funded each year. More recently the PCT has taken a more active role in setting policy and direction for the various state and federal NPS funding programs within the MPCA. The PCT has served as a useful touchstone for the MPCA because the members can bring a wider perspective from their programs.

Project funding has been widely distributed each year among Minnesota entities. The following is a sampling and not a comprehensive list:

- University of Minnesota
- Kandiyohi County
- Minnesota Board of Water and Soil Resources
- Stearns County Soil and Water Conservation District (SWCD)
- Southeast Minnesota Water Resources Board
- Renville County
- Valley Branch Watershed District
- Sibley County

Some examples of the kinds of projects that have been funded to date include:

- Big Birch Lake improvement project
- education to improve feedlot, manure and nutrient management
- targeted residential wastewater treatment project
- grazing management for trout stream improvement
- Whitewater watershed national monitoring project
- High Island implementation project
- Hawk Creek watershed improvement projects
- Shakopee Creek headwaters improvement project
- feedlot runoff pollution removal by the use of organic biofilters
- Valley Creek watershed repair and rehabilitation

Section 319 funding is also used to fund Total Maximum Daily Load (TMDL) projects. In fiscal year 2006, $600,000 of 319 funds were set aside to fund non-competitive TMDL studies. These studies clarify the extent of the reach impairment and determine the load allocation which, over time, will help the reach become unimpaired. In addition, $1,000,000 of 2006 Section 319 funds were used to fund TMDL implementation projects, with activities designed to begin correcting the impairment to river and stream reaches. Current plans are to continue to fund TMDL implementation projects at these levels, in order to make steady progress toward Minnesota's long-term goals of correcting watershed impairments.

Section 319 funding provides valuable support, but federal funds cover only a fraction of the work that needs to be done. It is uncertain how reauthorization of the CWA will affect Section 319 funding, but regardless of the outcome, it is clear that long term stable funding is needed to implement a successful program. Responsibility for future financial incentives will fall largely on state and local governments. Minnesota will need creative new ways to fund NPS controls. Examples of creative funding mechanisms used in some states for funding NPS programs include cost sharing, taxes, (property, sales, or cigarette), user fees, utility districts (storm water or septic system), and permit development.

Federal Farm Bill Title II — Conservation

Title II of the 2002-2007 Farm Bill authorized unprecedented levels of funding for agricultural conservation programs, including an estimated $785 million to Minnesota. Each of the past several Farm Bills has authorized new conservation programs, culminating in the seven major programs of the 2002-2007 Farm Bill listed below and in Table A. All of these programs are voluntary. Each program is described under its own heading later in this section.

- Conservation Reserve Program (CRP), including the CRP General Signup, CRP Continuous Signup (CCRP), and the federal-state Conservation Reserve Enhancement Program (CREP)
- Environmental Quality Incentives Program (EQIP)
- Conservation Security Program (CSP)
- Wetlands Reserve Program (WRP), and the federal-state Wetlands Reserve Enhancement Program (WREP)
- Wildlife Habitat Incentives Program (WHIP)
- Farm and Ranch Lands Protection Program (FRPP)
- Grassland Reserve Program (GRP)

1985	1990	1996	2002
CRP- - - - - -		- - - - CCRP/CREP - - - -	- - - - - - >
		EQIP - - - - - -	- - - - - - >
		WRP- - - - - -	WREP- - - - - - >
		WHIP- - - - - -	- - - - - - >
		FRPP- - - - - -	- - - - - - >
			CSP- - - >
			GRP- - - >

Table A. Farm Bill Conservation Programs, 1985-present.

From the signing of the 2002-2007 Farm Bill in May 2002 through October 2006, these programs have provided more than $787 million for agricultural conservation in Minnesota. This includes land rental payments (CRP, CCRP, CREP, and GRP), conservation easement purchases (CREP, WRP, WREP, FRPP, and GRP), cost-share and/or incentive payments to establish new practices (EQIP, CRP, CREP, WRP, WREP, WHIP, and CSP) and green payments to reward ongoing stewardship (CSP).

When assessing the size of the Farm Bill's contribution to soil and water conservation in Minnesota, it is worth noting that every dollar of Farm Bill conservation cost-share and incentive payments is automatically leveraged by program participant's required out-of-pocket cash contributions to establish and maintain practices. Landowners often invest amounts at least equal to the federal cost-share or incentives—sometimes aided by other agencies and organizations such as the US Fish and Wildlife, Pheasants Forever or the state.

Following are some examples:

1. From the time EQIP started in 1996 to the present, Minnesota producers have matched EQIP funds with an estimated $120 million or more in un-reimbursed expenses to implement conservation practices for 3 to10 years from the start of the EQIP contract.
2. Since 1997, when wetland restoration first became a CRP enrollment option, Minnesota producers' required out-of-pocket share of the cost to restore roughly 320,000 acres of wetlands has totaled an estimated $18 million or more.
3. At 2005 Farm Bill and state conservation funding levels, Minnesota farmers will contribute an estimated $40 million per year to establish practices cost-shared by federal and/or state conservation program dollars. These figures do not include the property taxes participating landowners continue to pay on CRP and WRP lands, nor do they include expenses associated with long-term conservation practice maintenance. A breakdown of 2002-2007 Farm Bill conservation funding to Minnesota is provided in Tables B and C below. Table B includes EQIP, WRP, WHIP, GRP and FRPP. The funding for these programs depends on annual Congressional appropriations as well as state allocations decided by the United States Department of Agriculture (USDA). All of the allocated amounts have been spent or obligated and there is a considerable backlog of eligible, unfunded applications for most of the programs. Table C shows funding from CRP and CSP, which are funded differently than the programs in Table B. The amount of CRP funding received in Minnesota in any year depends mainly on the number of signup opportunities and the number of acres landowners choose to enroll. There remain significant opportunities to enroll additional acreage before the current Farm Bill expires. The amount of CSP funding available in any year depends on annual Congressional funding decisions, the number of Minnesota watersheds selected, the number of eligible farmers in those watersheds and the percentage of eligible farmers who choose to enroll.

Program	FY02	FY03	FY04	FY05	FY06	Total to Date	FY07
EQIP	$9.3	$19	$24	$25.1	$25.1	**$102.5**	to be determined
WRP	$17	$15	$14	$16	$17	**$79**	to be determined
FRPP	$0	$1.3	$1.1	$1.6	$.5	**$4.5**	to be determined
WHIP	$.3	$.5	$.5	$.9	$.6	**$2.8**	to be determined
GRP	n/a	$.8	$.9	$.9	n/a	**$2.6**	to be determined
Total	**$26.6**	**$36.6**	**$40.5**	**$44.5**	**$43.2**	**$191.4**	

Table B. Estimated funding ($ millions) to Minnesota from five of the 2002-2007 Farm Bill's seven major conservation programs.

Program	FY02	FY03	FY04	FY05	FY06	Total to Date	FY07
CRP	$110	$110	$110	$110	$110	**$550**	$100
CSP	n/a	n/a	$17	$27	$2	**$46**	to be determined
Total	**$110**	**$110**	**$127**	$137	$112	$596	

Table C. Estimated funding ($ millions) spent or obligated in Minnesota for CRP and CSP under the 2002-2007 Farm Bill.

CRP figures include annual rental payments only (not cost-share) for about 1.8 million acres. CSP figures represent funds obligated for 5-year and 10-year contracts.

Examples of the types of conservation practices funded by each program are provided under the program-specific headings below.

Leveraging the Farm Bill

Minnesota ranks roughly third in the nation in Federal Farm Bill conservation funding. This is due at least partly to state conservation programs (see State Programs, below) that leverage the Farm Bill's investment in Minnesota's natural resources. In 2004, a state agency work group identified key strategies to help Minnesota do an even better job of leveraging Farm Bill dollars in support of Minnesota's clean water goals—especially impaired waters restoration. These strategies were incorporated in the Clean Water Legacy Act (CWLA) with the dual goal of attracting more Farm Bill conservation funds and targeting more of the Farm Bill funds received to NPS restoration and protection.

Farm Bill Leveraging Strategies

- Technical Assistance: Supplement technical assistance to landowners in priority watersheds
- Financial Assistance: Supplement low-interest loans, cost-share and incentive payments in priority watersheds
- Conservation Planning and Promotion: Intensify watershed-based efforts to develop farm conservation plans, coordinate TMDL implementation funding, and promote the most effective practices
- Agricultural Systems Research, Evaluation and Effectiveness Monitoring: Fund ongoing research to ensure that conservation practices are applied as cost-effectively as possible in priority watersheds.

One way to increase Minnesota's Farm Bill conservation funding is to increase the acreage enrolled in CRP and CSP. There is significant potential to increase Minnesota's share of the federal dollars for these programs because their funding is not based on a pre-determined state allocation. Instead, it depends on the amount and type of land accepted from Minnesota during each signup opportunity. CSP also depends on the number of Minnesota watersheds selected to participate and the extent and diversity of agriculture within them. The amount of land accepted depends mainly on landowner interest and land eligibility, which can be positively influenced by implementing the leveraging strategies listed above at the local and/or state level.

Another way to increase Minnesota's Farm Bill conservation funding is to help USDA implement and build landowner demand for programs whose funding is distributed via annual allocations to states (EQIP, WRP, WHIP, and GRP). States that supplement Farm Bill conservation program technical assistance and provide evidence of increased landowner demand may be rewarded with higher allocations in the future. Minnesota's high rank among the states in Farm Bill conservation funding is at least partly due to the leveraging strategies already in place, such as State Cost-Share and Agricultural Best Management Practice (BMP) Loans (see State Programs, below), both of which supplement Farm Bill conservation program financial assistance.

Yet another way to increase Minnesota's Farm Bill conservation funding is to take advantage of opportunities to develop special agreements with USDA that allow a portion of Farm Bill conservation program funds to be reserved for state or local priorities. The first such opportunity through the Farm Bill was the CREP, introduced in 1998. Minnesota was one of the first states to develop a CREP agreement. Since then, similar opportunities which Minnesota state and local agencies have successfully pursued under the 2002-2007 Farm Bill, include the WREP, a Driftless Area Resolution signed by the United States Department of Agriculture (USDA) and a special allocation of $200,000 for the Whitewater Watershed from EQIP.

Minnesota has also succeeded in attracting additional Farm Bill conservation dollars through two annual USDA conservation grant programs. It is difficult to know whether current levels of Farm Bill conservation funding will be sustained in the next Farm Bill. Regardless of future funding levels, the key point is that there are strategies Minnesota can pursue to increase its share of federal funds received, as well as the percentage of these funds that contribute to NPS restoration and protection.

While all of the leveraging strategies listed above can be applied to any or all of the 2002-2007 Farm Bill major conservation programs, certain strategies are especially suitable for a particular program (e.g., EQIP), a particular practice (e.g., nutrient management), or a particular natural resource goal (e.g., Prairie Pothole habitat restoration). Specific Farm Bill leveraging opportunities are described throughout this document where relevant.

Conservation Reserve Program (CRP) and Conservation Reserve Enhancement Program (CREP)

CRP is the oldest and by far the largest of the seven major Farm Bill conservation programs. Administered by the USDA Farm Service Agency (FSA), CRP offers 10 to 15 years of rental payments and one-time cost-share payments to landowners who retire highly erodible or other environmentally sensitive agricultural land to establish and maintain various resource-conserving covers. CRP conservation covers range from fields of switchgrass or trees to strategically placed conservation buffers as well as restored wildlife habitat and wetlands. Through these practices, CRP reduces soil erosion, improves water quality and creates wildlife habitat. Since it was first introduced in the 1985 Farm Bill, CRP has evolved to encompass three different types of signup opportunities—the General Signup, the Continuous Signup (CCRP) and the Conservation Reserve Enhancement Program (CREP).

- CRP General Signups typically involve whole fields of grass, trees, or specially designed wildlife habitat. The program is highly competitive and enrollment opportunities are fleeting. Signups lasting 30-60 days are typically announced about one month in advance. USDA has held three general signups to date under the 2002-2007 Farm Bill and may or may not hold another before this Farm Bill expires. Landowners' bids to enroll are ranked against all other bids nationwide using an Environmental Benefits Index which includes a cost factor. Only bids scoring above a certain threshold are accepted.

- The threshold, which varies with each signup, is determined only after the signup has ended and all bids have been evaluated.
- CCRP is non-competitive and available year-round, so eligible land may be enrolled at any time. When first introduced in 1996, it focused on conservation buffers for water quality but, since 2002, it has evolved to include wetland restoration options as well. Wetland restoration options available through the CCRP include several special initiatives important to Minnesota, including a Farmable Wetlands Initiative and a Duck Nesting Habitat Initiative. Higher rental payments and special one-time bonus payments are available for land enrolled in certain CCRP practices (certain types of conservation buffers and wetland restorations) as well as land in certain portions of designated wellhead protection areas.
- CREP is a federal-state partnership agreement that allows states to reserve a portion of the national maximum CRP acreage to address state or local priorities. Each CREP agreement is unique, specifying the eligible geographic areas and conservation practices, and the resource concerns to be addressed by targeting the reserved CRP acres to these areas. Minnesota was one of the first to develop a CREP agreement with USDA. Today, more than 80,000 acres are under permanent easements in the Minnesota River Basin CREP, and a CREP II is under way in northwestern, southwestern and southeastern Minnesota.

The Minnesota River CREP agreement combined $81 million from the state with $164 million from USDA, resulting in a leveraging ratio of more than 2:1. CREP II aims to enroll up to 120,000 acres by December 31, 2007 at a cost of $53 million from the state and $200 million from USDA (a 4:1 leveraging ratio). Land enrolled in CREP in Minnesota is subject to CRP rules and regulations for the first 10-15 years, after which it remains subject to a long-term or permanent conservation easement with the state. Minnesota landowners enrolled more than 1.8 million acres in CRP between 1986 and 1993. In the mid-1990s, when a large percentage of these contracts expired, enrollment dropped to about 1.1 million acres. Since then it has increased steadily to nearly 1.8 million acres today. In 2006, a second major wave of CRP contract expirations began nationwide and in Minnesota. This time, USDA developed a CRP re-enrollment and contract extension policy which allows certain eligible contracts — generally those that had the highest Environmental Benefits Index scores when first accepted into the program — to be automatically renewed for a second term of 10 or 15 years (15 years only for contracts with restored wetlands) or extended 2 to 5 years. Interested contract-holders with eligible contracts have a limited window of opportunity to apply in advance for these continuation options. However, all is not lost if a landowner misses the opportunity or their CRP contract is ineligible for automatic renewal or extension. If desired, they can re-enroll any part of the CRP land that qualifies in the CCRP or submit a competitive bid to re-enroll some or all of it in a future CRP General Signup. The 2002-2007 Farm Bill limits CRP to 39.2 million acres nationwide, of which 2 million are currently reserved for the CCRP and CREP. Approximately 36 million acres were enrolled as of October 2006. No more than 25 percent of a county's cropland may be enrolled in CRP and/or the WRP at any one time (except in counties that have successfully appealed for a waiver, including several in northwestern Minnesota). Certain CRP conservation practices are also subject to state-specific acreage caps.

Despite the above acreage limitations—and even though Minnesota ranks third nationwide in CRP participation and acreage-there is still room to increase the amount of CRP land in Minnesota significantly, particularly through the CCRP and CREP. However, the total acreage offered each year by landowners in Minnesota and nationwide has been declining over the last several years. Rapidly rising land values appear to be the main culprit. It remains to be seen whether a recent increase in CRP and CREP rental rates will help increase the amount of land entering the program each year.

Conservation Security Program (CSP)

CSP is the nation's first conservation program to reward agricultural producers who have a documented history of good land stewardship and offer incentives for all producers to do more. The program is designed to encourage producers to maintain a wide range of conservation measures on working farms. Eligible working lands include cropland, grassland, improved pasture, range land, orchards, vineyards, and forested land that is an incidental part of a farming operation. Since 2004, CSP has been offered in selected watersheds each year.

The program is open to most producers (when offered in their watershed) regardless of the size or type of operation. CSP is administered by the USDA Natural Resources Conservation Service (NRCS).

As the most innovative and comprehensive conservation program ever attempted in the U.S., CSP has significant potential to restore and protect water quality in Minnesota if fully funded. The version of the program rolled out in 2004-2006 has fallen far short of its potential. The 2002-2007 Farm Bill authorized CSP as an “entitlement” program available to all producers in all watersheds every year, but annual funding cuts have necessitated a set of complex rules that restrict program eligibility and signup opportunities. To date, three nationwide CSP signups have been held (in 2004, 2005 and 2006) in selected watersheds only, each lasting about 60 days. Certain rules of the program changed with each signup and the net effect has been a pilot program, with many lessons learned. In 2005, NRCS anticipated that, at 2005 funding levels, the program would reach all or nearly all watersheds in the country within eight years. However, at the significantly lower level of funding provided in 2006, it would take more than 20 years. In Minnesota, seven watersheds—the Blue Earth, Red Lake (Red Lake River), Red Lakes, Redeye, Redwood, Root, and Sauk—are among more than 330 nationwide where CSP has been offered to date. More than 200,000 acres in 712 contracts are now enrolled in CSP in Minnesota, totaling an estimated $44 million in federal conservation incentives. Additionally, a large percentage of Minnesota producers who enrolled in 2004 and 2005 opted to upgrade their contracts one year later by adding more farmland and/or more conservation practices on the acres already enrolled. The Thief River Watershed in northwestern Minnesota has been selected to participate in 2007 if there is enough funding to hold a signup.

The number of acres enrolled in a watershed could be significantly increased—even in years with limited CSP funding—if landowners and agencies knew at least two years in advance whether and when the program will be offered in their watershed. Advance notice would provide watersheds with a much stronger incentive to prepare for CSP and take advantage of the significant conservation and income-enhancement opportunity it offers.

CSP has several built-in mechanisms to stimulate increased conservation—including potentially significant benefits to water quality. First, farms have to meet certain soil and water quality standards to enter the program. This gives producers an incentive to take any steps necessary to meet these entrance requirements.

Second, the more conservation in place on a farm at the time of enrollment, the higher the contract payments will be, giving producers an incentive to exceed the minimum requirements. In fact, CSP applicants are placed into one of three payment tiers based on (1) whether all or part of the farm is involved and (2) whether the conservation measures in place go beyond the minimum soil and water entrance requirements. Tier 1 contracts address soil and water resource concerns on at least one field. Tier 2 contracts address soil and water resource concerns on the entire farm. Tier 3 contracts address a broad range of resource concerns on the entire farm and offer the greatest payment potential.

Third, depending on the level of CSP funding in any year, participants with existing contracts may apply to move up a tier or earn higher payments within the same tier by adding more land and/or conservation practices. So far, a high percentage of CSP participants have taken advantage of this option.

Finally, the 2002-2007 Farm Bill authorizes CSP to provide special incentive payments to producers who participate in government or university sponsored conservation research, demonstration projects, watershed or other area-wide projects involving a high percentage of area farms or farmland. If implemented, these provisions could help CSP improve water quality significantly.

For many Minnesota producers, the key to meeting CSP minimum soil and water quality entrance standards is to minimize tillage operations, follow University of Minnesota nutrient management recommendations and provide documentation, including soil test results. With limited CSP funding, however, meeting the program’s basic eligibility standards is only the first hurdle. To be funded, a CSP application must compete with all applications nationwide based on priorities determined by USDA for the given signup. These priorities have changed with each signup, requiring different application strategies each time. This has complicated efforts to deliver a consistent message when promoting CSP to producers. For example, in 2004 and 2005, Minnesota agencies advised producers to "get their foot in the door" by enrolling as little as a few acres (if that was all that qualified) with the understanding that they could expand the contract later, if desired.

Not surprisingly, a large percentage of the contracts accepted in those signups were part-farm (Tier 1) contracts. In contrast, the 2006 signup prioritized whole-farm applications and, consequently, nearly all of the contracts accepted were in Tier 2 or Tier 3.

The extent to which Minnesota can leverage CSP funding each year depends on several factors:

1. the total nationwide funding available for CSP each year
2. the number of watersheds that can reasonably participate at that funding level
3. the amount of eligible farmland and degree of good stewardship in the Minnesota watersheds selected compared to the watersheds selected in other states
4. the predominant type of farming in a watershed, as certain types of operations have more conservation challenges or opportunities than others—or simply different types of conservation challenges and opportunities not yet fully recognized by the program

In the first three CSP signups, watersheds with greater agricultural landscape diversity generally fared better. Aside from these major considerations, the amount of CSP funding Minnesota can attract in any signup depends on the degree to which producers in participating watersheds are prepared and the ability of conservation agencies to promote the program and help interested, eligible applicants document the conservation measures in place on their farm.

Environmental Quality Incentives Program (EQIP)

EQIP is administered by NRCS. It offers technical and financial assistance for a wide range of soil, water and habitat conservation practices on privately owned working lands. Management practices are eligible for three years of incentive payments on up to 250 acres. Examples include conservation tillage, cover crops, nutrient and pest management and rotational grazing. Vegetative and structural practices are eligible for 50 percent cost-share. Examples of vegetative practices include converting cropland to pasture, establishing a grass filter strip or planting trees. Examples of structural practices include feedlot water quality upgrades and fencing and watering systems for rotational grazing.

Currently, EQIP funds are distributed as follows: each year, Congress decides how much funding to appropriate, within the maximum amount authorized by the Farm Bill. The national NRCS office applies a state allocation formula to distribute a portion of the funds to each state NRCS office. Table B above shows Minnesota's EQIP allocations to date under the current Farm Bill. NRCS State Conservationists determine how the funds are distributed within their state. The approach of the Minnesota NRCS office has been to ensure that eligible landowners in every corner of the state have the opportunity to apply for EQIP funds and that every Soil and Water Conservation District (SWCD) has the opportunity to recommend funding priorities for their district.

Their funding recommendations must be based on local conservation priorities established in consultation with a local work group and must be consistent with national and state EQIP priorities.

While the vast majority of Minnesota's EQIP funds have been spent in this way, the State Conservationist has also reserved a small portion for special initiatives, such as nutrient management demonstrations and conservation on Tribal lands. Minnesota has consistently ranked third in EQIP financial assistance dollars behind Texas and California. Most of the practices funded help improve or protect water quality. For more information about the practices funded in Minnesota over the past few years, see the Minnesota NRCS 2005 report on conservation accomplishments.

- *www.mn.nrcs.usda.gov/news/State%20Story/2005_MN_Conservation_Accomplishments.pdf*
- *www.mn.nrcs.usda.gov/news/State%20Story/2006_MN_Conservation_Accomplishments.pdf*

Wetlands Reserve Program (WRP) and Wetlands Reserve Enhancement Program (WREP)

WREP is an NRCS program that offers technical assistance, cost-share and easement payments to landowners who restore wetlands on agricultural land and place them in 30-year or permanent easements. In Minnesota, WRP applications for permanent easements in locations that benefit migratory waterfowl have been prioritized for funding and account for nearly all of the WRP easements in the state. Additionally, the State has used RIM funds to purchase permanent easements on the small percentage of WRP contracts with 30-year terms. The state easements take effect when the federal easements expire.

In 2005, Minnesota recorded 73 WRP easements - more than any other state - involving 15,600 acres in 19 counties. In 2006, Minnesota reached a 50,000-acre milestone for fully recorded WRP easements. Overall, as of November 2006, more than 70,000 acres have been accepted into WRP in Minnesota.

Also in 2005, Minnesota became the second state to receive funds for WREP, a 5-year partnership between NRCS and the Minnesota Board of Water and Soil Resources (BWSR), in which Minnesota will contribute up to $1.2 million in money and in-kind services through the ReInvest in Minnesota (RIM) program. In the first year of the agreement, NRCS funded $5.3 million worth of WREP applications with 15 landowners in Freeborn and Mower Counties and the Manston Slough project in Wilkin County.

Wildlife Habitat Incentives Program (WHIP)

WHIP, run by the NRCS, offers technical assistance and up to 75 percent of the costs to develop and improve fish or wildlife habitat on private lands. Almost any type of land may be eligible, including, grassland, woodland, pastureland, wetlands, streams and riparian areas, agricultural and non-agricultural land. In Minnesota, practices eligible for WHIP cost-share vary every year but have generally included riparian buffers, components of wildlife-friendly grazing systems, prairie restoration and management, farmstead shelterbelt establishment or renovation, tree/shrub planting, timber stand improvement, woodland openings for wildlife and in-stream structures to improve fish habitat. Although intended for habitat, most of these practices can also significantly benefit water quality. Participants agree to maintain cost-shared practices for 5 -10 years and allow NRCS access to monitor their effectiveness. NRCS field offices take applications year-round and make funding decisions periodically during the year.

Grassland Reserve Program (GRP)

GRP protects grassland for grazing and other purposes. It offers landowners several enrollment options, from rental contracts lasting 10, 15, 20 or 30 years to permanent or 30-year easements. In addition to easement and rental payments to protect existing grassland (e.g., from conversion to crops or urban development), the 2002-2007 Farm Bill also authorized GRP to provide cost-share assistance to restore degraded or already converted grassland. However, little or no restoration cost-share is included in the GRP contracts and easements funded to date. GRP was first offered in 2003 and within three years all of the funding authorized over the life of the 2002-2007 Farm Bill was obligated. Minnesota's 2003, 2004 and 2005 state allocations for GRP totaled $2.6 million, funding 97 rental contracts that protect nearly 15,000 acres of grassland.

Farm and Ranch Lands Protection Program (FRPP)

FRPP is an easement program designed to help preserve agricultural land. Funding is available through an annual competitive process open only to state or local entities that have a purchase-of-development-rights

(PDR) or similar program. As of November 2006, Dakota County is the only entity in Minnesota that has successfully applied for FRPP funding. Its voter-approved Farmland and Natural Areas Program (FNAP) has received FRPP funding every year since 2003, culminating in $4.5 million to date.

The FNAP is important for water quality because it targets - in addition to priority natural areas - high-quality agricultural land within a half-mile of rivers and streams. The nearly 2,000 acres approved for Dakota County FNAP farmland easements to date will be permanently protected from conversion to non-agricultural uses. Federal FRPP dollars pay for up to half the cost of the farmland protection easements. The county pays the rest, including costs associated with securing the easements.

Minnesota could potentially increase its FRPP funding by encouraging local governments to develop PDR or similarly eligible programs. Washington County recently passed a voter referendum that could enable it to develop this type of program.

Conservation Grant Programs

In addition to the seven major conservation programs described above, the 2002-2007 Farm Bill authorized two new, competitive grant programs with significant potential to aid NPS projects in Minnesota: EQIP Conservation Innovation Grants (CIG) and Cooperative Conservation Partnership Initiatives (CCPI) grants. Both are described below.

- CIG grants fund up to 50 percent of conservation projects that are designed to stimulate innovative approaches to leveraging federal investments in environmental enhancement and protection.
- Examples of innovative approaches include market-based pollution credit trading and new conservation technologies such as conservation drainage. Since the program started in 2004, nearly $1.3 million has been awarded to projects based in Minnesota and nearly $3.3 million has been awarded to multi-state projects that include Minnesota. Nearly all of these projects could significantly benefit water quality in Minnesota by improving the effectiveness of certain conservation practices and systems and/or accelerating their adoption throughout the state where applicable.
- Authorized by a Partnerships and Cooperation clause in the 2002 Farm Bill, the first round of CCPI grant funds, distributed in 2004, and funded $1 million worth of watershed conservation planning and partnership-building projects. Another $1 million was distributed in 2005, including $200,000 to BWSR for conservation planning in the Zumbro Watershed, led by a 501(c) (3) watershed partnership. In 2006, CCPI funding quadrupled to $4 million, with $2 million each for Conservation Priorities grants and Rapid Watershed Assessment grants. Rapid Watershed Assessments provide a foundation for watershed planning by summarizing resource concerns and opportunities, and estimating where conservation investments would best address the priorities of landowners, conservation districts and other stakeholders.

Wellhead Protection Program

The 1986 Amendments to the Safe Drinking Water Act (SDWA) require states to develop and implement wellhead protection programs. Minnesota's wellhead protection program was approved by USEPA in March 1996 and the state wellhead protection rules were promulgated in November 1997. The 1996 Amendments to the SDWA provide funding for wellhead protection efforts using a set-aside from the Drinking Water Revolving Fund. The level of funding through this set-aside is insufficient to support specific non-point source control projects within wellhead protection areas. However, the MDH provides technical support to public water suppliers and state/local agencies regarding the benefits of proposed non-point control efforts within wellhead protection areas. The most appropriate use of federal and state funds for controlling NPS contamination in wellhead protection areas is to support local NPS pollution controls that are specified in wellhead protection plans that are approved by MDH.

US Geological Survey Cooperative Money

The US Geological Survey (USGS) has a long-term involvement with various MPCA and other state and federal projects. Ongoing USGS research projects conducted in Minnesota include those found on the following Web site: *mn.water.usgs.gov/minnesotaCurrentStudies.html*

The USGS also heads up the Interdisciplinary Research Initiative (IRI). IRI is research of lakes, wetlands and streams. It consists of scientists from the USGS and professors and students from universities in Minnesota.

Coastal Zone Management Funding

The Coastal Zone Management (CZM) program assists states in implementing and enhancing CZM programs that have been approved by the Secretary of Commerce. Funds are available for projects in areas such as coastal wetlands management and protection, natural hazards management, public access improvements, reduction of marine debris, assessment of impacts of coastal growth and development, special area management planning, regional management issues, and demonstration projects with potential to improve CZM.

Minnesota's Coastal NPS Pollution Program

The Coastal Nonpoint Pollution Program is designed to reduce NPS pollution in the Lake Superior Basin. It was developed as part of both the Lake Superior Basin Plan, (which is facilitated by the MPCA), and Minnesota's Lake Superior Coastal Program, (which is facilitated by MDNR). The Coastal Nonpoint Program is being co-facilitated by both the MPCA and MDNR. Numerous partners are involved in this effort, including state, federal, tribal and local governments, agencies, and citizens.

The Coastal Nonpoint Program Document summarizes Minnesota's existing nonpoint pollution programs and policies. It demonstrates how they compare to the guidelines suggested by the USEPA and the National Oceanic and Atmospheric Administration (NOAA).

Benefits of Coastal Nonpoint Program

The Coastal Nonpoint Program provides opportunities for securing federal funding and technical assistance in order to protect and enhance local natural resources and support community goals. Program development also encourages cooperation and improves efficiency among partners managing natural resource programs. This coordinated and multi-faceted approach leads to pro-active approaches and better measures to control polluted runoff from reaching the many high quality waters of Minnesota's Lake Superior Basin.

Background Information

Minnesota's Lake Superior coastal areas became part of the Coastal Zone Managment Act (CZMA) after receiving federal approval in July 1999. Upon acceptance to the national program, the state was legally obligated under Section 6217 of the CZMA to produce a companion coastal nonpoint program. Minnesota proceeded to produce a coastal nonpoint program plan describing the State's ability to meet the intent of 55 "Management Measures" or performance standards established jointly by USEPA and NOAA. As with most state program submissions, Minnesota's program was conditionally approved in 2003. The resource management agencies then worked to develop a supplemental program package, which was provided to the federal agencies in November of 2005. Full program approval occurred in 2006.

Public Review

A Coastal Nonpoint Program Document was developed in stages:

- The Scoping Document consisted of two existing documents: a 1995 summary of state NPS pollution programs and enforceable policies, and the 1996 federal response. The Scoping Document was available for public review August 28-October 6, 2000.
- Comments received on the Scoping document were incorporated into the Draft Coastal Nonpoint Program Document, which was out for public review March 10-April 13, 2001.
- After incorporating comments received on the Draft Coastal Nonpoint Program Document, a Final Draft was prepared and went out for review in July-August, 2001.
- After the final revisions were made, and the state agencies signed off on the Program Document, it was submitted to NOAA and USEPA in August, 2001.
- NOAA and USEPA reviewed the program document and conditionally approved the State's program in 2003. Six conditions were placed on the program.
- The resource management agencies (MDNR, MPCA, and BWSR) proceeded to address the conditions and to submit a supplemental program package.
- Full approval of the Coastal Nonpoint Program occurred on July 27, 2006.

Further information about the Coastal Nonpoint Program can be found at *www.pca.state.mn.us/water/basins/superior/coastalnp.html*, *www.dnr.state.mn.us/waters/lakesuperior/index.html*.

Targeted Watershed Grants Program

The Targeted Watersheds Grant Program is a nationally competitive grant program, sponsored by USEPA that encourages the protection and restoration of the country's water resources through cooperative conservation. The program supports collaborative water partnerships that are ready to implement on-the-ground restoration and protection activities designed to achieve quick, measurable environmental results. The goal is to build on existing partnerships and coalitions that have evaluated and assessed their watershed, devised technically sound watershed plans and are ready to embark on steps to implement their plans. In Minnesota, two watershed organizations have received grant funding through USEPA's Targeted Watershed Grants Program.

Blue Earth River (2003) [$800,000]

The lead watershed group for this watershed is the Three Rivers Resource Conservation and Development Council. The council was awarded funding to demonstrate effective ways to improve water quality within the Blue Earth River basin in Minnesota and Iowa. The focus it to:

- demonstrate conservation cost-share projects, encouraging third crop rotation to minimize erosion
- implement wetlands restoration projects to improve habitat and other valuable functions
- offer nutrient trial demonstrations and incentive programs to reduce nutrient runoff
- install 300 acres of riparian buffers
- conduct water quality education and demonstration projects
- sponsor workshops for homeowners, businesses, and industry on construction erosion control and rain gardens
- support citizen stream monitoring
- carry out public outreach through numerous public presentations

Vermillion River (2005) [$675,000]

The Vermillion River Watershed Joint Powers Organization proposes to protect the water quality of a high quality stream in an urbanizing setting. Funds will be used to establish a framework that balances regulatory controls and trading system. It will promote land use and runoff management practices, prevent instream flow and thermal loading, and protect this nationally recognized trout stream.

Primary State Funding Sources

The following state funding programs are the major sources, or most stable sources of state funding for NPS pollution abatement. They are not the only funding programs.

Clean Water Partnership

The CWP program was created in 1987 specifically to address NPS pollution. The program provides local governments, citizen groups, county water resources staff, and environmental groups with financial and technical resources to protect and improve lakes, streams and ground water. CWP funding for local water quality projects is awarded in two phases.

In the first phase of a project, called a resource investigation, the local sponsors work with the MPCA to collect data and information on the watershed and water resource. The information is used to identify sources of pollution, define water quality goals and objectives, and complete a diagnostic study of the water of concern. The final step of the resource investigation phase is to develop an implementation plan that identifies the combination of education, best management practices (BMP) and other activities to protect or restore water quality.

The second phase involves implementing the BMPs and other activities identified in the diagnostic study and implementation plan. Projects can be done without CWP funding, but, in order to be eligible for CWP funds for later phases, the project must meet program requirements. Financial assistance available through the program falls into two categories: grants and SRF low interest loans. CWP grant funds are available for up to 50 percent of the project costs. Loans can be used for the implementation phase and can cover the entire cost of implementation or supplement a grant.

Beginning in the fiscal year 2006 funding cycle, the application process was streamlined to make the process easier for applicants and reviewers. The previous application and work plan process was replaced with a shorter proposal form. Those projects chosen for award are then requested to develop the more extensive application and work plan.

State Revolving Fund (SRF) Initiative

One of the more significant funding sources in Minnesota is the SRF. Minnesota has been using SRF as part of its NPS management program since 1995. The program uses existing state delivery systems already servicing targeted clientele.

Minnesota's Public Facilities Authority (PFA) currently receives the State's capitalization grant from the USEPA for the SRF. Until 1995, the SRF had been used exclusively for municipal wastewater treatment projects. Under the NPS SRF pollution initiative, the PFA has negotiated with the lead agencies to establish funding for their respective programs. Projects receiving NPS SRF funding are required to meet requirements of the Federal Clean Water Act, Title 3, Section 319. In addition, funds spent on NPS projects are noted in the Intended Use Plan (IUP), which the MPCA submits annually to the USEPA. The NPS projects are not part of the point source ranking in the IUP. Minnesota's NPS pollution initiative provides an innovative and flexible approach for local governments, farmers, individual homeowners, and businesses to access low-interest, environmentally directed loans. In the past ten years, there has been a tremendous surge in interest of local governments to improve water resources degraded by NPS of pollution. The Minnesota River Assessment Project (MRAP) and the several Basin Plans reflect strong local interest in addressing NPS pollution. Local interest is further demonstrated through Local Water Management Plans that establish a list of projects the communities want to carry out.

Identified problems are varied. They include runoff from agricultural land, pesticides and fertilizers, feedlots, urban runoff from streets, yards, and construction sites, leachate from septic systems, forestry and mining activities, highway de-icing chemicals, dredging and drainage activities, and the impacts from loss of wetlands.

Solutions include BMPs for urban, forest and agricultural areas; storm water control; erosion control; buffer zones; animal waste management systems; proper subsurface sewage treatment systems (SSTS) installation and maintenance; construction site management; well sealing; preservation of wetlands; and education.

Local project sponsors with approved implementation plans, who through public information and awareness have mobilized their communities for action, are placed in the unenviable position of having to wait because funds are not available. In many cases, a community has the opportunity to start projects with low interest SRF loans and 10 to 20-year repayment periods. Loan funds have been used to implement BMPs including: sedimentation basins for urban runoff and suburban areas; lakeshore landscaping for erosion control and stabilization; streambank stabilization; in-stream and in-lake chemical treatment and aeration; feedlot improvements; upgrades of individual sewage treatment systems; BMPs for ground water aquifer recharge areas; and education and outreach activities.

The SRF loan program has been integrated with several existing programs so clients can work within familiar systems. Clients are varied, (individual farmers to watershed districts), so the delivery system must be flexible. For example, farmers apply for SRF loans through the agriculture BMP Program at the Minnesota Department of Agriculture (MDA). Watershed districts or other units of government can obtain SRF loans through the CWP Program, thereby leveraging limited grant funds. This multi-agency approach provides service delivery as close as possible to the client.

The SRF nonpoint loan program is a cohesive and comprehensive approach that uses existing state agency delivery systems to leverage grant and loan funds for maximum environmental benefits. In addition, the development and support of an expanding local watershed management "infrastructure" will have positive long-term effects.

Agriculture and Rural NPS Pollution

Agriculture Best Management Practices Loan Program:
Lead Agency: MDA Estimated Annual Allocation: $10 million.
MDA and BWSR have developed and implemented systems for delivering SRF loan funds to individual land owners for agricultural and rural NPS projects. The counties have been the major vehicles in coordinating applicants' requests with existing grants and technical capabilities. MDA has identified existing agricultural lending entities to administer individual SRF loans.

Watershed Management – CWP

Watershed management is a comprehensive, coordinated approach, which targets the restoration and protection of a specific water resource.

Lead Agency: MPCA. Estimated Annual Allocation: $3 million.

Resource based, locally sponsored, NPS projects done through the MPCA CWP program are the targeted clientele for the SRF loan program. SRF loans have enabled following activities:

A. Projects with approved implementation plans which have not received grant funds are able to initiate implementation with loan dollars
B. Projects waiting for additional funding have been able to accelerate implementation
C. Communities have been able to plan environmentally beneficial activities that are better suited for loan funds, such as individual sewage treatment systems
D. Communities have used SRF as match funds to help finance the local share of CWP grant projects

Metropolitan Council NPS Grant Programs

The Council has two grant programs for local units of government that can be used to address non-point source pollution issues, though it is not the main purpose of these grant programs. In 1995, the Minnesota Legislature passed the Livable Communities Act (LCA). The LCA (Minnesota Statutes, Section 473.25) created a voluntary, incentive-based approach to address the Metropolitan Area's affordable and lifecycle housing issues and to help communities grow and succeed. It established the Metropolitan Livable Communities Fund, including three on-going accounts from which eligible communities could apply for funding. Two of these accounts can be used to address non-point source issues when central to the re-development of an area:

- The Tax Base Revitalization Account (TBRA) helps cities clean up contaminated urban land and buildings for subsequent redevelopment that could include commercial, industrial, or housing opportunities. Restoring the tax base and developing more jobs near existing housing and services is a primary objective of this account. In 2006, the TBRA provided $5.8 million in grants.
- The Livable Communities Demonstration Account (LCDA) funds development and redevelopment projects that achieve connected development patterns that link housing, jobs and services, and maximize the development potential of existing or planned infrastructure and regional facilities.

While NPS management is not a stated objective of this program, costs for stormwater management practices such as ponds, infiltration basins, rain gardens and the like that are an integral part of these development or re-development projects are eligible under this grant program. In 2006, LCDA provided $8.9 million in grants.

BWSR Challenge Grants

The Board of Water and Soil Resources (BWSR) is a state agency dedicated to helping local units of government manage natural resources. BWSR aims to improve local capacity through providing technical, financial, and administrative assistance. They administer a number of grant programs all aimed at NPS pollution abatement including a block grant program, feedlot water quality management, nonpoint engineering, wetland conservation, lakeshore easement programs and special project grants. Most of the grant programs require a 50 percent cost share. The programs cover a wide range of activities including education and information, monitoring, planning and environmental controls, and land and water treatment. For specific information about the applications and eligibility, please see their Web site at: *www.bwsr.state.mn.us/*.

Clean Water Legacy Act

In 2006, the Minnesota Legislature enacted the CWLA. The CWLA establishes policies for the purpose of protecting, restoring, and preserving the quality of Minnesota's surface waters. The new law clarifies authorities, provides direction, and identifies the resources required to restore and maintain water quality as required by CWA. The CWLA legislation was created through several years of work by an unprecedented partnership of state and local governments, environment/conservation organizations, business, and agricultural interests.

The CWLA and associated start-up funding of $25 million in fiscal year 2007and over $53 million for the following biennium began to accelerate the comprehensive testing of Minnesota's waters every decade. It also provides resources for developing specific plans to clean up Minnesota's most contaminated waters. By targeting additional financial resources to existing state and local programs designed to achieve improved water quality, it will also leverage additional federal, local and private resources whenever possible. Approximately 80 percent of the first-year funds will go towards clean up of Minnesota's most polluted waters and is utilized for on-the-ground restoration or protection activities in local communities and watersheds – mostly through existing programs.

The CWLA also creates two new programs under the Public Facilities Authority (PFA) to deliver

1. phosphorus reduction grants for municipalities
2. assistance for small community wastewater treatment systems

These programs are designed to provide resources to local government and individuals for critical wastewater treatment needs identified throughout the state.

No long term funding source has been chosen at this time, and further budgetary discussions will occur in subsequent legislative sessions.

Additional Implementation Support

Besides financial support, state and local governments must take advantage of the many beneficial services provided by citizens and volunteers.

Concerned people and organizations like Lake Associations, Scouts, high school students, recreational organizations, historical preservationists, and university programs are continually seeking opportunities to get involved and improve their environment in a tangible way.

Watershed awareness has significantly increased citizen participation in cleanup, preservation and restoration activities. Just getting local residents out on a river in a canoe, rivers they have lived near all their lives, has had a profound effect on how they view their watersheds.

Summary of Potential NPS State and Federal Funding Sources

Additional state and federal funding sources and programs that could potentially be used to accomplish some of the objectives laid out in this Management Program are summarized in Tables 1 and 2. In addition, programs that play a role in the control of NPS pollution are cited throughout this document, with specific programs and authorities described in appropriate chapters.

Summary of Eligible and Ineligible Expenses Under the Section 319 and Clean Water Partnership Programs

The following Table sets out a list of activities and whether they would be eligible or not for funding under the rules governing CWP and guidance from USEPA. The PCT and MPCA decide on the eligibility of certain items as a matter of policy even if funding was allowed under the CWA. This list is evolving and thus is subject to change. Check with the MPCA 319 and CWP managers for the most current information.

TABLE 1
Page 1

State: Water Quality Focused Programs

			Program Focus							Water Resources						NPS Category								
Program	Lead Agency	Funding Source	Water Quality	Wetlands	Fish and Wildlife	Erosion Control	Shoreland	Habitat Rehab	Conservation	Streams/Rivers	Lakes	Ground Water	Watershed	Great Lakes	Wetlands	Agriculture	Forestry	Mining	On-Site	Construction	Hydraulic Modification	Highway	Urban Stormwater	Program Description
Ambient Ground Water Quality Monitoring	MPCA	General Fund	X									X												The Ground Water Monitoring and Assessment Program (GWMAP) is currently focused on monitoring the effects of nonpoint source pollution on ground water and drinking water supplies. Current projects include sampling 25 domestic wells in each of 10 metro area communities in conjunction with Metropolitan Council to evaluate how residential areas serviced by ISTS's are impacting ground water quality. Also, we are evaluating how effective certain permitted manure containment systems statewide are at protecting shallow ground water. GWMAP has also looked at the impacts of different land uses on ground water quality in two studies. Additionally, monitoring of agricultural BMP's and their impacts on ground water quality in two wellhead protection areas in southwestern MN are ongoing. GWMAP is currently working on establishing a statewide nitrate monitoring project. Additional networks might be added in the future to address other contaminants, as resources are available

State: Water Quality Focused Programs

Program	Lead Agency	Funding Source	Program Focus							Water Resources						NPS Category								Program Description
			Water Quality	Wetlands	Fish and Wildlife	Erosion Control	Shoreland	Habitat Rehab.	Conservation	Streams/Rivers	Lakes	Ground Water	Watershed	Great Lakes	Wetlands	Agriculture	Forestry	Mining	On-Site	Construction	Hydraulic Modification	Highway	Urban Stormwater	
Ambient Surface Water Quality Monitoring	MPCA	General Fund, Federal 100	X							X	X		X											Routine monitoring provides background water quality data necessary for several Agency water programs and for responses to requests from individuals and groups interested in water quality. Water samples are analyzed for a variety of chemical, physical, a
Citizens Lake Monitoring Program	MPCA	General Fund, SRF loan program	X								X													Volunteers assist in the assessment of water quality by measuring the clarity of lakes using Secchi discs.
Clean Water Partnership Program	MPCA	Federal 319 Grants, General Fund	X							X	X	X	X		X	X	X	X	X	X	X	X	X	The program provides financial assistance through matching grants and technical assistance to local governments to lead water resource restoration and protection projects with an emphasis on watersheds.
Feedlot Program	MPCA	Federal 106, Federal 319, general funds	X							X	X	X			X	X								Any facility that meets the definition of feedlot with greater than 1,000 animal units (AU) needs an NPDES permit. Any new facility greater than 300 AU needs an NPDES permit. In addition, any facility that is creating a pollution hazard may be required to get a permit. NOTE: Section 319 funding cannot be used to fund feedlots that are required to have an NPDES permit.

State: Water Quality Focused Programs

Program	Lead Agency	Funding Source	Program Focus: Water Quality	Wetlands	Fish and Wildlife	Erosion Control	Shoreland	Habitat Rehab.	Conservation	Water Resources: Streams/Rivers	Lakes	Ground Water	Watershed	Great Lakes	Wetlands	NPS Category: Agriculture	Forestry	Mining	On-Site	Construction	Hydraulic Modification	Highway	Urban Stormwater	Program Description
Individual Sewage Treatment System	MPCA	General Fund	X									X							X					MPCA has minimum standards and criteria for the design, location, installation, and the use and maintenance of Individual Sewage Treatment Systems. The Agency, along with the U of M conducts training workshops, based on these minimum criteria, to assist those involved in construction and servicing these systems.
Intensive Surveys Program	MPCA	General Fund, Federal 106	X							X	X													Intensive surveys are conducted on streams/rivers/ditches receiving discharges from municipal wastewater treatment plants where stream flows are considered inadequate to protect water quality standards. Data collected from the surveys is used to determine appropriated effluent limits so that water quality standards are maintained and the designated uses of a particular water area protected.
Lake Assessment Program	MPCA	EPA Lake Assessment Grants	X							X	X		X			X	X	X	X	X	X	X	X	The program is a cooperative study of a lake involving MPCA staff and local citizens. The studies characterize a lake's condition and provide some basic information regarding the interaction of the lake and its watershed.
Lake Studies Program	MPCA	General Fund	X								X													The program inventories the physical, chemical and biological characteristics of Minnesota's lakes for informed decision making of state fisheries and lake management programs.

State: Water Quality Focused Programs

Program	Lead Agency	Funding Source	Program Focus							Water Resources						NPS Category								Program Description
			Water Quality	Wetlands	Fish and Wildlife	Erosion Control	Shoreland	Habitat Rehab.	Conservation	Streams/Rivers	Lakes	Ground Water	Watershed	Great Lakes	Wetlands	Agriculture	Forestry	Mining	On-Site	Construction	Hydraulic Modification	Highway	Urban Stormwater	
SDS Permit Program	MPCA	General Fund, Permit Fees	X							X	X	X				X			X					This program regulates the land application of sludge. Some municipal sewage, sewage sludge, and industrial wastes are disposed of by land application such as spray irrigation. The SDS permits generally require permit holders to monitor ground water at sites where the waste is applied and to submit quarterly or annual reports.
Underground Disposal Control Program	MPCA	General Fund	X							X	X	X							X				X	The UDCP works to limit or eliminate disposal of industrial and other nondomestic wastewater in on-site septic systems. This currently under-development program will serve as a corollary to the EPA Underground Injection Control Program.
Individual Sewage Treatment System Installer/ Maintenance Certification, training, and assistance	MPCA	License fee, general funds	X							X	X	X	X		X			X						Certification is required for those who install and maintain ISTS. Certification is obtained through a combination of past experience and by passing a written examination. Training is provided by the MPCA and the University of Minnesota.
Individual Sewage Treatment System Grant Program	MPCA	General Fund	X							X	X	X	X		X				X	X				Provides a 50% match grant to low income communities for the installation of ISTS and small cluster systems

State: Water Quality Focused Programs

Program	Lead Agency	Funding Source	Program Focus: Water Quality	Wetlands	Fish and Wildlife	Erosion Control	Shoreland	Habitat Rehab.	Conservation	Water Resources: Streams/Rivers	Lakes	Ground Water	Watershed	Great Lakes	Wetlands	NPS Category: Agriculture	Forestry	Mining	On-Site	Construction	Hydraulic Modification	Highway	Urban Stormwater	Program Description
Water Quality Certification Program	MPCA	General Fund, Federal 106	X									X			X					X	X	X		Any applicant for a federal permit or license for a project that has the potential to affect water quality must obtain a certification from MPCA that water quality standards will be met before the license or permit may be granted.
Lake Sampling Program	Metropolitan Council	General Fund	X								X									X	X		X	The Metropolitan Council has undertaken a lake sampling program since 1980 in the Metro area. This program is used to assess the quality of area lakes. This assessment is used to both establish policies and in reviews of local comprehensive plans.
MN Water Well Construction Code	MDH	Regulatory Fees	X									X								X			X	The program sees to the proper construction and sealing of wells and borings including water supply wells, monitoring wells, environmental bore holes, and mineral exploration drill holes. Proper location, construction, and maintenance of wells and borings can reduce the potential for ground water contamination.
Public Water Supply Program	MDH	Regulatory Fees	X									X				X							X	The Minnesota Department of Health regulates public drinking water supplies for the purpose of protecting public health. MDH has the authority under the federal and state Safe Drinking Water Act to set maximum contaminant levels and monitoring frequencies for over 10,000 public water systems in the state.

State: Water Quality Focused Programs

Program	Lead Agency	Funding Source	Program Focus: Water Quality	Wetlands	Fish and Wildlife	Erosion Control	Shoreland	Habitat Rehab.	Conservation	Water Resources: Streams/Rivers	Lakes	Ground Water	Watershed	Great Lakes	Wetlands	NPS Category: Agriculture	Forestry	Mining	On-Site	Construction	Hydraulic Modification	Highway	Urban Stormwater	Program Description
Wellhead Protection Program	MDH	General Fund, Well Fortification Filling and Permit Fees, Clean Water Act 106 & 319	X									X	X			X		X	X			X	X	The program, which is currently under development, will be designed to protect public wellhead areas from contaminates that may adversely affect human health. Public water suppliers will be required to delineate public wellhead areas, investigate a potential contaminate source, and develop a program for managing these sources.
Cost-Share Program	BWSR	General Fund	X			X				X	X				X	X				X				The purpose of this program is to provide financial assistance to landowners and operators for installation of erosion, sediment, and water quality control projects. Wetlands being enhanced or restored for the purpose of water quality protection may be eligible for this program.
Local Water Resources Protection and Management Program	BWSR	General Fund ($2.5 million)	X	X						X	X					X	X	X	X	X	X	X	X	The purpose of this program is to provide grants to counties to assist in administration and implementation of approved and locally adopted local water plans. An inventory of wetlands is an eligible use ot these grant funds.
Aquatic Plant Management Program	DNR	Game and Fish Funds, Federal Cost Share	X								X					X								The program issues permits to lake property owners to kill aquatic vegetation on their property, using herbicides or mechanical removal.
Fish Contaminant Monitoring Program	DNR	RIM Funds	X							X	X							X				X	X	Data is collected from fish in lakes statewide to monitor levels of PCBs and mercury. The data is then provided to the Minnesota Department of Health, which issues fish consumption advisories.

State: Water Quality Focused Programs

Program	Lead Agency	Funding Source	Program Focus: Water Quality	Program Focus: Wetlands	Program Focus: Fish and Wildlife	Program Focus: Erosion Control	Program Focus: Shoreland	Program Focus: Habitat Rehab.	Program Focus: Conservation	Water Resources: Streams/Rivers	Water Resources: Lakes	Water Resources: Ground Water	Water Resources: Watershed	Water Resources: Great Lakes	Water Resources: Wetlands	NPS Category: Agriculture	NPS Category: Forestry	NPS Category: Mining	NPS Category: On-Site	NPS Category: Construction	NPS Category: Hydraulic Modification	NPS Category: Highway	NPS Category: Urban Stormwater	Program Description
Flood Plain Management Program	DNR	General Fund, FEMA Cap Funds	X	X			X		X	X	X		X	X	X					X				Standards provide for identifying floodplains, floodways, and flood fringe areas. Standards describe flood protection measures for new construction in the flood fringe. Standards require that only open space uses are to be allowed in floodway areas.
Regulation of Fertilizers, Soil & Plant Amendments	MDA	Tonnage Fees on Fertilizer	X							X	X	X	X		X	X								The program sets out the strategy through which the state agencies will promote BMPs. The program also describes the framework through which action will be taken in the case of ground water degradation by incorrect fertilizer application.
MN Pesticide Control Act	MDA	Regulatory Fees	X									X				X								The program is intended to regulate pesticide use in the state of Minnesota.

State: Water Quality Focused Programs

TABLE 2
Page 1

Program	Lead Agency	Funding Source	Program Focus							Water Resources						NPS Category								Program Description
			Water Quality	Wetlands	Fish and Wildlife	Erosion Control	Shoreland	Habitat Rehab.	Conservation	Streams/Rivers	Lakes	Ground Water	Watershed	Great Lakes	Wetlands	Agriculture	Forestry	Mining	On-Site	Construction	Hydraulic Modification	Highway	Urban Stormwater	
Streambank, Lakeshore & Restoration Program	BWSR	General Fund				X										X				X		X		The purpose of this program is to provide financial assistance to local units of government, although private landowners control problems on these sites. Priority is given to projects eligible for federal matching funds.
Wetland Establishment & Restoration Program	BWSR	General Fund		X									X		X						X			The purpose of this program is to allow landowners to apply to a county watershed management organization for assistance to restore or enhance a wetland in identified high priority areas.
Wetlands Biological Assessment	MPCA	LCMR		X											X									This two-year research project is in response to the U.S. EPA's request that states begin developing biological criteria for assessing water quality. The project consists of selection of least disturbed reference wetland sites, use of standardized sampling procedures, and assessment of diverse parameters. The results will be the basis for development of practical criteria for making decisions about impacts to high quality wetlands.
National Resources Parks Program	Metropolitan Council	Appropria-tions from the State Legislature							X	X	X									X			X	The program provides funding to the regional park agencies for the operation, maintenance, development, and acquisition for the parks in the metropolitan area.
National Resources Planning Program	Metropolitan Council	Ad Valorem Tax Levy, Chargebacks to Regional Agencies							X				X										X	The Metropolitan Council reviews and comments on local government Comprehensive Plans. If the Council determines that the local Comprehensive Plan will impact on the metropolitan systems, the Council can require the local plan be modified to be consistent with Council planning.

State: Water Quality Focused Programs

Program	Lead Agency	Funding Source	Program Focus: Water Quality	Wetlands	Fish and Wildlife	Erosion Control	Shoreland	Habitat Rehab.	Conservation	Water Resources: Streams/Rivers	Lakes	Ground Water	Watershed	Great Lakes	Wetlands	NPS Category: Agriculture	Forestry	Mining	On-Site	Construction	Hydraulic Modification	Highway	Urban Stormwater	Program Description
Aeration Program	DNR	Game and Fish Funds, Federal Cost Share		X							X													The program issues permits to operate aeration systems in public waters to prevent winter fish kills.
Aquatic Exotics Program	DNR	Water Recreation Account, Boat Licenses, Surcharge Fees						X		X	X		X											The program includes the inventory, monitoring, and control of infestations of purple loosestrife, milfoil, and zebra muscles. It also provides public education information, and conducts research on control and eradication of exotics.
Aquatic Management Areas	DNR	State Bonding, License Fees, Sport Fish Restoration Funds			X			X			X													Easement acquisition along lakeshore to provide corridors for angler access, riparian protection, habitat improvement or rehabilitation, or fish structure/barriers.
Creel Surveys (Study IV Surveys)	DNR	General Fund			X					X	X													Ten fish creel surveys are completed annually on lakes and rivers. The program monitors fishing pressure, harvest, and catch and recreational use parameters. It is then combined with other surveys to estimate impacts of fishing on fish populations.
Fish Kill Investigations Program	DNR	Game & Fish Funds, Federal Cost Sharing			X					X	X	X	X	X	X	X	X	X	X	X	X	X	X	Investigations of pollutants that cause fish and wildlife kills. When the problem is found, the pollutant is traced to the discharger, and damages are assessed based on damage to fish and wildlife.

State: Water Quality Focused Programs

Program	Lead Agency	Funding Source	Program Focus: Water Quality	Program Focus: Wetlands	Program Focus: Fish and Wildlife	Program Focus: Erosion Control	Program Focus: Shoreland	Program Focus: Habitat Rehab.	Program Focus: Conservation	Water Resources: Streams/Rivers	Water Resources: Lakes	Water Resources: Ground Water	Water Resources: Watershed	Water Resources: Great Lakes	Water Resources: Wetlands	NPS Category: Agriculture	NPS Category: Forestry	NPS Category: Mining	NPS Category: On-Site	NPS Category: Construction	NPS Category: Hydraulic Modification	NPS Category: Highway	NPS Category: Urban Stormwater	Program Description
Fisheries Research Program	DNR	Dedicated Fund Appropriation to Section of Fisheries (most work is 75% reimbursable)			X					X	X													The program includes a large number of research projects studying a variety of fish populations and water bodies throughout Minnesota. The goal of the research is to develop tools to better manage fisheries within the state.
Flood Damage Reduction Program	DNR	General Funds, State Bonding		X				X		X	X		X	X	X					X	X			The program provides matching grants to Local Units of Government to implement flood damage reduction projects. Some projects have created or enhanced wetlands for flood water storage areas.
Game Lake Inventory	DNR	General Fund						X			X				X									The program is a survey of shallow lakes and wetlands to inventory plants, water quality, and wildlife habitat.
Habitat Management on Public Lands	DNR	RIM, Deer Hunting License Fees, Pheasant Stamp Funds			X			X					X											The program includes the maintenance and development of grasslands, woody cover, food plots, forest stands, forest openings and improvement of prescribed burns to improve wildlife habitat on public lands.
Lake Habitat Improvement	DNR	Fishing License Revenues, Partially Reimbursed by Sport Fish Restoration Funds			X			X			X										X			The program includes a variety of methods to manage lake communities and improve or maintain angling opportunities. These may include shoreline stabilization, vegetative restoration or improvement of development of fish spawning habitat.

State: Water Quality Focused Programs

TABLE 2
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Program	Lead Agency	Funding Source	Program Focus: Water Quality	Program Focus: Wetlands	Program Focus: Fish and Wildlife	Program Focus: Erosion Control	Program Focus: Shoreland	Program Focus: Habitat Rehab.	Program Focus: Conservation	Water Resources: Streams/Rivers	Water Resources: Lakes	Water Resources: Ground Water	Water Resources: Watershed	Water Resources: Great Lakes	Water Resources: Wetlands	NPS Category: Agriculture	NPS Category: Forestry	NPS Category: Mining	NPS Category: On-Site	NPS Category: Construction	NPS Category: Hydraulic Modification	NPS Category: Highway	NPS Category: Urban Stormwater	Program Description
Lake Reclamation	DNR	Fishing License Revenues, Partially Reimbursed by Sport Fish Restoration Funds			X			X			X													This intensive habitat improvement program includes use of chemicals to effect fish kills and reclaim lakes for desired sport fish populations.
Lake Survey Program	DNR	State Fish & Game Fund, Reimbursed by Sport Fish Restoration Fund			X						X													An annual survey of 600 lakes, including fish populations, water quality and habitat conditions. The monitoring effort tracks long-term trends in fish resources and habitat conditions.
Large Lake Program	DNR	State Fish & Game Fund, Reimbursed by Sport Fish Restoration Fund			X						X			X										This intensive annual sampling of the state's 11 largest lakes for detailed fish population, water quality and habitat data.
MinnAqua	DNR	RIM General Funds, LCMR, Non-Game Fund Check-Off						X		X	X													The program includes Urban Angling and Volunteer Instructor Training programs to teach people about lake and stream ecology by teaching them to fish.
Northern Pike Spawning Area Development	DNR	Fishing License Fees, Federal Aid, RIM			X						X				X						X			The purpose of this program is to develop controlled Type II wetlands adjacent to lakes and streams to function as northern pike spawning and nursery habitat. Sties are selected where natural spawning habitat is limited or lost to drainage or shoreland development. Ponds are developed by diking a site and manipulating water levels with a control structure. Most sites are less than 15 acres.

State: Water Quality Focused Programs

			Program Focus							Water Resources						NPS Category								
Program	Lead Agency	Funding Source	Water Quality	Wetlands	Fish and Wildlife	Erosion Control	Shoreland	Habitat Rehab.	Conservation	Streams/Rivers	Lakes	Ground Water	Watershed	Great Lakes	Wetlands	Agriculture	Forestry	Mining	On-Site	Construction	Hydraulic Modification	Highway	Urban Stormwater	Program Description
Other Study IV Surveys	DNR	State Fish & Game Funds Partially Reimbursed by USF&WS Sport Fishing Restoration Fund			X					X	X													The program includes a variety of special investigations to assess particular fish populations and characteristics, such as the effects of bass tournaments on populations, etc. The program is targeted to particular research issues.
Protected Waters & Wetland Inventory	DNR	LCMR		X											X						X			DNR has created an inventory of waters and wetlands for which permits are required. Inventory consists of hard copy maps on county highway maps base, and legal description for each protected lake, stream, and wetland. DNR is in the process of digitizing the protected water inventory on the computerized National Wetlands Inventory map base.
Protected Waters & Wetland Permit Program	DNR	General Fund, Permit Fees		X						X	X			X	X	X				X	X	X	X	Program provides for orderly and consistent review of permit applications in order to conserve and utilize the water resources of the state. A protected water permit is needed to do any work which will change or diminish the course, current, or cross-section of any lake, marsh or stream that is designated as a protected water or wetland by the DNR.
Shoreland Management & Wild Scenic Rivers Program	DNR	General Fund					X			X	X					X		X	X			X	X	Standards have been established for development of shoreland areas; land within 300 ft. of a stream or 1000 ft. of a lake or wetland, or extent of the floodplain. Standards address subdivision of land, structure setbacks, vegetative management, land alterations, agricultural activities, and sewage treatment.

State: Water Quality Focused Programs

TABLE 2
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Program	Lead Agency	Funding Source	Program Focus: Water Quality	Program Focus: Wetlands	Program Focus: Fish and Wildlife	Program Focus: Erosion Control	Program Focus: Shoreland	Program Focus: Habitat Rehab.	Program Focus: Conservation	Water Resources: Streams/Rivers	Water Resources: Lakes	Water Resources: Ground Water	Water Resources: Watershed	Water Resources: Great Lakes	Water Resources: Wetlands	NPS Category: Agriculture	NPS Category: Forestry	NPS Category: Mining	NPS Category: On-Site	NPS Category: Construction	NPS Category: Hydraulic Modification	NPS Category: Highway	NPS Category: Urban Stormwater	Program Description
Stream Flow Data	DNR	General Fund							X	X			X											A stream flow summary is produced weekly by the Division of Waters from March to September. The summary contains current flow data, trends, low flow, and flood flow warnings. The summary was developed to identify watersheds where flows were below critical levels and water appropriation permits should be suspended.
Water Appropriation Permit Program	DNR	General Fund, Permit Fees	X		X					X	X	X			X	X	X	X		X				Permits are required for appropriations of surface or ground water exceeding 10,000 gallons per day or 1 million gallons per year.

Table 2 Eligible and Ineligible Expenses For Fiscal Year 2007

(To be annually reviewed and amended as necessary).

Activities	Fundable with 319 Program Grants	Fundable with CWP Grants	Fundable with CWP Loans
In-lake treatment	#Yes	* No	*Yes
Dredging	#Yes	* No	*Yes
Phase I resource investigation	#No	*Yes	* No
SSTS	No, only match money may be used	* No	*Yes
"Sewage treatment system upgrades"	#No	* No	*Yes
Feedlot BMP'S if not part of enforcement	#Yes	*Yes	*Yes
Activities started before G/L agreement is signed	#No	* No	* No
O & M of BMP'S	#Yes (limited)	* No	* No
Commercial operations (except farms)	#No	* No	* No
Mining activities	#Yes	* No	* No
Building and utility construction	#No	* No	* No
Highway and road construction	#No	* No	* No
Activities primarily for flood control	#No	* No	* No
Monitoring, data & information collection & analysis	#Yes, up to 20 %	*Yes	*Yes
Fiscal and management activities	#Yes, up to 10%	*Yes	*Yes
Development, review, selection, design, installation of BMP'S	Yes	*Yes	*Yes
Development & implementation of educational materials	Yes	*Yes	*Yes
Development & implementation of official controls (ordinances)	Yes	*Yes	*Yes
Acquisition of easements and property	Only with match money	*Yes	*Yes
Other activities determined to be necessary to carry out the project	Yes	*Yes	*Yes
Activities related to federal and state pollution control statutes such as CERCLA, RCRA, ECLA, and CLA.	No	*No	*No
Activities regulated by the NPDES permit program except costs	No	*No	*No
Activities regulated by solid or hazardous waste permit or rules	No	*No	*No
Publicly owned treatment works	#No	*No	*No
Regulated practices to control spills	No	*No	*No

Activities	Fundable with 319 Program Grants	Fundable with CWP Grants	Fundable with CWP Loans
Regulated practices to manage toxic or hazardous materials	No	*No	*No
Activities that violate state, local, & federal rules, statutes & regs.	No	*No	*No

* Set out in CWP rules

Set out in the CWA, or USEPA guidance

Chapter 3 Minnesota's Watershed Approach

Over the years, Minnesota's water program has evolved from its point-source driven beginnings in the early days of the Clean Water Act in the 1970s-80s, to a broadening into other water program areas such as feedlots and stormwater in the 1980s-90s, to a Basin Management focus in the 1990s-2000s, to the current Watershed Approach.

The Introduction (pages 1-9) and the section on Restoration and Protection Strategy Development (pages 32-45) are particularly pertinent to nonpoint source management issues, as are portions of the Implementation section (begins on page 46).

The current Watershed Approach that Minnesota takes to managing nonpoint source issues, and its water program as a whole, is detailed in Minnesota's current Continuing Planning Process (CPP) document. The current CPP was completed in December of 2010, was approved by USEPA in early 2011, and is available at: http://www.pca.state.mn.us/index.php/view-document.html?gid=15647.

Chapter 4 Overall Strategies for Each Water Resource

4.1 Ground Water

Introduction

Groundwater is a vitally important resource in Minnesota that provides many Minnesotans with their primary source of drinking water. In many rural and metropolitan area communities, groundwater supplies nearly 100 percent of Minnesotans with their drinking water and 90 percent of the water used for agricultural irrigation. More than 75 percent of Minnesotans receive tap water that is tested, treated and regulated by nearly 10,000 public water suppliers.[1] Private wells furnish drinking water for many other Minnesotans, with testing and any treatment being the responsibility of the well owner. Treatment removes or partially removes many chemical contaminants and naturally occurring metals and salts, as well as most bacteria and other pollutants. Although water quality testing and treatment of water supplies protects public health, it also comes at a cost. Therefore, it is important to prevent and minimize contamination of groundwater used for both public and private drinking water supplies.

Overall, groundwater quality in Minnesota is considered to be good; however, studies of vulnerable aquifers or those found in certain geologic settings have shown that certain land use practices or natural geology can impact groundwater quality, which may limit its use as a drinking water source. For some aquifers the source of contamination has been attributed to non-point sources (NPSs) of contamination from agricultural fertilizers and pesticides, urban runoff, manure applications, septic systems, road salt and stormwater infiltration.

Some of the most common, non-naturally occurring groundwater contaminants detected in Minnesota groundwater include nitrates and pesticides in rural settings, and road salt, petroleum compounds, and volatile organic compounds in urban areas. In addition, new chemicals of potential concern are being identified, such as endocrine active compounds from both natural and human sources, raising questions about what health risk they might pose to our drinking water resources.

Prior to 2000, Minnesota state agencies and local partners used many of their limited resources on cleanup, source control, and direct protection efforts, and required groundwater monitoring at many sites to determine individual facilities' compliance with hazardous chemical management. Since then, Minnesota has increased its emphasis on NPSs, including the development of Best Management Practices (BMPs) for sources such as feedlots, manure management, stormwater infiltration and agrichemical application.

This groundwater strategy reviews Minnesota's NPS groundwater protection activities, conducted at both a state agency and local government level and provides additional information through web-based links for the following programs and activities.

1. Groundwater Protection Programs, Projects and Activities
    1) Nutrient and Pesticide Management Programs
    2) Non-point Source Program Activities
        a) Animal Feedlots
        b) Subsurface Sewage Treatment Systems
        c) Stormwater Program
    3) County Atlas & Regional Assessment Program
2. Groundwater Data Access and Sharing

[1] http://www.health.state.mn.us/divs/eh/water/factsheet/com/dwprog.html

3. Groundwater Monitoring and Assessment
4. Local Government's Role

1. Groundwater Protection Programs (Wellhead, Source Water Protection), Projects and Activities

Minnesota state agencies and many local government units (LGUs) have developed their groundwater protection strategies in accordance with the Groundwater Protection Act (GWPA) of 1989 (Minn. Stat. § 103H) and related legislation. https://www.revisor.mn.gov/statutes/?id=103h. The goal of the GWPA is to maintain groundwater in its natural condition, free from any degradation caused by human activities. The GWPA also recognizes that for some human activities the prevention goal cannot be practicably achieved. However, where prevention is practicable, it is intended that it be achieved. Where it is not currently practicable, the development of methods and technology that will make prevention practicable is encouraged.

In Minnesota, the prevention of groundwater degradation has been implemented through voluntary BMPs promoted through education, support programs, incentives and other mechanisms.

For example, studies of groundwater quality in Minnesota over the last two decades have linked elevated nitrate concentrations to land uses where there are NPSs of nitrate in combination with vulnerable geology. Most nitrogen that enters groundwater comes from anthropogenic sources such as animal manure, fertilizers used on agricultural crops, failing subsurface septic treatments systems (SSTS), fertilizers used at residences and commercially, and nitrous oxides from the combustion of coal and gas. Nitrate is one of the most common contaminants found in Minnesota's groundwater.

The Minnesota Pollution Control Agency (MPCA) and Minnesota Department of Agriculture (MDA) are the two lead state agencies that manage programs to prevent and reduce nitrate impacts to waters of the state. The MPCA and MDA also partner with the Minnesota Department of Health (MDH) in source water protection efforts. Programs that address NPSs of nitrate/nitrogen include the: MDA's Nutrient Management Programs, Minnesota's SSTS Program, Animal Feedlot Program, Stormwater Program, and numerous LGU planning efforts.

To prevent water quality degradation from other NPS contaminants as well as nitrate, state programs use a combination of regulatory and non-regulatory tools that include: BMPs, technical assistance, water quality testing efforts (including community "clinics"), statewide ambient groundwater monitoring programs, environmental and technical reviews, facility inspections, operator training, guidance documents, fact sheets, and more. Examples of some of the programs that deal with NPS pollutants are described below:

1. **Nutrient and Pesticide Management Programs** – The MDA Nutrient Management and Pesticide Management Programs focus on nonpoint source agrichemical contamination of the state's rural and urban water resources using the Ground Water Protection Act (Minn. Stat. § 103H) as their foundation. The enabling legislation requires that MDA work to properly manage agricultural chemicals and to adequately protect groundwater from their impacts. State programs are primarily implemented through the Nitrogen Fertilizer Management Plan and the Pesticide Management Plan (and Pesticide Control Act, Minn. Stat. § 18B). Much of this effort is directed to the development of BMP's for nitrogen fertilizer and pesticide use and the prevention, evaluation and mitigation of nonpoint source occurrences of agricultural chemicals in waters of the state. Efforts include on-farm demonstrations, in partnership with landowners, local partners, University of Minnesota scientists and extension personnel to address research needs. Additionally, programs work cooperatively with area farmers, dealers and communities in finding solutions to complex water quality problems; for

example, an advisory committee meets quarterly to assess and review field scale drainage water quality demonstrations conducted at working farms; see http://www.mda.state.mn.us/protecting/bmps/drainagedemos.aspx.

A cooperative effort between the MDA and MDH has established the Source Water Protection Web Mapping Application, providing assistance to municipal drinking water authorities and members of the public in identifying where source water protection areas are located and the probability of potential contamination impacts and sources; see http://www.mda.state.mn.us/protecting/waterprotection/ waterprotectionmapping.aspx. And a multi-stakeholder Acetochlor Impairment Response Plan Advisory Committee guides the development and implementation of a pesticide impairment response effort in a watershed south of Mankato.

A significant effort has been the establishment of the Nutrient Management Initiative (NMI) available to farmers in southern Minnesota. The NMI program provides a framework for farmers to evaluate their own nutrient management practices compared with nutrient rate guidance promoted by the USDA- Natural Resources Conservation Service (NRCS). Results assist the USDA-NRCS and MDA in assessing their nutrient management guidance on a regional scale. Farmers receive $1200 for providing data and completing the program requirements. Participants are required to work with a certified crop adviser, who assists with site design, and validates cropping information and yield results. Funding for the program is through the Environmental Quality Incentives Program (EQIP) and is administered by the NRCS. The MDA assists through promotion, data collection, and compilation of data for the program. A report of results for the 2011 growing season is available at http://www.mda.state.mn.us/~/media/Files/protecting/nmi/2011nmiresults. More information can be found at http://www.mda.state.mn.us/chemicals/fertilizers/nutrient-mgmt.aspx.

A broad set of state Clean Water Fund activities related to NPS nutrient management and groundwater quality protection is being administered by MDA in the form of on-farm projects, pesticide monitoring, groundwater and drinking water protection, clean water research and new tools and technology.

The MDA also administers the Agricultural Best Management Practices Loan Program, providing low interest loans to implement practices that improve and protect water quality. Loans are typically provided for: feedlot improvements, manure storage basins, and spreading equipment; conservation tillage equipment; terraces, waterways, sediment basins; shore and river stabilization; and septic systems. More information is available at http://www.mda.state.mn.us/en/grants/loans/agbmploan.aspx.

2. **Nonpoint Source Activities** – the MPCA monitors and regulates NPS pollution through several programs that include the: Animal Feedlot Program, SSTS, and Stormwater Program projects, as described below.

   1) Animal Feedlots – Animal manure contains significant quantities of nitrogen which, if improperly managed, can lead to nitrate contamination of groundwater. The Animal Feedlot program regulates the land application and storage of manure in accordance with Minnesota Rules § 7020 for over 25,000 registered feedlots in Minnesota. The feedlot program requires that the land application of manure, and its storage in manure storage basins, is conducted in a manner that prevents nitrate contamination of waters of the state. Manure management plans, facility inspections, permitting, technical assistance and record keeping are all used to manage nitrogen impacts to water quality.

   The Animal Feedlot Program has set its program objectives to prevent the impairment or degradation of state waters by: 1) maintaining a high percentage compliance for National

Pollutant Discharge Elimination System (NPDES) feedlot production areas; 2) inspecting all non-NPDES feedlots in sensitive areas by 2015; 3) inspecting land application areas for all NPDES sites by 2015; and 4) conducting inspections of land application areas at feedlots with 300 to 999 animal units (which are not covered by NPDES permits). Additional information on the Animal Feedlot Program can be found on the MPCA website link: http://www.pca.state.mn.us/index.php/topics/feedlots/feedlots.html.

2) **Subsurface Sewage Treatment Systems (SSTS)** – Of the approximate 450,000 septic systems across the state, slightly over 100,000 of them are estimated to be failing and could be sources of pollution to Minnesota's water resources. A failing system is one that does not provide adequate separation between the bottom of the drainfield and seasonally saturated soil. The wastewater in SSTS contains bacteria, viruses, parasites, nutrients and some chemicals. SSTS discharge treated sewage into the ground, ultimately traveling to the groundwater. Therefore, SSTS must be properly sited, designed, built and maintained to minimize the potential for disease transmission and contamination of groundwater and surface waters.

   The SSTS program is engaged in a number of different efforts to prevent and minimize impacts to water quality degradation that include: incorporating nitrogen BMPs into SSTS rules, requiring registration of treatment products for nitrogen reduction and identifying imminent threats to public health and safety from uncontrolled discharges. The SSTS Program is also in the middle of a 10-year plan to upgrade and maintain Minnesota's SSTS. One of the main objectives of the SSTS Program is to strengthen local county programs to reduce the percentage of failing SSTS from 39 percent to less than five percent by January 1, 2014. http://www.pca.state.mn.us/index.php/water/water-types-and-programs/wastewater/subsurface-sewage-treatment-system-ssts/minnesota-s-subsurface-sewage-treatment-systems-program-ssts.html.

3) **Stormwater** – The MPCA Stormwater Program regulates the discharge of stormwater and snow melt runoff from municipal separate storm sewer systems (MS4s), construction activities, and industrial facilities, mainly through the administration of NPDES/State Disposal System (SDS) permits.

   The management of stormwater runoff is increasingly reliant upon the infiltration of stormwater into the soil's unsaturated zone, which ultimately leads to groundwater. To control the volume of stormwater runoff, a number of stormwater control structures infiltrate stormwater into the soil where it can recharge groundwater aquifers. The impacts of these practices on groundwater quality have yet to be thoroughly evaluated.

   At present there is a lack of empirical data to fully understand the impacts of different stormwater BMPs on groundwater quality. Because of the increased use of these BMPs, local government units, such as cities, counties, watershed districts, water management organizations, and some state agencies (MDH, MPCA) have identified the need to monitor their impacts on groundwater quality.

   The MPCA stormwater staff has identified the need to evaluate the impacts of stormwater infiltration on groundwater quality in locations where stormwater BMPs are used in certain situations (at contaminant remediation sites and within wellhead protection areas) and to assist local government units and development authorities.

3. County Atlas – Regional Assessment Program – The County Atlas – Regional Assessment Program is a joint program of the Minnesota Geological Survey (MGS) and Minnesota Department of Natural Resources (MDNR). This Program identifies groundwater resources that may be susceptible to NPS contamination by mapping geology and aquifers throughout the state and includes efforts to identify and map karst features and springs. Knowing where aquifers may be susceptible to contamination from land management practices is of particular importance for addressing potential NPS pollution.

Map-based reports of counties and multicounty regions in Minnesota are prepared to convey geologic and hydrogeologic information and interpretations to government units at all levels. Both atlases and assessments are done to meet local needs for geologic, groundwater, and related information. Local committees help define the scope and products of each atlas project. http://www.dnr.state.mn.us/ waters/groundwater_section/mapping/status.html.

The program is conducting a systematic study of the states' geologic and groundwater resources, which includes near surface deposits and bedrock, aquifer capacity, flow direction and sensitivity to pollution. Groundwater studies include flow systems, aquifer capacity, groundwater chemistry, and sensitivity to pollution. Roughly 1/3 of the state has been reviewed by these studies, with a number of reports in various stages of completion. Mapping began in 1982 and updates to the earlier maps are now necessary and modernization of these maps will include making them available in Geographic Information System format.

Groundwater sampling is done at selected wells to support groundwater sensitivity mapping. Approximately 80 to 100 wells are sampled in each investigated county to determine major ion and trace element concentrations and tritium values. Stable isotopes of oxygen, hydrogen, and carbon-14 age dating analysis also were conducted in a few wells that were suspected of having very old water. After completion of each atlas, a Workshop for the local units of government (LGU) cooperators is held to introduce County and other local users to the atlas products.

2. Groundwater Data Sharing and Access

Minnesota's water resource managers, groundwater hydrologists, and decision-makers have long acknowledged the growing need for readily accessible groundwater quality and quantity data to make informed decisions regarding the management of groundwater resources. The ability to identify groundwater contaminant plumes, evaluate the impacts of land use practices and conduct data analysis have been identified as critical components to groundwater protection strategies in both state and local groundwater protection plans (Groundwater Protection Spending Proposal, 2010).

In recent years, state agencies have made some progress enhancing access to environmental data through web portals such as the MPCA's Environmental Data Access site (EDA) and the MDH's County Well Index (CWI). Data from the MPCA's ambient groundwater monitoring network, and from landfills (open, closed, and demolition) is available on the MPCA's website at the following web address (URL): http://www.pca.state.mn.us/index.php/water/water-types-and-programs/groundwater/index.html .

Data for well construction, and associated geology, can be found online in the CWI, which is a system developed for the storage, retrieval, and editing of water-well information. The CWI database contains information regarding the location, construction, and static water level, for many wells drilled in Minnesota. CWI on-line (a web-based portal built off of the CWI database) also provides mapping of wells onto aerial photos, allowing users to visually identify well locations, provided at the following web address: http://mdh-agua.health.state.mn.us/cwi/cwiViewer.htm.

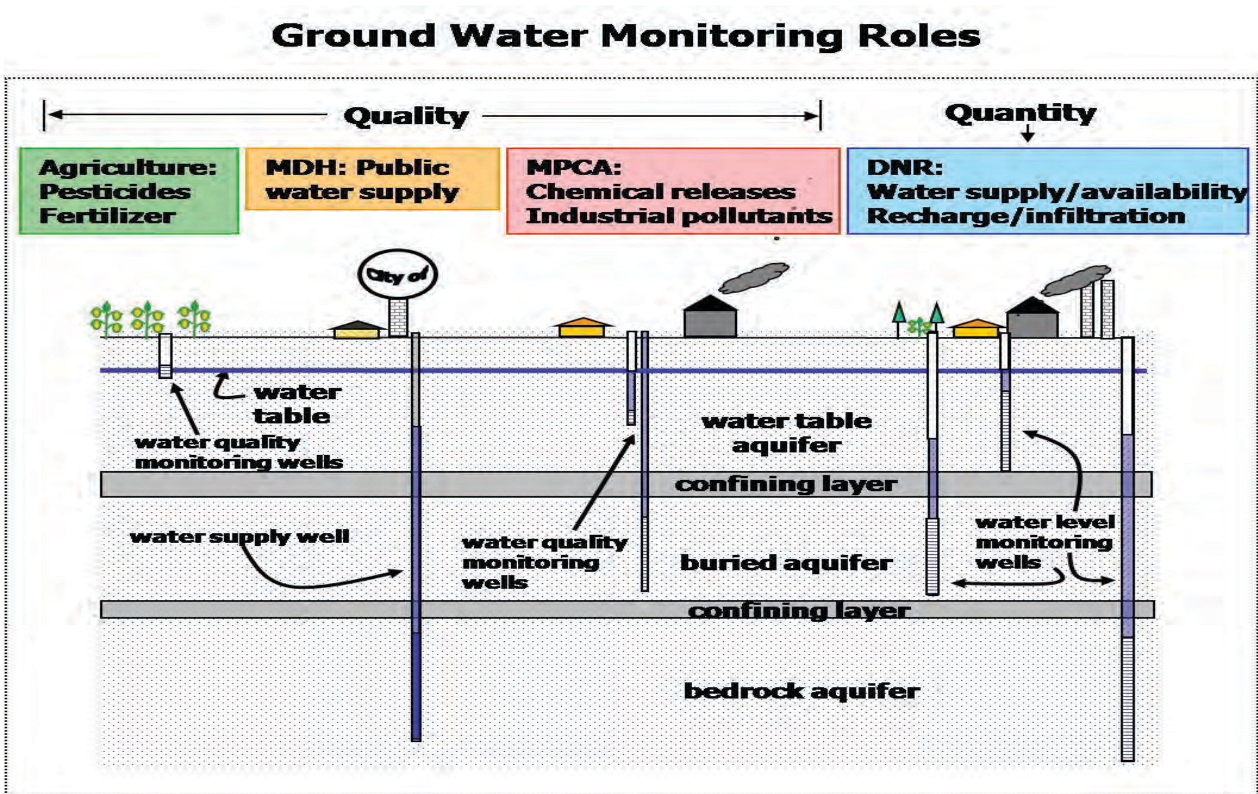
At present, there is no clearinghouse for groundwater quality and related quantity data in the state that allows for ready access and interpretation of results. A majority of groundwater data has been collected independently and is stored in different electronic formats and paper files with no common set of standards for data quality. Additional efforts are needed to integrate the various state agency and LGU groundwater data sets to make them accessible on the Internet, meet Global Information System based standards, and conform to a common set of data quality standards.

The MPCA has recently switched to a database system called EQuIS (Environmental Quality Information

System) to store water quality data for surface water sampling performed from streams and lakes across the state. EQuIS is capable of providing groundwater data that is GIS-based, Internet accessible, and it is being used to store groundwater quality data from various MPCA programs and some MDA groundwater data sets. An ongoing conversion to this database system for groundwater and surface water data will allow state agencies and others access to this data. Additional information about the EQuIS data system can be found at the following web address: http://www.pca.state.mn.us/index.php/water/water-monitoring-and-reporting/equis/equis-program-and-surface-water-data.html.

3. Groundwater Monitoring & Assessment

Minnesota employs a multi-agency approach to monitoring groundwater that requires a wide range of technical expertise to evaluate and assess groundwater resources. It takes the concerted effort of all the state agencies, along with local and federal partners, to build a comprehensive picture on the status of the state's groundwater resources. An Interagency Integrated Ground Water Quality Monitoring Strategy was developed between the MDA, MPCA and MDH. The plan identifies how the monitoring conducted by the Agencies will be conducted in an integrated fashion providing a comprehensive, statewide assessment of ground water quality resources for the future. The plan also establishes inter-agency cooperation in shared monitoring design, sample collection, sampling location selection, evaluation of sensitive areas, and data management to ensure efficiencies in the system. The groundwater monitoring roles conducted by various state agencies are shown in the figure below.



The MPCA, MDA, and MDH each have important statutory responsibilities in protecting the quality of Minnesota's groundwater. The MPCA and MDA conduct statewide ambient groundwater quality monitoring. The MDH conducts groundwater monitoring for the purpose of regulating public and private water supply wells and to evaluate the risk of contaminants in groundwater to human health (O'Dell

2007). In addition to these agencies, the MDNR monitors groundwater quantity conditions across the state through a network of groundwater monitoring wells.

The MPCA and MDA conduct statewide ambient groundwater quality monitoring. This monitoring focuses on aquifers that are vulnerable to anthropogenic (manmade) contamination from the land surface. Monitoring groundwater in vulnerable aquifers increases the likelihood that human impacts on groundwater quality will be detected within a reasonable time frame. The MPCA ambient monitoring efforts are conducted in non-agricultural areas of the state, with a majority of samples collected in quaternary (glacial) sand and gravel aquifers. The MDA monitoring focuses on agricultural regions in quaternary sand and gravel aquifers, with additional samples collected from springs in the southeastern part of the state where little or no quaternary deposits are present. In addition to monitoring ambient groundwater conditions, the MPCA collects groundwater quality information at contaminant spill and release sites, permitted landfills and land treatment facilities. The MPCA remediation programs alone have investigated a cumulative total of 20,699 sites, with the main focus of protecting groundwater resources.

The MDA also manages a remediation program which collects a large volume of groundwater quality information from contaminant spill and release sites. Over 500 sites have been investigated and one of the main priorities of these investigations is to protect groundwater resources.

MDH water-quality monitoring efforts focus on assessing public water supplies, which often utilize groundwater(a majority of the nearly 1,000 community water supply systems across the state obtain their drinking water supplies from groundwater). Including private well systems, the MDH estimates the total number of Minnesotans reliant on groundwater resources for drinking water and other purposes is 3.84 million, or 73 percent, of the state's population (MDH Memo 2009).

Private drinking water wells are not tested as part of the effort described above; however, the MDH reviews nitrate, coliform bacteria, and arsenic data collected by well drillers from newly installed drinking water wells to determine the potability of the water. Approximately 20 percent of Minnesotans are served by private water systems (almost entirely wells). State regulations, administered by the MDH, now require licensed water well contractors (and anyone constructing a new well for his or her personal use) to have the water from each new drinking water well tested once for arsenic. The MDH continues to administer the state's wellhead protection program, which is designed to protect public water supplies from sources of groundwater contamination. There are roughly 8,300 public water supply systems in the state that mostly use groundwater. Wellhead protection planning is required to protect the groundwater resources and potable water from contamination sources. For many of the larger community water supply systems, extensive groundwater protection plans are required and reviewed by the MDH.

The MDNR maintains a groundwater level monitoring network across the state. There are approximately 750 wells in this statewide network. Data collected from the network are used to assess groundwater resources, determine long-term trends in water levels, interpret impacts from pumping and climate, plan for water conservation, and evaluate water conflicts. Water level readings are measured monthly in cooperation with soil and water conservation districts or other LGUs. Site specific monitoring is required of 123 permittees. An ongoing water supply planning effort is guiding establishment, or improvement, of monitoring plans for all public water suppliers. More than 650 communities in the state have public water supply systems and 320 of these are currently involved in the planning effort.

Continued effort is needed to fully realize the state's groundwater quality goals. In particular, ongoing monitoring of vulnerable aquifers is critical to identify and track trends and to evaluate the success of management efforts.

4. Local Government's Role

Local governments, including counties, cities, Soil and Water Conservation Districts, Watershed Districts, Joint Powers Organizations, and others, have crucial roles in ground water protection. This is in part because of their authority to manage land use activity through planning and zoning restrictions, but also because ground water impacts are usually local in scope. Individuals need to understand how their behavior and activities impact their local ground water resources, and protection programs must continue to be developed and implemented at the local level.

To assist local government and individuals, most State agencies dealing with NPS concerns have websites that provide guidelines, fact sheets, technical and financial assistance, and sample regulations to assist local government efforts. Assistance is also provided to fund local efforts, as well as the state programs that support local efforts. For example the Metropolitan Council provides public access to groundwater information through an on-line mapping application http://giswebsite.metc.state.mn.us/publicmaps/makeamap.

The state has developed a number of programs to encourage local protection efforts, including local water management. These include county based comprehensive surface and ground water management in the 80 Greater Minnesota counties, and county based ground water management in the seven counties of the Metropolitan Area. These local plans are designed to be comprehensive in scope and must recognize the importance of managing non-point sources of contamination.

In Minnesota, the Board of Water & Soil Resources (BWSR) allocates competitive Clean Water Grants and Natural Resources Block Grants which are used by LGUs to protect state water resources. Portions of these grants fund activities and promote BMPs that protect groundwater and drinking water sources from NPS pollutants. Examples include: conservation easements in vulnerable wellhead protection areas, well sealing, feedlot water quality projects, SSTS abatement grants for low-income individuals, and accelerated implementation grants to counties.

Needs, Priorities, and Action Steps

The Action Plan provided below summarizes the goals and milestones identified in the preceding sections. There is no priority given to the order in which they appear in this report. It must be emphasized that many of the milestones listed below, as well as the implementation of specific projects, are contingent upon adequate funding and local involvement.

Chapter 4.1 Ground Water

Needs, Priorities and Milestones Action Plan

The action plan provided below summarizes the goals and milestones for this planning period. Many of the milestones listed below, as well as the implementation of specific projects, are contingent upon adequate funding and local involvement.

Goal 1: Support groundwater protection programs, projects and activities.

Milestones (Action Steps)	13	14	15	16	17	Funding Source(s)	Lead Agency(ies)
1. Support efforts to identify groundwater resources that may be susceptible to NPS contamination by mapping geology and aquifers throughout the state.	X	X	X	X	X	CWA (319), state	MDNR, USGS, MDH
2. Improve ground water management within regional, basin, watershed, and local water management efforts.	X	X	X	X	X	CWA (319) state	MDNR, MetC, MPCA, BWSR, MDA, MDH, USGS
3. Evaluate the effectiveness of Agricultural BMPs to mitigate NPS sources of fertilizers and pesticides on groundwater resources.	X	X	X	X	X	CWA (319), state	MDA, MPCA, UM
4. Develop and test model programs, projects, or materials, with specific target audiences to evaluate the effectiveness of new education and outreach programs for ground water protection.	X	X	X	X	X	CWA (319), state	MDNR, MDA,MPCA, UM
5. Provide incentives to land owners through loans and grants to implement BMPs that improve and protect groundwater quality.	X	X	X	X	X	CWA (319), state	BWSR, MDA, MPCA, MDH

Goal 2: Enhance Ground Water Data Access and Sharing within the state.

Milestones (Action Steps)	13	14	15	16	17	Funding Source(s)	Lead Agency(ies)
1. Support efforts to improve groundwater data access and sharing with the purpose of ground water protections including: developing and disseminating data management standards and coordinating development of web based applications.	X	X	X	X	X	CWA (319), state	MPCA, MDA, MDH, MDNR, MetC, USGS.

2. Provide guidance and training for programs that develop, collect, and manage ground water data at the state and local level, leading to more consistent and effective information from ground water survey, assessment, and monitoring programs.		X	X	X	X	CWA (319), state	MPCA, MDA, BWSR, MDH, USGS, Met C., MDNR
3. Conduct workshops, training and guidance for SWCDs, NRCS, county staff and other LGUs on groundwater databases and web based applications.		X	X	X	X	CWA (319), state	MPCA, MDA, BWSR, MDH, USGS, Met C., MDNR

Goal 3: Conduct Groundwater Monitoring to Assess the Effectiveness of Programs and BMPs in Reducing or Preventing the Impacts of NPS to Ground Water.

Milestones (Action Steps)	13	14	15	16	17	Funding Source(s)	Lead Agency(ies)
1. Support ground water monitoring projects at scales appropriate to measure the effectiveness of BMPs implemented to protect ground water.	X	X	X	X	X	CWA (319), state	MPCA, MDA, MDH
2. Monitor source specific BMPs in various hydrogeological, ecological, and climatic settings at appropriate research scales to determine their effectiveness.	X	X	X	X	X	CWA (319)	MPCA, MDA, UM, USGS
3. Support the assessment of adoption of voluntary BMPs in conjunction with ground water monitoring.	X	X	X	X	X	CWA (319), state, federal	MPCA, MDA, USGS, USDA
4. Monitor and evaluate stormwater BMPs that promote infiltration and have the potential to transport contaminants in vulnerable groundwater settings.		X	X	X		CWA (319)	MPCA, UM, MDH, USGS, Met C.
5. Conduct water level monitoring to detect changes in flow patterns that result in changes in groundwater contaminant movement.	X	X	X	X	X	CWA (319)	MDNR, MPCA, MDH, MDA
6. Evaluate effects of groundwater/surface water interactions on movement of NPS pollutants for BMP development in land use planning.	X	X	X	X	X	CWA (319)	MPCA, MDNR, MDA

Goal 4: Support local government Units in Development and Implementation of Ground Water Protection Programs

Milestones (Action Steps)	13	14	15	16	17	Funding Source(s)	Lead Agency(ies)
1. Assist LGUs in identifying geologically sensitive areas and areas where ground water may be vulnerable to NPS pollutants.	X	X	X	X	X	CWA (319), state, local	MDNR, MDH, Met Council
2. Support LGU integration of groundwater data into watershed plans and programs to make land use-groundwater quality link to comprehensive planning and zoning efforts.	X	X	X	X	X	CWA (319), state, local	MDNR, Met Council, BWSR MPCA, MDA, MDH

3. Assist LGUs in the implementation of BMPs for ground water protection.	X	X	X	X	X	CWA (319), state, federal	MPCA, MDA, MDH, USDA
4. Support LGU addressing NPS through state approved well head protection plans.	X	X	X	X	X	CWA (319), SDWA, state	MDH

Chapter 4.2 Lakes Strategy

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Introduction

Preserving Minnesota's more than 12,000 lakes from nonpoint source (NPS) pollution requires a balanced approach of protection and restoration, using a variety of management strategies, within a structure that recognizes regional differences in lake ecology and land use. Restoring lakes with degraded water quality or habitat has been the major focus of management efforts in the past. There has been a growing recognition that protecting unpolluted lakes from future degradation is as high a priority as restoring polluted lakes. Management strategies include regulations, incentives, best management practice (BMP) installation where appropriate, education, planning, and acquisition. These strategies are appropriate throughout a lake's watershed as well as along the shoreline.

Lakes are a key part of Minnesota's history, culture, economy, and recreation. When assessing the condition of lakes, ponds, and reservoirs, these water bodies are often viewed as existing along a continuum from impacted to pristine. While this approach is useful for evaluating the overall health of our waters, it is insufficient to adequately evaluate their suitability for alternative and often conflicting uses. Ecosystem services are defined as the benefits people obtain from ecosystems. They are often critical for life and enhance human well-being. An ecosystem services perspective is an acknowledgement that nature has value and that the value can be measured and used to support environmental management decisions. These benefits can be separated into: 1) goods and products extracted from lakes and, 2) services that depend on local ecosystem processes or Lake Infrastructure (U.S. Environmental Protection Agency (USEPA); http://www.epa.gov/aed/lakesecoservices/ecosl.html.

In most cases, the ecosystem service benefits closely resemble the designated use categories that states have defined under the Clean Water Act (CWA). Clean Water Act (Section 303(c)) requires states to designate beneficial uses for all lakes, and to develop water quality standards to protect each designated use. Water quality standards include the following:

1. Beneficial uses — identification of how people, aquatic communities and wildlife use our waters. Use classes include:
    - domestic consumption;
    - aquatic life and recreation;
    - industrial consumption;
    - agriculture and wildlife;
    - aesthetic enjoyment and navigation

A lake may be protected for multiple uses. For example, a lake may be protected for aquatic recreation (swimming, wading and other water recreation) and for aquatic consumption (safe consumption of fish).

1. Numeric standards — allowable concentrations of specific pollutants in a water body, established to protect the beneficial uses.
2. Narrative standards — statements of unacceptable conditions in and on the water.
3. Non-degradation — extra protection for high-quality or unique waters and existing uses.

Monitoring lakes and evaluating water quality data to determine baseline condition is typically the starting point to further lake planning. If a lake meets water quality standards and designated uses, then it is a candidate for protection from future degradation. If a lake does not meet standards, then it must be restored so it can support the uses for which is has been designated. The Minnesota Pollution Control Agency (MPCA) is responsible for supporting monitoring and assessment of lakes, streams and wetlands.

Protecting lakes from future degradation should be a major focus of nonpoint source (NPS) pollution management. Because Minnesota has such a vast number of lakes, not all are monitored and assessed. Even those selected for monitoring may not be sampled to determine support for all designated uses. For instance, lakes are protected for aquatic life, but we currently lack a tool to allow us to sample for aquatic communities and gauge that field information against the aquatic life standards. It is important to look for opportunities to prevent NPS pollution that may degrade lake biota. Therefore, our definition of lakes requiring protection from NPS pollution should be broadly defined and include lakes whose status we are unsure of, as well as lakes that meet water quality standards.

About 1.5 million people in Minnesota receive their drinking water from a surface water source (lake or river). Furthermore, a growing body of evidence suggests that contamination in lakes and streams can affect groundwater used for drinking water through groundwater-surface water interactions. The Federal Safe Drinking Water Act requires states to conduct source water assessments for drinking water sources. A guidance document prepared by USEPA assists states in developing source water assessment programs and recognizes the importance of addressing nonpoint pollution sources during the assessment process. The susceptibility of a surface water source to contamination is considered high because there is no practical means of preventing all potential contaminant releases into surface waters (in contrast to ground water). Source water protection (SWP) is critical to ensure safe drinking water supplies and minimize the expense of treatment technologies. Source water protection represents a new focus and a major change in thought in protection of drinking water supplies. Source water protection is a part of a multiple barrier approach used to provide safe drinking water – which includes wellhead protection, source water assessments, and protection of surface water intakes.

On November 4, 2008, Minnesota voters approved the Clean Water, Land and Legacy Amendment to the constitution to protect drinking water sources; to protect, enhance, and restore wetlands, prairies, forests, and fish, game, and wildlife habitat; to preserve arts and cultural heritage; to support parks and trails; and to protect, enhance, and restore lakes, rivers, streams and groundwater. The amendment increases the sales and use tax rate by three-eighths of one percent on taxable sales, starting July 1, 2009, continuing through 2034. Of those funds, approximately 33 percent are dedicated to a clean water fund (CWF) to protect, enhance, and restore water quality in lakes, rivers, streams and groundwater, with at least five percent of the fund targeted to protect drinking water sources. This funding has greatly increased monitoring, assessment, restoration/protection plan development and implementation activities and SWP opportunities since 2008.

The purpose of this chapter is to describe approaches used to identify lakes requiring restoration and protection, common sources of nonpoint pollution, and management strategies to mitigate these sources of lake degradation.

Protection and Restoration Approaches

Before prioritizing investment of resources to address NPS pollution, there must be adequate evaluation of the current status of Minnesota's lakes. A variety of monitoring activities, qualitative assessments, modeling techniques, and new technologies are used at the local, regional and state levels to help evaluate the status of lakes and trends in water quality, and to direct NPS reduction and lake protection efforts. Chapter 5 describes monitoring supported by state agencies conducted to determine lake condition. By far, the most common type of pollution is excess nutrients found in watershed runoff. Changes in a lake's trophic state caused by additional nutrients are reflected by changes in the frequency and intensity of algal blooms, abundance of aquatic plants and changes in fish population dynamics. Once a lake becomes eutrophic, it develops nuisance algal blooms some of which can develop harmful toxins. It is important to bear in mind, though, that there are numerous non-nutrient stressors, including altered hydrology (land use change that increases impervious surface area in the catchment area and thereby increases stormwater runoff), physical changes to habitat (littoral and riparian area vegetation removal), and NPS discharges to lakes (runoff from developed property surround the lake, lakeshore erosion). Chapters 7-14 describe in detail the sources of NPS pollution to lakes.

The state's current approach to managing NPS impacts on lakes is implemented through a partnership of federal, state and local governments working in concert with local volunteers in lake associations or other organizations. The specific local government involved in this partnership varies across the state. Generally watershed management organizations are the lead local government in the Twin Cities metropolitan area with counties, Soil and Water Conservation Districts (SWCD) and/or watershed districts (WD) where they are formed being the lead local governmental units (LGUs) outside the Twin Cities metropolitan area. Notable exceptions exist where other local governments (e.g., city, park board, water utility) have a keen interest in specific lake resources and take the lead role.

This approach reflects the overall responsibility and technical expertise of federal and state government and the overall authority of local governments in land use planning and management. In addition to the role of government, citizen participation often through lake association involvement is an important driving force in lake management.

Much can be achieved in the prevention and abatement of NPS pollution through appropriate planning in development and use of the landscape. Beyond good stewardship in planning, our management of resources within given land uses can have significant effect in the prevention or abatement of NPS pollution. The statewide plan for monitoring and assessing lakes for support of beneficial uses follows the watershed approach described in the Monitoring chapter (Chapter 5) of this document. From the ambient monitoring and assessment work, watershed-wide restoration and protection plans will be developed that include the actions that are particularly suited for the local conditions. For lakes that have not been included in such a watershed-wide plan, or for general planning purposes, the following hierarchical scheme may serve as a guide:

1. Practices that avoid pollution
2. Practices that control/contain pollution
3. Practices that treat pollution
4. Practices that mitigate pollution

Further, BMPs can be viewed in a priority hierarchy to reduce NPS:

1. On-site
2. In transition from on-site to off site
3. Pre-discharge to a receiving water
4. In-situ (in the resource of concern, this would be an effort of last resort)

Projects, BMPs, ordinance changes, and community planning efforts instituted as part of a protection strategy are not that much different than those that might be addressed in the course of a watershed-wide restoration. One difference is the intensity of the effort and the associated costs of doing a few projects to protect or make slight improvements in current in-lake conditions rather than numerous projects across large watersheds in an attempt to make large improvements in lake conditions. Some information on existing programs that can help address NPS pollution follows.

Agricultural Watershed Projects

There are many opportunities to institute protection activities in the agricultural landscape. Projects of most significance, from a water quality protection standpoint, are those that minimize the amount of nutrients and sediments which move from the land to watercourses and ultimately to lakes in the watershed. Targeting lands adjacent to tributaries, ditches, or on the lakeshore may make the most sense where water flows are directly connected to the lake. Potential projects include: fencing livestock out of watercourses; ensuring that all livestock containment facilities in direct contact with a watercourse have adequate containment of wastes and adequate land to apply wastes; observing a setback when land-applying manure adjacent to streams, ditches and lakeshore areas; installation of vegetative buffer areas adjacent to watercourses of highly erodible lands adjacent to or near watercourses; and restoring wetlands whenever possible. Many programs are available to help with a number of agricultural BMPs for riparian buffer strips and highly erodible land management or retirement such as the Conservation Reserve Program (http://www.fsa.usda.gov/FSA/webapp?area=home&subject=copr&topic=crp) or Reinvest in Minnesota (http://www.dnr.state.mn.us/grants/land/rim.html) (http://www.bwsr.state.mn.us/easements/rim/index.html).

Results in NPS reduction/protection BMPs which provide the most significant improvement or the greatest degree of protection should have the highest priority. For example, priority should be given to projects on lakes where nutrient loads from shoreland areas are (or could) be a major contributor to the lake's nutrient budget. Another priority may be reduction/protection efforts that reach the largest number of people/impact the largest shoreline area. For example, while acquisition may provide complete protection/restoration of a particular parcel, its total impact to the lake may be limited by the cost of acquiring property.

Education

Education will be an important component of any protection or restoration strategy. Involving youth in these efforts targets the future beneficiaries of these efforts as well as future resource managers. The Lake Ecology curriculum, supported by Minnesota Waters and local lake associations, is one example. Educational programs should deal with both the nature of specific threats to lake health and practical means for preventing damaging pollutant loadings from being exceeded. Another example would be the University of Minnesota Extension Service's Shoreland Education Workshops (http://www.extension.umn.edu/shoreland/). A last example would be encouraging homeowners to comply with the law and use phosphorus-free fertilizers (http://www.mda.state.mn.us/phoslaw).

Urban/Residential Watershed Projects

Addressing stormwater from existing and future developments is the number one water pollution concern in urban or urbanizing watersheds. The best opportunity to address stormwater impacts, and protect a lake or stream, is before land is being considered for development. Stormwater management criteria integrated into building permits and zoning ordinances can minimize the downstream impacts of changing land use and land cover associated with development. Other protective measures include street sweeping, leaf litter control, stenciling stormwater drains (to discourage the introduction of pollutants), and other educational opportunities intended to encourage BMPs throughout the watershed. As areas are re-developed this also affords an opportunity for BMP implementation.

Source Water Protection

The preparation of source water protection plans is voluntary for the state's surface water-based public water supplier. Smaller public water suppliers (population served less than 3,300) would benefit from assistance by local units of government in plan development, preparation, and implementation. Minnesota Department of Health has developed a guidance document to define the approach to source water protection for surface water intakes, and also offers grant funding to local water suppliers to protect the source of their drinking water (http://www.health.state.mn.us/divs/eh/water/dwp_cwl/grants/index.html).

Acquisition of Critical Shoreland Areas

Various programs are already in place that acquire shoreland tracts to enhance resource value or improve resource management. For example, the Fisheries Section in the MDNR acquires property adjacent to critical fish spawning areas to protect/enhance the fishing resource. Lake associations have also been instrumental in working with private shoreland owners to establish conservation easements of critical shoreland areas.

Shoreland Development Rules

The MDNR's Shoreland Management Program's mission is to inform citizens about the shoreland management options open to them (http://www.dnr.state.mn.us/waters/watermgmt_section/shoreland/index.html). On a broad scale, Minnesota has addressed the impacts of shoreland development through the establishment and implementation of the shoreland management rules. In some instances, LGUs have amended the shoreland rules to be more stringent than the state standard. In other instances there may be a need for lake-specific setback and development rules for land-locked lakes or other lakes which are prone to drastic lake level increases. The rules, initially developed in 1969 - 1970, and revised in 1989, no longer reflect current development trends.

Shoreland Restoration/Protection

Non Point Source impacts from shoreland development can be further reduced by initiating and promoting BMPs that protect or restore shoreland buffers and minimize shoreland disturbances. Shoreland buffer strips reduce runoff, filter nutrients, stabilize shorelines, minimize wave damage and provide habitat.

The MDNR's shoreland restoration webpage (http://www.dnr.state.mn.us/lakescaping/index.html) provides excellent information to guide restoration practitioners, including several publications available to landowners and professionals interested in or participating in shoreland development and restoration. *Lakescaping for Wildlife and Water Quality and the Restore Your Shore* CD-ROM are both powerful tools for restoring or protecting shoreland habitat. The MDNR also offers Shoreland Habitat Restoration Grants (http://www.dnr.state.mn.us/grants/habitat/shoreland.html) to expand the diversity and abundance of native aquatic and shoreland plants.

Board of Water and Soil Resources (BWSR) has greatly expanded its grant programs in recent years. The grant programs are closely tied to state approved, locally adopted comprehensive local water management plans and eligible activities can be identified in wellhead protection plans, source water protection plans, Total Maximum Daily Loads (TMDLs) and others Eligible local governments include Counties, SWCDs, Watershed Districts, Water Management Organizations and metro area cities that are required to have their water management plans approved by a Watershed District or Watershed Management Organization. Clean Water Land and Legacy funds can be used for targeting and prioritizing activities, and to install BMPs for, stormwater management, shoreland restoration, feedlot upgrades, erosion control low income Subsurface Treatment Systems (SSTS) among others. For more information: http://www.bwsr.state.mn.us/grants/.

Lastly, the University of Minnesota Extension Service has been offering Shoreland Education Workshops focusing on the education of residents on water quality and plant identification, and also a segment on shoreland revegetation. More information on Shoreland Education Workshops can be found at: http://www.extension.umn.edu/shoreland/.

Permitting and Ordinances

In addition to voluntary BMPs, education and other methods, there are "regulatory" approaches that can help to protect and improve lake water quality. National Pollutant Discharge Elimination System (NPDES) permits on upstream point sources play an important part in the management of nutrient loading to some reservoirs and lakes with upstream dischargers; however, these reductions often need to be complemented by NPS control, as well – especially during high flow years.

Some counties are beginning to use land-zoning authority to exclude intensive land uses such as livestock feedlots from locating within a lakeshore zone.

Erosion control and stormwater ordinances, developed at the local level, may be helpful tools as well (http://www.pca.state.mn.us/nwqha90). Other measures include observing proper setbacks when developing lakeshore property, minimizing erosion during construction, and requiring individual sewage treatment systems (ISTS) systems to be in compliance with state and local codes. In 2004, new legislation was passed restricting lawn fertilizers to contain no phosphorus (within testing tolerances) with some exceptions. More information and the complete report are available at: http://www.pca.state.mn.us/jsrifaa.

Increased attention has been placed on ISTS in recent years, and there is a great deal of interest on behalf of lake associations and others to bring systems in the shoreland areas up to code. The MPCA and the Board of Water and Soil Resources offer grants for treatment system upgrades.

The primary control strategies for mercury (Hg) include a reduction in the use of Hg-bearing products, use of fossils fuels low in Hg and instituting limits on emissions from primary sources of Hg to the atmosphere such as coal-fired power plants. Recent research suggests that a large portion of the Hg that reaches lakes in central and southern Minnesota is a product of watershed loading and hence measures to reduce runoff and sediment loading in urban and agricultural watersheds should reduce the Hg burden as well. Site-specific strategies can also include assessing the affect hydro-modification (lake level management) may have on methyl mercury formation. MPCA currently has an USEPA Approved Statewide Mercury TMDL which can be viewed at: http://www.pca.state.mn.us/index.php?option=com_k2&Itemid=2818&id=872&layout=item&view=item.

Prioritization

As noted in the previous section, the statewide plan for monitoring and assessing lakes for support of beneficial uses follows the watershed approach (Chapter 5 – Monitoring), which will result in the development of watershed-wide restoration and protection plans. These plans will indicate lakes that are at higher risk and are in greatest need of restoration and protection. Over time, it is likely that these restoration and protection plans will likely have similar elements and a general hierarchy for prioritizing work, while still allowing flexibility based on local needs and conditions. Since plan development work is still in its infancy, a clear description of the common elements of these plans is not available. The prioritization criteria listed below are examples that may be relevant to incorporate into a watershed plan or for local groups to consider if a watershed plan has not yet been developed for their area.

Public Water Supply

Because of their inherent importance to a community and public health implications, lakes or reservoirs that serve as public water supplies should be a high priority for protection.

Lake Water Quality

Once a lake has become nutrient-rich, it is exceedingly difficult to return it to an unimpaired state. For this reason, it is important to focus attention to lakes that may be threatened with changing water quality. Lakes located in or near areas undergoing rapid development, lakes in or near urban areas, lakes that have ditches or streams flowing into them are at higher risk of receiving phosphorus from their catchments. If a given lake has been monitored and found to be close to lake eutrophication water quality standards, it has the most potential to be remediated or to benefit from protection as compared to a lake that is already eutrophic.

Economic Contribution

Certain lakes because of their size, depth, fishery and aesthetic values, or other characteristics may have a significant impact on a local or county economy. High resort usage, an abundance of public access, and/or a high tax base might reflect this. As a result, these lakes may be deemed a high priority for monitoring or protection.

Lake Characteristics

Lake depth is an important parameter to consider for further prioritization. In general, deeper lakes, which stratify, tend to have lower phosphorus concentrations as compared to shallow lakes in the same region. From a restoration perspective, deeper lakes should be prioritized higher than eutrophic, shallow lakes since they are more likely to respond favorably to reductions in nutrient loading, whereas shallow lakes may suffer from excess internal loading of phosphorus even after external phosphorus loads have been reduced.

Conversely, from a protection perspective good quality shallow lakes (with abundant and diverse submersed vegetation) might be considered a higher priority than deep lakes since small increases in phosphorus loading to a shallow lake may lead to rapid eutrophication, which may be difficult to reverse.

Lakes that provide unique and valuable ecosystem services are important to protect or restore. For instance, naturally producing wild rice beds are extremely valuable to local and migratory wildlife, local economies and as a cultural resource. Wild rice is challenged by disturbance for access and raised water levels among other things.

Watershed Size

Give lower priority to lakes with large watershed size as compared to lake surface area. Lakes with very large watershed-to-lake ratios (e.g. 100:1 or greater) often have very high NPS loads, and it may be difficult to address enough sources of nutrients in their watersheds to exhibit visible improvement in lake quality.

Potential for Significant Changes in Land Use

Lakes classified as needing protection are often very susceptible to increased nutrient loading. One source of increased loading comes from dramatic changes in land use (e.g. urbanization of idle agricultural land or forestland). Lakes where these threats are currently occurring, or projected to occur in the near future, should be prioritized higher than those with threats anticipated in the distant future. For example, a high quality lake on the fringe of an urban area is more likely to have extensive development in its watershed in the near term than is a lake of similar quality, but very distant from a population center. Lakes with large amounts of publicly owned land in their watershed will likely be less vulnerable than lake watersheds with a high degree of private ownership.

Strategy 4.2 Lake

Needs, Priorities, Milestones, Action Plan

The action plan provided below summarizes the goals and milestones identified in the preceding sections. Many of the milestones listed below, as well as the implementation of specific projects, are contingent upon adequate funding and local involvement.

Goal 1: Continue the Development of an Index of Biotic Integrity (IBI) to Allow the Evaluation of Lakes for Aquatic Community Health.

Milestones (Action Steps)	13	14	15	16	17	Funding Source(s)	Lead Agency(ies)
1. Work to finalize fish and aquatic plant IBIs for lakes to support watershed assessment process	X	X	X	X	X		MDNR MPCA

Goal 2: Promote Lake monitoring and restoration/protection planning process at the local level by implementing the statewide watershed approach. Incorporate results, where feasible, into County Local Water Management Plans.

Milestones (Action Steps)	13	14	15	16	17	Funding Source(s)	Lead Agency(ies)
1. Provide grants to local water plans for intensive watershed monitoring.	X	X	X	X	X	CWF	MPCA
2. Collaborate on the development of watershed-wide protection and restoration plans.	X	X	X	X	X	CWF, 319	MPCA, LGUs

Milestones (Action Steps)	13	14	15	16	17	Funding Source(s)	Lead Agency(ies)
3. Collaborate on prioritization with local water plans – provide an analytical framework and develop management tools for LGUs to prioritize lake protection efforts.	X	X	X	X	X	319, 104(b)3 CWF	BWSR, LGU, MPCA
4. Support integration of NPSMPP strategies into local water management and comp plans.	X	X	X	X	X	319	BWSR MPCA MDNR
5. Encourage and support comprehensive lake management planning. Integrated with local water management plans.	X	X	X	X	X		LGU

Goal 3: Fund lake protection and restoration projects based on priorities developed through the watershed-wide protection and restoration plans and other lake-specific evaluation efforts to restore and/or protect high priority.

Milestones (Action Steps)	13	14	15	16	17	Funding Source(s)	Lead Agency(ies)
1. Provide long-term lake water quality (WQ) trend analysis to assist LGUs with prioritization decisions	X	X	X	X	X	319,314,CWP, CWF	MPCA, BWSR
2. Support projects proposed through local water plan.	X	X	X	X	X	319, 314, CWP,CWF	BWSR, MPCA, LGU
3. Compile case studies on current and past projects (e.g. CWP and Clean Water Stories) http://www.bwsr.state.mn.us/cleanwaterfund/stories and LCC website to evaluate success of projects.		X	X			319, 104(b)3 CWF	MPCA, BWSR
4. Integrate protection-oriented prioritization concepts into project selection.		X	X			319 CWF,General Fund LSOHC	MPCA, BWSR, LGU,MDA, MDH, MDNR

Goal 4: Expand State's Lake Water Quality Database via Conventional and New Technologies and use of Citizen Volunteers. Focus on Those Lakes Most Likely to be impacted by Development and Other Land Use Changes.

Milestones (Action Steps)	13	14	15	16	17	Funding Source(s)	Lead Agency(ies)
1. Conduct a targeted effort, using Surface Water Assessment Grants, to acquire trophic status data on all lakes of 100 acres or more.	X	X	X	X	X	CWF	MPCA
2. Encourage local partners to submit their lake monitoring data to EQuIS to enhance watershed-wide understanding of condition.	X	X	X	X	X		MPCA,

Milestones (Action Steps)	13	14	15	16	17	Funding Source(s)	Lead Agency(ies)
3. Provide data sets and analytical assistance acquired through remote sensing such as LIDAR on a watershed basis to assist LGUs with land management and water quality protection strategies						CWF, 319	BWSR, MPCA, MDNR
4 Increase amount of information in EQuIS, state water quality database and access to it.	X	X	X	X	X	State General Funds, CWF	MPCA, ~~USEPA~~
5. Expand and promote Citizen Lake-Monitoring Program (CLMP).	X	X	X	X	X	State General Funds	MPCA
6. Expand and promote Monitoring Plan Design Trainings.	X	X	X	X	X	CWF	LGU
7. Integrate monitoring of lake tributaries with CLMP and other monitoring efforts to help identify priority management areas.	X	X	X	X	X	CWF, General Funds, 319, CW	BWSR

Goal 5: Use comprehensive watershed plans to identify key lake protection and restoration strategies that need to be enhanced/strengthened and invest in efforts to improve local government capacity, rules and ordinances, BMPs, planning tools, etc.

Milestones (Action Steps)	13	14	15	16	17	Funding Source(s)	Lead Agency(ies)
1. Fund projects through local water plan process.	X	X	X	X	X	319, state match, CWF	MDNR, BWSR, Extension, LGU
2. Increase efforts to protect vegetation through easement and other incentives.	X	X	X	X	X	State General Funds USDA funds, CWF, LSOHC	MDNR, BWSR, Extension
3. Continue and expand education.	X	X	X	X	X	State General Funds	Extension, MDNR
4. Increase number of baseline GIS vegetation maps for trend assessment purposes.	X					LCCMR	MDNR
5. Mainstream application of these techniques at the local level (move past demonstration).	X	X				319, State General Fund, LCCMR	Extension, MDNR, MLA
6. Improve shoreland zoning practices and standards.	X	X	X	X	X		MDNR, MLA, LGU

Goal 6: Expand Information and Education on Appropriate BMPs, Ordinances and Strategies for Lake Protection and Restoration.

Milestones (Action Steps)	13	14	15	16	17	Funding Source(s)	Lead Agency(ies)
1. Share experience of zoning administrators and provide training as needed for ordinance development and implementation.		X	X			319	MPCA, BWSR, Extension, MLA
2. Address growth-related issues as they relate to lake protection and responsibilities of LGU.	X	X				LCCMR	State Planning, BWSR, LGU
3. Educate realtors and developers on lake-friendly techniques for development and maintenance.		X				319	Extension, BWSR, MLA, LGU
4. Reconvene the Lake Forum on a routine basis to address issues at a statewide scale.	X	X				319, LCCMR	ILCC, MLA, U of M
5. Conduct outreach to local decision-makers on lake planning, shoreland BMP projects, etc. Assist with ordinance development as needed.		X	X	X		319	BWSR, MLA, Extension, MDNR
6. Promote watershed focus to lake associations for lake management planning, BMP installations and community involvement.	X	X	X	X	X		BWSR MPCA, MDNR, LGU MLA

Goal 7: Promote Monitoring and Compilation of Bacteria at Beaches and Education of Toxic Algae Blooms.

Milestones (Action Steps)	13	14	15	16	17	Funding Source(s)	Lead Agency(ies)
1. Continue education, distribution of posters, press releases, and fact sheets on toxic blue-green algae. Conduct related monitoring & research as needed.	X	X	X	X	X	CWF	MPCA, MDH, MDNR

Goal 8: Minimize the Impact of Urban Stormwater Runoff to Lakes.

Milestones (Action Steps)	13	14	15	16	17	Funding Source(s)	Lead Agency(ies)
1. Enforce stormwater rules as needed to ensure compliance with Phase II.	X	X	X			State General Funds	MPCA, LGU, Met Council
2. Encourage development of erosion control and stormwater ordinances to prevent problems.	X	X				State General Funds	BWSR, MPCA, LGU, U of M
3. Ensure lake protection is built into MS4 permits. Promote ordinances as needed.	X	X	X	X	X		MPCA, LGU

Milestones (Action Steps)	13	14	15	16	17	Funding Source(s)	Lead Agency(ies)
4. Develop additional sampling techniques and modeling tools to aid in assessment of stormwater impacts on lakes.	X	X				State general fund, 319	MPCA, Met Council

Goal 10: Review Impacts to Downstream Lakes from Ditched/Drained Wetlands.

Milestones (Action Steps)	13	14	15	16	17	Funding Source(s)	Lead Agency(ies)
1. Develop alternative designs for ditch projects that incorporate nutrient and sediment reduction strategies. Will consider Field Office Technical Guides for alternative designs.		X	X			319	MDA
2. Evaluate significance of phosphorus loss from partially drained or ditched wetlands.	X	X				LCCMR	MDA ,MPCA,
3. Develop techniques for monitoring impact of drained wetlands on lakes and for rehabilitating impacted wetlands in compliance with QMP requirements.	X	X	X				MPCA, MDA, BWSR

Chapter 4.3 Rivers and Streams Strategy

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Introduction

Streams and rivers integrate aquatic and terrestrial conditions of the landscape. This interaction occurs along three measurable dimensions:

1. physical — incorporating hydrologic and geomorphic processes, relating to the movement of water and its action on the channel, riparian area, and watershed
2. chemical — relating to the cycling of materials from the land through the water
3. biological — relating to the processes that support plant and animal life in the stream and river and in its watershed

To assure the health of streams and rivers, effective nonpoint source (NPS) pollution management strategies must recognize these processes and their interrelationships. Emphasizing one or the other will alleviate a symptom, but not remove a cause.

Since the passage of the national Clean Water Act (CWA) in 1972, pollution mitigation concentrated on measurement of the chemical processes of water quality, and consequently, regulated use of rivers according to measures of water chemistry, chiefly through the regulation of point source discharges to rivers.

Today, resource managers recognize that they must pay attention to the movement of water through upland landscape, riparian zone and the stream channel, including the shape of the channel, associated habitat and biological processes it engenders, as well as its chemical composition, to understand if a river is healthy. Water resource managers recognize that NPS pollution results when a river's natural processes are disturbed.

Human activities degrade water resources by altering one or more of five groups of attributes:

1. Water quality — temperature, turbidity, dissolved oxygen, organic and inorganic chemicals, heavy metals, toxic substances.
2. Habitat structure — substrate type, water depth and current velocity, spatial and temporal complexity of physical habitat.
3. Flow regime — water volume, temporal distribution of flows.
4. Energy source — type, amount, and particle size of organic material entering stream, seasonal pattern of energy availability.
5. Biotic interactions — competition, predation, disease, parasitism.

The Rivers and Streams strategy will discuss briefly the status of NPS issues in Minnesota's major river basins, and then examine the significant water quality disturbances linked to NPS pollution in Minnesota, particularly, hydrologic and associated habitat modification, sediment disequilibrium, nutrient over-enrichment or eutrophication, and biotic impairment.

This strategy will provide some guidance for managers seeking to improve understanding of how NPS pollution arises and how it can be managed, and then present goals, milestones and action steps to manage NPS pollution in Minnesota's streams and rivers for the next five years.

Nonpoint source pollution is a critical issue for Minnesota's streams and rivers. Rivers and streams are important ecologically and economically to Minnesota and its residents.

Here's a partial list of functions performed by rivers and streams that are important to Minnesotans:

- flow of water
- storage of floodwaters
- enrichment of the soil through sedimentation
- removal of pollutants through movement through riparian zones
- dilution and/or removal of wastes
- regulation of temperature
- cycling of oxygen, carbon, nitrogen and phosphorus
- export of organic and inorganic materials
- habitat for fish and game
- recreational use
- source of drinking water
- economic use through the capture and release of flow
- economic uses through the storage and release of waters

Resource Manager's Guide to Stream Health

What questions does a resource manager need to answer in order to develop an integrated understanding of a stream's health? The list below is taken from United States Department of Agriculture (USDA) Stream Corridor Restoration: Principles, Processes, and Practices, 1999, Chapter 2. This invaluable manual is available on-line at: http://www.nrcs.usda.gov/wps/portal/nrcs/detailfull/national/water/quality/?cid=stelprdb1043448.

Hydrologic Processes

- Where does the stream flow come from?
- What processes affect or are involved with stream flow?
- How fast, how much, how deep, how often and when does water flow?
- How is hydrology different in urban stream corridors?

Geomorphic processes

- What factors affect the channel cross section and channel profile?
- How are water and sediment related?
- Where does sediment come from and how is it transported downstream?
- What is an equilibrium channel?
- What should a channel look like in cross section and in profile?
- How do channel adjustments occur?
- What is the floodplain?
- Is there an important relationship between a stream and its floodplain?

Chemical Processes

- What are the major chemical characteristics of the water?
- What are some important relationships between physical habitat and key chemical parameters?
- How are the chemical and physical parameters critical to the aquatic life in a stream corridor?
- What are the natural chemical processes in a stream corridor and water column?
- How do disturbances in the stream corridor affect the chemical characteristics of stream water?

Biological Processes

- What are the important biological components of a stream corridor?
- What biological activities and organisms can be found within a stream corridor?
- How does the structure of stream corridors support various populations of organisms?
- What are the structural features of aquatic systems that contribute to the biological diversity of stream corridors?
- What are some important biological processes that occur within a stream corridor?
- What role do fish have in stream corridor restoration?

Stream Corridor Functions and Dynamic Equilibrium

- What are the major ecological functions of stream corridors?
- How are these ecological functions maintained over time?
- Is a stream corridor stable?
- Are these functions related?
- How does a stream corridor respond to all the natural forces acting on it (i.e., dynamic equilibrium)?

"A river and it's basin is an ecological system, a set of processes that each contribute to its health: Nonpoint source pollution results when a river's natural processes are disturbed."

Review of Conditions in Minnesota's Major Drainage Basins

Minnesota's rivers and streams have been disturbed in many ways. Minnesota's NPS pollution management plan for rivers and streams needs to begin with an assessment of the scope of the problems.

Minnesota has nine major river systems — Red, Rainy, St. Louis-Lake Superior, Upper Mississippi, the Lower Mississippi and its tributaries, the St. Croix, Minnesota, Cedar and Des Moines rivers. The Rainy and the Red Rivers, which drain the Canadian Shield and the Lake Agassiz Basin, flow northward toward Hudson Bay. Water from the St. Louis River and the many swift-flowing streams emptying into Lake Superior along its North Shore reaches the Atlantic Ocean via the Great Lakes and the St. Lawrence River. The Des Moines River, which drains a portion of southwestern Minnesota, enters the Missouri River, which eventually joins the Mississippi River. These rivers are significant sources of drinking water for approximately 11 cities, including the state's largest metropolitan areas. Rivers provide water for the state's energy industry. Rivers are the backbone of the state's significant game fishery.

A review of conditions in the state's major river basins helps to define the challenges facing NPS pollution managers.

The **Red River Basin** lies on the remnants of Glacial Lake Agassiz. The basin is home to the world's most productive agricultural soils.

The river valley is bounded to the east by a series of steep beach ridges defined by the glacial lake. The valley floor has almost no topographical relief. Most of this land is cultivated for agriculture. An extensive drainage system has been built from the beach ridge to the river channel. Nonpoint source pollution problems are significant in this basin. Examples of NPS pollution in the Red River Basin are:

- increased runoff
- incised channels
- increased erosion
- impaired fish and wildlife habitat, less diversity and more pollution tolerant species
- increased flooding
- unsewered communities
- high background levels of carbon and mercury

The **Rainy River Basin** is relatively undeveloped, including lands lying within two national wildlife preserves: Voyageur's National Park and the Boundary Waters Canoe Area. Point sources of air and water pollution were significant before the passage of the CWA and other federal legislation, and have been largely remedied. Nonpoint source pollution problems are not significant in this basin. Issues of concern are:

- recovery from industrial pollution
- contaminated sediments
- erosion from logging
- unsewered communities
- stream bank erosion

The **St. Louis/Lake Superior Basin** is relatively healthy. Part of the basin lies within the Boundary Water Canoe Area. The St. Louis River has been the target of federal and state programs to reduce pollution to it, and these have been successful in improving water quality. However, contaminated sediment in the river and at its mouth to Lake Superior is a continuing issue. Nonpoint source pollution problems are not significant in this basin. Issues of concern are:

- mercury
- polluted sediments
- shoreline development
- noncompliant subsurface sewage treatment systems (SSTS)
- vegetation removal and changes to stream watersheds
- removal of wetlands
- unsewered communities
- erosion from logging
- stream bank erosion
- sediment disequilibrium

The **St. Croix Basin** is one or the least impacted of Minnesota's major drainage basins; it is also home to Minnesota's only National Wild and Scenic River. Nonpoint source pollution problems are not significant in this basin. Issues of concern are:

- small municipal wastewater treatment plants
- sprawl/urbanization pressures
- recreational uses
- nutrient management plan
- unsewered communities
- erosion from logging
- stream bank erosion
- sediment disequilibrium

The **Upper Mississippi River Basin** begins its course flowing through five state parks and the Chippewa National Forest. On the whole, the basin is relatively healthy. However, this basin is complicated, and its future should be closely monitored. A number of land uses that contribute to NPS pollution converge in the greater St. Cloud area. These include animal agriculture, especially feedlots for poultry and cattle, urban growth and management of municipal wastewater treatment plans, suburban or "exurban" growth and the development of Subsurface Sewage Treatment Systems (SSTS). Logging is a significant activity in the basin. The following issues are critical:

- loss of vegetation and hydrologic modifications
- increasing runoff
- stream bank erosion
- sediment disequilibrium
- eutrophication
- contaminants
- noncompliant SSTS
- ground and surface water connections
- nitrates in sand plain aquifers and alluvial outwash materials
- contribution to hypoxic conditions in downstream locations

The **Minnesota River Basin** has been significantly altered, with most of its land area converted from wetlands and shallow lakes to agriculture. The natural drainage system has been hydrologically modified to accelerate the flow of water to the Minnesota. The basin has been the target of intensive water quality diagnostic and remediation work. As a result, the point source contribution of phosphorus has been significantly reduced. "River friendly" practices such as conservation tillage have been implemented throughout the basin, which have contributed to the reduction of sediment in the river. However, NPS issues remain significant. Issues of concern are:

- loss of wetlands and storage
- increased volume of water flowing off the land
- increased velocity of water flow
- flooding
- increased sediments and nutrients
- increased fecal coliform bacteria
- contribution from wastewater treatment plants
- unsewered communities
- noncompliant SSTS
- contribution to hypoxic conditions in downstream locations
- feedlots
- stream bank erosion
- sediment disequilibrium

The **Lower Mississippi Basin** has been significantly altered, through logging and agriculture, industrialization and urbanization more recently. These changes introduced a variety of chemicals to the region. Land use changes, and the connection between ground and surface water, led to contamination of rivers and ground water. Nonpoint source pollution is a concern in this basin, and significant issues are:

- contribution from industry
- contribution from wastewater treatment plants
- unsewered communities
- eutrophication
- fecal coliform contamination

- increased sediment
- increased nutrients
- impaired trout habitat
- stream bank erosion
- sediment disequilibrium

The **Metro "Basin"**, the seven county greater metropolitan areas of Minneapolis and St. Paul and the surrounding suburbs, is technically not a hydrologic basin but for purposes of NPS pollution management and control it is considered as a separate basin. The nonpoint issues of greatest concern in the Metro Basin are urban stormwater related. The following issues are critical:

- urbanization
- hydrologic modifications through increased impervious surfaces and vegetation loss
- increased volume, rates, and timing of runoff
- stream bank erosion
- sediment disequilibrium
- eutrophication of area lakes
- noncompliant SSTS in the developing fringe
- disruption in the ground and surface water connections
- nitrates in sand plain aquifers and alluvial outwash areas

Water Quality Standards and NPS Pollution

The CWA is the keystone for surface water quality protection and restoration at the federal, state and local levels. The CWA requires states to designate uses for all stream segments, called reaches. Designated uses for streams, lakes, and wetlands include, but are not limited to, fishing, swimming, aquatic plant and animal diversity, and drinking.

In CWA Section 303(c), and accompanying regulations and guidance, the CWA requires states to create water quality standards to protect designated uses. Water quality standards are both narrative and numeric. An example of narrative water quality standards is chapter 7050.0222, subpart 4:

> *"The quality of Class 2B surface waters shall be such as to permit the propagation and maintenance of a healthy community of cool or warm water sport or commercial fish and associated aquatic life, and their habitats. These waters shall be suitable for aquatic recreation of all kinds."*

An example of a numeric water quality standard is un-ionized ammonia, which has a chronic water quality standard (WQS) of 40 micrograms nitrogen per liter. Section 303(d) of the CWA and accompanying regulations and guidance requires states to monitor lakes and streams and list those waterbodies that are not fully supporting designated uses. Placement on the state's 303(D) list triggers the response of establishing a Total Maximum Daily Load (TMDL) list of impaired waters. The state must study listed waterbodies and create pollution reduction budgets so that designated uses can be regained. In its current usage, the acronym TMDL can mean either a process to determine a pollution reduction budget or the pollution reduction load goal itself.

Minn. R. ch. 7050 (Chapter 7050) provides authority to the Minnesota Pollution Control Agency (MPCA) to set standards for allowable levels of chemical parameters depending on intended uses of the streams, rivers, wetlands or lakes. Chapter 7050 provides narrative standards protecting for biota and habitat as well. Chapter 7050 assigns multiple water use classifications to all surface waters of the state. These include:

Class 1 Domestic Consumption; Class 2 Aquatic Life and Recreation; Class 3 Industrial Consumption; Class 4 Agriculture and Wildlife; Class 5 Aesthetic Enjoyment and Navigation; Class 6 Other Uses; and Class 7 Limited Resource Value Waters. While not all surface waters in Minnesota are specifically listed in Chapter 7050, all surface waters are classified with assigned uses. As a simplified description, the State's multiple use classification system classifies all surface waters of the state Class 3 through 6. Depending on the existing and attainable uses of these waters (or certain reaches of these waters), they are then either designated as Class 2 aquatic life and recreation waters or as Class 7 limited resource value waters. In addition, certain waters may also be designated as Class 1 waters for drinking water purposes, and some are also designated separately for a higher level of nondegradation protection (i.e. Outstanding Resource Value Waters).

Class 7 limited resource value waters are primarily low flow streams and ditches where the stream flows are generally intermittent or have a flow at the once in ten year, seven day low flow (7Q10) of less than one cubic foot per second. Class 7 waters are protected for secondary water contact use by humans, for recharge of ground water for potable use, and for aesthetic qualities. As noted above, Class 7 waters are also assigned Class 3 through 6 uses. Effluent limits assigned to continuous discharges to Class 7 waters are often times less restrictive than those assigned to a Class 2 water of comparable size. All other things being equal, for low flow watercourses, a Class 7 discharger would likely be assigned 15 milligrams per liter (mg/L) carbonaceous biochemical effluent limit and a Class 2 discharger would likely be assigned a five mg/L biological oxygen demand (CBOD5) effluent limit along with seasonal ammonia effluent limits.

Minnesota does not have a standard for total suspended sediment. However, the state has a turbidity standard, of 25 nephelometric turbidity (NTUs) for Class 2B waters and 10 NTUs for Class 2A waters. A correlation for total suspended sediment in mg/l and NTUs can be developed for a specific monitoring station.

Disturbance to Streams that Cause NPS Pollution

Minnesota's NPS pollution problem has its origins in four types of disturbances:

1. hydrologic modification of the stream's flow regime, including the size and shape of the channel, the flow of water from watershed to channel and the connection between the channel and its floodplain
2. sediment, which is associated with hydrologic modification, but also results from changes to land use in the watershed
3. nutrient enrichment
4. impairment of biological conditions and the ability to support aquatic life

Other issues are more localized in scope. These include bacteria, mercury, chlorides, floatable trash and the emerging issues of pharmaceuticals and pesticides in streams and rivers. To a large extent, addressing the first four issues will help resolve the critical local issues.

The hydrologic cycle describes the movement of water from atmosphere to, over and through the ground and its return to atmosphere. Input of pollutants can take place at any point within the cycle.

Preventing or mitigating NPS pollution in streams and rivers requires techniques that protect or support the key processes of streams and rivers, and consequently, protect or enhance the ecological goods and services of the river or stream. The key processes of rivers and streams change over time and space, which is a complicating factor for resource managers developing NPS reduction plans. For example, a river's water quality changes throughout the year. Water flow decreases in dry times and increases in wet times. A river's capacity to accommodate disturbances to its watershed changes from its headwaters, to its confluence's with tributaries, and at its mouth.

Development of the flood plain is another example of the cumulative effect of disturbances to a river system. A relatively stable river system uses the flood plain to relieve the energy during high flow events. When a river or stream is cut off from its floodplain through development, the channel itself must carry high flows. The channel now starts a long process to down cut, widen and recreate a floodplain to balance the energy at all flow regimes. However, as the floodplain becomes developed with impervious surfaces, more overland runoff will be carried directly into the channel rather than filtering through the vegetation and landforms of an undisturbed floodplain. Therefore, the loss of the floodplain increases the delivery of materials produced as byproducts of land uses in the watershed – sediment, nutrients, bacteria, toxic materials — to the river channel. River channels naturally incise. However, in many areas of Minnesota, especially the Minnesota and Red River basins, human actions have accelerated this process. Management of the floodplain and the stream channel as a unit could minimize loading rates or loss of assimilation capability.

The growing “dead zone” in the Gulf of Mexico illustrates that NPS pollution has both a local and a cumulative effect. The dead zone results from the loss of oxygen (hypoxia), which has been determined to be largely the result of excess nitrogen. Minnesota contributes eight percent of the nitrogen load, much of which has its origins in subsurface tiles in the Minnesota River Basin. It’s an example of how an alteration to a stream’s natural conditions – elevated nutrients — can grow from a local concern to a national one — threatening the fishery of the Gulf of Mexico, located more than 2,000 miles from the Minnesota farmland.

Each element of the cycle (air, surface, and ground) is interconnected. For example, improper applications of pesticides on the land may be washed into ditches and streams. Flooding may then redistribute these pollutants across the floodplain with potential impact to the source water of public wells (ground water).

Nonpoint source pollution is the accumulation of many sources within a watershed that drains to a waterbody. Best Management Practices (BMPs) must be designed on a case-by-case basis to prevent, capture and treat NPS pollution as close to the source as possible. The larger the watershed, the more complex and costly the treatment required to protect its water quality. The primary pollutants of concern are sediment, nutrients (nitrogen and phosphorus) pathogens (bacteria, etc.) and mercury. To effectively control NPS pollution, it is necessary to address both the source reduction of the pollutants and the pathways/mechanisms and quantities of flow which move and concentrate them.

Wind and water are the two major movers for NPS pollution with water usually being the primary factor. Moving water dislodges soil particles and mobilizes chemical compounds. Both the quantity and velocity of moving water affect the water quality. Erosion and sediment transport are natural and continuing processes that can be accelerated by changes in the landscape resulting from changes in land use and the intensity of that land use. These alter the pools and riffles of a natural stream system, washing out coarse bottom sediments (riffles) and filling in pools and interstices with finer sediment causing deterioration of the natural habitat and biota.

Minnesota’s diverse climatic factors, land use, land cover, soil and geologic materials and topography all affect the shape, size, density and quality of its rivers and streams, lakes, wetlands and other land forms.

Hydrological Modification

Hydrologic modification of the watershed can have the following cumulative effects:

- Increased runoff, increased peak stream flows and volumes of both high and low flow events occur with an increase in impervious surface.
- Increased pollutants occurring as increase in flows causes loading to the stream.

- Increased and decreased volume of stream flows resulting from changes in land use and land-use intensity (e.g. vegetative cover from perennial communities to annual crops). High flows becoming higher and low flows becoming lower.
- Loss of stability to stream channels as natural vegetation is removed (particularly, healthy riparian forest cover) along streambanks and within flood plains.
- Incising of stream channels and increased erosion as stream channel modifications steepen stream channel gradients increasing stream flow velocities and subsequent erosion.
- Increased volume and frequency of flood events occurs with drainage of wetlands, ditching and surface tile inlets.

The cumulative effects of these changes, over space and time, result in alterations in the volume, rates, and timing of runoff with corresponding changes in the transport of pollutants such as sediment and nutrients from streams and rivers, accelerating their effects upon the land. Control of these effects is just as important as source reduction of pollutants. An effective NPS program must address both.

Stream channelization and drainage "improvements" disturb the dynamic equilibrium established by natural stream flow regime and sediment supply. These result in increased stream bank erosion, channel enlargement, down cutting above the project and increased frequency of over bank flows and elevation of stream bed below it. The resulting unstable flows and sediment regimes cause frequent short duration floods which can kill or flush fish eggs or fry out of the system. Heavy sediment loads also fill pools and interstitial spaces between rocks, which are important habitat for invertebrates, fish eggs and fry. Given time, streams and ditches slowly revert to a more sinuous, stable channel.

Restoration of stream channels to natural shape and function provide benefits of improved water quality, moderation of flood peaks, reduced erosion and enhanced fish and wildlife habitat. Ditches built with consideration of these hydrologic functions will require less maintenance. However, it is just as important that riparian vegetation be restored and maintained along with the channel.

Finally, removal of in stream impoundments also improves the health of a natural river system and increases its connectivity. Historically, Minnesota has more than 2,500 dams that have fragmented its rivers, blocked fish migration and disturbed natural flow and sediment regimes. The cost of removing unwanted, unused, unsafe dams is high, but the benefits of a healthier river system are even higher, in the long run. The construction of any new in-stream impoundment should be closely scrutinized in light of these issues.

Sediment (sediment disequilibrium)

Suspended sediment is a major water quality concern in several of Minnesota's major river basins.

Suspended Sediment and Turbidity

Turbidity is the measure of the impact of fine-grained suspended sediment. Turbidity reduces light penetration causing a decline in desirable periphyton and thereby shifting stream primary productivity to undesirable phytoplankton species. High phytoplankton productivity also causes turbidity, resulting in streams that are turbid much of the time, even when inorganic sediment is not running off the landscape. The presence of sediment can increase stream temperature, as the particles absorb the sun's warmth. Increased temperature also reduces dissolved oxygen concentrations.

In addition to turbidity, suspended sediment transports attached phosphorus, often in concentrations that exceed 200 micrograms per liter (ug/L) (Payne 1994). Toxic substances also can be attached to sediment particles and thereby moved from source areas to become problematic in downstream reaches and accumulating in areas of sediment deposition. Mercury, for example, is strongly associated with suspended sediment transport, originating as atmospheric deposition on the landscape but subsequently transported to stream channels during runoff events.

Suspended sediment in stream and rivers results from gully erosion, sheet erosion of upland landscape surfaces, or from scour of stream banks and beds. Several of Minnesota's major river basins contain poorly drained, fine-grained soils that have been drained by an extensive system of ditches and subsurface tile. Tiles often have drop inlets that allow field-eroded soils to be transported to streams. Many of the ditches and channelized natural streams show evidence of bank and bed instability, either down cutting or meandering, which adds to the amount of sediment in transport. Some of the larger natural channels show evidence of down cutting to the extent that they are becoming isolated from their floodplains during annual floods.

Once isolated, these channels can no longer deposit a portion of their sediment load on the floodplain, and as a result carry most of their sediment loads downstream, becoming ever more sediment-laden as they accumulate loads from each of their tributaries. Part of the eroded bank material is sand-sized. The sand-sized material typically is transported as bed load, but can be part of the suspended load during high-magnitude flood events. When deposited in low-velocity river reaches, backwaters, and pools, this material also can degrade habitats and impede navigation. Bed load transport is not well quantified in Minnesota, but is evidenced by changes in channel depth and the presence of moving dunes at some locations.

Urban Erosion

In urban areas, erosion from construction sites is of concern as well as the changes of volumes, rates, and timing of stormwater runoff and the impact this has on the receiving streams bed and banks. Also, highway sanding and salting can have localized impacts on sediment pollutant loadings.

Agricultural Erosion

In agricultural areas, most of the intensively cultivated basins have fine-grained soils that are subject to erosion and that once suspended are difficult to remove from the water column. Sediment concentrations, loads and yields increase substantially during runoff periods causing wide fluctuations in annual delivery. In the Minnesota River Basin, which drains about 20 percent of Minnesota, the mean annual yield of total suspended solids prior to 1994 was about 74 tons per square mile (tons/mi^2), but ranged from about 12 tons/mi^2 to 240 tons/mi^2 annually (Payne 1994). The average annual yield of total suspended solids at the Minnesota River at Fort Snelling was 35 tons/acre for the period 2007 – 2009 (MPCA Watershed Pollutant Load Monitoring Network, 2007-2009 Annual Loads). Another major basin, the Red River of the North, had a mean annual yield of about 24 tons/mi^2 (Tornes and Brigham 1994). Average yield for the Red River of the North at Grand Forks was 27.5 tons/mi^2 for the period 2007-2009 through the Watershed Pollutant Load Monitoring Network. Most of suspended sediment is fine grained silt and clay, and can be transported long distances before settling out. When deposited, it fills pools and backwaters, which limits the ecological processes and functions of the river system. Sediment also settles in portions of stream channels leading to deterioration of stream habitat.

Gully Erosion

Gully erosion has been shown to be a major source of the sediment entering Minnesota's rivers and streams. This gully erosion is typically formed at the transition zone between a river's floodplain and the surrounding upland area. Gully erosion is particularly evident on the Minnesota River and its tributaries, where the systems transition from the uplands to the Minnesota River Valley floor.

Contaminated Sediment

Potential chemicals of concern can attach to suspended particulates in the water, and subsequently settle out to the bottom mud (sediment). Through complex chemical, physical and biological interactions, these pollutants may be further transformed and transported to other parts of the aquatic ecosystem.

At elevated concentrations, contaminated sediments contribute too many impaired uses, including fish advisories, habitat impairments and restriction on dredging. Additional information about contaminated sediments can be found on the MPCA website at: www.pca.state.mn.us/water/sediments/index.html.

Eutrophication

The presence of nutrients alters the aquatic environment. Changes can include:

- depletion of dissolved oxygen (DO) concentrations
- increased plant growth
- warmer temperatures
- stress to aquatic life, including fish kills
- noxious taste and odor, affecting recreational use and drinking water supplies
- toxic effects to livestock, pets and people

Reducing nutrient over-enrichment is a significant water quality goal for Minnesota. An important step toward achieving this goal is the development of nutrient criteria tailored to reflect the different types of waterbodies and the different ecoregions of the country. These ecoregion-based nutrient criteria will be used to assist states in adopting numeric water quality standards.

Nutrient enrichment is a significant issue for NPS pollution, especially due to linkages between hydrologic modification and sedimentation and the cycling of nutrients through a stream system. For example, the U.S. Geological Survey (USGS) found that total phosphorus concentrations in agricultural streams were among the highest measured and generally correlated with nonpoint phosphorus inputs across the nation. In general the USGS found the phosphorus concentrations were highest where high concentrations of suspended sediment from erosion are common. Urban discharges of phosphorus are highest in densely populated areas. The MPCA has developed ecoregion-based guidelines for phosphorus. Generally, background levels increase from the northeast to the southwest in the state, ranging from 0.052 milligrams per liter (mg/l) in the Northern Lakes and Forest ecoregion, to 0.340 mg/l for the Western Corn Belt ecoregion. Minnesota is participating in a national project, administered by U.S. Environmental Protection Agency (USEPA), to develop ecoregion-based nutrient criteria.

Hypoxia in the Gulf of Mexico

On the Gulf of Mexico's Texas-Louisiana Shelf, an area of hypoxia (low dissolved oxygen levels) forms during the summer months. The area has been measured as large as 8,500 square miles; the most recent five year running average (2004 — 2008) is 6,600 square miles in area. This condition is caused, in part, by a complicated interaction of excessive nutrients transported to the Gulf of Mexico by the Mississippi River. While nitrogen has been considered a cause of hypoxia for some time, more recent studies implicate phosphorus as an additional cause. About two-thirds of the nitrogen load to the hypoxic zone comes from upstream agricultural land use. About eight percent of that total nitrogen load is estimated to come from Minnesota. Row crop farmland is a major source of nitrogen and is transported through tile system to surface waters. Other factors include physical changes to the landscape and river, such as channelization and loss of natural wetlands and vegetation both in the uplands and along the banks; the resulting impact of eutrophication is exacerbated by the interaction of freshwater from the river with the saltwater of the Gulf. The spring loading of nitrogen to the gulf is of greatest concern.

The goal is to reduce the aerial extent of hypoxia to a five year running average of 1500 square miles while simultaneously improving the quality of waters within the basin and improving the quality of life for communities and economic conditions across the basin. Approximately 40 percent of the U.S. fisheries landings, including a substantial part of the Nation's most valuable fishery (shrimp), come from this productive area. Commercial landings of all species in 2010 for the five Gulf states were 1.3 billion pounds (http://www.epa.gov/gmpo/about/facts.html).

Phosphorus

Phosphorus exists in the water column and landscape. Phosphorus contained in wastewater discharges is readily available to aquatic life in the receiving water. That is, up to 80 percent of the discharged phosphorus will be used in the stream or river. Conversely, most of the total phosphorus running off the landscape after storm events is sediment attached, and has to go through a biological process to be taken up in the aquatic environment.

Iron, aluminum and calcium content of soils naturally limit the transport and biological cycling of phosphorus. However, the binding properties of soil are limited and can be overwhelmed when too much fertilizer or manure is applied. The result is that phosphorus runs off the landscape and is not bound to the soil. Chemical bonds are also broken down over time by several natural processes in the rivers, streams, wetlands and lakes present in the system.

Algae and bacteria will liberate sediment-attached phosphorus for their use when other forms of phosphorus are less available. Under anoxic conditions, iron can be reduced and release phosphorus. Potential of Hydrogen (pH) determines the ability of aluminum and calcium in the soils to bind phosphorus.

The setting and physical conditions of a river influence its capacity to assimilate or flush nutrients. For example, nutrients move quickly in high-gradient streams, but linger in the pools of meandering rivers. Phosphorus enrichment is a process that occurs to the nutrients carried in runoff. A study by Dr. David Mulla and associates found that a typical field in the Minnesota River basin contains an average of 1.25 pounds of total phosphorus per ton of soil (F. Fang, P.L. Brezonik, D.J. Mulla, and L.K. Hatch. 2005. Characterization of Soil Algal Bioavailable Phosphorus in the Minnesota River. Soil Sci. Soc. Am. J. 69:1016-1025). The capacity of the soil particles to bind phosphorus varies with soil type. Silts and clays have more binding capacity than sands. Sands are more likely to be deposited while clay and silts are more likely to be carried. This natural sorting process contributes to phosphorus enrichment. According to Dr. Gyles Randall et. al. (1997), enrichment process may increase sediment phosphorus up to six times the original upland soil levels.

Minnesota has drafted regional river eutrophication criteria that are intended to be protective of streams and downtstream resources. The draft critiera are for total phosphorus with summer average concentrations not to exceed exceed 55, 100, and 150 micrograms/liter in the North, Central, and South Nutrient Regions of Minnesota (http://www.pca.state.mn.us/index.php/view-document.html?gid=14947).

Nonpoint source contributions of phosphorus can be managed by limiting the phosphorus content of soil in any source area, or by protecting soils from eroding or interrupting the transport process prior to delivery to the riverine system. In Minnesota, the MPCA has developed a phosphorus strategy to guide regulation of point source discharges. Some dischargers will be required to develop phosphorus management plans as a condition of future renewal of permits.

Nitrogen

Nitrogen exists in the environment in many forms and is far more soluble than phosphorus. Nitrite, nitrate, ammonia, and nitrogen gas are common forms that cycle through the air, water and soils in Minnesota. Nitrogen is most persistent in rivers and streams when in the form of nitrate nitrogen. The nitrogen cycle is complex in the soil and water, yet less complex than the phosphorus cycle.

There has been an increase in nitrate nitrogen in the recent decades, consistent with a national trend towards increased use of fertilizer. Rate, timing and type of nitrogen applications all affect the release of nitrogen into the environment. The University of Minnesota has developed regional nitrogen application rate and method/timing BMPs that provide effective guidelines for optimum crop or lawn productivity. They also minimize the release of nitrogen into the ground water or surface water.

Another factor in Minnesota is the growing use of subsurface tile drainage systems that intercept the infiltrating water and soluble nitrate and provide a direct pathway to the river, stream or ditch. This new pathway avoids or minimizes the time the ground water is exposed to the de-nitrifying process (Magner et. el. 2004). There is no water quality standard for nitrogen. However there are water quality standards for nitrate and ammonia.

Nitrate nitrogen has a standard for drinking water at 10 mg/l to protect infants from methemoglobinemia. The un-ionized ammonia chronic toxicity standard (protecting aquatic life from long term exposure) for Class 2b waters is 0.040 mg/l. Nonpoint source of nitrogen should be limited by practicing nutrient management on the upland areas and providing effective zones to de-nitrify such as, wetlands, biofilters and aquatic plant life. In addition, de-nitrification can be enhanced by managing the time of release or reuse of the water using alternative designs of depth and spacing in subsurface tile drainage or controlled drainage. These methods have been shown to reduce nitrate releases to the hydrologic system by approximately half.

Biotic Impairment

Minnesota is home to over 150 species of fish and a large variety of aquatic invertebrates, the majority of which may be found in Minnesota's vast network of rivers and streams. Because each species requires specific physical and chemical conditions in order to survive they are excellent indicators of the state of our water resources. Stream systems that support well-balanced and adaptive aquatic communities are said to have a high degree of biological integrity.

Minnesota has been largely successful at control of point source discharges, and we are now beginning to understand the complexity associated with watershed system. Addressing NPS of pollution will depend on how well we understand the watershed system. The focus thus far has been on maintenance of resource quality by restricting and managing the influx of chemical pollutants into stream systems. However, biological integrity in rivers and streams is dependent on the protection of physical resource quality (i.e., instream habitat, hydrologic and geomorphic processes) as well as chemical quality (Asmus et, al. 2007).

Because of the diversity of Minnesota's rivers and streams, it is impossible to entirely characterize the wide range of naturally occurring stream habitats; however, there are certain characteristics that are found in almost all healthy stream systems throughout the state.

The vast majority of headwater streams in Minnesota were at one time influenced greatly by wetlands or lake systems or springs. Headwater streams influenced by natural pathways and processes are very stable and diverse. For example, wetland influenced streams are typically very low gradient meandering streams that are relatively deep and narrow. The stream bottom is typically composed of fine silts and detritus. Stream cover occurs in the form of overhanging vegetation, undercut banks and or woody debris is abundant. Riparian wetlands act as filters by removing pollutants before they reach the stream and also act as hydrologic buffers by moderating flow extremes (Magner, 2001). This unique environment provides excellent habitat for aquatic organisms including dragonfly and damselfly larvae and fish species such as the pearl dace, northern red belly dace, and fine scale dace. The morphology of most Minnesota streams can be characterized as a series of riffles, runs, and pools.

Each one of these distinct habitat types provides a unique environment for specialized aquatic organisms. Riffles provide fast water, and course substrates for riffle fish species such as the long nose dace, and log perch as well as excellent habitat for caddis flies, mayflies, and stoneflies.

The course substrates found in the fast flowing, oxygenated water of riffles provides suitable areas for feeding, reproduction, and shelter. Runs and pools provide slower, deeper areas that are used by pool dwelling species such as the smallmouth bass, bluegill, and channel catfish.

The meanders that are so prevalent in natural low-gradient streams produce undercut banks and scour pools that act as cover and velocity shelters for fish and invertebrates. Silt and fine material in pools provide a suitable substrate for aquatic plants, which in turn provides both food and cover for fish and invertebrates. Pools are particularly important to the fry of many fish species whose survival depends on the prevalence of deep pools filled with aquatic vegetation.

Many land use practices negatively affect the quality of instream habitat. Anything that is done to alter the diversity and stability of naturally occurring stream habitats inevitably affects the aquatic community of organisms residing in streams. Also, because streams are flowing, interconnected systems, alterations that occur in the uplands will eventually be reflected in the lower stream reaches. Stream habitat may be compromised by altering the streams natural morphology through ditching and channelization or through land use practices that occur outside of the stream channel such as removal of the riparian vegetation, drainage tiling, and residential development. Increased human land use practices alter the natural hydrologic cycle of streams so that water is removed faster from the landscape. However, in this process stream habitat diversity can be seriously reduced. Bankfull peak flows that were once historically slowed by bends, pools, and woody debris in the water column can move faster when the stream has been straightened. This faster flowing water carries with it an increased shear strength which carries more sediment, some of which is deposited in the downstream reaches. Many fish and invertebrate species cannot use substrates that are laden with excessive silt for reproduction, feeding, or cover. Riffles and pools become scarce or absent as the stream is converted from riffle, run, pool sequences to long runs. By removing water from the system faster, the natural hydrologic timing is altered. The overall effect is an increase in the extremes of the high and low flow events. Streams in which the surrounding vegetation has been removed or altered can have an increase in the amount of silt-laden runoff. Also, water temperatures within the stream may rise as the overhead canopy is removed exposing the stream to full sunlight.

When habitat alterations cause a loss of habitat diversity and stability, the fish and invertebrate communities change in characteristic and predictable ways. Sensitive fish and invertebrate species are replaced by a few tolerant species such as the fathead minnow and brook stickleback.

These tolerant species are able to take advantage of degraded habitat and out-compete the more intolerant members of the community. Species such as the creek chub and green sunfish may invade streams in which the stability of the habitat has become compromised. These species are known as pioneer species because they are the first to recolonize a stream after a catastrophic event such as a severe flood or drought.

Darter and many other riffle dwelling species that depend on coarse substrates to reproduce may become scarce or absent.

Stoneflies and dragonflies that rely on course substrates and woody debris on which to cling are forced out of their refuges by heavy silt loads that fill in the interstitial spaces surrounding course substrates and cover.

Warmer water temperatures negatively influence cold water trout streams by forcing trout to seek colder water refuges and at the same time allowing the invasion of tolerant cool water fish species into the stream.

In summary, the biological integrity of rivers and streams is influenced by both the chemical and physical stream characteristics. Land use practices may alter the physical features of a stream so that the diversity and stability of instream habitat is reduced. Because aquatic communities depend on stable and heterogeneous habitats, there is often a reduction in biological integrity associated with many of these land use practices.

Reduced biological integrity may be expressed in many ways including, but not limited to, a change in number of species found within the stream, a decrease in the number of sensitive or specialized species, or an increase in the number of tolerant and pioneering species.

Other Nonpoint Source Pollution

Oxygen Depletion

The DO content of a river or stream is negatively impacted by several factors. A competitive environment for game fish can be reduced to one for rough fish or areas that have no life present at all. The total loss of DO across a reach will not only limit the presence of species in that reach of a river or stream but becomes an effective barrier to migration upstream of the reach as well. Presence of DO can be limited by chemical reactions in the water, including temperature increases that reduce the capacity of the water to hold oxygen, or by bacterial decay of organic matter in the water. Oxygen depletion impairment has been identified as a parameter of concern on Minnesota's 303(d) list. As a result of this listing, affected communities will work with the state to set Total Maximum Daily Loads (TMDL). For instance, reaches on the Crow, Red, Minnesota and Mississippi rivers have been listed as impaired due to oxygen depletion. Standards for Class 2b (warm water fisheries) in Minnesota typically are to maintain a 5 mg/l level of DO. For Class 2a waters, cold water fisheries, the state has set an oxygen standard of 7 mg/l. www.pca.state.mn.us/water/tmdl/index.html.

Bacteria

The state water quality standard for bacteria is 126 organisms per 100 milliliters (org/100ml) for Escherichia (E.) coli. E. coli is used as an indicator species for all potentially harmful waterborne bacteria. An indicator species is one which, if found in high concentration, "indicates" that there is a likelihood that harmful bacteria are also present in concentrations high enough to be of a health concern.

E. coli is found in the intestinal tract and, therefore, the feces of all warm-blooded animals. Common sources of bacteria contamination in our rivers and streams include; inadequately treated sewage from wastewater treatment facilities, direct discharges from septic systems, domestic animal manure, and wildlife.

In rural areas, NPS pathways are non-compliant SSTS, and surface runoff from fields with manure applications. A reduction in SSTS contributions could reduce that source down to zero if compliant systems were installed. Land application of manure best management practices (BMP) methods are set up be effective at minimizing the loading of oxygen depleting substances, nutrients and bacteria. In urban areas, fecal coliform enter rivers and streams via stormwater sewers. These connect impervious surfaces with the receiving rivers and streams directly. Urban stormwater often contains high levels of bacteria. Sources include wildlife, pet waste, animals such as raccoons and rats living in storm sewers or along conveyances and others sources. Many of these sources are controllable and have programs set up to manage them. However, the standard is exceeded in many waterways throughout Minnesota.

Heavy Metals and Human Made Chemicals

Heavy metal and Polychlorinated Biphenyls (PCB) pollution is typically highest in urban areas where there are more sources such as cars, pavement and buildings.

Heavy metal contamination is typically associated with industrial discharges of wastewater in most individuals' minds. However, the transport process associated with runoff affects the level of heavy metals entering into a river system. Many times the metals have an affinity for sediment and are transported with eroding soils. Another pathway is a source or work area exposed to precipitation. Metals like zinc or cadmium, originating from roofing material or car tires, are washed across impervious surfaces by precipitation and delivered to the river or stream.

Mercury, being the only liquid metal at normal temperatures, is volatile and exists as a gas and in precipitation. More than 95 percent of the mercury in the state's waterways is contributed by atmospheric deposition, and more than two-thirds of that mercury originates from combustion of fossil fuels. When mercury is methylated in wetlands or the bottom of lakes, it changes to a form that can accumulate in the muscles of animals; it enters the food chain and eventually accumulates in fish and other animals at the top of the food chain.

The MPCA developed a mercury TMDL, with considerable review and comment from interested citizens and groups. The statewide TMDL recommends a 93 percent reduction worldwide in mercury emissions from anthropogenic sources. The TMDL was approved by USEPA in 2007 and is available at http://www.pca.state.mn.us/index.php/water/water-types-and-programs/minnesotas-impaired-waters-and-tmdls/tmdl-projects/special-projects/statewide-mercury-tmdl-pollutant-reduction-plan.html.

Chlorides

The main source of chloride contributing to the impairment of Minnesota's rivers and streams is runoff containing deicing products. Chloride is a main component of most deicing products, the most of which is road salt. Road salt contributes to chloride levels in urban and highway runoff areas. The USGS reports a correlation between chloride concentrations in surface waters and percent impervious surface. Ten sites were monitored ranging from less than five percent impervious surface up to 28 percent. The concentrations of chlorides ranged from a low of below 20 mg/l to over 120 mg/l during this study period. Sodium and chloride were also negatively correlated with fish species diversity.

Road safety is dramatically increased during the winter months with road salt application in Minnesota. However, the use of road salts may result in increased chloride concentrations. This can alter lake thermoclines by changing water density and increasing conductivity. Chloride can harm aquatic organisms by disrupting natural processes that help regulate their metabolism. Applying BMPs to salt storage sites, salt application forms and methods, operator training, snow stockpile storage, and street sweeping can minimize NPS pollution impacts. The water quality standard for chloride for Class 2 water

(Mn R.ch. 7050) is 230 mg/l for chronic toxicity based on the 4-day average and an acute standard of 860 mg/l for a one-hour duration.

Floatable Trash and Litter

Floatable trash and litter can be a NPS problem for streams and rivers. There are many sources and modes of transport for these materials, but the problem is generally most serious within and downstream from urban, commercial, industrial and recreational land use areas. Trash can be directly deposited in the water or on streambanks by water users, flushed in through storm sewers or overland runoff and, in some cases, wind blown. Many of these materials are nonbiodegradable and will persist in the environment for many decades until removed or in some cases buried through sedimentation processes within the floodplain. Flooding can increase the volume of litter. Trash and litter constitute a major impairment to the recreational use and esthetic appreciation of the state's rivers and streams and can be hazardous to humans and wildlife.

Guidance for Managers

Managing NPS pollution requires involving everyone whose land use activities affect the watershed. Some of these users are regulated, but many are not. The challenge is to help citizens and the public to understand the need for watershed stewardship, so that they can choose actions that promote, rather than impair water quality, and so that they can be an advocate within their community for public policies that promote watershed stewardship.

Water quality managers need to incorporate a watershed perspective, develop a sound scientific basis for making decisions and include all stakeholders in the decision making process.

This shift has been encouraged by mandates to the states from the federal government, including:

- wellhead protection
- source water protection
- impaired waters under 303(d) of the CWA and subsequent
- development of TMDLs

These initiatives ask managers to assess and inventory all known sources of problems for a watershed. Developing remedies requires participation of all stakeholders. The USEPA provides thorough guidance to understanding and applying these concepts, including case studies of how communities and units of local government have engaged in watershed-based river management programs. These materials can be found at the following Internet address: www.epa.gov/watertrain/.

The most effective NPS pollution management plans are watershed-specific (see Box 3) and should incorporate the following elements:

1. Identification of the specific soil, landscape and climatic factors influencing water quality of a watershed.
2. Identification of sources and impact of NPS pollution on the subject watershed.
3. Identification of a suite of cost effective practices that can reduce NPS pollution.
4. Identification of water quality goals and a determination of the roles of each participant.
5. Information about practices that mitigate NPS pollution, and training to help citizens learn how to implement these practices, or teach them to others, and to implement at appropriate levels.
6. Long-term water quality monitoring to diagnose problems; sentinel watershed systems are needed to define trends in water quality and to measure success of measures to reduce NPS pollution.

7. Information campaign plans, to help build dialogues among all who live in a watershed about stewardship, and to inform the public of status (and successes) of NPS mitigation programs
8. Funding to support the administration and management of local organizations, which should be raised from the community as much as possible.9. Funding to support technical work done by local organizations for health of the watershed, which should be supported by the state.

Guidance from the Web

Technical assistance required for developing effective NPS pollution management plans is just a click of the browser away! Here are two excellent guides:

Ecological Restoration - USEPA 841-F-95-007 (November 1995) – http://water.epa.gov/type/watersheds/archives/ecology_index.cfm

Watershed Academy Web (www.epa.gov/watertrain). This Web site offers a variety of self-paced training modules that represent a basic and broad introduction to the watershed management field. Modules vary in the time they take to complete, from ½ hour to 2 hours.

Role of Local Government

Generally, NPS pollution is not subject to regulation, as are point source discharges to public waters. However, land use is managed and controlled by numerous local ordinances, which have been delegated by the state to the counties. These local land use controls can be the most effective management tools for the management of NPS pollution. Examples of local land use controls that manage NPS pollution are:

1. shoreland rules, including setbacks and vegetation removal
2. subdivision rules
3. individual on-site sanitary treatment system rules
4. feedlot rules
5. land application of biosolids

These regulatory programs are critical elements of any watershed's NPS pollution management plan, since the administration of these rules is an opportunity to implement BMPs that will reduce NPS pollution.

Incentives should be provided through current block grant funding programs from the state to local government to assure that NPS issues and the watershed perspective are considered in the review and update of rules.

Local governments are critical players in the planning led by the state for NPS pollution and other watershed management efforts. From the state level, the Minnesota Environmental Quality Board (EQB) develops a state water plan every ten years, which is an overview of the state's goals for its water resources.

The MPCA develops Major Watershed plans for each of the state's 81 major watersheds. These build a coordinating structure for all water pollution programs, and link NPS and point source programs.

Watershed districts develop five year plans to guide decision-making about water resources. The 80 rural counties develop comprehensive local water plans on a five to 10-year cycle, and a similar planning effort occurs in the seven-county metropolitan area.

Each of these plans, and the related planning effort, is an opportunity to educate stakeholders about NPS pollution, and to establish local and regional goals and strategies to address NPS problems.

Citizens appointed by county commissioners make decisions about local ordinances. Therefore, a successful NPS management program should provide training and information for elected and appointed decision makers.

Role of State and Federal Government

The state and federal government provides technical and financial support for the mitigation of NPS pollution. These programs are available as funds authorized by the national CWA, and incentives provided through the National Resource Conservation Service (NRCS) and incentives provided through the NRCS Farm Services Agency. Moreover, both state and federal government are encouraging indirectly through services, and directly through funding, management by major drainage basin.

Broad-scale public policy can have major effects on land use, and subsequently on the nonpoint pollution entering waterways. These effects may be direct or indirect and are sometimes unintended, but ultimately exert strong influence on the quality of aquatic and terrestrial habitats within watersheds and across the country. Current policy development processes that will be important for the state of Minnesota are the Federal Farm Bill. It is the responsibility of state and federal government to provide balance in the formulation of social, economic, and environmental goals, and to establish their compatibility through effective integration into policy.

Role of the Private Sector

Minnesota has an active philanthropic community, as well as a tradition of individual giving. Money from private foundations, environmental advocacy organizations or corporate giving programs can be an opportunity to launch a community based watershed group.

Support from private foundations is less than five percent of overall charitable giving. Many communities are establishing local foundations that can provide ongoing support to local river groups. A network of local funding will help assure the long-term success and viability of local watershed "watch" groups. There are many nongovernmental organizations that support NPS management. Many of them are linked to the USEPA's watersheds website: www.epa.gov/OWOW.

Summary and Call to Action

Nonpoint source pollution management for Minnesota's streams and rivers is at a critical junction. The state has made great strides in reducing point source pollution. The state has launched effective NPS pollution reduction strategies in the most disturbed river basins. However, the ability to continue this effort, and to expand it to all rivers, requires commitment to two basic principles: first, that we must address the ecological underpinnings of NPS pollution problems in the state's rivers, and second, that we must support and encourage an infrastructure to guide management of rivers that is informed by the best science, provides meaningful and appropriate incentives, and has a decision-making structure accessible to all the residents of the watersheds of the state's rivers.

The following set of goals encourages that integration. The first four goals respond to the critical issues facing all rivers in the state. Addressing these issues by implementing milestones and action steps recommended in the accompanying matrix is a first step to solving any local impacts, ranging from bacteria to pharmaceuticals.

The final three goals recommend the systems that need to be built, encouraged and supported in order to fully develop a NPS pollution management strategy for Minnesota's rivers.

Healthy Hydrological Regime

Promote hydrological management that enables rivers and streams to reach proper function conditions (as defined by the U.S. Bureau of Land Management). Characteristics of properly functioning hydrologic conditions include the presence of adequate runoff management, vegetation, land form and large woody debris to:

1. dissipate stream energy associated with high water flows, thereby reducing erosion and improving water quality
2. filter sediment, capture bed load and aid flood plain development
3. improve floodwater retention and ground water storage
4. develop root masses that stabilize streambanks against cutting action
5. develop diverse ponding and channel characteristics to provide the habitat and the water depth, duration and temperature necessary for fish production, waterfowl breeding and other uses
5. support biodiversity

Allowing rivers and streams to function as physics demands with balanced or semi-balanced flow regimes, defined flood plains, meander belts and appropriate grades will improve the health and stability of the waterbody in addition to increasing the assimilation capacity of the resource. The hydrological conditions of a river's watershed can be measured using the following attributes: total (annual) discharge, seasonal (monthly) discharge, peak flows, minimum flows, annual flow duration, rainfall records, size and shape of the watershed. Channel processes that should be measured to assess this condition in streams are flow characteristics, channel dimensions, shape, profile and pattern, substrate composition, floodplain connectivity and evidence of entrenchment and/or deposition.

Healthy Sediment Budget

Promote practices that balance sediment size and quantity with stream flow and grade to restore or maintain an ecologically appropriate equilibrium. This balancing includes stabilizing the system's hydrology so that erosion and aggradation are minimized, banks are vegetated and access between the flood plain and the river is maintained. The attributes of a healthy sediment regime in a watershed can be measured by the following attributes: watershed cover and soil health, presence of dams or in-stream impoundments, dominant erosion processes, rates of surface erosion and mass wasting, sediment delivery ratios, channel erosion processes and rates, and sediment transport functions. Sediment is the largest single pollutant problem our rivers and streams are facing in Minnesota and, therefore, requires special attention in the state's Nonpoint Source Management Program Plan (NPSMPP). Sediment transports other pollutants — from nutrients to pharmaceuticals. Sediment transport changes create an imbalance in riverine systems that rivers respond to by aggrading or degrading to correct the imbalance. Therefore, assuring a healthy sediment budget in a river's watershed is the dominant step in addressing other NPS pollution issues for rivers.

Healthy Nutrient Budget

Enrichment due to nutrients is a significant statewide issue for Minnesota's streams and rivers. The state is participating in a national nutrient criteria development project, which will inform development of future water quality standards. However, delivery of phosphorus and nitrogen to rivers and streams must be addressed as a statewide issue in Minnesota's NPSMPP. The recognition that eutrophication occurs in our riverine systems as well as our lake environments is central to management of the biotic health and uses of our river systems. Many of the rivers and streams eutrophically impacted in Minnesota are phosphorus limited while others differ at different times between nitrogen and phosphorus. Downstream estuary impacts, such as hypoxia, are more related to nitrogen. Measurable attributes are color, temperature, DO, suspended sediment, total phosphorus, orthophosphorus, ammonia, nitrate nitrogen.

Healthy Biological Communities

As river management is better informed by river science, we recognize that, "the most direct and effective measure of a water body's integrity, and of its place in the water cycle, is the status of life in the water. Living communities reflect watershed conditions better than any chemical or physical measure because they respond to the entire range of biogeochemical factors in the environment.

Goal Setting

Proper goal setting at the watershed level starts with information gathering about the resource, identification of problems and opportunities, and identification of potential tools. Tools must be analyzed to determine which are appropriate, and then selected and applied. Applications must be evaluated for performance. This process of collection, review, application and evaluation includes political and social action. It is the agenda that brings together resource managers, users and citizens of the watershed. The list of issues given above must be defined and prioritized by the decision-makers involved in watershed management and land use management.

Infrastructure Support

This foundation goal encourages development of a proper supporting structure for government and citizen NPS programs. This structure should incorporate several elements, including: development of a comprehensive planning structure that supports using a watershed and ecological approach to stream management; information programs targeted for decision-makers and elected officials about how to incorporate watershed-based goals in projects and planning; and an effective structure of citizen based organizations to assure participation in the decision-making and in implementation, such as through volunteer monitoring. This step also requires development of financial and material resources to support these tasks.

Research, Education and Demonstration

This foundation goal encourages development of comprehensive research and education activities for NPS pollution management. The educational component includes the research needs, educational materials, training and demonstrations necessary to identify and promote effective changes in cultural and operational practices for the terrestrial, riparian and channel zones of the basin.

Successful NPS pollution management is the result of good science and stakeholder-based decision-making. A solid research, education and demonstration program for the state is the critical link between science and stakeholders.

Development of this step will assure that Minnesota can manage the hydraulic, chemical and biological functions of our streams and rivers.

Strategy 4.3 Rivers and Streams

Needs, Priorities, and Milestones, Action Plan

The action plan provided below summarizes the goals and milestones identified in the preceding sections. Many of the milestones listed below, as well as the implementation of specific projects, are contingent upon adequate funding and local involvement.

Goal 1: Promote a Healthy Hydrological Regime for Minnesota's Streams and Rivers

Milestones (Action Steps)	13	14	15	16	17	Funding Source(s)	Lead Agency(ies)
1. Promote a basic understanding of channel evolution, hydrology and available tools to use when making decision at the Local Governmental Unit (LGU) level and certain levels of land management. Emphasize the connection between downstream effects and significantly increased hydrographs or shortening the return frequency of the event.	X	X	X	X	X	319 funds	MDNR, MPCA, NRCS, U of M
2. Develop/adopt a methodology for assessing hydrologic "health" for rivers, including hydraulic geometry regional curves, and an index of physical integrity (IPI).	X	X	X	X	X	319 funds, LCCMR	MPCA, MDNR, NRCS, USGS, U of M
3. Assess Minnesota's major river systems to identify rivers unaltered and free-flowing and systems where the hydrologic has been disrupted.	X	X	X	X	X	319 funds	MPCA, USGS
4. Identify causes of disruption to hydrologic regimes and determine which problems should be fixed first.	X	X	X	X	X	319 funds	USGS, MDNR, MPCA, U of M

Goal 2: Promote Healthy Sediment Regime for Minnesota's Streams and Rivers

Milestones (Action Steps)	13	14	15	16	17	Funding Source(s)	Lead Agency(ies)
1. Promote stream restoration projects that restore connectivity between rivers and their flood plains. Remove artificial in-channel barriers (obsolete dams, etc.).	X	X	X	X	X	319 funds	MPCA, MDNR, Watershed District (WD)
2. Promote full funding for the Conservation Reserve Program and other programs that can provide mechanisms for restoring overland runoff.	X	X	X	X	X	319 funds	MPCA, MDNR, BWSR
3. Encourage the implementation of appropriate stormwater management practices by local units of government not regulated under the NPDES stormwater programs by following the Minnesota Stormwater Manual or similar guidance and develop new approaches for stormwater management.		X	X	X	X	319 funds	USEPA, MPCA

Milestones (Action Steps)	13	14	15	16	17	Funding Source(s)	Lead Agency(ies)
4. Promote BMPs in upland areas which enhance water storage/hydrograph characteristics (e.g.) controlled drainage, conservation tillage, surface tile intake alternatives).	X	X	X	X	X	319 funds EQIP	MPCA, BWSR, MDA, NRCS
5. Through an interagency work group, develop training materials and provide training to policy makers, local governmental officials, etc. on incorporating hydrologic principles into local and state decision making.		X	X	X	X	319 fund EQIP	BWSR, MPCA, MDA, MDNR, NRCS
6. Develop an approach to prioritize rivers for restoration at the state and major watershed level.		X	X	X	X	319 funds	MPCA, MDNR
7. Develop/adopt a methodology for assessing sediment "health" for rivers. This milestone will be worked on through the cooperation and coordination of the lead agencies. It is expected that individual tools and approaches will be consolidated with additional research to provide a more robust assessment of river sediment condition.	X	X	X	X	X	319 funds	MPCA, MDNR, NRCS, USGS, U of M
8. Identify rivers with excessive sediment budgets (loads) using the methodology developed in the previous milestone.	X	X	X	X	X	319 funds	USGS, MPCA
9. Establish sediment TMDLs for impaired rivers.		X	X	X	X	319 funds CWLA funds	MPCA
10. Identify and categorize causes of excessive sediment in affected rivers.	X	X	X	X	X	319 funds EQIP	NRCS, MPCA, U of M
11. Develop an interagency program to assess/control streambank erosion and gulley erosion.	X	X	X	X	X	319 funds EQIP	MPCA, MDNR, BWSR, MDA, NRCS
12. Promote Conservation Reserve Enhancement Program (CREP) and Conservation Reserve Program (CRP) and similar programs.	X	X	X	X	X	319 funds EQIP	BWSR, MDNR, MPCA, MDA, FSA
13. Promote conservation tillage on steeper landscapes and in vulnerable agroecoregions.	X	X	X	X	X	319 funds EQIP	NRCS, SWCD, U of M, MDA
14. Promote conversion of tile intakes to blind inlets.	X	X	X	X	X	319 funds EQIP	NRCS, SWCD U of M, MDA, MPCA
15. Target the use of USDA and similar programs in priority management zones as identified in major watershed restoration and protection WRAP strategies according to available resources.	X	X	X	X	X	319 funds EQIP	MPCA, NRCS
16a. Assemble inter-agency committee to study and report the effect and enforcement of mandatory vegetative buffer strips on protected waters (Shoreland Management) and public drainage ditch projects.	X	X				319 funds	MDNR, BWSR, MPCA, MDA, WD's

Milestones (Action Steps)	13	14	15	16	17	Funding Source(s)	Lead Agency(ies)
16b. Utilizing the results of the study and a survey of how buffer strips have been used in other areas, develop recommendations on how they can be improved in Minnesota.		X	X			319 funds	MDNR, BWSR, MPCA, MDA, WD's, LGUs, U of M
16c. Implement recommended changes. (Changes may include enhanced enforcement of existing controls, rule changes or other mechanisms identified by the committee).			X	X	X	319 funds	MDNR, BWSR, MPCA, MDA, WD's, LGUs
17a. Establish multiple small watersheds across Minnesota as Sentinel watersheds to capture both climatic and land use change.	X	X	X	X	X	319 funds, CWF, LCCMR	U of M, MPCA, MDA, BWSR
17b. Implement BMPs and monitor their effectiveness in Sentinel watersheds.	X	X	X	X	X		U of M, MPCA, MDA, BWSR
17c. Construct, calibrate, and validate several models to project water quality change over time.	X	X	X	X	X	319 funds, CWF	U of M, MPCA, MDA, BWSR
18. Provide funding to the University of MN to conduct additional research, and to compile a synthesis of existing research on the effects of surface tile intakes.	X	X	X			319 funds LCCMR	MPCA, USEPA
19. Continue the interagency work group for developing the Agricultural Certification standards.	X	X	X			319 funds	MPCA, MDNR, MDA, BWSR, NRCS
20. Enhance the understanding of sediment sources, by inventorying problems, surveying managers, and monitoring. Develop sediment budgets for select river segments, partitioning sediment by source categories and associated loads.	X	X	X	X	X	319 funds EQIP	NRCS, MPCA, BWSR

Goal 3: Promote Healthy Nutrient Regime for Minnesota's Streams and Rivers

Milestones (Action Steps)	13	14	15	16	17	Funding Source(s)	Lead Agency(ies)
1. Adopt Sentinel Watershed Systems methodology for assessing nutrient regime "Health of a River."	X	X	X	X	X	319 funds	MPCA, UGSG, MDNR, NRCS, U of M
2. Identify rivers with unbalanced nutrient budgets (loads).	X	X	X	X	X	319 funds	MPCA, USGS
3. Identify sources of nutrients in affected rivers.	X	X	X	X	X	319 funds, EQIP	MPCA, MDA, USGS, NRCS
4. Accelerate development of ecoregion specific nutrient standards, and minimum effluent requirements for nutrients.	X	X	X	X		319 funds	MPCA, U of M
5. Develop/promote nutrient management planning tools and BMPs in affected river drainage areas.	X	X	X	X	X	319 funds	MPCA, NRCS, MDA, U of M
6. Target restoration programs.	X	X	X	X	X	319 funds, EQIP	MPCA, NRCS, MDA, SWCDs

Milestones (Action Steps)	13	14	15	16	17	Funding Source(s)	Lead Agency(ies)
7. Provide U of M Extension funding to develop and promote treatment trains of BMPs.	X	X	X	X	X	319 funds, CWF	MPCA, MDA, U of M,BWSR
8. Research and develop varying combinations of bioreactors, wetlands, saturated buffers, oxbow systems and other nutrient treatment technologies.	X	X	X	X	X	319 funds, CWF	MPCA, MDA, U of M,MDNR

Goal 4: Promote Healthy Biological Communities for Minnesota's Streams and Rivers

Milestones (Action Steps)	13	14	15	16	17	Funding Source(s)	Lead Agency(ies)
1. To the extent possible/practical, ensure full funding for MPCA initiatives for refining the Index of Biotic Integrity (IBI) for all river basins of the state, leading to biological criteria for water quality standards.	X	X	X	X	X	USEPA/ State	MPCA
2. Identify rivers with most unhealthy biological communities using IBI.	X	X	X	X	X	319 funds	MPCA, MDNR
3. Develop assessment protocols and a manual for restoring healthy biological communities in each river basin.	X	X	X	X	X	319 funds	MPCA, MDNR, USGS, U of M
4. Target restoration programs.	X	X	X	X	X	319 funds Farm Bill	BWSR, MDA, MPCA, USDA
5. Develop effectiveness monitoring at restored stream reaches to capture biotic response and water quality change.	X	X	X	X	X	319 funds, CWF	MPCA, U of M

Goal 5: Promote Wise Goal-Setting for Citizens and Government

Milestones (Action Steps)	13	14	15	16	17	Funding Source(s)	Lead Agency(ies)
1. Establish an interagency task force to work with the Governor's office to provide NPS guidance to the Farm Bill and other major policy initiatives.	X	X	X	X	X	319 funds	MPCA, MDNR, MDA, BWSR, NRCS, USGS, USFWS, FSA
2. Establish interagency tracking system linking implementation programs and funding to reductions in pollutant loads.	X	X	X	X		319 funds	BWSR, NRCS, MPCA, MDA
3. Develop review committees to oversee targeting and implementation strategies for all Clean Water Partnership projects.	X	X	X	X	X	319 funds	MPCA
4. Encourage incentives to incorporate river friendly practices in zoning ordinances, county local water plans, watershed district plans and ditch projects.	X	X	X	X	X	319 funds	MDNR, BWSR, LGUs, WDs, MPCA, U of M - Extension

Milestones (Action Steps)	13	14	15	16	17	Funding Source(s)	Lead Agency(ies)
5. Use MPCA Major Watershed plans to identify river friendly practices for each drainage basin.	X	X	X	X	X	319 funds	MPCA
6. Use comprehensive plans, watershed district plans and Local Water Planning to implement the goals and objectives of this plan.	X	X	X	X	X	319 funds	MPCA, BWSR, MDNR, WDs,
7. Research and develop tools and techniques for engaging landowners in priority management zones.	X	X	X	X	X	319 funds, CWF	U of M, MPCA, BWSR
8. Research and develop decision support tools to guide priority implementation.	X	X	X	X	X	319 funds, CWF	U of M,MDA, BWSR, MPCA

Goal 6: Support Infrastructure for NPS Pollution Management that is Holistic, Comprehensive and Watershed-Based, and Provides Access to Decision - Making for all Residents and Users

Milestones (Action Steps)	13	14	15	16	17	Funding Source(s)	Lead Agency(ies
1. Based on Sentinel Watershed knowledge, develop an instruction manual on procedures for targeting restoration efforts to most vulnerable locations in a watershed.	X	X	X	X	X	319 funds, EQIP	MPCA, U of M, NRC
2. State agencies work together, with constituents and the Governor's office to provide effective input for drafting of the Farm Bill.			X	X	X	319 funds	MPCA, MDNR, BWSR, MDA, Governor's Office

Goal 7: Research, Demonstration and Education that Encourages Understanding of Origin and Remedy for NPS Pollution Problems

Milestone (Action Steps)	13	14	15	16	17	Funding Source(s)	Lead Agency(ies)
1. Develop instruction manual to identify most appropriate BMPs by Major Watershed, ecoregion, and agroecoregion.	X	X	X	X	X	319 funds	MDA, MPCA
2. Develop case studies on downstream impacts of NPS pollution (Lake Pepin, Gulf of Mexico, etc).	X	X	X	X	X	319 funds	MPCA, U of M, MDA, NRCS
3. Establish paired watershed demonstration projects to illustrate impacts of BMPs on water quality and crop productivity.	X	X	X	X	X	319 funds	MDA, U of M, MPCA
4. Study and begin development of ecologically based water quality standards; including phosphorus in rivers and the bioavailability of particulates.	X	X	X	X	X	319 funds	MPCA, U of M
5. Conduct watershed modeling studies to assist in targeting restoration efforts, evaluation of policy, and development of TMDLs.	X	X	X	X	X	319 funds, EQIP, CWLA funds	NRCS, U of M, MPCA, USGS

Milestone (Action Steps)	13	14	15	16	17	Funding Source(s)	Lead Agency(ies)
6. Study potential for denitrification of tile drain effluent nitrate in tile lines, ditches and wetlands.	X	X	X	X	X	319 funds CIG	MPCA, U of M, NRCS
7. Study the current relationship between cumulative drainage practices and downstream channel stability.	X	X	X	X	X	319 funds	U of M, NRCS, MPCA, USGS, MDNR
8. Study alternative drainage ditch designs to develop designs that will increase channel stability, maintain drainage capacity, provide nutrient control, and improve ecological condition of ditches.	X	X	X	X	X	319 funds	U of M
9. Study alternative tile drainage management systems to develop and promote temporary water storage for downstream hydrologic and nutrient impacts and provide adequate drainage for agricultural production.	X	X	X	X	X	319 funds	U of M
10. Evaluate assignment of a point source definition for surface tile intakes as part of the state water quality rule.				X	X	319 funds	MPCA
11. Study sediment in streams and rivers to determine the contribution of sediment and nutrients from field and non-field sources.	X	X	X	X	X	319 funds	MPCA, U of M, MDA, NRCS
12. Evaluate BMPs for the control of gully and bluff erosion and for reducing the amount of sediment and nutrients from these sources.	X	X	X	X	X	319 funds	MPCA, U of M, MDA, NRCS
13. Assess urban/suburban channel stability in association with BMP implementation to protect water quality.	X	X	X	X	X	319 funds	MPCA
14. Research and develop urban runoff capture and focused recharge BMPs in riparian corridors to augment base flow in streams and other minimum impact designs for urban areas.	X	X	X	X	X	319 funds, CWF	MPCA, U of M

Chapter 4. Overall Strategy for Each Water Resource

Chapter 4.4 Wetlands Strategy

Authorship

Authorship of this strategy benefited from input from several members of the Interagency Wetland Group (IWG). Since the early 1990s the Minnesota Interagency Wetland Group (IWG) has been an effective ad hoc wetland policy and coordination review forum, principally among state and federal agency partners. As with past versions of the Nonpoint Source Management Program Plan (NPSMPP) Wetland Strategy input into the content of this section was provided by several IWG members. The Wetland Strategy benefited greatly from prior statewide and regional wetland planning efforts, including:

Minnesota Wetland Program Plan (2012) http://www.bwsr.state.mn.us/wetlands/wq-bwm062512_090412.pdf

Minnesota Wetland Conservation Plan 1.02 (1997) http://files.dnr.state.mn.us/eco/wetlands/wetland.pdf

Red River Valley (RRV) Flood Damage Reduction Mediation Agreement (1998) http://www.rrwmb.org/html/info.cfm?ID=10#mediation

Minnesota Wetland Assessment, Monitoring, and Mapping Strategy (Gernes and Norris 2006) http://files.dnr.state.mn.us/eco/wetlands/wetland_monitoring.pdf

Great Lakes; Lakewide Management Plans (2008) http://www.great-lakes.net/lakes/ref/lamps.html

Wetlands Restoration Strategy (BWSR 2009) http://www.bwsr.state.mn.us/wetlands/Restoration_Strategy.pdf

Minnesota Wetland Mitigation Inventory and Assessment Report (Barr 2009) http://www.bwsr.state.mn.us/wetlands/wca/NE_mitigation.html.

Revision and oversight of this wetland strategy was coordinated by Minnesota Pollution Control Agency (MPCA) staff.

Introduction

Since the beginning of statehood in 1858, Minnesota wetlands have been a resource in transition. Across Minnesota the wetland resource varies greatly in extent, complexity and history. Consequently the state faces different regional challenges with respect to wetlands. For example in northeastern Minnesota, 80 percent or greater of the historic wetlands are present today and thus protection or at least wise management is the primary need. In the Red River Valley (RRV) of northwestern Minnesota, where greater than 50 percent of the historical wetlands have been developed or drained, the major concern is reducing the frequency and effects from floods http://files.dnr.state.mn.us/aboutdnr/reports/redriver_nrefforts_pdf4.pdf. In southern Minnesota, greater than 50 percent and often significantly more of the historic wetlands have been drained, or developed. In this region, the need for targeted restoration of wetland and upland habitat complexes are tied to water quality improvements and wildlife habitat.

Minnesota's wetland landscape will continue to change. Directing the types of wetland changes and how they occur into the future is an important reason for including a separate wetland strategy in this NPSMPP Strategy. Several effective wetland protection, maintenance and restoration (conservation) programs already exist in Minnesota, and are consistent with the U.S. Environmental Protection Agency (USEPA) Core Elements Framework of an effective wetland program. Many of these programs are central to Minnesota's ongoing efforts to protect wetlands and they are anticipated to continue, to the extent allowed by available resources. On the other hand, budget issues are anticipated to be an important consideration for new or expanding wetland conservation efforts for the foreseeable future. Consequently, Minnesota intends to improve on the efficiency and effectiveness of existing wetland programs, particularly related to maximizing the benefits of wetland restoration and protection efforts.

Changes in public policy toward wetlands began in the 1950s and were slow to take hold, but in the last 20 years significant advances have been made toward conserving the remaining wetland resources in Minnesota's landscape. Most notable are the Minnesota Wetland Conservation Act (WCA) of 1991, implementation of section 404 within the Federal Water Pollution Control Act (Clean Water Act) and the Food Security Act of 1985 and subsequent "Farm Bill" reauthorizations. The WCA and Section 404 programs strive to achieve a no-net-loss of wetland acreage through a regulatory sequencing process to first avoid and then minimize the loss of wetland areas, and if that is not possible then to mitigate the losses by restoring or creating wetlands with similar functions and values, generally within the same county or watershed. Since the focus of the Section 319 Nonpoint Management Program is on non-regulatory action items support for direct regulatory items associated with WCA and Section 404 are not included in this strategy.

Minnesota's Wetland Strategy - Goal/Vision -

> *To achieve no net loss and increase the quantity, quality and biological diversity of Minnesota's wetlands by continuing effective wetland protection and conservation program implementation while emphasizing regional strategic restoration, protection and enhancement of wetland functions.*

To achieve this vision the following goals are set forth for this chapter of the 2013-2017 Minnesota Nonpoint Source Management Program Plan:

1. Effective Monitoring and Assessment of Wetlands at the State and Local Level – the NPSMPP supports efforts to identify the quality and integrity of wetlands and provide status and trends of wetland condition. This goal strives toward improved estimates of wetland functional capacity.
2. Enhance Local Government Wetland Management and Protection – the NPSMPP supports efforts to inform and sensitize land use decision-makers concerning the needs and practices to protect wetlands and assure their chemical, biological and hydrological integrity are maintained in addition to the physical quantity of wetlands.
3. Strengthen Wetland Restoration and Protection – the NPSMPP seeks to leverage federal farm bill and related programs with state and local funding initiatives.
4. Improve Wetland Landscape Data, Research and Education – the NPSMPP intends to work toward enabling better linkages between applied scientific studies and wetland management decisions.

Needs, Priorities and Milestones, Action Plan

Many of the milestones listed below, as well as the implementation of specific projects, are contingent upon adequate funding and appropriate partnerships.

Goal 1: Effective Monitoring and Assessment of Wetlands at the State and Local Level

Milestones (Action Steps)	13	14	15	16	17	Funding Source(s)	Lead Agency(ies)
1. Research level I assessment methods which use remote sensing and/data GIS to assess wetland quality			X	X	X	319; various other sources	Acad. Inst. MPCA, MDNR
2. Expand the Wetland Health Evaluation Program (WHEP) beyond Hennepin and Dakota Counties		X	X	X	X	319; various other sources	LGU's, MPCA
3. Improve MnRAM or other wetland functional assessment methods to better meet program needs including training			X	X	X	319; various other sources	MDNR, MPCA, BWSR, COE
4. Implement wetland monitoring protocols for Flood Damage Reduction (FDR) projects to assess wetland integrity and /or functional capacity associated with FDR	X	X	X	X	X	319; various other sources	MDNR, MPCA

Goal 2: Enhance Local Government Wetland Management and Protection Efforts

Milestones (Action Steps)	13	14	15	16	17	Funding Source(s)	Lead Agency(ies)
1. Fund LGUs to develop local wetland management plans which designate priority existing and potentially restorable wetlands.		X	X	X	X	319; various other sources	BWSR, USDA, COE
2. Work with LGUs to develop incentive programs to discourage land use activities within wetland buffer (fringe) areas that would negatively impact wetlands.	X	X	X	X	X	319; various other sources	BWSR, Met Council, MDNR, NRCS
3. Work with LGUs and other partners to install conservation drainage systems to benefit wetlands and other downstream waters.	X	X	X	X	X	319; various other sources	BWSR, MDA, MPCA
4. Prioritize and install BMPs, including enhanced or improved nutrient management as well as related conservation practices that benefit wetlands and downstream waters.		X	X	X	X	319; various other sources	MDA, BWSR, MPCA,
5. Support sustainable forestry management practices in forested wetlands.	X	X	X	X	X	319; various other sources	MDNR, BWSR

Goal 3: Strengthen Wetland Restoration and Protection

Milestones (Action Steps)	13	14	15	16	17	Funding Source(s)	Lead Agency(ies)
1. Develop and implement an Integrated Wetland Program Accounting geo-database to capture and manage wetland restoration data.		X	X	X	X	319; various other sources	BWSR, USFWS, MDNR, MPCA
2. Develop and apply a decision framework to prioritize wetland restorations to maximize watershed water quality outcomes.	X	X	X	X	X	319; various other sources	USFWS, MPCA, MDA, BWSR, Acad. Inst.
3. Amplify state and/or federal land preservation easements or contracts within impaired watersheds by increasing financial incentives for wetland management or restoration.	X	X	X	X	X	319; various other sources	MPCA, BWSR
4. Develop guidelines and apply a decision framework to prioritize and fund the installation of barriers to passage of undesirable fish into wetlands via artificial drainage network connections.	X	X	X	X	X	319; various other sources	MDNR, BWSR, MDA, MPCA, Acad. Inst.
5. Improve guidelines and criteria, including vegetative coverage, hydrology and diversity to evaluate wetland restoration success.	X	X	X	X	X	319; various other sources	BWSR, MnDOT, MDNR, COE
6. Develop and apply decision frameworks or other tools to assist local water resource managers to prioritize large and small scale water storage and retention projects to reduce downstream impacts to wetlands and waterways.	X	X	X	X	X	319; various other sources	MDNR, BWSR, MDA, MPCA, LGUs, Acad. Inst.

Goal 4: Improve Wetland Landscape Data, Research and Education

Milestones (Action Steps)	13	14	15	16	17	Funding Source(s)	Lead Agency(ies)
1. Complete updating of Minnesota's National Wetland Inventory	X	X	X	X	X	319; various other sources	MDNR, BWSR, MPCA, USFWS
2. Develop dose response relationships of wetland taxa to pollutants or other stressors.		X	X	X	X	319; various other sources	MPCA, MDNR, Acad. Inst.
3. Research restoration of wetlands on mine tailing sites, abandoned gravel pits and peat mined locations.	X	X	X	X	X	319; various other sources	BWSR, MDNR, Acad. Inst. MnDOT
4. Research techniques for control or treatment of wetland invasive plants and/or exotic species including undesirable fish.		X	X	X	X	319; various other sources	MDNR, MnDOT, BWSR, Acad. Inst.

Milestones (Action Steps)	13	14	15	16	17	Funding Source(s)	Lead Agency(ies)
5. Research the social and economic benefits and costs of restoring and maintaining wetlands	X	X	X	X	X	319; various other sources	MPCA, BWSR Acad. Inst. MDNR
6. In an improved agricultural economy, with high land and commodity prices, target tax or other incentives to effectively change decisions which would be detrimental to wetland quality and/or downstream water quality.	X	X	X	X	X	319; various other sources	Acad. Inst.
7. Evaluate the needs and impacts of wetland biomass harvesting in marshes and shrub-carrs.		X	X	X	X	319; various other sources	MDNR, Acad. Inst. MPCA
8. Research conservation drainage systems and related practices to benefit wetlands and other downstream waters.	X	X	X	X	X	319; various other sources	MDA BWSR Acad. Inst.

Chapter 5 Monitoring

"Minnesota's Water Quality Monitoring Strategy 2011 to 2021" was completed in September 2011 and submitted to the U.S. Environmental Protection Agency (USEPA) Region V. The Strategy is organized into three main sections that discuss overall goals and objectives for water monitoring, surface water monitoring, and groundwater monitoring. The Strategy is available at: http://www.pca.state.mn.us/index.php/water/water-monitoring-and-reporting/water-quality-and-pollutants/minnesotas-water-quality-monitoring-strategy.html.

The Strategy references the previous 2008 version of this Plan on page 10, presenting its broad monitoring goals. These goals are general, and remain relevant and important to work toward achieving. They are listed immediately below as items to be considered for funding. Additional action steps follow in the subsequent table providing more specificity regarding particular monitoring program development items that may be addressed as resources allow.

Needs, Priorities and Milestones Action Plan

The action plan provided below summarizes the goals and milestones for this planning period. Many of the milestones listed below, as well as the implementation of specific projects, are contingent upon adequate funding and local involvement.

Goal 1: Develop baseline data necessary to allow establishment of good status and trend information relative to surface water and groundwater at the state/regional level.

Milestones (Action Steps)	13	14	155	166	17	Funding Source(s)	Lead Agency(ies)
1. Augment the statewide groundwater level network.	X	X	X	X	X	CWF, 319	MDNR
2. Continue to monitor contaminants of new concern utilizing national surface water surveys and the ambient groundwater network. Modify monitoring approach as determined appropriate as knowledge and understanding improve.	X	X	X	X	X	CWF, 319, USEPA, USEPA 106	MPCA, MDA, MCES
3. Pilot large river intensive monitoring, and implement in state's large rivers.	X	X	X	X	X	CWF, 319, USEPA 106	MPCA
4. Integrate wetland monitoring into the intensive watershed monitoring framework.	X	X	X	X	X	CWF, 319, USEPA 106	MPCA
5. Continue to implement and develop the Sentinel Lakes program, with expansion into a Sentinel Watersheds program.	X	X	X	X	X	CWF, 319, USEPA 106	MDNR, MPCA, MDA

Goal 2: Establish reference conditions, criteria or standards for those water body types or types of measurement for which such references do not currently exist.

Milestones (Action Steps)	13	14	15	16	17	Funding Source(s)	Lead Agency(ies)
1. Continue development of and pilot Lake IBI using fish and plant indicators.	X	X	X	X		CWF, 319, USEPA 106	MPCA, MDNR
2. Explore with USEPA the possibility of developing lake recreational suitability criteria based on pathogens.	X	X				319, USEPA 106	MPCA, MDH
3. Establish nutrient criteria/standards for streams.	X	X	X			319, USEPA 106	MPCA
4. Explore with USEPA the possibility of developing additional drinking water indicators for surface waters.	X	X	X	X	X	319, USEPA 106, SDWA	MPCA, MDH
5. Complete development of and implement a tiered aquatic life use framework.	X	X	X	X	X	CWF, 319, USEPA 106	MPCA

Goal 3: NPS 3. Improve monitoring designed to characterize nonpoint source (NPS) contributions to water quality problems.

Milestones (Action Steps)	13	14	15	16	17	Funding Source(s)	Lead Agency(ies)
1. Expand current major watershed outlet load monitoring network to the subwatershed level, adding about 1-3 permanent sites per Watershed. Supplement with short-term monitoring as needed and possible	X	X	X			CWF	MPCA, MDNR, MCES

Goal 4: Promote effective use of BMPs through assessing the improvement in water quality relative to specific NPS reduction actions.

Milestones (Action Steps)	13	14	15	16	17	Funding Source(s)	Lead Agency(ies)
1. Support stormwater monitoring efforts to quantify NPS stormwater impacts and BMP effectiveness.	X	X	X	X	X	CWF	MPCA, MDNR, MCES

Goal 5: Design monitoring programs to meet management information needs concerning identified geographic areas or issues of concern, then use information obtained for resource management decision-making.

Milestones (Action Steps)	13	14	15	16	17	Funding Source(s)	Lead Agency(ies)
1. Support fluvial geomorphology and hydrologic alteration monitoring efforts to quantify NPS impacts and BMP effectiveness.	X	X	X	X	X	CWF, 319	MPCA,MDNR, MDA

Goal 6: Improve communication linkages both between state and local resource managers, as well as among the various local, state and federal agencies within the state for purposes of expanding the water quality monitoring database and enhancing accessibility to it.

Milestones (Action Steps)	13	14	15	16	17	Funding Source(s)	Lead Agency(ies)
1. Continue development and implementation of the MPCA Watershed Data Integration Project (WDIP) to provide better access to data and information; http://www.pca.state.mn.us/index.php/water/water-types-and-programs/surface-water/watershed-approach/watershed-data-integration-project.html.	X	X	X	X	X	CWF, 319	MPCA
2. Begin development of multiagency Minnesota Water Data Portal	X	X	X	X	X	CWF, 319, USEPA 106	MPCA, MDNR, MDA, MDH, MCES, BWSR
3. Connect sate data integration efforts to the USEPA/USGS National Water Quality; http://www.waterqualitydata.us/	X	X	X	X	X	CWF, 319, USEPA 106	MPCA;
4. Develop and begin implementation of a communications plan for water monitoring data and information	X	X	X	X	X	CWF, 319, USEPA 106	MPCA

Chapter 6 Information and Education

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Highlights

Five major information and education (I&E) goals are set for this Nonpoint Source Management Program Plan (NSMPP) to address nonpoint-source (NPS) water pollution. They are:

1. build and improve capacity to deliver NPS-related I&E at state and local level
2. raise awareness of the general public about the nature of NPS pollution, how communities and individuals contribute to it, and what governmental organizations and individuals are doing about it
3. foster coordination and cooperation between governmental agencies and private, nonprofit and other organizations to carry out information and education efforts
4. include NPS I&E in formal and informal educational curricula
5. effectively measure impact of NPS I&E activities

Introduction

Investment in education must be considered an essential and integral part of every step in the NSMPP. Education cannot be a viewed as a minor component of the NSMPP, but one of the many steps that must be taken to meet the management plan's goals. In almost every other chapter of this management plan, education is recognized as an important means for effecting change with respect to NPS water pollution problems.

As Minnesota's clean water program continues moving to a watershed approach with a commitment to identify and address remaining water-quality problems, good information about the condition of waters and the health of aquatic systems on a watershed scale is absolutely critical. Unlike when previous versions of this plan were prepared, Minnesota is now very much in the business of conducting Total Maximum Daily Loads (TMDLs) on impaired waters. The Clean Water Act's impaired waters provisions call for taking measures to mitigate NPS pollution, but neither state nor federal agencies have the authority to regulate much of the activity that causes such pollution. Many of the needed mitigation measures will consist of education and pollution reduction incentives. This makes it all the more important to have in place sound I&E approaches and strategies for NPS issues.

Chapter 6 Information and Education

Needs, Priorities and Milestones, Action Plan

The action plan provided below summarizes the goals and milestones identified in the preceding sections. Many of the milestones listed below, as well as the implementation of specific projects, are contingent upon adequate funding and local involvement.

Goal 1: Build and Improve capacity to deliver NPS-related information and education at state and local levels.

Milestones (Action Steps)	13	14	15	16	17	Funding Source(s)	Lead Agency(ies)
1. Encourage and develop more involvement of outreach and educational specialists, staff of state agencies on NPS issues.	X	X	X	X	X	319	MPCA, BWSR, MDNR, MDA
2. Provide information to include in newsletters of local water planners and watershed managers to share information about Best Management Practices (BMPs) that have been used successfully in Minnesota.	X	X	X	X	X	BWSR and 319	BWSR and UMES
3. Initiate, develop and implement education programs on NPS officials for municipal officials.	X	X	X	X	X	319 and USDA Extension Water Quality	UMES and MPCA
4. Sponsor and/or support regional and statewide conferences that are about or have tracks on NPS I&E.	X	X	X	X	X	Many	MPCA, WDNR, IDNR, NRCS-USDA, USDA-ARS-MSA, UMES, MDA, MDNR and USEPA Region 5
5. Provide training support to local water planners and NPS educators.	X	X	X	X	X	319, BWSR grants, and UMES grants	BWSR and UMES
6. Provide information and materials support to local water planners and NPS educators.	X	X	X	X	X	319, BWSR grants, and UMES grants	UMES, MPCA and BWSR
7. Provide educational program support on NPS educational issues of regional importance.	X	X	X	X	X	319, BWSR grants, and UMES grants	All
8. Assist local water planners in review, assessment, and improvement of NPS educational plans.	X	X	X	X	X	BWSR County Local Water Planning Grants	BWSR and UMES

Goal 2: Raise awareness of the general public about the nature of NPS pollution, how communities and individuals contribute to it, and what governmental organizations and individuals are doing about it.

Milestones (Action Steps)	13	14	15	16	17	Funding Source(s)	Lead Agency(ies)
1. Develop and coordinate multi-agency media campaigns designed to raise awareness of and change behavior on NPS issues.	X	X	X	X	X	319	MPCA and UMES
2. Develop and share print and multimedia resources for I&E on NPS issues.	X	X	X	X	X	319	MPCA and UMES
3. Improve utilization of involved agencies' public information offices as a mechanism for disseminating NPS news items.	X	X	X	X	X	319	MPCA, BWSR, MDNR, MDA

Goal 3: Foster Coordination and Cooperation between Governmental Agencies and Private, Nonprofit and other Organizations to Carry out Information and Education Efforts.

Milestones (Action Steps)	13	14	15	16	17	Funding Source(s)	Lead Agency(ies)
1. Identify and publicize lessons learned from 319- and Clean Water Partnership (CWP) - funded demonstration projects through Web sites, newsletters, and print media articles.	X	X	X	X	X	319	UMES and MPCA
2. Ensure that educational efforts within this overall NPS I&E strategy are implemented and reported back to the Project Coordination Team.	X	X	X	X	X	319	MPCA and UMES
3. Foster the sharing of available resource materials by expanding new and existing Web sites and clearinghouses to include materials for broad audiences.	X	X	X	X	X	319	MPCA and UMES
4. Support the work of regional water quality teams to implement I&E efforts for NPS issues.	X	X	X	X	X	319 and Metro Council Water Quality Initiative Grants	Watershed Partners, UMES and MPCA
5. Support technical forums where professionals can exchange information and gain information on NPS pollution issues.	X	X	X	X	X	319 and UMES Funding	MPCA and UMES

Goal 4: Include NPS and in Formal and Informal Educational Curricula.

Milestones (Action Steps)	13	14	15	16	17	Funding Source(s)	Lead Agency(ies)
1. Assess existing classroom (formal) science curricula and state standards related to NPS.	X	X	X	X	X	USDA Extension Water Quality Grants, Extension Director's Grants, 319	Dept. of Education
2. Assess existing non-formal curricula and educational efforts related to NPS (e.g. Project (WET), MinnAqua, etc.).	X					USDA Extension Water Quality Grants, Extension Director Grants, 319	MDNR, UMES, MDA
3. Increase and improve/enhance the number of NPS educational messages in adult/continuing professional education programs.	X	X				USEPA education grants, 319	UMES
4. Pilot use of new and emerging delivery methods/technologies to reach targeted audiences.	X	X					MPCA (TEA Division)

Goal 5: Effectively Measure Impact of NPS and Activities

Milestones (Action Steps)	13	14	15	16	17	Funding Source(s)	Lead Agency(ies)
1. Utilize existing surveys (e.g. state, Met Council) to measure changes in attitudes and behavior as a result of NPS I&E.	X	X	X	X	X	319	MPCA and UMES
2. Develop and institute a standardized format or tool to measure outcomes and impacts of NPS-related I&E efforts.	X	X				319 and CWP	MPCA
3. Increase use of social indicators as measures of effectiveness.	X	X	X	X	X	319 and CWP	MPCA, UM
4. Compile and report on use of social indicators to assess outcomes from 319-funded projects.	X	X	X	X	X	319	MPCA, UM
5. Pull together other data sources reflecting behavioral changes of Minnesotans with respect to NPS pollution.	X	X	X	X	X	319	MPCA and UMES

Chapter 7 Feedlots

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Introduction

Description of Current Issues in Minnesota

The animal production industry is an important component of Minnesota's economy. Farm marketing cash receipts for livestock were $4.93 billion in 2004, representing 50 percent of total agricultural sales. Total farm cash receipts were $9.79 billion (Minnesota Agricultural Statistics 2005). The full economic impact of Minnesota's livestock production exceeds $10.7 billion when indirect and induced inputs are considered (MDA IMPLAN analysis, 2004).

Table 7.1: Minnesota's Rank among States - Livestock, Dairy, and Poultry Production - (from "Minnesota Agriculture Statistics 2005," Minnesota Agricultural Statistics Service)

Type of Production	Rank Nationally
Turkeys raised, 2004	1nd
Hogs Marketed, 2004	3rd
Total Cheese Produced, 2004	5th
Milk Production, 2004	6th
Red Meat Production, 2004	6th
All Chickens, December 2004	10th
Eggs Produced, 2002-2004	11th
Cattle/calves on Feed, January 1, 2002	11th

In a series of University of Minnesota (U of M) papers focusing on the importance of Minnesota' livestock industry, U of M economists determined that the poultry, dairy, and pork industries alone support 108,000 jobs in the state in production, processing, supply, distribution, and retailing (1996-1997 data). The same studies attribute $4.3 billion in total income for those three industries (G. W. Morse and W. Lazarus, Dept. Applied Economics, University of Minnesota). Table 7.1 illustrates the rank and importance of Minnesota production nationally.

Despite Minnesota's role as a leader in agricultural production, some producers of farm products face difficult financial challenges. For example, a survey of farm financial records volunteered by participants in the Minnesota State Colleges and Universities' farm business management program and farm business management associations for 1999 was conducted. The farm operations surveyed had cash farm income (including government payments) of $306,474. Net farm income was $48,183, of which all but $7,630 was accounted for by government payments, which are not likely to continue at this level. While this information cannot be generalized because the survey was not a representative sample of Minnesota farmers, it does illustrate the slim profit margins facing some producers. Slim profits tend to make new capital investments (e.g. for pollution abatement systems) very difficult. Therefore, it will be a challenge to provide economical, environmentally sound alternatives to these producers for storing and managing the manure produced by their operations.

Animal manure, when properly used as fertilizer, is a useful resource. It contains valuable nutrients such as nitrogen, phosphorus and potassium. It can improve soil quality, including aggregate stability, infiltration, water holding capacity, aeration, soil organic matter levels, and earthworm activity. However, animal manure improperly stored, handled, disposed of and allowed to leach or run off into surface or ground waters can create serious water pollution hazards. These hazards include excess nitrogen, excess phosphorus, pathogens, and possible antibiotics, hormones, or trace metals. The impacts of this pollution can be felt locally, regionally, or nationally, as in the issue of hypoxia in the Gulf of Mexico. A study prepared by the Minnesota Nitrogen Task Force (funded by the Minnesota State Legislature) has indicated that although Minnesota farmers are generally doing a good job of managing nutrients applied in commercial fertilizers, often inputs of nutrients from other sources such as manure are not credited accurately.

Results from numerous Minnesota Department of Agriculture (MDA) studies conclude that Minnesota producers are generally managing commercial nitrogen inputs successfully in non-legume cropping systems. However, in the areas studied so far, most producers underestimate the nitrogen (N) credits associated with manure and legume inputs. Although the overall N contributions are typically minor in relationship to commercial fertilizer, the lack of proper crediting can result in significant over-applications of commercial fertilizer, particularly when manure is applied to previous legume crops (see Chapter 9 Agricultural Nutrients for additional details on these studies).

Nutrients in manure, while useful on cropland, can promote algae and weed growth in surface waters. Manure and runoff from animal confinement and manure storage areas may also contain (1) substances that deplete oxygen in surface waters, (2) materials, such as ammonia, that in high concentrations can be toxic to aquatic life, and (3) disease-causing organisms.

Ground water concerns include potential human and animal health effects from nitrates and pathogens. Potential pathways for these pollutants to enter ground water include infiltration through cropland soils, leakage from earthen storage basins, access through improperly constructed drinking water wells, and recharge from polluted surface water bodies.

This overview of water quality impacts will primarily address impacts from animal confinement and manure storage facilities. Please refer to the Agricultural Nutrient Management Chapter (Chapter 9) of this document for various water quality impacts of manure management on cropland. Hazards or potential effects of animal confinement and manure storage facilities are discussed in greater detail within this chapter.

Phosphorus

Phosphorus typically does not leach through soils in large quantities. However, phosphorus from animal manure can be a significant pollutant if runoff-containing manure is allowed to enter surface water. Phosphorus is usually the limiting nutrient in lakes. Therefore, if animal manure or feedlot runoff is allowed to enter a lake, it can lead to nuisance weed and algae growth. One pound of phosphorus will produce approximately 500 pounds of weeds or algae growth in a lake.

A 2004 statewide study examining phosphorus sources to waters estimated that feedlot runoff from open lots contributes less than one percent of all phosphorus to waters. However, in certain small watersheds, feedlot runoff can represent a larger fraction of the phosphorus loading. Phosphorus from cropland runoff, including fields with manure application, was found to be a much larger contributor to statewide phosphorus loading. A phosphorus index has been developed for Minnesota to estimate the relative risk of phosphorus transport to waters from various combinations of site conditions and management. See www.mnpi.umn.edu/.

Organic Matter

Animal manure also includes organic materials, which may be used by microorganisms as a food source. If this decomposition occurs in surface waters, these microorganisms can deplete oxygen in the water. The lack of oxygen can kill fish or degrade the water quality to the point that no fish or only less desirable rough fish can survive. Many fish kills are the result of excess organic materials being allowed to enter surface waters. Animal manure and feedlot runoff are relatively concentrated sources of these pollutants.

Pathogens

Animal manure can also include potential pathogens (disease-causing micro-organisms). If carried in either surface or ground water, pathogens can spread disease to other animals, and in some cases to humans. Bacteria can originate in feedlot runoff or land application of manure. Bacteria standards were exceeded in one Total Maximum Daily Load (TMDL) watershed where there were no human sources or feedlot runoff sources, leaving land application of manure, pastures and natural sources as the primary contributors.

Nitrogen

Manure can create ground water pollution if it is improperly stored, is washed off a feedlot into a low area where it seeps into the ground water, or if it is improperly land applied. Ground water nitrogen pollution resulting from animal manure is typically in the form of nitrate nitrogen, but can also be in the form of ammonia nitrogen. Nitrogen in the form of ammonia can also be toxic to aquatic life if manure runs off into surface water.

Other

Other potential contaminants in some manure include antibiotics, hormones, and metals.

Production Facilities

Animal confinement facilities may be grouped into three general types: (1) total confinement, where animals are indoors at all times; (2) partial confinement, where animals are either indoors or in a "lot" open to the air and precipitation at various times; and (3) open lots or pens, where there are no roofed areas.

Animal pastures, in contrast, do not involve confinement. Ideally, animals on pasture are either given sufficient space or regularly rotated so that ground cover is maintained on the pasture. Animals are not allowed continuous access to surface water so that the impact on water bodies is minimized. However, animal-grazing systems, if poorly managed, can lead to water quality problems. These problems typically occur in pastures where animals are allowed continuous access to adjacent streams and lakes, resulting in direct deposit of manure and urine in the water body. This can be minimized through rotational grazing where access to water bodies is limited to brief periods of time.

Manure may be stored in a solid, semi-solid, or liquid form in constructed storage facilities, or stockpiled in solid form on soil. In general, the likelihood of water pollution caused by these facilities increases with proximity to surface waters like lakes, streams or waterways, or in areas with shallow aquifers easily contaminated by seepage of pollutants from the surface. Total confinement facilities, when properly designed and managed, present minimal hazard to surface waters, since all manure is under roof and cannot be carried away in runoff from rain or snowmelt. Partial confinement facilities and open lots have areas where precipitation can come into contact with manure. Runoff may carry manure away to surface waters, or seep into the soil.

Manure is sometimes stored in areas where runoff to surface waters or seepage to ground water may occur. This poses the same types of hazards to water quality as animal confinement areas.

Feedlot Numbers in Minnesota

The Minnesota Pollution Control Agency (MPCA) feedlot registration database developed in 2002 includes 29,818 feedlots. Many (2909) of these feedlots had less than 10 animal units (AU), and nearly 3000 were located outside of shoreland areas and had between 10 and 50 animal units. The registration databased includes 23,912 feedlots which hold at least 50 animal units outside of shoreland, or greater than 10 animal units in shoreland areas. This figure includes beef, dairy, swine, turkeys, chickens, sheep and some horses. An animal unit is a unit of measurement that allows comparison of manure production by different types of livestock or poultry. A 1,000 lb. steer is the equivalent of one animal unit.

The 23,912 figure may slightly under-represent the actual number of feedlots in the state since some feedlots did not register, especially those in counties without county feedlot officers.

Of the 23,912 registered feedlots (>50 AU or >10 AU in shoreland), they fall into the following size categories:

10-50 AU:	16%
50-100 AU:	26%
100-299 AU:	40%
300-499 AU:	7%
500-999 AU:	7%
1000 or more:	4%

The number of feedlots in Minnesota is declining, while total animal numbers remain relatively stable.

Dairies and hog feedlots with less than 300 AU have declined by more than 10 percent per year since 2001 according to Minnesota Agricultural Statistics. A 2003 survey of soil and water conservation districts (SWCD) indicated that about 34 percent of all feedlots are estimated to need additional improvements to comply with the feedlot rules. A 2005 survey of county feedlot officers indicated that roughly 42 percent of feedlots with less than 300 AU need open lot runoff fixes to comply with feedlot rules.

The total cost to bring all feedlots into full compliance with the rules is estimated to exceed 313 million dollars (Minnesota Department of Agriculture, 2004).

Accomplishments and Progress

More feedlot and manure management work has been accomplished during the past five years than during any other five-year period. Substantial progress has been made with education, awareness, research, new tools, regulations, compliance, permitting and more. A summary of key accomplishments made during the past five years are included below.

Agriculture Better Management Practices Loan Program

The MDA loan program supplied about $2 million per year to fix feedlot runoff problems.

Certified Commercial Applicator Program

The (CAWT) program was established and about 360 technicians became certified after passing the test. Several opportunities were provided each year for continuing education.

Construction Guidelines

Several publications were produced and distributed: Siting feedlots in the karst region; Setbacks from open waters and wells; Feedlot planning and operations manual; Liquid manure storage area requirements; Stormwater runoff plans at construction sites, and others.

Consultants

The Technical Service Provider (TSP) program was implemented and training was provided.

County Feedlot Program

Delegated Counties were organized into an association, which has held annual conferences. Other improvements included: quarterly training; increased accountability and documentation of progress; more inspections; newly required annual workplans; and MPCA conducted extensive reviews of 29 county programs.

Dairy Environmental Quality Assurance (EQA) Program

Minnesota Milk Producers developed an EQA guidebook; trained technicians; provided financial assistance for improvements; and worked with the MPCA to evaluate the program.

Database

A feedlot registration database was developed which contains information on nearly 30,000 feedlots.

Dead Animals

Completed and distributed mortality composting guide book and guidelines for developing animal mortality management plans, and trained feedlot officers on mortality management. Concrete bins for dead animal composting are now quite common.

Environmental Assessment Worksheets (EAW)

The process for writing EAWs for feedlot projects was simplified. Policies were reviewed and modifications were made.

Federal Regulation Revisions

Minnesota addressed new federal regulations for Confined Animal Feeding Operations (CAFO) at the state level and a new general permit was written, with much stakeholder involvement/discussion.

Feedlot Water Quality Management Cost-Share

Minnesota state government provided $1.3 to $2 million per year in cost-share grants (up to 75 percent) through SWCDs for feedlot pollution abatement. This averages roughly $20,000 per district. Eligible practices include storage and/or treatment for manure, feedlot runoff, milkhouse waste and silage leachate, as well as roof structures.

Feedlot Inspections

Average inspections per year have approximately doubled, averaging nearly 4000 per year. All CAFOs and other National Pollutant Discharge Elimination System (NPDES) permit holders are inspected, and inspections by county staff greatly increased.

Filter Strips

New research on filter strips was performed by the USGS, and Natural Resources Conservation Service (NRCS) standards and MPCA guidelines were drafted/tested.

Financial Needs Assessment

Minnesota studied costs to fix pollution problems, with reports written in 2002 and 2004.

FLEval Model

The feedlot runoff model was upgraded and made more user friendly. Training on FLEval was conducted at four locations.

Governors Livestock Task Force

This task force developed a series of policy recommendations for the state to consider, including: livestock siting, permit notification, economic development, odor research, and education and outreach.

Karst Area Protection

A karst workgroup met and developed a report to the Legislature. Karst rules have resulted in more attention to careful siting of new feedlots in the karst region.

Land Application of Manure

Developed publications and computer tools. Extensive training for producers and others was held on the topics of: land application rules, sensitive area management, record keeping forms and spreadsheet, manure management plan development (step by step guides and computer programs), and nitrogen and phosphorus management. Additionally a spreadsheet and Access-based programs were developed for use when writing manure management plans. Farmer adoption of manure spreading Best Management Practices (BMPs) and rules was evaluated.

Manure Testing

A manure testing laboratory certification program was developed. Manure testing substantially due to new rules, Environmental Quality Incentive Program (EQIP), better labs, and increased value of manure.

Milkhouse Wastewater Treatment Technologies

Several different technologies for treating milkhouse wastewater were tested and demonstrated.

New Technologies

Anaerobic digesters at dairies were constructed, and training was provided on installation of digesters.

Nonpoint Engineering Assistance Program

Provided approximately one million dollars per year of state funding to SWCD Technical Services Areas for shared engineering assistance involving work on a variety of conservation practices, including feedlot pollution abatement.

NPDES Permitting

Permitted and inspected nearly all Concentrated Animal Feeding Operations (CAFOs) and feedlots over 1000 AU (over 900 sites). Minnesota revised its general permit to fit with new federal permit, drafted forms for completing plans required for permits, developed general fact sheets; forms for emergency response, animal mortality management, etc.

Odor Control

Odor management plan forms and OFFSET model for managing odor (Odor from Feedlot Setback Estimation Tool) were developed. Multiple workshops on OFFSET and odor control were held, and research on odor control progressed.

Open Lot Runoff

A trifold brochure on Open lot agreement (OLA) was written and sent to 20,000 producers. A project initiated to examine low cost runoff filters downslope of feedlots. Nearly 4000 OLAs were signed with many improvements made.

Phosphorus Index (P)

Minnesota developed and tested a P index, provided training on the model, and used the P index on certain high P soils.

Permit Issuance

State and federal permits were issued in a timely manner (to meet state statutes 60 day turn-around time requirement) in over 90 percent of cases.

Rotational Grazing

Substantial technical assistance was provided for rotational grazing and handbooks and grazing plans were written.

Seepage from Basins/Concrete

We evaluated ground water quality around different types of basins and developed a report on the results. Concrete leakage studies were also completed.

Statewide Phosphorus Study

We identified the relative contribution of feedlots in large river basins throughout the state.

Tools for Assisting Producers with Feedlot Rules in General

Minnesota developed the following: feedlot rules at a glance, producer's guide to feedlot rules, and internet decision making tool for producers, fact sheets for each size of operation; directory of feedlot resources and several other publications for aiding producers in understanding the rules.

Tracking Progress

E-link program was developed for tracking progress in practices which lead to environmental improvement.

Training

Over 10,000 people in Minnesota attended feedlot-related training. Audiences included producers, consultants, agencies and people from other organizations.

Winter Feeding of Beef

Guidelines were developed for meeting state rules and minimizing runoff at winter feeding sites.

Emerging/Recent Trends and Developments

Several of the key new developments which may affect the way we approach feedlot pollution issues during the next five years are summarized below.

New CAFO Regulations

In April 2003, new federal regulations for CAFOs went into effect. These regulations increased the number of feedlots required to obtain NPDES permits (from about 550 to over 900 feedlots). Additionally, the general NPDES permit was modified in January 2005 to reflect necessary changes. Winter-time manure spreading by CAFOs is now more restrictive and annual reports are required from all CAFOs.

State Feedlot Rules Implemented

The MPCA Feedlot Rules (Minn. R. ch. 7020) were last revised on October 23, 2000. Major areas of the rule that were changed include:

- a new provision requiring registration of all feedlots over 50 animal units (10 animal units in shoreland)
- inclusion of clear technical standards for feedlots, manure storage, and land application of manure which apply to all facilities (not just those which go through permitting)
- modifications to the permitting process
- strengthened and clarified requirements for delegated county feedlot programs
- a phased-in compliance period for controlling open lot runoff at feedlots less than 300 animal units in size (open lot agreement)
- Manure management plans required for 300+ animal units

Much attention has focused on these rules during the past five years. Numerous education, demonstration and implementation activities have surrounded these rules. More information on the feedlot regulatory program is found at: *www.pca.state.mn.us/hot/feedlots.html*.

Advisory Committee Changes

In 1994, legislation established an advisory group called the Feedlot and Manure Management Advisory Committee (FMMAC). This group, comprised of producer groups, environmental groups and manure experts, has advised MPCA on the technical and policy aspects of its regulatory program. FMMAC also had statutory duties to advise MDA and MPCA on research priorities, and has formed several subcommittees to deal with various issues.

The statutory provisions which established this committee ended in 2003. However, members of FMMAC continued to meet on several occasions in 2003 and 2004 to advise on Minnesota's response to the revised federal regulations.

Feedlot Generic Environmental Impact Statement Completed

Another directive of the state Legislature in 1997 was for the Minnesota Environmental Quality Board to conduct a generic Environmental Impact Statement (GEIS) on Animal Agriculture. This effort was completed in 2002, and several recommendations were made through this process. Additionally, the state gained new insights into the relative contributions of pollution sources. For example, land application of manure was found to be a much more significant contributor of phosphorus than open lot runoff. This same conclusion was verified during a statewide phosphorus study. The study can be found at: *www.eqb.state.mn.us/geis/*

Legislation to Protect Small and Medium Sized Farms

In 2000, legislation was passed to protect farmers with less than 500 animal units from being forced to spend large sums of money to fix pollution when 75 percent cost share is not available.

The legislation limits the state or counties from requiring expenditures exceeding the following amounts when 75 percent cost share is not available: $0 if 1-99 AU; $3000 if 100 to 299 AU; $10,000 if 300-499 AU and no limit if 500 or more AU. Also, the NRCS changed its policy on EQIP cost share to provide 50 percent of the costs instead of 75 percent. In some counties, state cost share contributions bring the total cost share to 75 percent. However, for large portions of the state, only the lower cost fixes can be required at feedlots with less than 500 AU, since the 75 percent cost share is not available.

Governor Appointed Task Force

In 2003, the Governor appointed a Livestock Advisory Task Force to evaluate the status of Minnesota's animal agriculture industry and make recommendations to support its retention and growth. The 14-member panel included representatives from the state's livestock industry, as well as agricultural finance, producer organizations, academia and state government. Its final report was completed in June 2004, and was supplemented with additional recommendations on feedlot siting in January 2005. The report made recommendations on local livestock siting; state permitting and environmental review; access to capital; research, technology, and productivity; and preservation of investment. The report and recommendations can be found at: *www.governor.state.mn.us/.*

Total Maximum Daily Loads (TMDL) Written and Implemented

Total Maximum Daily Loads have been written for numerous lakes and stream reaches in Minnesota. TMDLs are also being written for several other water bodies, including a TMDL for elevated phosphorus and turbidity in Lake Pepin. The Lake Pepin TMDL will affect much of the agricultural region of the state. Feedlot runoff and land application of manure are two sources of pollution noted in TMDLs.

Urban Development

Agricultural land is continuing to be bought and converted to urban and housing development. Because of policies on land swapping, manure producers find that it is too expensive to buy additional land for farming purposes.

2002 Farm Bill and Federal Cost Share Programs

The 2002 Farm bill had several effects on Nonpoint Source (NPS) pollution at feedlots. There have been several major changes in the 2002 Farm Bill that have specifically impacted feedlots.

The EQIP is the Farm Bill program used for feedlot pollution abatement projects. Under the 2002 Farm Bill, EQIP received substantial increases in funding with 60 percent targeted towards animal agriculture. In the federal fiscal year 2005, approximately $12,000,000 of EQIP funds were directed to animal agriculture for financial assistance on hundreds of farms in Minnesota. Typical projects included manure and wastewater storage, wastewater treatment systems, grazing systems, odor control, and roof structures.

The 2002 Farm Bill removed the size limit on operations eligible for cost sharing, so large CAFO size operations are now eligible for cost share assistance. However, most large CAFO size operations in Minnesota are currently in compliance and have not requested EQIP assistance for feedlot runoff problems. The maximum amount of cost sharing allowed through EQIP has now been raised from $50,000 per operation to $450,000 per operation.The maximum cost share rate paid to producers through EQIP in Minnesota has been reduced from 75 percent down to 50 percent. This has increased the number of producers receiving cost share assistance, but at a reduced rate. This reduced level of cost sharing is being supplemented in some cases by state cost share funds to raise the rate to the 75 percent level.

The use of roof structures for pollution abatement as a cost shared practice is a substantial change from traditional approaches. Roof structures are used to eliminate all outdoor feedlots and thereby provide full runoff control. A lower cost share rate is applied to these structures which results in a lesser input of public funds over traditional storage ponds in many cases.

EQIP has also funded several treatment system demonstration projects for milk parlor wash water and biofilters for odor control.

In order to deal with the increased workload, the NRCS has been encouraging producers to utilize private sector Technical Service Providers (TSPs). NRCS then reimburses producers for a portion of the engineering fee through the EQIP contract. This has increased the participation of private sector consultants in pollution abatement work in Minnesota.

New Tools Available

The phosphorus index is available for evaluating management options to protect surface waters from phosphorus. The feedlot runoff evaluation model (FLEval) was updated and modified to estimate annual pollutant loading for nitrogen, phosphorus and oxygen demand. The Odor from Feedlot Setback (OFFSET) tool is now available for evaluating odor control strategies. Three new computer programs for developing manure and nutrient management plans were produced and are available to the public.

Changes in the Dairy Industry

Minnesota has been losing a number of dairies farms at a rate of about 13 percent per year during the past four years. Drivers for this trend of fewer dairy farms include retirement, economic considerations, competition from western states, and the cost of upgrading dairy facilities. Also, the dairy processing infrastructure has been reduced and Minnesota has lost 21 of its dairy processing plants. Minnesota has seen an increase in larger dairy farms during the 2000's.

Rotational Grazing

Rotational grazing is becoming a more commonly chosen management system for some dairy farms. Organic dairy products is another emerging trend that has become more prevalent in recent years.

Agriculture as an Energy Source

The push for biofuels has increased. Anaerobic manure digesters have been built at a few Minnesota dairies. Additionally a poultry litter burning plant is currently under construction for converting poultry litter into energy.

Decreasing Resources

A substantial reduction in available state and federal money for research and education has occurred during the past several years. State cost-share for feedlot pollution abatement has been reduced to help balance the state's budget. Additionally, several feedlot regulatory staff positions were lost during the past five years.

Increased Value of Manure

The cost of commercial fertilizer has increased with increasing fuel costs. This change has resulted in an increased value of manure. Additionally, research showing the soil and yield benefits of applying manure has been presented, further increasing the value of manure. This is coinciding with new University of Minnesota nitrogen fertilizer recommendations, which place a greater emphasis on economic return.

New Nitrogen Recommendations for Corn

The University of Minnesota, in cooperation with universities in four other mid-western states, developed new nitrogen fertilizer recommendations for corn.

These recommendations are based on current research and include consideration of nitrogen cost and the expected price for corn.

Geographic Areas of Particular Concern

Minnesota has a number of regions where livestock and poultry production activities have the potential to create significant water quality pollution problems.

Figure 7.1 - Ground Water Sensitivity - Susceptibility to Contamination Figure 7.2 - Livestock Manure - Annual Nitrogen Production, by County Figure 7.3 – Livestock Manure – Annual Phosphorus Production, by county.

In general, the highest densities of livestock and poultry are in the southern half of the state (see Figure 7.2 and 7.3). These areas include portions of the Upper Mississippi, Minnesota, Missouri, Des Moines, and Lower Mississippi River Basins. They also include the driftless area characterized by Karst topography, and the Anoka Sand Plain. The Red River, Rainy River, Lake Superior, and the northern half of the Upper Mississippi River Basins are relatively low in livestock densities. Runoff from animal confinement or manure storage areas is a potential pollution hazard to surface waters as described in the first section of this chapter. Animal confinement and manure storage areas also have the potential to pollute ground water.

Nitrates may come from many sources, among them animal confinement and manure storage areas. Some areas of the state where highest the concentrations of animals occur are also in the areas most sensitive to ground water pollution (see Figure 7.1).

Examples of major regions of particular concern in regard to ground and/or surface water pollution are given below.

1. Karst Region **-** Southeastern Minnesota has many areas that have fractured bedrock within a few feet of the surface. These shallow bedrock layers may serve as aquifers.
2. Surface activities, such as livestock production and improper manure management, along with other land management activities, may present pollutants that can be carried quickly through the fractured bedrock from the surface to the aquifer. This area is particularly sensitive in terms of ground water pollution, although the presence of short steep slopes also presents potential for surface water impacts.
3. Anoka Sand Plain **-** The Anoka Sand Plain, beginning near the northwest corner of the Minneapolis-St. Paul metropolitan area and extending into Stearns, Benton and Sherburne Counties, is characterized by coarse soils and shallow aquifers. These aquifers are easily affected by pollutants leaching from the surface. Over-application of crop nutrients (in particular nitrogen) has been implicated in ground water pollution.
4. Eastern portion of the Minnesota River Watershed and the North and South Fork of the Crow River. Land use in these watersheds is predominantly agricultural. Topography is flat to rolling, and most soils are thick glacial tills and moraines or lacustrine sediments. Heavy precipitation leads to large amounts of runoff or drainage.
5. Coteau and Inner Coteau regions – Southwestern Minnesota has shallow bedrock overlain by soil developed from glacial moraines. Ground water wells installed in shallow alluvial material or the Sioux Quartzite aquifer using poor construction methods are at risk for ground water contamination from surface runoff.
6. Alluvial and Outwash sediments in Central Minnesota – Drinking water wells overlain by coarse textured soils or in alluvial sediment along river channels are vulnerable to leaching of nitrate to ground water.

Groundwater Contamination Susceptibility (July 1989)

Figure 7.1

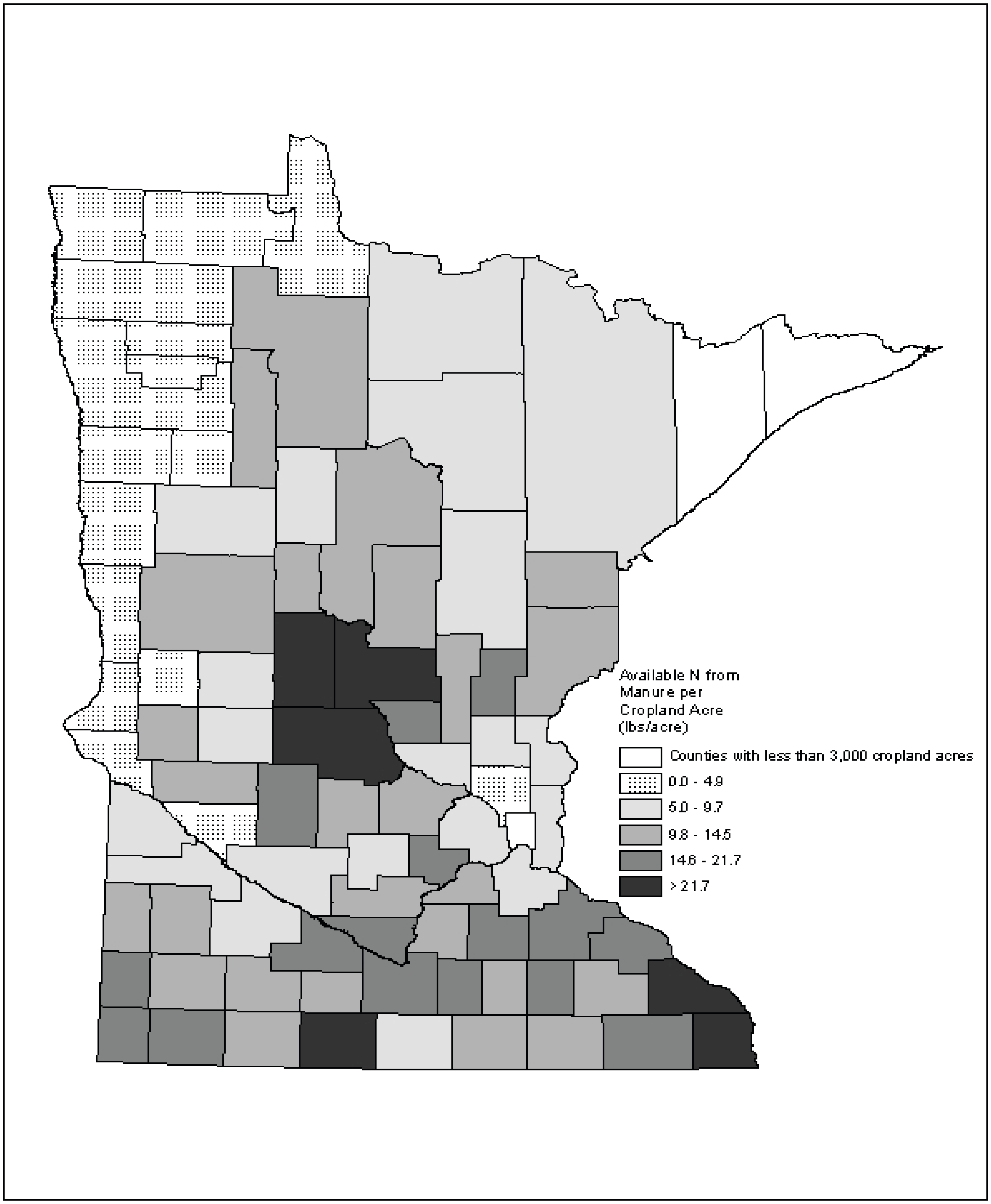

Figure 7.2 Pounds of crop-available nitrogen from manure generated per year per cropland acre in the county. Based on 2002 agricultural census information.

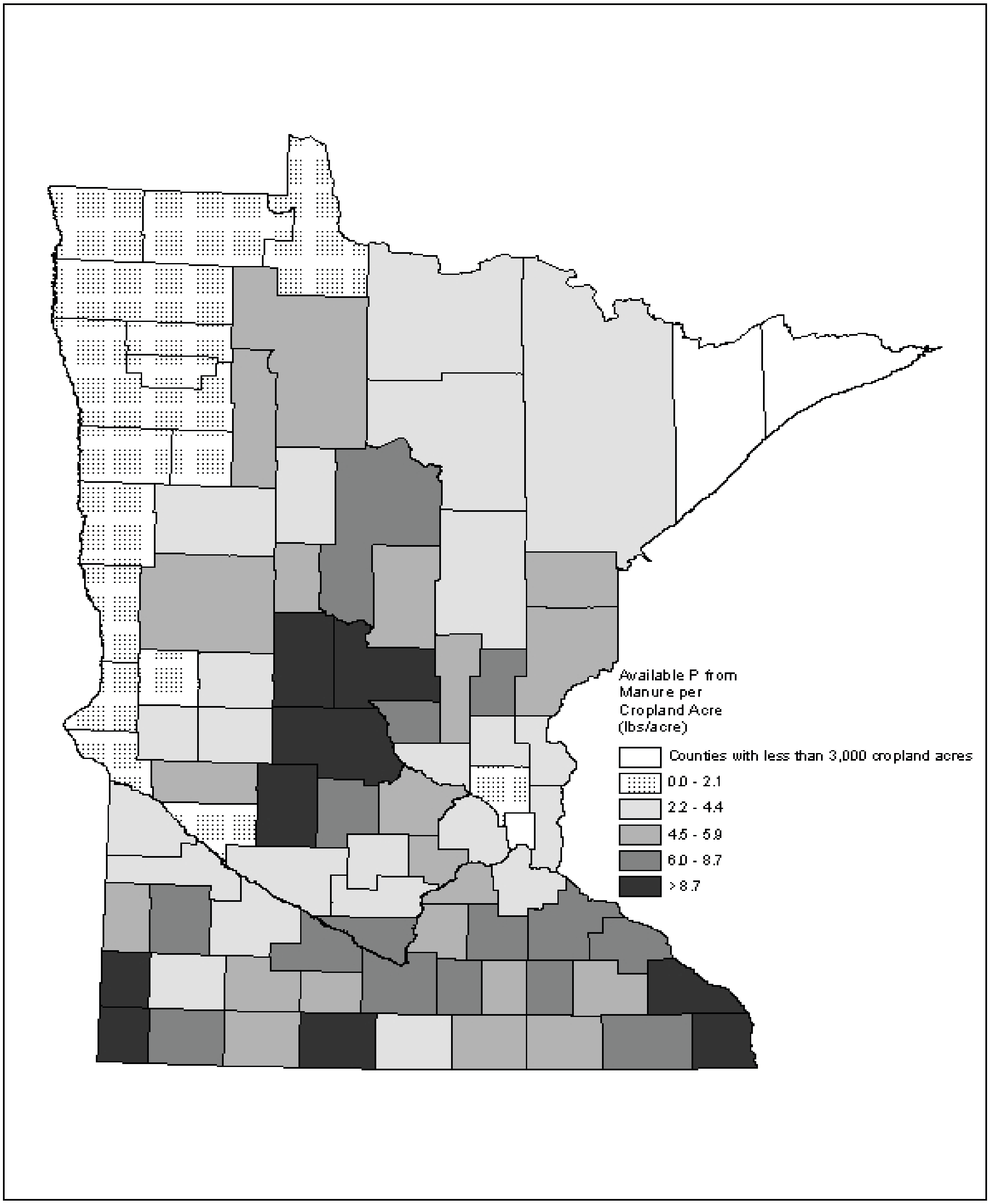

Figure 7.3 Pounds of crop-available phosphorus from manure generated each year per cropland acre in the county. Based on 2002 agricultural census data

Currently Applied Best Management Practices and Associated Challenges

The primary potential hazards to water quality associated with animal confinement, manure storage and manure application are:

1. Snowmelt or precipitation runoff carrying both dissolved and particulate material from areas where animals are confined, manure is stored, manure is land applied, and feed storage areas.
2. Leaching of pollutants into ground water from areas where animals are confined, or manure is stored or land applied.

Currently applied BMPs to bring feedlots with an existing pollution hazard into compliance with state and federal water quality protection requirements include such measures as:

1. clean water diversions (e.g. rain gutters, waterways and/or roofs)
2. resizing and management of open lots via fencing and livestock use control
3. livestock exclusion from surface water via fencing, prescribed grazing and alternative watering sources
4. vegetated buffer areas or vegetated filter strips, often including solids settling and runoff management from open lots
5. collection and storage systems for manure, feedlot runoff and silage leachate (e.g. concrete tanks, earthen basins lined with clay and/or man-made liner material, anaerobic manure methane digestion systems, composting or stacking areas for solid manure)
6. milkhouse waste treatment practices, including a number of research and demonstration projects for various types of anaerobic digestion
7. nutrient management for increased profitability and reduced runoff or leaching of nutrients from land where manure is applied
8. feedlot relocation

There are numerous challenges associated with application of these BMPs, including:

1. Continue federal, state and local regulations that are effective, workable, compatible, predictable and well understood by the farmers and all those involved with feedlots and water quality protection.
2. Maintaining consistency in the application of regulations and BMPs, while providing appropriate flexibility for site-specific applications. This is primarily a challenge of training and coordination for regulators and technical assistance providers, which involves numerous federal, state and local government staff, as well as private consultants.
3. The vast majority of feedlots with existing pollution hazards are small to medium sized, located in riparian areas and operated by farmers with very limited financial resources. Feedlot pollution abatement often requires substantial capital investment and significant technical expertise. Therefore, there is a great need for technical and financial assistance for application of feedlot BMPs.
4. Identification and application of cost effective alternatives to achieve feedlot pollution abatement, with due consideration of site sensitivity. This challenge involves further development of low cost alternatives, the expertise to know where and how to apply them and the expertise to effectively operate and maintain them.
5. Adoption of more effective procedures, methods, and alternatives to use manure on farms where manure is land applied. Manure is a very good source of nutrients for crop production and organic matter for soil quality improvement. However, effective crop nutrient management using manure as a primary source of nutrients requires a higher level of testing and management than use of commercial fertilizer alone. This challenge involves further research and development of effective nutrient management tools, effective and workable regulations, education to develop understanding and commitment and training to develop the associated expertise of producers, consultants (both public and private) and regulators. The fundamental desired outcome is more effective use of manure nutrients, which implies reduced use of commercial fertilizer on fields where manure is land applied. Because private crop consultants are key players in this regard, it is desirable to promote the sale of more technical assistance and less commercial fertilizer by crop consultants.

Responsibilities, Roles and Programs

The Minnesota Nonpoint Source Management Program Plan (NSMPP) (1988) describes the requirements for an effective system to address pollution related to animal confinement facilities (feedlots) as follows:

"For the feedlot permit program to be effective, it requires not only good county-state cooperation, but also close coordination between other state and federal agencies involved in feedlot pollution control. The USDA-Farm Service Agency (FSA), USDA-Natural Resources Conservation Service (NRCS), Board of Water and Soil Resources (BWSR), and MPCA coordinate their animal waste control programs so that federal and state cost-share funds, technical assistance programs, and the state permit program will work together efficiently. The NRCS and BWSR each have cost-share programs to provide incentives to install pollution control practices for animal waste management. The NRCS and SWCD provide technical assistance. The MPCA permit program acts as a catalyst to bring farmers into these programs by establishing a regulatory incentive."

Responsibilities for feedlot-related issues fall into five primary categories – 1) research and technical evaluation, 2) information/training and education, 3) technical assistance, 4) financial assistance, and 5) regulation. The following list outlines the current relevant federal, state, and local programs and authorities.

Finally, there is a high level of communications between government agencies, research and extension staff, producer groups, and environmental groups in Minnesota.

It is imperative that these lines of communication remain open and are encouraged.

Agency Responsibilities

1) Research And Technical Evaluation

Federal: USDA-ARS
State: MN Agricultural Experiment Station
Minnesota Department of Agriculture
Minnesota Extension Service
Minnesota Pollution Control Agency
Minnesota Environmental Quality Board

2) Information/Training/Education

Federal: Natural Resources Conservation Service
State: Minnesota Extension Service Board of Water and Soil Resources
Minnesota Department of Agriculture
Minnesota Pollution Control Agency
Local: Soil and Water Conservation Districts
Watershed Districts
County Environmental Services and Local Water Management/Planning

3) Technical Assistance

Federal: Natural Resources Conservation Service
State: Board of Water and Soil Resources
Minnesota Department of Agriculture
Local: Soil and Water Conservation Districts
Watershed Districts
Counties

4) Financial Assistance

Federal: Farm Service Agency/Natural Resources Conservation Service

State: Board of Water and Soil Resources
Minnesota Department of Agriculture
Local: Clean Water Partnership Projects

5) Regulation

Federal: Environmental Protection Agency
National Oceanic and Atmospheric Administration
State: Minnesota Pollution Control Agency
Minnesota Department of Natural Resources - Conservation Officers
Local: County Feedlot Programs
County Law Enforcement

Agency Roles

Minnesota Agricultural Experiment Station

- Conduct needed research as identified by industry and agencies to provide an adequate scientific base for proper feedlot siting.
- Provide research that contributes to a reduction of the pollution potential of livestock manure.
- Incorporate livestock issues in farming system and sustainable agriculture research.

Minnesota Extension Service

- Provide leadership to implement educational programs related to feedlots and manure management.
- Cooperate with state and federal agencies in distributing information relating to feedlots through use of the existing Minnesota Extension Service network.
- Conduct applied research to evaluate and adapt existing and new technologies.
- Cooperate in providing training for local governmental officials that results in a consistent interpretation and application of criteria to evaluate feedlot impacts.

Minnesota Board of Water and Soil Resources

Enable local government units to provide educational, technical and financial assistance to livestock producers for feedlot pollution abatement and proper manure management. Specifically:

- Serve as the administrative agency for the statewide Local Water Management Program, which is key to definition of local water priorities and integration of local, state and federal water quality programs at the local level. Administer Local Water Management Challenge Grants to local government units for implementation of local water management plan priorities, including feedlot pollution abatement.
- Administer State Cost-Share Programs, including Feedlot Water Quality Management and regular State Cost-Share Program grants to SWCDs for feedlot pollution abatement. These grants are for both technical and financial assistance.
- Administer the state Nonpoint Engineering Assistance Program, which provides grants to SWCDs for shared engineers and technicians in 11 SWCD Technical Services Areas to provide technical assistance for feedlot pollution abatement and many other conservation practices.
- Develop and/or disseminate information and education materials.
- Provide technical and administrative training and assistance to local government units and other partners.
- Coordinate with local government units, other involved state and federal agencies, the University of Minnesota and others to help ensure effective and efficient delivery of education, training and technical and financial assistance.
- Provide a forum for coordination and policy development that fosters effective water and soil resource management through local units of government.
- Provide dispute resolution services for certain state water management laws and programs.

Minnesota Department of Agriculture

- Develop and disseminate information and education materials statewide and participate in multi-agency efforts to provide effective delivery of information and technical resources to livestock producers.
- Assist in the environmental prioritization of targeting state and local funds for environmental upgrades to feedlots.
- Assist producers in the assessment of their environmental, economic and business options during their decision-making process of deciding how to respond to, or comply with state and federal feedlot regulations and programs.
- Conduct research on economically and environmentally viable options for producers to manage livestock waste.
- Develop, evaluate, improve and refine best management practices.
- Provide assistance to local governments in developing local ordinances for feedlots and integrating feedlot planning into local comprehensive plans. The MDA has statutory authority to review these plans and local governments are required to report to the MDA on changes with their plans.
- Where appropriate, working with the MPCA and local governments, deliver information to producers through the MDA Milk Inspectors in accordance with an memorandum of understanding (MOU) between the agencies (e.g. registration, open lot agreement, etc.)
- Provide information and data to assist producers and local governments in the siting of livestock facilities.
- Provide education and financial assistance for sustainable agriculture practices such as rotational grazing and organic farming methods. Assistance is also provided with dead animal composting, in conjunction with the Board of Animal Health.
- Provide financial assistance for animal waste control structures, manure management equipment, abandoned well sealing, and other work that mitigates or prevents nonpoint source pollution.
- Coordinate the certification program for licensing animal waste technicians who apply manure for hire.
- Manage the manure testing lab certification program.

Minnesota Department of Natural Resources (MDNR)

Provide enforcement backup through Conservation Officers, including assisting in on-site investigations with uncooperative operators. Criminal law enforcement investigation authority regarding water pollution and other environmental violations rests with MDNR Conservation Officers.

- Investigate fish kills, working with MPCA on kills that involve feedlots.
- It should also be noted that the MPCA and the MDNR maintain a Memorandum of Understanding concerning pollution enforcement. The MPCA is responsible for regulation of pollution caused by animal confinement facilities in Minnesota, through Minn. R. ch. 7020 and the Federal National Pollutant Discharge Elimination System program. Criminal law enforcement investigation authority regarding water pollution and other environmental violations rests with MDNR Conservation Officers, and the Memorandum of Understanding clarifies how they will be used in feedlot enforcement.

The statutes most commonly used when dealing with feedlot related violations include: M.S. 609.671 subd. 8 and 9, and M.S. 115.061, 115.07, and 115.071; and M.S. Chs 97A.341 and 97A.345.

Minnesota Environmental Quality Board

The Environmental Quality Board (EQB) is currently studying the mandatory category threshold levels in the environmental review rules (Minn. R. parts 4410.4300 and 4410.4400) to determine whether the thresholds are still appropriately placed to balance environmental protection and public benefit with administrative burden. In addition, the Governors Livestock Advisory Task Force Report (June 2004) contained a recommendation for the Governor to: “Direct the EQB to evaluate animal unit thresholds triggering EAWs.” An amendment to the animal feedlot mandatory category threshold level is currently under consideration by the EQB.

Farm Service Agency (FSA)

The Farm Service Agency, of the USDA, administers various farm commodity, conservation and environmental protection and emergency programs. The USDA-Natural Resources Conservation Service (NRCS), local SWCD, the Forest Service, and State Forest agencies provide technical program guidance to FSA. The University of Minnesota Cooperative Extension Service also provides educational support and planning assistance. FSA provides various forms of payments under several conservation programs. Cost-share and incentive payments are available under the EQIP.

Soil and Water Conservation Districts

Enable agricultural producers and other private landowners to be more effective stewards of water and soil resources, including feedlot runoff control and manure management. Specifically:

- Work directly with producers to identify feedlot and manure management problems and potential solutions.
- Provide information and education to producers regarding feedlot best management practices.
- Serve as the employer and local administrator for shared engineers and technicians employed via the state Nonpoint Engineering Assistance Program.
- Provide technical and administrative assistance to producers for conservation practice design and implementation.
- Coordinate financial assistance for eligible feedlot pollution abatement and manure management practices, including local administration of State Cost-Share Programs and the Agricultural BMP Loan Program.
- Review and determine eligibility and amount of financial assistance for remediation projects under some financial assistance programs.
- Provide construction inspection assistance for practice implementation.
- Periodically monitor operation and maintenance of practices installed with state cost-share.
- Provide advice and assistance to local governments, state agencies, and federal agencies to develop and implement effective environmental programs at the local level.

Counties

- May develop official controls for manure utilization, application, incorporation, and establish setbacks from potential sources of contamination of manure disposal and the location of feedlots from other land uses where those uses may not be compatible. These controls must be as stringent as the state standards and may impose additional requirements.
- Implement the Local Water Management Program (often in cooperation with the SWCD) to develop comprehensive local water management plans and to implement local water management challenge grants.

County Feedlot Officer

- Assist the livestock producers with registration and completion of the MPCA feedlot permit application.
- Assist the MPCA with public education on requirements within the livestock industry and to be the contact for the livestock producers and the MPCA.
- Direct producers to potential cost-share programs.
- Determine that all state and federal permits have been applied for.
- Conduct inspections to determine if pollution problems exist, respond to complaints and take appropriate actions to ensure compliance with rules.

Minnesota Pollution Control Agency

- Administer rules regulating animal confinement facilities, including both Minnesota state rules and NPDES permit program. Conduct inspections, respond to complaints and take appropriate actions to ensure compliance with rules.
- Set state standards for control of potential pollution hazards from feedlots.
- Provide technical assistance to county feedlot officers with administration of county feedlot program.
- Conduct environmental reviews when EAWs are required for new and expanding feedlots.
- Provide information, education and technical assistance to producers, consultants, government agency staff and the public.
- Evaluate technical information related to water quality impacts of animal confinement and manure storage facilities.
- Adopt appropriate technical standards for manure storage facility construction and manure nutrient management.
- Maintain records of facilities reviewed for potential pollution hazards.

Natural Resources Conservation Service-USDA

- Provide technical assistance for the planning, investigation, design, and construction of feedlot pollution abatement systems.
- Prepare manure management plans for cooperators.
- With input from others, prepare and maintain technical standards for conservation practices, including pollution abatement components.
- Responsible for certifying the need for and completion of conservation practices for federal cost sharing.
- Provide technical assistance for planning and application of conservation practices for erosion control and water quality improvement on agricultural lands, including practices for pasture and streambank management.
- Administer the EQIP. Environmental Quality Incentives Program provides up to *50 percent* cost-share payments to farmers for installation of conservation practices, including animal waste storage structures.

Agency Programs and Activities

Research and Technical Evaluation

Technical expertise to conduct research on manure management and feedlot issues is available at the University of Minnesota, College of Agricultural, Food, and Environmental Sciences, and the Minnesota Agricultural Experiment Station. Technical evaluation is conducted by UM Extension Service faculty and other state and federal staff.

Between 1994 and 2003, the Feedlot and Manure Management Advisory Committee (FMMAC) provided advice on the issues and priorities for research needs on manure management and odor and air quality measurement and mitigation. In 1998, as a result of recommendations from FMMAC members and others, a Generic Environmental Impact Statement (GEIS) on animal agriculture was funded by the state Legislature. The GEIS study was completed in 2002.

Results from the GEIS will be incorporated into future standards and specifications for construction, operation and maintenance of feedlot facilities. It will be important that the research priorities be set on the basis of interaction with local officials and planning staff, so that research can be brought to bear on the critical questions facing producers. The GEIS has provided significant information regarding animal agriculture issues.

Information and Education

All federal, state and local government units and the Minnesota Extension Service have a role in information and education efforts. Training and education to meet these various needs should be carried out in a number of ways, ranging from the development of fliers, information sheets, and/or video tapes, to workshops, seminars, and demonstration projects, and one-on-one contacts between livestock producers and staff from state and local governments. Modular displays for county fairs, local meetings, or other gatherings can be used to communicate on a grass roots level.

In 2001, the MPCA and MDA developed a Memorandum of Understanding (MOU) to guide MDA milk inspectors in providing information to dairy producers. This MOU was revised in 2004 to more clearly define the roles of the MPCA and the MDA in the agreement.

Computer programs to assist in the development of manure management plans will assist local conservation officials and will be a direct benefit to producers who have computers available to them. The Minnesota Extension Service should have the leadership role in development of decision aids and educational programming on management and utilization of manure. The development of decision aids and educational programming on management and utilization of manure should include input from producers and other private and public agricultural professionals.

Prevention of pollution from animal manure requires not only appropriate pollution control facilities, but good management as well. Many of the practices that prevent pollution from animal manure also maximize its value as fertilizer and provide a financial benefit to the producer. Further education and training is needed for producers to increase the implementation of such practices.

County Feedlot Officers, zoning officials, water planning staff, and other local officials could benefit from additional training to identify feedlot pollution problems and to be able to effectively administer programs and projects designed to control nonpoint source (NPS) pollution from animal feedlots.

In addition, private crop consultants who work with livestock producers must be knowledgeable about the utilization of manure for its nutrient value.

There is also a need for farmers, farm lenders, realtors and others involved in agriculture to become more knowledgeable of the MPCA Feedlot Permit requirements. The rule revisions change the requirements for permitting significantly, and producers need to be aware of what types of activities require permits. Agencies should also consult with producers, custom applicators, contractors, and other private professionals who work closely with producers.

Technical Assistance

Technical assistance is provided for feedlot pollution control systems (e.g. structural and management practices) at the local level through federal, state and local government programs and staffing, with technical training and support at the regional and state level. Federal, state and local government units currently providing assistance at the local level are the NRCS, SWCDs and UM Extension. Assistance provided includes:

1. inventory and evaluation
2. planning for structural and management practices
3. site inspections
4. design
5. comprehensive nutrient management and manure management planning
6. technical assistance for implementation
7. operation and maintenance follow-up

At the regional or state level, assistance provided includes training, development of standards and technical aids, direct assistance for complex problems, technical review and approval of designs.

Manure storage structures must be designed by a professional engineer or under NRCS-BWSR-SWCD Engineering Technical Approval authority for federal and state cost-share programs. The State of Minnesota Board of Architecture, Engineering, Land Surveying, Landscape Architecture, Geoscience and Interior Design regulates the practice of engineering in Minnesota. Consultants can provide technical assistance for the EQIP Program as a Technical Service Provider and for State Cost-Share Programs. Interest in this work by engineers outside the NRCS and SWCD staff is increasing.

At the present time, the demand for technical assistance for the design of animal manure pollution control facilities and nutrient management planning exceeds the capacity of the agencies involved. With increasing environmental awareness, it is expected that the demand for technical assistance for animal manure pollution control systems and nutrient management will remain at high levels. When federal cost-share funds are involved, consultant-prepared plans must be reviewed by NRCS unless the consultant is a certified TSP.

In that case, the consultant has certified to the NRCS that they are familiar with NRCS standards, and no review is performed prior to construction. NRCS may reimburse landowners for a portion of the engineering fees when a certified TSP is used. Only post-construction quality assurance reviews are then performed by the NRCS.

Program needs include staffing, training, design standards and methods, engineering supervision and approval, and technical assistance for non-cost-shared work.

Staffing levels need to be increased to match technical assistance needs. At this time, availability of technical assistance at the local level limits design and construction of feedlot pollution control systems. However, if staffing is increased at the local level, an increase at the regional and state levels will also be needed for training and technical support. Funding sources for increased technical assistance must be identified and developed. Funding for additional technical assistance should be directed to high priority areas of the state. Additional staff were hired in southeastern Minnesota through a 319 grant to assist with promotion and implementation of Open Lot Agreement. Additional efforts such as these should be encouraged.

Training of both existing and new staff must be provided to make the most efficient use of limited technical and financial assistance. This training should be focused on both structural and management practices and be coordinated among all cooperating agencies. Technical design standards and methods need to be developed and improved to more efficiently provide assistance to cooperators. NRCS standards need to be evaluated and updated to reflect current technology, and environmental concerns. Existing tools and models used to assess pollution potential from feedlots need to be reviewed and updated.

Technical decision aids are needed for the development of nutrient management plans. The Minnesota Extension Service, together with NRCS, BWSR, and MPCA developed a technical training manual on manure management that is accompanied by a computer program to assist in the development of these plans. By standardizing manure management recommendations between these various agencies in this way and by providing tools such as the computer program, staff time devoted to developing manure management plans and confusion on the part of producers has been reduced.

Public technical assistance for non-cost-shared work is almost nonexistent at this time. Improperly designed and constructed systems can present a serious pollution hazard. Additional guidance for consultants and contractors working on pollution abatement and manure storage and handling systems would be helpful. Minnesota Extension Service, in cooperation with other agencies, could provide training and support to these professionals.

Financial Assistance

The EQIP provides financial assistance in the form of cost sharing and incentive payments to farmers for applying conservation practices on their land. At this time, at least half of this assistance must be targeted toward livestock related practices. These include waste management systems and grazing systems. Contracts are awarded on a competitive basis and can result in the operator receiving up to 50 percent cost share for the five to ten year contract. Limited state cost share monies are available, which can provide or increase the total cost share amount to 75 percent at some sites. Technical assistance on EQIP practices is provided by NRCS, SWCDs, private Technical Service Providers, MDNR, and the U.S. Forest Service.

The state cost-share programs administered by the BWSR provide financial assistance through local Soil SWCDs, including feedlot pollution abatement systems. Clean Water Partnership (CWP) grants from the MPCA may provide funding for correction of pollution problems associated with CWP projects.

The MDA's Energy and Sustainable Agriculture Program provides grants and loans on a competitive basis to support sustainable agriculture practices, such as alternative livestock production systems, on-farm composting, manure utilization, and testing. The grants are for up to $25,000 and the loans are up to $15,000 per farmer and up to $75,000 for groups of farmers.

Another program that in the past provided valuable incentives for construction or purchase of pollution control facilities and equipment was a ten percent state income tax credit on such expenditures. This program was eliminated. It had provided over $1,000,000 per year in assistance to farmers. Efforts should be made to either restore the program, or to replace the lost pollution control funds by increasing funds directed to state cost share programs.

The State Revolving Fund (SRF) program provides low interest financing through the MDA's Agricultural BMP Loan Program for installation of animal waste control facilities and manure management equipment for operations with less than 1,000 animal units. The Minnesota Legislature has also contributed additional funds for feedlot upgrades through this program. These funds are available through counties, watershed districts or local Soil and Water Conservation Districts. The Rural Finance Authority can provide loans to qualifying individuals for feedlot improvements.

Regulation – Permitting and Enforcement

State rules regulating feedlots have been in effect since 1971, were revised in 1979 and again in 2000. These rules give Authority to the MPCA to control pollution from livestock facilities, and to delegate Authority to county government for non- NPDES permitting. National Pollutant Discharge Elimination System permits are required for all facilities with 1000 or more animal units under state law and those which are less than 1000 animal units but which exceed the animal number thresholds established by the USEPA. The other smaller feedlots are regulated through state authorities and are considered to be nonpoint sources.

The purpose of the MPCA feedlot program is to review facilities for their potential water pollution hazards so that existing problems may be identified and corrected, or potential hazards with new facilities can be prevented prior to construction. Authority to administer this program for certain facilities can be delegated to county government.

In the process, producers must submit information regarding their livestock facilities and manure management. Both existing and proposed livestock facilities are reviewed for potential water pollution hazards. If pollution hazards are created by existing facilities, the MPCA requires that these hazards be corrected within twenty-four months of issuance of a MPCA interim permit, unless it is not possible for technical reasons to correct the pollution problem within this time. For more difficult problems, the MPCA may allow up to five years for correction using a State Disposal System (SDS) permit.

The MPCA also may take enforcement actions when compliance cannot be attained through assistance and permitting. A wide variety of enforcement tools are available, from "Letters of Warning" to "Administrative Penalty Orders" to civil and criminal actions. Existing facilities that meet the technical standards of the rule and do not propose to expand or change do not need permits, but they must register their operation with the state or delegated county. State permits are not required for construction or expansion of facilities with less than 300 animal units as long as the technical requirements of the rule are met. Correcting pollution hazards at these smaller sites may require an interim permit.

Manure storage capability and having adequate land available to allow maximum utilization of nutrients need to be goals for livestock producers. Incorporation of these components in the planning and permitting process could provide management, economic and water quality benefits.

Participation of counties in the feedlot program through administration of the MPCA county feedlot program provides an excellent mechanism for the county to coordinate planning and zoning efforts with feedlot permit issuance. Fifty-three counties are currently delegated to issue permits for facilities which do not require an NPDES permit. In addition, cost-share and technical assistance programs are administered at the local level, so local needs and efforts on feedlot pollution control may be efficiently administered through county staff coordination, reducing the number of agencies the producers must deal with.

There are two primary reasons why counties have chosen not to administer this program:

1. Lack of funding for the required staff.
2. Lack of support from the county board to regulate agricultural practices. Education of local government staff, livestock owners and the general public on issues related to feedlot pollution problems may help resolve the lack of support for county feedlot programs

USEPA's National Pollutant Discharge Elimination System Program for feedlots is also administered by the MPCA, resulting in the requirement of all producers housing more than 1000 animal units to apply for a NPDES permit. Currently over 900 Minnesota feedlots have NPDES permits. MPCA has developed a general permit for livestock production facilities. The general permit has been designed to cover most facilities required to operate under an NPDES permit, except those with current discharges, past enforcement history and where special considerations result in additional conditions needed in the permit.

The Minnesota Department of Natural Resources is involved with the regulation of fish kills. The primary statutes used when dealing with such violations include M.S. 609.671 subd. 8 and 9, and M.S. 115.061, 115.07, and 115.071.

Best Management Practices (BMP)

The following BMP are commonly used to reduce nonpoint source pollution from feedlots. This list is not comprehensive and does not suggest additional BMPs would have no benefit but, is provided to highlight the more common BMPs for feedlots.

Please refer to Part I Agricultural BMPs, Part II Erosion and Sedimentation BMPs and Part III Other Cultural and Structural BMPs included in Appendix B of the NSMPP for definitions of the following BMPs.

Part I Agricultural BMP's

8 Critical Area Planting
10 Deferred Grazing
11 Diversion and Terraces
12 Fencing
17 Grassed Waterway or Outlet
21 Lined Waterway or Outlet
22 Use Exclusion
23 Nutrient Management
25 Pasture and Hayland Management
26 Pasture and Hayland Planting
28 Prescribed Grazing
33 Riparian Buffer
34 Shade Areas
36 Soil Testing and Plant Analysis
41 Vegetative Filter Strip

42 Waste Management System
43 Waste Utilization
44 Water and Sediment Control Basin
45 Water/Feeder Location

Part II: Erosion and Sediment Control BMPs

8 Filter Strips
12 Level Spreader
24 Subsurface Drain
50 Rooftop Runoff Disposal
51 Storage/Treatment Facilities
52 Underdrain Storm Water Filter Systems

Part III: Other Cultural and Structural BMPs

55 Compost Production and Use Lane Absorption Areas
59 Maintain Set Backs From Surface Waters

Chapter 7 Feedlots

Needs, Priorities and Milestones, Action Plan

The action plan provided below summarizes the goals and milestones identified in the preceding sections. Many of the 2013 through 2017 milestones listed below, as well as the implementation of specific projects, are contingent upon adequate funding and local involvement.

Goal 1: Reduce pollutant transport to surface and ground waters associated with land application of manure.

Milestones (Action Steps)	13	14	15	16	17	Funding Source(s)	Lead Agency(ies)
1. Feedlot officer inspections of records: Increase inspections of land application records and actual practices to assess compliance, and to provide more opportunity to discuss with producers the importance of proper land application practices. Improve existing forms and processes used to inspect land application records, and provide associated training.	X	X	X	X	X	MPCA	MPCA, MN Association of County Feedlot Officers (MACFO)
2. Commercial applicator training: Offer high quality training options for commercial animal waste technicians, who are required to maintain a certain level of continuing education.	X	X	X	X	X	Workshop Fees, MDA,	MDA MPCA U of M - Extension MACFO
3. Inspections of commercial applicator activities: Increase inspections of commercial applicator records and of actual practices during manure spreading.	X	X	X	X	X	MPCA, MDA	MPCA, MDA
4. Research opportunities at the Discovery Farms: gather water quality information under real-world conditions, providing practical, credible, site-specific information to enable better farm management.	X	X	X	X	X	MDA	MDA, SWCD
5. Education Programs: Hold regularly offered in-depth educational courses in manure application and nutrient management for a wide variety of audiences, including technical service providers, producers, agency and county staff, and others.	X	X	X	X	X	Workshop fees MACFO	U of M- Extension MPCA, NRCS, MDA

Milestones (Action Steps)	13	14	15	16	17	Funding Source(s)	Lead Agency(ies)
6. Publications: Keep existing publications and materials up-to-date and develop new and/or improved ways of communicating land application requirements and voluntary best management practices. Build from past efforts such as the GEIS documents, where possible.	X	X	X	X	X	MACFO	MPCA, MDA, NRCS
7. Demonstrate equipment and practices: Hold on-farm demonstrations of equipment and practices which are practical and protect water quality. Emphasize equipment and technologies which can achieve low enough rates to meet state rule requirements, and injection equipment which maintains residue cover.	X		X		X	MDA, MPCA, MACFO	U of M-Extension, MPCA, MDA,
8. Software for manure management planning: Survey users of computer programs. Work toward improving existing software programs used for writing manure management plans. Provide training on these computer tools to producers, technical service providers, and agency staff. Ensure that software activities are coordinated amongst the agencies. Work to simplify manure management planning and make it more useful for producers.	X	X	X	X	X	NRCS, , software fees	U of M-Extension MPCA, NRCS
9. Assess current rules: Assess existing feedlot rules for ways in which the rules reduce the real or perceived value of manure. In particular examine alternative approaches to rules dealing with transferred ownership of manure for land application.	X	X				MPCA	MPCA
10. Alternative uses: Research, identify and communicate alternative uses for manure and how to market alternative uses (e.g. manure composting). Develop informational publications on ways to use manure as a source of energy, including anaerobic digesters and incineration. Research new ways to convert manure into energy sources.	X	X	X	X	X	U of MN, USDA/ Agricultural Utilization Research Institute	MDA U of M-Extension Agricultural Utilization Research Institute

Goal 2: Assist producers with methods to correct feedlot runoff and discharges to surface saters.

Milestones (Action Steps)	13	14	15	16	17	Funding Source(s)	Lead Agency(ies)
1. Technical assistance staff for low cost solutions: Secure new positions with SWCD Technical Services Areas to work on providing technical assistance for low cost improvements to open lot runoff (i.e. without need for cost share).	X	X	X	X	X	BWSR	BWSR, MPCA Jt. Powers Bds
2. Financial Assistance Coordinate cost share and regulations on open lots. Seek to supplement 50% EQIP cost share for fixing high priority open lot runoff problems.	X	X	X	X	X	MDA, BWSR	MDA, BWSR
Milestones (Action Steps)	**13**	**14**	**15**	**16**	**17**	**Funding Source(s)**	**Lead Agency(ies)**
3. Training on MNFARM Hold training sessions for technical service providers and agency/county employees on the use of the model.		X		X		MPCA	U of M-Extension, MPCA,

Goal 3: Ensure that ground water quality is protected at manure storage areas

Milestones (Action Steps)	13	14	15	16	17	Funding Source(s)	Lead Agency(ies)
1. Further Evaluate Large Liquid Storage Liners** Conduct ground water monitoring (e.g. geoprobe and monitoring well investigations) at large liquid manure storage areas used for 5-10+ years to evaluate long term effectiveness of liners. Conduct monitoring in different areas of the state and focus on the highest risk situations.	X	X	X	X	X	MPCA	MPCA
2. Training on manure storage design, construction and inspection* Provide periodic training for public and private technical service providers, regulatory staff and others on design, construction and inspection of manure storage areas.	X	X	X	X	X	Workshop Fees NRCS	U of M-Extension NRCS MPCA
3. Review standards* Review manure storage standards to ensure that standards and policies provide protection that is up-to-date with the collective body of research and monitoring.	Xx	X	Xx	X	X	MPCA	MPCA NRCS BWSR U of M-Extension MDA

Goal 4: Collect, assess and quantify current feedlot and manure management practice information and establish risk-based priorities, programs and policies from this information and associated feedlot research

Milestones (Action Steps)	13	14	15	16	17	Funding Source(s)	Lead Agency(ies)
1. Evaluate relative risks: Evaluate which types of feedlot runoff scenarios present the greatest relative risk to water quality and evaluate which scenarios should be the highest priority based on such factors as cost/benefit analysis and mass loading reductions to achieve TMDLs.	X	X	X	X	X	MPCA	MPCA, U of M-Extension, MDA
2. Evaluate feedlot sources for TMDLs: Quantify the extent of feedlot pollution problems in watersheds with TMDLs. Identify which of the feedlot facility activities impact waters the most and how these impacts compare to other pollution sources in the watershed. Develop standardized approaches and tools for greater efficiency when evaluating relative risks of feedlot and manure spreading activities for TMDL development.	X	X	X	X	X	MPCA	U of M-Extension MDA, MPCA
Milestones (Action Steps)	**13**	**14**	**15**	**16**	**17**	**Funding Source(s)**	**Lead Agency(ies)**
3. Database improvement: Improve the Minnesota feedlot information database and include more information about which sites have pollution problems that are a high environmental priority. Consolidate existing databases if necessary to simplify data extraction and analysis. Allow better tracking of nitrogen and pathogen control.	X	X	X	X	X	MPCA	MPCA
4. Risk based work plans: Develop guidelines for state feedlot staff and county feedlot officers to develop risk based work plans which aid in prioritizing inspections and follow-up work. Develop inspection prioritization scheme of highest risk feedlots/ locations at both NPDES - and non-NPDES permitted sites.	X	X	X	X	X	MPCA	MPCA, MACFO
5. Cost Share Priorities: Assess cost share rate policies to ensure alignment with highest environmental priorities. Ensure agencies work together to enhance alignment of priorities for financing feedlot water quality improvements. Coordinate with other agencies how open lot runoff situations are prioritized for inspection, technical assistance and cost share.	X	X	X	X	X		NRCS, BWSR, MDA, MPCA

Goal 5: Improve communication and coordination avenues associated with feedlot regulations, research, education, and assistance.

Milestones (Action Steps)	13	14	15	16	17	Funding Source(s)	Lead Agency(ies)
1. Improve electronic communications: Maintain and improve feedlot communications through electronic newsletters, e-mail prompts and updates; web sites, and other technologies	X	X	X	X	X	MPCA, MDA, U of MN, NRCS	MPCA, MDA U of M, NRCS
2. Feedlot education forum and Website Maintain a statewide manure and feedlot training opportunities Website	X	X	X	X	X	UM-Extension	UM-Extension
3. Update Feedlot Policy Guides, reference guides, and web-links: Update the feedlot resource guide listing various agencies, consultants, county contacts, etc., involved in feedlot and manure management. Develop and improve feedlot reference guides with web links to all key documents.	X	X	X	X	X	MPCA, MDA	MPCA, MDA

Goal 6: Evaluate and expand ways to make it easier for livestock producers to work on pollution prevention through evaluating and improving existing feedlots, and finding the best sites for new feedlots.

Milestones (Action Steps)	13	14	15	16	17	Funding Source(s)	Lead Agency(ies)
1. Help identify best sites for new feedlots. Provide assistance to producer groups on the issue of finding new feedlot sites and technologies which provide the needed environmental protection. Seek further development of Geographic Information System (GIS) data layers that assist good environmental siting of new feedlots.	X	X	X	X	X	State, MDA	MDA, MPCA
2. Expand financial assistance: Expand availability of loans and consider tax credit program to provide greater level of incentives for implementing required fixes. Continue zero interest loans for digesters and other financial assistance for new facilities which exceed 7020 rules for environmental protection. Continue the dairy business planning grants program.	X	X	X	X	X	State	MDA
3. Assess regulations: Evaluate how the rules are working to provide an efficient, environmentally sound, community/producer friendly regulatory process. Also assess how important regulation is in driving feedlot improvements (i.e. compared to education and assistance).	X	X	X	X	X	MPCA	MPCA, MDA

Milestones (Action Steps)	13	14	15	16	17	Funding Source(s)	Lead Agency(ies)
4. One stop shopping: Promote, evaluate and further develop one stop shopping to make it easier for producers to meet financial, technical and regulatory needs when modifying or expanding a feedlot facility.	X	X	X			MPCA	MPCA, MDA, NRCS, BWSR, SWCD's

Chapter 8 Agricultural Erosion

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Introduction

Soil is one of Minnesota's most valuable resources. Our fertile topsoil and skilled agricultural producers make Minnesota one of the outstanding crop producing regions in the world. Because our population and agricultural markets are becoming larger on a global basis, there is an expanding demand for the numerous products (e.g., food, clothing, and shelter) that come from the soil. It is important that this demand be translated into careful conservation and management of soil and not into exploitation. Minnesota's soil, and water resources, must be maintained as a permanent, useful resource because future needs for productive soil will be even greater than those of the present.

In 2002, Minnesota's agricultural production resulted in $8.58 billion in agricultural products sold, which ranked the state sixth, nationally. Minnesota ranks fifth nationally for total crop production based on the strength of its feed gains, wheat, soybeans and related products (2002 Census of Agriculture State Profile United States Department of Agriculture, Minnesota Agricultural Statistics Service). Minnesota's soil resources and climate provides the foundation for this agricultural abundance. While agricultural producers often lament they have no control over the weather, they do in fact have the ability to manage the soil resource to sustain this bountiful production as well as to assure the long-term productivity and quality of our state's irreplaceable soil and water resources.

There are approximately 21.4 million acres of cropland in Minnesota Natural Resources Conservation Service (NRCS 1992b). Pastureland accounts for an additional 3.3 million acres. Combined, these agricultural land uses reflect a majority (53 percent) of Minnesota's landscape. Consequently, it is appropriate to focus on this land use as a potential source of nonpoint source (NPS) pollution and to recommend strategies for the control of erosion and sediment from these lands. Erosion arising from forested agricultural lands, except for those that are grazed, is not discussed in this chapter. Silviculture is addressed in Chapter 12, Forestry.

Pollutants and Impacts

Soil and water quality problems caused by agricultural land uses are now recognized by society as a significant environmental concern. Sediments from eroded cropland interfere with the use of waterbodies for transportation; threaten investments made in dams, locks, reservoirs, and other developments, and degrade aquatic ecosystems. Sediments contain nutrients that accelerate the rate of eutrophication of lakes, streams and wetlands. Compaction and declining levels of organic matter in the soil are other forms of soil degradation that may result in accelerated erosion and greater sedimentation.

Stormwater and snowmelt runoff from cropland and pastureland carry sediment nutrients, bacteria and organic contaminants into nearby lakes, streams and wetlands. Table 8.1 indicates the nonpoint source water quality impacts resulting from sediment and nutrients.

The U.S. Department of Agriculture indicates that the primary source of pollution to those rivers and lakes of the nation that are affected by nonpoint source pollution is agriculture. Specifically, 64 percent of the nation's affected rivers and 57 percent of the nation's affected lakes receive most of their pollution from agricultural sources. Sediments and nutrients combine for 60 percent and 81 percent respectively, of the primary type of pollutants to rivers and lakes. Sediment accounts for nearly half of all pollutant types in the nation's rivers and over one-fifth of all pollutants in the nation's lakes (Carey, 1991).

Additional information regarding the impacts of sediment in Minnesota's waters is incorporated in Chapter 1, Updated NPS Assessment. This information is excerpted from Minnesota's 2004 National Water Quality Inventory (305(b)) Report.

Agricultural nutrient management is addressed in Chapter 9. For a broader review of the sources and impacts of nutrients on the quality of Minnesota's surface and ground waters, please refer to that chapter.

Sediment as a NPS Pollutant

Sediment is the single most significant water pollutant resulting most frequently from agricultural land uses, particularly cropland. Sediment that enters waterbodies and makes the water turbid is often referred to as suspended sediment. Suspended sediment discharge is the rate at which dry weight of sediment passes through a section of stream in a given time.

Suspended sediment yield is the suspended sediment load per unit of drainage area for a stream [(tons/day)/square mile]. Suspended sediment yields are greatest on intensively cropped clay and loessial soils of southern Minnesota.

Mallawantantri and Mulla (1998) estimated that annual sediment yields range widely in the Minnesota River Basin, from 471 metric tons per month in the Pomme De Terre watershed to 18,825 metric tons per month in the lower Minnesota River Watershed.

Meyer and Schellhaass (2000) report that climatic and landscape variability in watersheds make the prediction of sediment loadings very complex. However, all basins studied would benefit from stabilization of riparian areas and restoration of wetlands. Table 8.2 contains estimated annual suspended sediment yields for selected watersheds in Minnesota including data from studies by Tornes (1986), Finley (1993), NRCS (1993, 1992a and 1987b), and Hawkins and Stewart (1990).

The above discussion focuses on suspended sediment. Another type of sediment is bedload. Bedload can cause the aggradation of the bed of streams and rivers, which can contribute to increased flood stages.

Drainage and Streambank Erosion

Many wetlands have been drained to increase the acres of arable land. The drainage area of the Blue Earth River in the glaciated area of west-central Minnesota, for example, has almost doubled due to extensive tile drainage of depressional areas that formerly stored surface runoff. Studies to identify sources of sediment in this watershed have been made, and as a result, farmers have complied with reduced tillage and increased crop residue recommendations to help decrease the suspended sediment load in the river.

Table 8.1 NPS Water Quality Impacts

Pollutant	Origins	Impacts on Water Quality and Associated Users
Sediment	Agriculture, Urban Runoff, Construction, Mining, Forestry	Decrease in transmission of light through water • Decrease in primary productivity (aquatic plants and phytoplankton) upon which other species feed, causing decrease in food supply • Obscures sources of food, habitat, hiding places, nesting sites; also interferes with mating activities that rely on sight and delays reproduction timing Directly affects respiration and digestion of aquatic species (e.g., gill abrasion) Decreases viability of aquatic life; decreases survival rates of fish eggs and therefore size of fish population; affects species composition Increases temperature of surface layer of water; increases stratification and reduces oxygen-mixing lower layers, therefore decreasing oxygen supply for supporting aquatic life Decreases value for recreational and commercial activities • Reduces aesthetic value • Reduces sport and commercial fish populations • Decreases boating and swimming activities • Interferes with navigation
Nutrients (Phosphorus and Nitrogen)	Agriculture, Animal Feedlots, Urban Runoff, Construction, Forestry, Subsurface Sewage Treatment Systems (SSTS)	Promotes accelerated aging of lakes • Algal blooms and decay of organic materials create turbid conditions that eliminate submerged aquatic vegetation and destroy habitat and food for aquatic animals and waterfowl • Blooms of toxic algae can affect health of swimmers and aesthetic qualities of waterbodies (odor and murkiness) • Favors survival of less desirable fish species • Interferes with boating and fishing • Reduced dissolved oxygen levels can suffocate fish • Reduces waterfront property values Degradation of ground water quality • Reduces quality of drinking water • Nitrates can cause infant health problems

Source: Minnesota Pollution Control Agency, 1986;

Table 8.2 Summary of Suspended Sediment Yields for Selected Watersheds

Location	Drainage Area (sq. mile)	Average Annual Sediment Yield (T/ sq.mi.)	Location	Drainage Area (sq. mile)	Average Annual Sediment Yield (T/ sq. mile)
Baptism R., at Beaver Bay	140	14.2	Chippewa R., at Milan	1,870	5.8
St. Louis R., at Forbes	713	1.4	Redwood R., at Marshall	303[a] 73[b]	57.9
Deer Creek, at Holyoke	7.77	236	Redwood R., at Redwood Falls	697	17.6
Pelican R., at Fergus Falls	482	1	Minnesota R., at New Ulm	9,530	5.5
Buffalo R., at Hawley	322	5	Cottonwood R., at New Ulm	1,280	55.7
So. Branch Buffalo R., at Sabin	522	3.2	Watonwan R., at Garden City	812	54
Buffalo R., at Dilworth	1.040	4.5	Minnesota R., at Mankato	14,900	66.1
Wild Rice R., at Twin Valley	888	17.2	Straight R., at Faribault	442	44.1
Middle R., at Argyle	265	4.9	Zumbro R., at Zumbro Falls	1,130	49.3
Little Fork R., at Littlefork	1,730	33	Zumbro R., at Kellogg	1,400	104
Crow Wing R., at Nimrod	1,010	1.2	Whitewater R., at Beaver	271	260
Elk R., at Big Lake	615	2.2	Mississippi R., at Winona	59,200	5.1
Crow R., at Rockford	2,520	5.1	Root R., at Lanesboro	615	249
Mississippi R., at Anoka	19,100	8.1	Root R., at Houston	1,270	221
Whetstone R., at Big Stone City, SD	389	22.5	South Fork Root R., at Houston	275	173
Yellow Bank R., at Odessa	398	31.5	Cedar R., at Austin	425	30.9

Location	Drainage Area (sq. mile)	Average Annual Sediment Yield (T/ sq.mi.)	Location	Drainage Area (sq. mile)	Average Annual Sediment Yield (T/ sq. mile)
Kanaranzi Creek/Little Rock R., Nobles-Rock Counties	310	103.2	Des Moines R., at Jackson	1,220	14
Upper North Branch Root R., at Lake Florence	119.4	385.3	Redwood R., above Lake Redwood	640	226
Middle Branch Whitewater R., Winona County	55	292.2	Clear Creek, at Seaforth	N/A	187
Three Mile Crk, at Green Vly	N/A	84			

Sources: Finley, 1993
Hawkins and Stewart, 1990
NRCS, 1992a and 1987b

[a] = Tornes, 1986
[b] = Finley, 1993

Monitoring programs have, however, indicated that sediment problems have not been solved. Streambank and ditch bank erosion, not erosion from agricultural lands, is the major source of sediment in areas such as northwestern Minnesota, where low topographic relief contributes to reduced sediment yield. However, wind erosion, which is significant in northwestern Minnesota (Table 8.3), is believed to contribute significant sediment to drainage ditches and watercourses.

Geographic Areas of Concern

The highest suspended sediment yields in the state occurred in watersheds draining into the Mississippi River in southeast Minnesota. Adjacent watersheds of the Straight River and the upper reaches of the Zumbro River had similar average annual yields approaching 50 tons per square mile. The highest annual yields in the state were 260 tons per square mile, found on the main stem and South Fork of the Root River and Whitewater River (Tornes, 1986). Except in the situations noted earlier, stream bank erosion usually ranks behind upland areas as a sediment source to watercourses. Activities that increase or alter runoff patterns in the watershed, such as hydrologic modification, or alter near bank vegetation can aggravate streambank erosion (NRCS, 1998).

Existing erosion rate and sediment yield data and water quality assessment inventories have been compiled on several geographic scales. For example, the National Resource Inventory (NRI) contains erosion data that have been compiled at the county level and also at the major land resource area (MLRA) level. However, most water quality data cited within this chapter has either been compiled at a sub-watershed level or at the four-digit hydrologic unit code (HUC) level. Still other water quality assessments have been done at the ecoregion level. Where possible, this chapter attempts to assemble erosion rate, sediment yield and water quality data on as similar a geographic basis as possible. The four-digit HUC level was selected for the best overall representation since it directly corresponds to the water quality assessment inventories conducted by the Minnesota Pollution Control Agency (MPCA).

High Priority Agricultural Erosion Areas

Since the principal source of nonpoint source pollution is agriculture and one of the primary types of pollutants is sediment, it is appropriate to address the geographic areas in the state where erosion results in off-site sedimentation. To do so, some generalizations and initial assumptions are in order:

- cultivated cropland is usually more susceptible to erosion than other agricultural land uses
- cultivated cropland on rolling to steeply sloping topography usually contributes higher sheet and rill erosion rates than relatively level topography
- typically, a greater potential exists for off-site deposition of sediment from lands where there are few swales and depressions for on-site deposition to occur - these areas are characteristically smaller watersheds with rolling to steeply sloping topography
- in Minnesota, a small percentage of Minnesota croplands contribute proportionally higher loadings of sediment

The previous generalizations are not intended to describe any specific geographic region or watershed. Rather, these generalizations help to explain some of the relative differences between such areas and watersheds that can contribute to the actual or estimated erosion rates and suspended sediment yields in specific areas or watersheds that are observed.

Erosion from agriculture is generally described by its transport mechanism, either water or wind. The following text describes in a general way the location and magnitude of these types of erosion occurring in Minnesota.

Water Erosion

In 2004, a "Detailed Assessment of Phosphorus Sources to Minnesota Watersheds" was prepared by Barr Engineering with its partners Limno Tech, Inc., Dr. David Mulla, and Dr. Prasanna Gowda of the University of Minnesota, under contract for the Minnesota Pollution Control Agency. As part of the report a number of technical papers were prepared that help describe and estimate the phosphorus losses occurring in Minnesota. Mulla, Gowda, and Runke (2004) provided an estimate of phosphorus losses from agricultural lands for this assessment.

In predicting the phosphorus loading from agricultural land, estimates of water erosion were calculated for watersheds throughout the state.

Wind Erosion

Average annual wind erosion rates for selected MLRAs (Figure 8.1b) and agricultural land uses are contained in Table 8.3. MLRA 56 exhibits the highest average annual wind erosion rate for cropland. This area is referred to as the Red River Valley of the North and covers most of nine counties in northwestern Minnesota. Most Soil and Water Conservation District (SWCD's) have also identified and may have delineated more localized high priority erosion and sedimentation areas within their comprehensive resource management plans. These plans are available for viewing at each local SWCD office.

Table 8.3
High Priority Agricultural Wind Erosion Areas

1987 Cropland Wind (tons/acre/year)	Major Land Resource Area (MLRA)	1992 Cropland Wind (tons/acre/year)
8.5	56	12.6
7.6	88	6.6
6.7	57	6.0
6.1	91	5.3
5.4	102A	6.0

Source: (Soil Conservation Service, 1987a)
(SCS, 1992b)

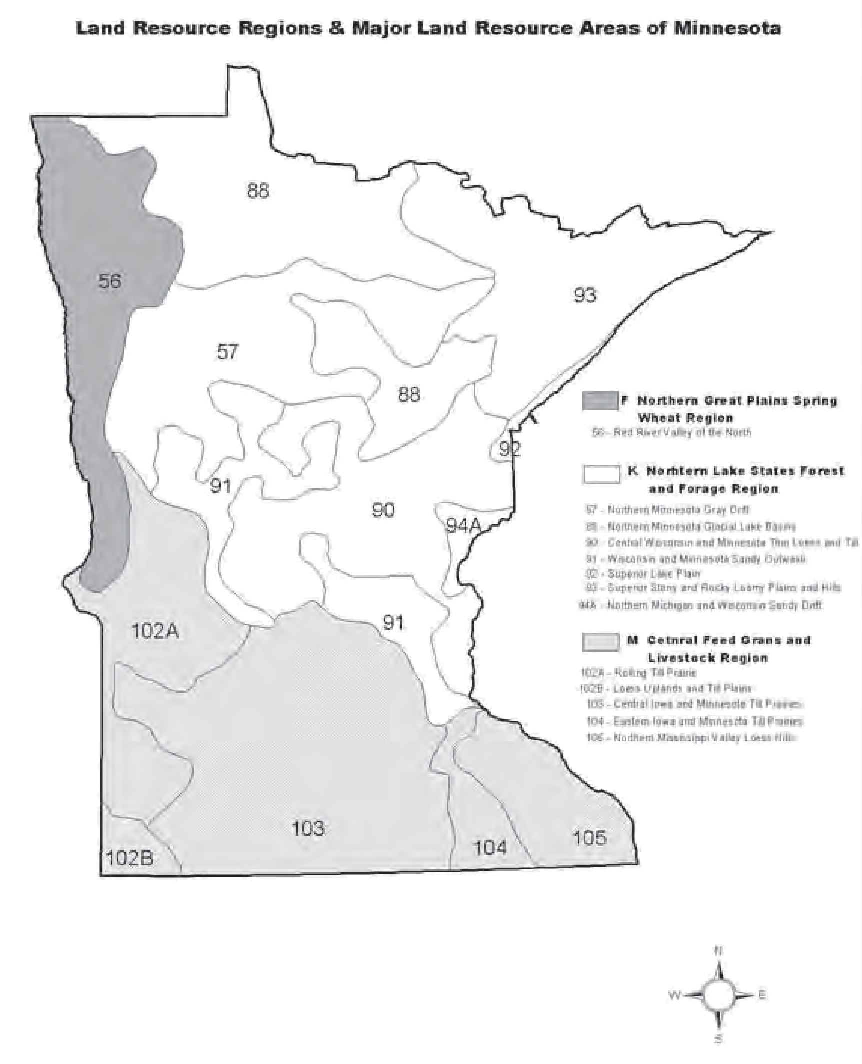

Figure 8.1b Land Resource Regions and Major Land Resource Areas of Minnesota

Water Quality Impacts from Agricultural Erosion in Minnesota

Assessing the extent of nonpoint source pollution problems is very difficult because of the large number of pollutants that must be considered and the diversity of Minnesota's lakes, stream and ground water resources. The MPCA has facilitated a general assessment of nonpoint source pollution problems in Minnesota. That assessment addresses the state's ecoregions.

Ecoregions (Figure 8.2) are based on similarities of land use, soils, land surface form, and potential natural vegetation.

Land use, topography, and water body characteristics of the ecoregions were reviewed to assess the nonpoint source pollution problems across the state. This review is compiled in MPCA (1986).

The four ecoregions that correspond to the principal crop-producing area of the state show the greatest impact to each region's water resources. These ecoregions are referred to as (1) the Red River Valley, (2) the Northern Great Plains, (3) the Western Cornbelt Plains, and (4) the Driftless Area.

Trends in stream water quality have been monitored in these ecoregions during the period 1973 through 1985 by the MPCA and their compiled results are shown in Figure 8.3 (MPCA). This monitoring shows water quality trending upwards in five of the seven eco-regions for the 12-year period reported.

Data from many sources (see references) indicate that the greatest nonpoint source pollution impacts to Minnesota rivers results from agricultural sources, especially from croplands. Agricultural sources of nonpoint pollution also significantly impact the state's lake resources, second only to the runoff and leachate resulting from on-site wastewater systems. However, nonpoint pollutants resulting from urban runoff provide a nearly equivalent degree of impact to Minnesota's lake resources, as do agricultural sources.

Overall in Minnesota, especially given the extensive land area devoted to agricultural production, it is appropriate to focus on agricultural sources of nonpoint pollution, especially sediment resulting from erosion. Agricultural sources of nonpoint pollution are often identified in water quality assessments throughout the state. A compilation, from many sources, of agricultural sediment sources for selected major watersheds in Minnesota is presented as Table 8.4.

These data clearly indicate that the greatest degree of water quality impairment from cropland and pastureland occurs in the Minnesota River Watershed.

The Minnesota River, Red River and the Upper Mississippi River watersheds appear to be the most impacted by agricultural sources of nonpoint pollution of the nine major hydrologic sub-basins in the state.

Figure 8.2

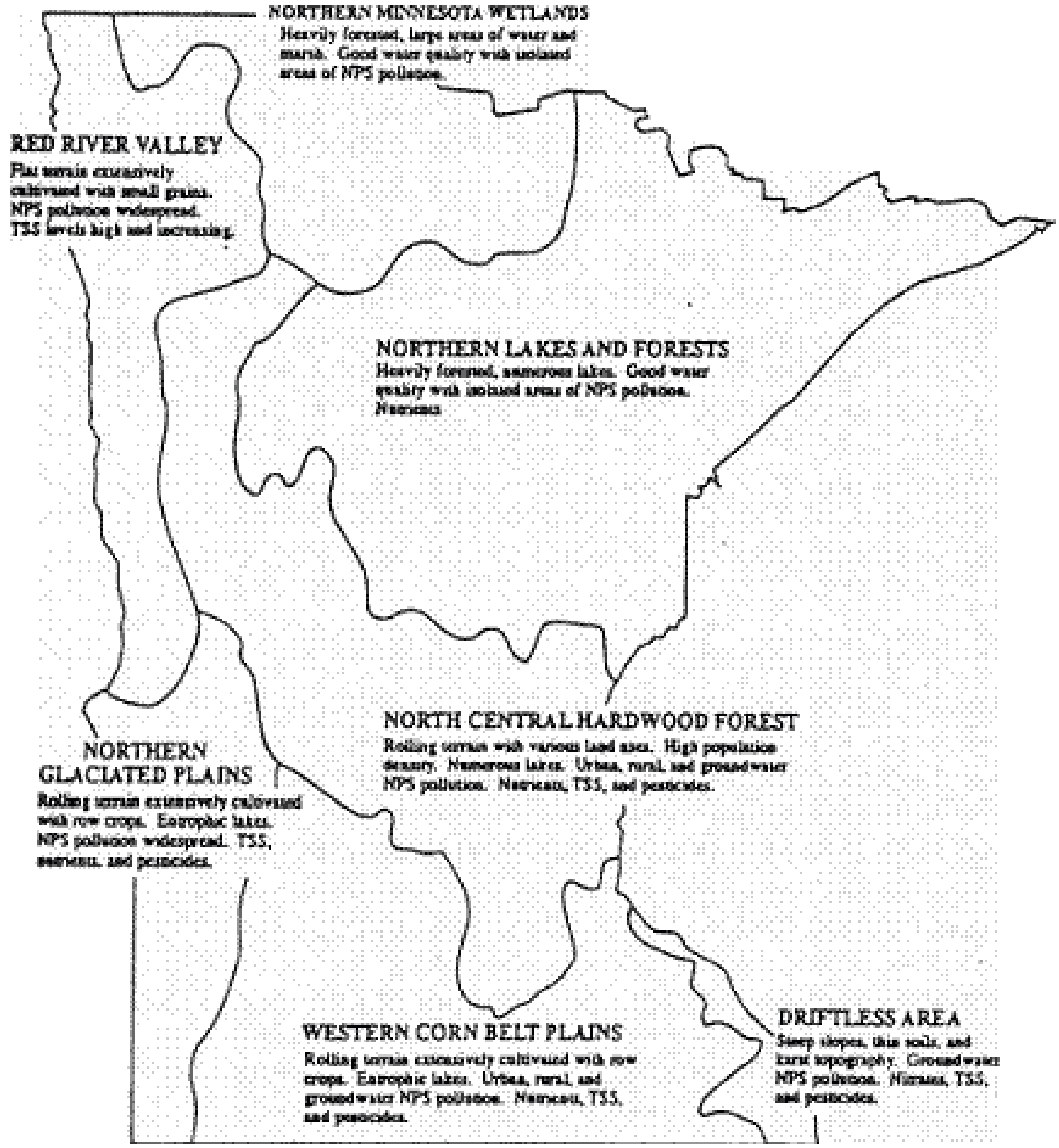
NORTHERN MINNESOTA WETLANDS
Heavily forested, large areas of water and marsh. Good water quality with isolated areas of NPS pollution.
RED RIVER VALLEY
Flat terrain extensively cultivated with small grains. NPS pollution widespread. TSS levels high and increasing.
NORTHERN LAKES AND FORESTS
Heavily forested, numerous lakes. Good water quality with isolated areas of NPS pollution. Nutrients
NORTH CENTRAL HARDWOOD FOREST
Rolling terrain with various land uses. High population density. Numerous lakes. Urban, rural, and groundwater NPS pollution. Nutrients, TSS, and pesticides.
NORTHERN GLACIATED PLAINS
Rolling terrain extensively cultivated with row crops. Eutrophic lakes. NPS pollution widespread. TSS, nutrients, and pesticides.
WESTERN CORN BELT PLAINS
Rolling terrain extensively cultivated with row crops. Eutrophic lakes. Urban, rural, and groundwater NPS pollution. Nutrients, TSS, and pesticides.
DRIFTLESS AREA
Steep slopes, thin soils, and karst topography. Groundwater NPS pollution. Nitrates, TSS, and pesticides.

Table 8.4
Summary of Agricultural Sediment Sources for Selected Impacted Waters

Source of Sediment	Hydrologic Sub-Basin (Code # & Name)	IMPAIRED River Miles	IMPAIRED River Ranking	IMPAIRED Lake Acres	IMPAIRED Lake Ranking	THREATENED River Miles	THREATENED River Ranking	THREATENED Lake Acres	THREATENED Lake Ranking
Cropland: Non-irrigated	0702: Minnesota River	2,397	1	133,791	1	342	4	34,435	3
	0902: Red River	1,159	2	92,562	2	1,112	1	76,279	1
	0701: Upper Mississippi River	620	4	92,005	3	576	3	71,763	2
	0704: Lower Mississippi River	761	3	11,839	5	634	2	13,083	4
	0710/0708/0706: Cedar, etc.	220	5	18,185	4	191	6	7,876	6
	1017: Missouri River	194	6	504	7	244	5	10,105	5
	0903: Rainy River	91	7	0	N/A	75	7		
	0703: St. Croix River	0	N/A	10,551	6	56	8	1,939	7
	0401: Lake Superior, etc.	0	N/A	0	N/A	0	N/A	52	8
Cropland: Irrigated	0702: Minnesota River	589	1	36,762	1	46	4	5,182	2
	0701: Upper Mississippi River	435	2	27,730	2	496	1	4,659	3
	1017: Missouri River	194	3	504	4	33	5	0	N/A
	0704: Lower Mississippi River	83	4	448	5	19	6	0	N/A
	0710/0708/0706: Cedar, etc.	68	5	0	N/A	52	3	0	N/A
	0703: St. Croix River	0	N/A	5,018	3	0	N/A	387	4
	0902: Red River	0	N/A	0	N/A	235	2	15,383	1
	0903: Rainy River	0	N/A	0	N/A	0	N/A	0	N/A
	0401: Lake Superior, etc.	0	N/A	0	N/A	0	N/A	0	N/A
Pastureland	0702: Minnesota River	692	1	80,221	1	175	5	21,513	4
	0902: Red River	638	2	76,552	2	499	3	49,098	3
	0704: Lower Mississippi River	516	3	10,840	5	587	2	3,780	5
	0701: Upper Mississippi River	408	4	70,148	3	673	1	56,708	2
	1017: Missouri River	158	5	504	7	203	4	1,178	6
	0710/0708/0706: Cedar, etc.	151	6	9,013	6	141	6	776	7
	0401: Lake Superior, etc.	13	7	0	N/A	19	9	0	N/A
	0703: St. Croix River	0	N/A	12,355	4	56	8	601	8
	0903: Rainy River	0	N/A	0	N/A	115	7	220,800	1

Notes:
Units of impaired and threatened river miles or lake acres are not additive since each unit may be impacted by more than one source of nonpoint pollutant.
N/A - not applicable

In 1993, the NRCS, formerly the Soil Conservation Service, assessed the magnitude of nonpoint pollution sources in ten agricultural sub-watersheds of the Blue Earth, Watonwan and LeSueur River watersheds of the Minnesota River sub-basin (HUC #0702). Cropland comprised 86 percent of the area studied and 85 percent of the cropland was under a two-year crop rotation of corn and soybeans. Table 8.5 includes the predicted annual suspended sediment yield for each of the ten sub-watersheds. Other recent studies have indicated similar annual suspended sediment yields for watersheds with a predominance of agricultural land use; those estimates are included in Table 8.2. For example, the NRCS studied watersheds in southeastern and southwestern portions (respectively) of the state; the former contained 85 percent cropland and 4 percent pastureland while the latter contained 88 percent cropland and 5 percent pastureland. While both watersheds yielded significant amounts of sediment, the southeastern Minnesota watershed contributed considerably more. This relative difference can be explained mostly by the obvious and considerable differences in topography and soils between the two watersheds. Nevertheless, each study indicates a significant loading of suspended sediment to the rivers and streams contained within each watershed.

Table 8.5 Priority Ranking of Selected Minnesota River Sub-Watersheds

Sub-Watershed		Drainage Area (square miles)	Watershed		Annual Suspended Sediment Yield	SCS Ranking
Common Name	Hydrologic Code		Common Name	Hydrologic Code		
County Ditch #44	30050	10.6	Blue Earth River	07020009	707.5	1
County Ditch #60	30030	4.3	Blue Earth River	07020009	581.4	2
County Ditch #26	30047	10.3	Blue Earth River	07020009	524.3	3
Cobb River Tributary	32073	8.8	LeSueur River	07020011	465.9	4
Judicial Ditch #3	30056	10.6	Blue Earth River	07020009	377.4	5
Maple River Tributary	32042	908	LeSueur River	07020011	326.5	6***
County Ditch #5	32067	15.1	LeSueur River	07020011	344.4	7***
Mountain Lake	31058	10.3	Watonwan River	07020010	252.4	8
Duck Lake	28033	8.3	Middle Minnesota River	0702007	168.7	9
St. James Creek	31015	17.9	Watonwan River	07020010	134.1	10

* Indicates a code used by the Minnesota Department of Natural Resources.
** Indicates a code used by the USDA NRCS
*** NRCS (1993) ranked these watersheds as shown. As illustrated in this table, the ranking would be interchanged based on the computations of average annual sediment yield. The difference in ranking of these two sub-watersheds is due to rounding of numbers used in the computations.

In its study of the ten agricultural sub-watersheds of the Minnesota River sub-basin (1993) developed three strategies to address sedimentation. The three sediment management strategies that were developed included:

- (SED MGT-1) using whatever conservation tillage practices necessary to reduce sheet and rill erosion to soil loss tolerance levels;
- (SED MGT-2) using conservation tillage practices on all cropland in the ten watersheds; and
- (SED MGT-3) treating only those erosion areas located adjacent to drainage ditches, grass waterways, and streams downstream of large wetlands and lakes.

Table 8.6 illustrates the effectiveness of the three sediment management strategies. In its report SCS (1993) recommended that SED MGT- I be implemented first, followed by SED MGT-3, and then add SED MGT-2 until a desired goal is attained. Each strategy that reduced sediment yield by at least one ton per acre of treatment was highlighted on the table. In a similar study for the Upper Branch Root River in southeastern Minnesota, SCS (1992a) data suggest that each of two alternative management strategies would reduce sediment yield in that watershed by approximately 1.7-1.8 tons per acre treated.

Significant reductions in erosion and associated sediment from the application of best management practices have been identified as an effective land treatment strategy in the phosphorus reduction strategy of the Minnesota River (MPCA, 2000).

Best Management Practices (BMP) for Agricultural Erosion and Sediment Control

Description and Effectiveness

Table 8.7 (Brach, 1991) indicates the types and effectiveness of BMPs often used to protect surface and ground water from agricultural sources of nonpoint source pollution. For the purpose of this chapter, the principal focus of the selected BMPs is to address sedimentation into surface waters. Accordingly, it is evident that the most effective practices to control sediments are structural practices. Unfortunately, these practices often are relatively expensive to establish and maintain. However, the effective life of such practices (with proper maintenance) often exceeds 15 years whereas most vegetative and tillage practices established derive only annual benefits and must be reestablished each year. Consequently, vegetative and tillage practices are relatively inexpensive to establish, yet often require a greater degree of on-going management to fully realize the anticipated water quality benefits.

On-going Application of BMPs in Minnesota

Best management practices are commonly used in Minnesota to address a number of resource concerns including erosion and sediment control. Many BMPs provide multiple benefits including water quality improvement, and creation and or enhancement of fish and wildlife habitat. This section illustrates accomplishments made by local, state and federal conservation agencies in the areas of conservation practices and land set-aside programs.

Conservation Practices

There are three main programs which provide financial assistance to private landowners to offset a portion of the cost of planning, designing and constructing conservation practices. They include the USDA NRCS Environmental Quality Incentives Program (EQIP), the Board of Water and Soil Resources (BWSR) Erosion Control and Water Quality Protection Cost-Share Program, and the Minnesota Deparment of Agriculture (MDA) BMP Loan Program. Significant strides have been made since the last version of the State Nonpoint Source Management Program Plan was prepared due to a tremendous increase in funding for conservation in programs such as EQIP and Conservation Reserve Program/Conservation Reserve Enhancement Program.

Table 8.8a provides a snapshot of accomplishment through the EQIP program for the time period of 2002 and 2003. Table 8.8b is a summary of conservation practices reported to the BWSR by SWCD and counties through its electronic reporting program (eLINK.) eLINK, is unique in the country in that it not only keeps track of the number and type of conservation practices it also estimates the amount of erosion, sediment, and phosphorous reduction that occurs, at the field level, for the practices reported, and all financial partners including the landowners.

eLINK also uses Geographic Information System (GIS) to keep track of the actual location of the practices, which greatly aids in the use of this data for watershed modeling.

Conservation tillage is another very important practice in controlling erosion and the transport of sediment to surface waters. It deserves separate attention in that many acres of conservation tillage are a direct result of landowners adopting this practice, not simply the cause of conservation financial assistance programs. In fact many agricultural producers have integrated some form of conservation tillage with most of their crop rotations. Table 8.10 provides us a look at the adoption of conservation tillage in Minnesota. It shows an overall increase from 2002 to 2004, with nearly 25 percent of crop acres utilizing some form of conservation tillage, in 2004.

Table 8.6 Effectiveness of Sediment Management Strategies for Selected Priority Sub-Watersheds

				Sediment Management Strategies								
		Sub-Watershed		#1			#3			#2		
SCS Ranking Of Annual Suspended Sediment Yield	Suspended Sediment Yield (T/yr./sq. mi.)	Common Name	Hydrological Code*	Annual Yield	% Reduced	Reduction Per Acre Treated	Annual Yield	% Reduced	Reduction Per Acre Treated	Annual Yield	% Reduced	Reduction Per Acre Treated
1	707.5	County Ditch #44	30050	424.5	40	1.07 ton	622.6	12	0.82 ton	367.9	48	0.62 ton
2	581.4	County Ditch #60	30030	488.4	16	1.00 ton	465.1	20	0.83 ton	325.6	44	0.46 ton
3	524.3	County Ditch #26	30047	291.3	44	1.14 ton	446.6	15	2.00 ton	223.3	57	0.52 ton
4	465.9	Cobb R. tributary	32073	329.5	29	1.00 ton	409.1	12	0.56 ton	261.4	44	0.35 ton
5	377.4	Judicial Ditch #3	30056	349.1	7	0.60 ton	311.2	18	0.64 ton	188.7	50	.033 ton
6**	326.5	Maple R. tributary	32042	295.9	9	1.00 ton	285.7	13	0.44 ton	224.5	31	0.33 ton
7**	344.4	County Ditch #5	32067	258.3	25	1.08 ton	304.6	12	1.00 ton	165.6	52	.038 ton
8	252.4	Mountain Lake	31058	223.3	12	0.60 ton	N/A	N/A	N/A	194.2	23	0.19 ton
9	168.7	Duck Lake	28033	144.6	14	0.25 ton	N/A	N/A	N/A	108.4	36	0.18 ton
10	134.1	St. James Creek	31015	122.9	8	0.50 ton	122.9	8	0.40 ton	83.8	38	0.10 ton

NOTES:
* Indicates a code used by the Minnesota Department of Natural Resources
"N/A" indicates not applicable.
** = SCS (1993) ranked those watersheds as shown. As illustrated in this table, the ranking would be interchanged based on the computations of average annual sediment yield. The differences in ranking of these two sub-watersheds are due to rounding of numbers used in the computations.

Table 8.7

Best Management Practices Summary Guide	Surface Water							Ground Water	
	Sediment	Soluble Nutrients	Adsorbed Nutrients	Soluble Pesticides	Adsorbed Pesticides	Oxygen-Demanding Substances	Bacteria	Nitrogen Loss to Grand Wtr.	Pesticide Loss to Ground Wtr.
I. MANAGEMENT PRACTICES									
1. Nutrient Management	±	λ	λ	±	±	±	±	λ	±
2. Integrated Pest Management	±	±	±	λ	λ	±	±	±	λ
3. Proper Pesticide Use	±	±	±	λ	λ	±	±	±	λ
4. Irrigation Water Management	◆	◆	◆	◆	◆	±	±	◆	◆
II. VEGETATIVE AND TILLAGE PRACTICES									
5. Conservation Tillage	λ	±	λ	±	λ	±	±	▲	▲
6. Contour Farming	λ	◆	λ	◆	λ	◆	◆	▲	▲
7. Stripcropping	◆	◆	◆	◆	◆	◆	◆	±	±
8. Filter Strip	◆	±	◆	±	◆	◆	◆	±	±
9. Field Border	◆	±	◆	±	◆	◆	◆	±	±
10. Cover Crop	◆	◆	◆	◆	◆	±	±	◆	±
11. Crop Rotation	λ	±	λ	◆	λ	±	±	±	◆
12. Field Windbreaks	◆	±	◆	±	◆	±	±	±	±
13. Pasture Management	◆	±	◆	±	±	◆	◆	±	±
III. STRUCTURAL PRACTICES									
14. Ag Waste Management System	λ	λ	λ	±	±	λ	λ	λ	±
15. Runoff Management System	λ	λ	λ	±	±	λ	λ	λ	±
16. Terrace	λ	◆	λ	◆	λ	◆	◆	▲	▲
17. Water & Sediment Control Basin	λ	±	λ	±	λ	◆	±	▲	▲
18. Diversion	◆	±	◆	±	◆	±	±	±	±
19. Livestock Exclusion (Fencing)	λ	λ	l	±	±	λ	λ	±	±
20. Grade Stabilization Structure	◆	±	◆	±	±	±	±	±	±
21. Grassed Waterway	◆	±	◆	±	◆	±	±	±	±
22. Streambank Protection	λ	±	λ	±	±	±	±	±	±
23. Wetland Development	λ	◆	λ	±	λ	λ	◆	±	±
IV. MISCELLANEOUS PRACTICES									
24. Sealing Abandoned Wells	±	◆	±	◆	±	±	±	λ	λ
25. Onsite Sewage Disposal System	±	λ	±	±	±	λ	λ	λ	±
26. Sinkhole Protection	±	±	±	±	±	±	±	λ	λ

± No control to low effectiveness

◆ Low to medium effectiveness

λ Medium to high effectiveness

▲ May increase loading in some cases

Table 8.8a

2002-2003 EQIP Practices with Agricultural Erosion Reduction Benefits

EQIP Ag Erosion Practices		2002 + 2003		
Practice Code	**Practice Name**	**# of Contracts**	**Contract Units**	**Contract Dollars**
328	Conservation Crop Rotation	210	55,672	$2,510,539
329	Residue Management	342	167,129	$2,011,290
330	Contour Farming	5	186	$1,301
344	Residue Management Seasonal	122	66,268	$235,247
350	Sediment Basin	2	2	$26,125
362	Diversion	29	24,459	$57,087
393	Filter Strip	5	23	$4,600
410	Grade Stabilization Structure	64	84	$1,132,286
412	Grassed Waterway	164	300	$512,239
468	Lined Waterway or Outlet	3	3	$8,900
512	Pasture/Hayland	131	6,932	$812,223
580	Streambank and Shoreline Protection	2	302	$20,250
585	Contour Stripcropping	3	237	$3,561
586	Stripcropping Field	1	250	$1,750
587	Structure for Water Control	2	2	$3,500
600	Terrace	56	204,342	$454,296
638	Water & Sediment Control Basin	197	3,181	$1,012,833
650	Windbreak & Shelterbelt Renovation	6	9	$4,520
657	Wetland Restoration	4	34	$10,020
725	Sinkhole Treatment	4	5	$13,125
	TOTALS:	**1352**		**$8,835,692**

Practice	Practice Description	Count	Estimated Soil Loss Reduction (tons/yr)	Estimated Sediment Reduction (tons/yr)	Estimated Phosphorus reduction (lbs/yr)	Occupier	State Loans	State Grants	LGU & other	Federal	TOTAL
132	Wetland Creation	1				$12,380	$0	$2,500	$0	$4,120	$19,000
133	Wetland Restoration	18	212	34	96	$5,263	$0	$4,140	$2,309	$36,137	$47,850
148	Erosion Control	35	1,343	524	420	$22,411	$0	$28,357	$16,560	$0	$67,328
327	Conservation Cover	254	40,573	1,729	3,942	$32,703	$0	$256,507	$228,214	$20,160	$537,583
327M	Conservation Cover Easement	1							$5,000		$5,000
328	Conservation Crop Rotation	16	96		611	$0	$0	$0	$0	$14,168	$14,168
329	Residue Management	109	55658	8344	12734	$128,246	$722,568	$3,169	$5,880	$11,632	$871,495
342	Critical Area Planting	35	1,560	265	712	$27,958	$0	$63,099	$5,427	$4,260	$100,743
343	Critical or Sensitive Area Protection	27	321	134	158	$169,036	$0	$23,238	$14,909	$7,055	$214,238
344	Residue Management, Seasonal	22	176		1	$6,106	$0	$0	$0	$0	$6,106
350	Sediment Basin	43	398	164	416	$4,577	$409,706	$95,588	$41,680	$261,700	$813,251
362	Diversion	36	57,492	40,137	34,469	$44,788	$0	$97,086	$6,041	$8,497	$156,413
380	Windbreak/Shelterbelt Establishment	640	20,896		986	$189,061	$0	$398,696	$22,625	$144,644	$755,027
392	Field Windbreak	274	36,938		20,750	$160,322	$0	$227,801	$13,622	$287,762	$689,508
393	Filter Strip	365	10,860	3,106	12,604	$47,810	$22,790	$246,944	$102,639	$540,203	$960,386
410	Grade Stabilization Structure	102	19,303	49,901	34,687	$101,535	$1,242	$291,496	$43,242	$33,048	$470,563
412	Grassed Waterway	243	18,204	57,399	55,872	$194,086	$2,684	$463,813	$43,985	$65,094	$769,661
512	Pasture and Hayland Planting	11	1,254	55	96	$3,841	$0	$974	$4,405	$6,368	$15,588
571	Sinkhole Treatment	4				$1,517	$0	$2,823	$0	$0	$4,340
580	Streambank and Shoreline Protection	232	34,929	22,028	31,847	$854,556	$120,977	$1,044,149	$336,442	$353,664	$2,709,788
582	Open Channel	1	8	8	9	$1,150	$0	$11,449	$0	$0	$12,599
584	Stream Channel Stabilization	9	138	138	149	$8,802	$0	$40,442	$22,588	$14,390	$86,222
585	Strip Cropping-Contour	3	846	197	162	$612	$0	$1,750	$400	$0	$2,762
587	Structure for Water Control	4	14	1,809	2,800	$29,825	$0	$34,300	$8,736	$21,750	$94,611
589	Cross Wind Trap Strips	1	70			$0	$0	$0	$0	$0	$0
600	Terrace	98	15,176	4,635	4,903	$143,922	$3,123	$286,674	$24,497	$40,022	$498,238
612	Tree/Shrub Establishment	645	30,048	120	8,357	$236,184	$0	$73,427	$29,195	$389,924	$728,730
638	Water and Sediment Control Basin	168	10,337	8,997	8,131	$285,704	$9,716	$578,633	$84,754	$173,675	$1,132,483
639	Water and Sediment Control Basin Maint.	4	0	5	9	$1,208	$0	$3,623	$12,425	$0	$17,256
650	Windbreak/Shelterbelt Renovation	11	463			$1,404	$0	$7,897	$0	$0	$9,301
657	Wetland Restoration	2				$0	$0	$4,500	$5,500	$0	$10,000
659	Wetland Enhancement	1				$0	$0	$0	$6,500	$0	$6,500
	Totals	3,415				$2,715,007	$1,292,806	$4,293,075	$1,087,577	$2,438,273	$11,826,738

Table 8.8b
2002–2003 Land Water Treatment Practices with Agricultural Erosion Reduction Benefits

Land Set-aside and Conservation Easements

Cost-share and loan programs are usually designed to provide financial assistance to landowners that voluntarily establish conservation practices that protect soil resources of productive agricultural lands and adjacent water resources. However, there are some marginal and environmentally sensitive agricultural lands that should be retired from agricultural use, particularly crop production. Landowners with marginal and environmentally sensitive lands have participated in land retirement programs such as the federal Conservation Reserve Program (CRP), the federal Wetland Reserve Program (WRP) and the BWSR conservation easement programs known as the Reinvest In Minnesota (RIM) Reserve. Both CRP and WRP have an enhancement option, which allows states to submit projects to United States Department of Agriculture (USDA) to enhance these two existing programs through targeting, and adding extensions to contracts. In Minnesota we have both a Conservation Reserve Enhancement Program (CREP) and a Wetland Reserve Enhancement Program (WREP.) CRP offers annual payments to landowners that enroll eligible lands under 10 to 15-year contracts and establish permanent vegetative cover. RIM reserve offers a lump sum payment to landowners that enroll eligible lands under limited duration or perpetual conservation easements. CREP is a combination of RIM and CRP, which extends the benefits of CRP for a longer period of time, usually to perpetuity. WRP offers 35 year or perpetual easement options. WREP is a combination of RIM and WRP, which extends the financial and technical resources of each program.

Approximately 1.96 million acres of cropland in Minnesota have been enrolled in the various land set-aside or conservation easement programs. Table 8.9 illustrates the acreage and type of land set-aside or conservation easements enrolled through 2005. These programs offer an additional land management options for agricultural producers in Minnesota to address agricultural erosion and the associated impacts to water resources. Minnesota just recently entered into a new CREP agreement (CREP II) with USDA with an acreage goal of 120,000 acres.

Total Maximum Daily Loads (TMDL)

Section 303(d) of the Clean Water Act requires states to publish a list of stream and lakes that do not meet their designated uses because of excess pollutants every two years. Minnesota's 1998 303(d) List identified stream reaches as being impaired based on a comparison of available water quality data with the state's Water Quality Standards for turbidity, fecal coliform, pH, un-ionized ammonia, dissolved oxygen, mercury and others. Once specific stream reaches are identified as impaired, the Clean Water Act, Section 303(d), requires that a total TMDL be developed for those reaches.

Agricultural soil erosion and its subsequent transport into Minnesota's waterways directly influences turbidity in these waterways. As such, agricultural soil erosion will often be a major source of sediment for which TMDLs will develop local allocations designed for the attainment of water quality standards. In addition to the completion of individual TMDLs, work is needed to develop a process that adequately links turbidity to the biological responses in water systems. The process also needs to provide an adequate link back to the watershed landscape (hydrology, soils, land use, etc.). Issues of scale in the application of TMDLs to watershed management in Minnesota also need to be addressed.

Table 8.9
Conservation Easements and Land Set-Aside Programs

Program	Easement Type	Duration	# of Easements	# of Acres
RIM	Marginal Ag Land	Perpetual	465	11,049
		Limited	161	3,173
	Wetland Restoration	Perpetual	512	19,055
RIM/WRP	Wetland Restoration	Perpetual	118	6,686
RIM	Sensitive Ground water	Perpetual	32	1,041
		Limited	7	135
RIM	Riparian	Perpetual	463	17,322
		Limited	7	151
RIM	PWP	Perpetual	299	11,511
RIM	Other	Perpetual	252	6,262
		Limited	6	125
MN River CREP	Wetland Restoration	Perpetual	917	55,051
	Riparian	Perpetual	1,459	43,272
		Limited	94	2,134
CREP II	Wetland Restoration	Perpetual	7	180
120,000 acres	Riparian	Limited	21	378
	Ground water/Wellhead Protection	Limited	2	128
	HEL	Limited	2	22
	FDR - control system	Perpetual		
	FDR - riparian	Perpetual	3	37
	FDR - wetland restoration	Perpetual		
CRP	General CRP	Contract	n/a	1,147,259
	Continuous CRP	Contract	n/a	268,243
	CRP wetland restoration	Contract	n/a	373,000
		Total	4,827	1,966,214

(Board of Water and Soil Resources 2005)

Table 8.10
Conservation Tillage for Selected Crops in Minnesota, 2004

Crop	Total Planted (acres)	No-Till (acres) [% of crop]	Ridge-Till (acres) [% of crop]	Mulch-Till (acres) [% of crop]	Total in Conserv. (acres) [% of crop]
Corn	7,388,154	109,720 1.5%	46,992 0.6%	1,162,023 13%	1,318,735 18%
Soybeans	7,176,774	509,231 7%	57,157 0.8%	3,310,182 46%	3,876,570 54%
Small Grains	2,116,245	24,083 1.1%	809 0.04%	462,008 22%	486,900 23%
All Crops	17,985,616	667,700 3.7%	105,112 0.6%	5,184,144 29%	5,956,956 33%

Conservation Tillage in Minnesota, 1992-2004 (All Crops)

Year	Total Planted (acres)	No-Till (acres) [% of crop]	Ridge-Till (acres) [% of crop]	Mulch-Till (acres) [% of crop]	Total in Conserv. (acres) [% of crop]
1992	18,297,222	531,027 3%	572,799 3%	2,971,651 16%	4,075,477 22%
1993	17,737,678	809,306 5%	569,097 3%	3,449,875 19%	4,828,278 27%
1994	18,947,223	718,290 4%	509,148 3%	3,312,928 17%	4,540,366 24%
1995	18,154,182	592,282 3%	361,933 2%	3,370,300 19%	4,324,515 24%
1996	18,892,324	613,812 3%	300,296 2%	4,004,202 21%	4,918,310 26%
1997	19,280,160	654,515 3%	311,278 2%	4,149,228 22%	5,115,021 27%
1998	19,111,901	565,866 3%	153,107 1%	3,720,803 19%	4,439,776 23%
2000	18,459,188	457,790 2.5%	137,319 0.7%	3,986,656 21.5%	4,581,765 25%
2002		525,830 3%	138,205 0.8%	3,572,930 20%	4,236,965 23%
2004	17,985,616	667,700 3.7%	105,112 0.6%	5,184,144 29%	5,956,956 33%
Average	18,551,465	653,205 4%	437,425 2%	3,543,031 19%	4,633,661 25%

Source: Conservation Tillage Information Center (2004)

The water quality standard for turbidity in the Minnesota River is 25 Nephelometric Turbidity Units (NTU). The correlation between the concentration of total suspended solids (TSS) in the water and turbidity is fairly strong. As such, a link between the turbidity standard and TSS concentration may be made. In doing so, it appears that the turbidity standard is likely exceeded whenever flows are elevated due to storm events in agricultural watersheds. The development of suspended sediment-related standards must, in some way, accommodate both the actual conditions in the river and elevated turbidity levels from storm events. It must also account for differences in measurement techniques, specifically suspended sediment concentrations versus TSS concentrations and turbidity measurements.

Current Programs and Authorities

Federal Activities

Table 8.11 illustrates the federal agency activities in Minnesota to address agricultural erosion and sediment control. The principal technical assistance agency is the NRCS, formerly known as the Soil Conservation Service (SCS), and the principal financial assistance agency is the Farm Services Agency (FSA), both within the U.S. Department of Agriculture.

State Activities

Table 8.12 illustrates the state agency activities in Minnesota to address agricultural erosion and sediment control. The principal agency is the BWSR due to the focus of many of its land treatment programs to private lands and also because those programs are administered locally, through soil and water conservation districts (SWCDs). Other state agencies include the MPCA, the Minnesota Department of Agriculture and the Minnesota Department of Natural Resources (MDNR).

To better correlate BMP installation with pollutant reductions, several state and federal agencies, led by BWSR, have implemented a web-based interactive GIS system, eLink, that integrates practice location, and estimates of erosion, sediment and phosphorous reduction.

Local Activities

Table 8.12 illustrates local activities in Minnesota to address agricultural erosion and sediment control. The principal agency is the local SWCD due to its ability to provide technical assistance to private landowners and also because it locally administers land treatment programs offered by BWSR. The Metropolitan Council (Met Council) plays an active role in local activities in the Twin City metropolitan area and is also included in the following table.

Needs, Priorities and Milestones

Efforts to reduce and prevent water quality degradation from agricultural erosion must begin with soil and water resource management activities that protect and enhance soil quality. The quality of a soil depends on attributes such as texture, depth, permeability, biological activity, capacity to store water and nutrients, and the amount of organic matter contained in the soil. High-quality soils prevent water pollution by resisting erosion, absorbing and partitioning rainfall and snowmelt runoff, and degrading or immobilizing agricultural chemicals (National Research Council, 1993).

The table at the end of the chapter illustrates an action plan for years beginning 2008 for controlling sedimentation and associated nonpoint pollution resulting from agricultural erosion.

Table 8.11 Current Federal Activities in Agricultural Erosion and Sediment Control

Agency	Program	Program Delivery
NRCS	**Technical Assistance:** Assistance in developing conservation plans, planning and implementing practices on any land use for a wide variety of purposes including soil erosion, water conservation, water quality, gully control, soil productivity and animal waste management.	**District Conservationists** provide assistance to individuals, groups and governments as requested and as priorities allow. Contact county office to request technical assistance.
NRCS	**Cooperative River Basin Studies:** Efforts with other federal, state, and local agencies to appraise water and related resources and develop plans for conservation, use and development.	**Sponsors** of river basin projects requests assistance through Minnesota state office.
NRCS	**Flood Plain Management Studies:** Provide assistance to local and state agencies for programs to reduce existing and future flood damages.	**Project sponsors** request assistance through Minnesota state office.
NRCS	**Soil Survey Program:** Identifies maps and interprets soils to assist users in understanding and using soil wisely.	**District Conservationists** provide assistance to any user upon request. Soils information is available to the public on the web via web soil survey.
NRCS	**National Resource Inventories:** Collects data on land use, management, and conservation treatment needed to help public and private organizations, groups, and individuals make land use decisions.	**Inventory Specialist** provides inventory data to all users. **District Conservationists** collect and provide county level data to local users.
NRCS FSA	**Sodbuster Program:** Determines if fields that have been broken out of native vegetation are highly erodible. Provides assistance to develop and implement conservation plans on highly erodible fields. Farm programs benefits denied by other federal agencies if violations occur.	**NRCS District Conservation** makes technical determinations. **FSA County Executive Directors** oversee administration.
NRCS FSA	**Conservation Compliance:** Determines if cropland fields meet the highly erodible definition. Provide assistance to develop and implement conservation plans on highly erodible fields. Also determines if any wetland violations have occurred. Farm program benefits denied by other federal agencies if violations occur.	**NRCS District Conservationists** make technical determinations and assist preparation of conservation plans. **FSA County Executive Directors** oversee administration.
NRCS	**Environmental Quality Incentive Program:** Provides cost-sharing to agricultural producers for conservation practices that prevent soil erosion and water pollution, conserve water, preserve and develop wildlife habitat and encourage energy conservation.	**NRCS District Conservationists** accept applications, make technical determinations and provide technical assistance to install the desired practices.

Agency	Program	Program Delivery
FSA NRCS	**Conservation Reserve Program (CRP) and the Conservation Reserve Enhancement Program (CREP):** Provides annual rental payments to agricultural producers for 10 to 15-year retirement of certain cropland that is highly erodible or contributes to water quality problems. Also provides cost-sharing to establish necessary conservation practices.	**Local FSA offices** accept applications from producers; **Conservationists** assist preparation of conservation plans and installation of necessary practices.
NRCS	**Small Watershed Protection and Flood Prevention Program:** Assist local project sponsors to develop and implement watershed plans. Projects may include watershed protection, flood prevention, erosion and sediment control, or animal waste management.	**Sponsors** of watershed projects requests assistance through Minnesota State Office.
NRCS	**Conservation Security Program:** Rewards landowners for their previous conservation stewardship efforts and provides incentives for additional enhancements on working ag lands. Provides annual payments for 5to 10 years.	**NRCS** accepts applications and assists landowners with eligibility determinations.

(Martinek, USDA NRCS, 2005)

Table 8.12 Current State Activities in Agricultural Erosion and Sediment Control

Agency	Program	Program Delivery
BWSR	**General Services Grants**: Provides assistance to SWCDs to administer programs.	**Local SWCDs** provide technical assistance to individuals, groups and other local units of government as requested and as priorities allow. General services grant helps support these services.
MPCA	**Nonpoint Source Pollution Management Program**: Variety of activities to assess and reduce pollution of surface and ground water from nonpoint sources.	**MPCA Central Office and regional offices**, in cooperation with local governments and other state and federal agencies, implement the various management strategies.
BWSR	**Local Water Resources Protection and Management Program**: Provides grants to counties to assist in administration and implementation of approved and adopted local water plans. Inventorying, monitoring and data collection are allowed.	**BWSR administers the program through counties**. Local water planning task forces are often involved. Counties must have a state approved and locally adopted plan.

Agency	Program	Program Delivery
MPCA	**Clean Water Partnership Program**: Matching grants and technical assistance to local governments to conduct watershed management projects to protect and improve surface and ground water degraded by nonpoint pollutants. Pollution sources must be identified and assessed, and a watershed implementation plan that identifies best management practices must be implemented.	**Sponsors (local governments)** of projects request consideration through an annual application process conducted by the **MPCA.**
MPCA	**Minnesota River Projects:** Identifies, monitors and assesses nonpoint source pollutant loadings. Emphasis is currently on conducting and implementing TMDLs for the river.	**MPCA** coordinates cooperating agencies and a Citizen Advisory Committee.
DNR	**Shoreland Management Program:** Establishes standards for development of shoreland areas including subdivisions, structure setbacks, vegetative management, land alterations, agricultural activities, and on-site wastewater systems.	**MDNR** sets standards and local governments incorporate into their ordinances. **MDNR** also reviews and comments on certain local zoning actions.
BWSR	**Erosion Control & Water Quality Protection and Improvement Cost-Share Program:** Provides financial assistance to landowners for installation of erosion and sediment control and water quality protection practices.	**BWSR administers the program through SWCDs.**
BWSR	**Reinvest in Minnesota (RIM) Reserve Program and CREP:** Retires marginal agricultural lands from crop production through conservation easements. Landowners are compensated for conveying limited duration or perpetual easements that prohibit cropping, grazing and drainage of the easement areas enrolled.	**BWSR administers the program through SWCDs.**
MDA	**The Agricultural Best Management Practices Loan Program (Ag BMP Program)** portion of the State Revolving Fund (SRF) may be used to purchase conservation tillage equipment, for streambank stabilization projects, terracing, and other erosion control measures. These loan funds will be used on their own, or to leverage projects funded by cost share and other sources of public and private funding.	**MDA**

Current Local Activities in Agricultural Erosion and Sediment Control

Agency	Program	Program Delivery
SWCD	**Technical assistance:** Assistance in planning and implementing practices on any land use for a wide variety of purposes including soil erosion, water conservation, water quality, gully control, soil productivity and animal waste management.	**SWCD staff** provides assistance to individuals, groups and governments as requested and as priorities allow.
County	**Local Comprehensive Water Plan:** Document is compilation of local water resources and related resources data, which identifies, inventories, and assesses local natural resources. Also contains general and specific strategies that will be implemented by local units of government.	**County water plan coordinators** provide overall local coordination of implementation activities identified in the plan. Often **local SWCD** has a role in implementation.
Met Council	**Minnesota River Project:** Special funds that the Council can grant to local governments to implement nonpoint source pollution programs or other measures to protect and enhance the quality of the Minnesota River.	**Council and participating local governments** develop projects that are implemented at the local level.

Best Management Practices (BMPs)

The following Agricultural BMPs are commonly used to reduce nonpoint source pollution from agricultural erosion areas. This list is not comprehensive and does not suggest additional BMPs would have no benefit. Please refer to Part I Appendix B Best Management Practices of this Nonpoint Source Management Program Plan for definitions of the following BMPs.

Part I Agricultural BMPs

Access Road
4 Conservation Crop Rotation
5 Contour Farming
8 Critical Area Planting
11 Diversion and Terraces
12 Fencing
13 Field Border
14 Field Windbreak
16 Grade Stabilization Structure
17 Grassed Waterway or Outlet
20 Irrigation Water Management
21 Lined Waterway or Outlet
22 Use Exclusion
23 Mulching
25 Pasture and Hayland Management
26 Pasture and Hayland Planting
28 Prescribed Grazing Residue Management (no till, strip till, mulch till and ridge till)
31 Residue Management-seasonal
33 Riparian Buffer
37 Streambank Protection
38 Stripcropping
40 Tree Planting
41 Vegetative Filter Strip
44 Water and Sediment Control Basin

Chapter 8 Agricultural Erosion

Needs, Priorities and Milestones, Action Plan

The action plan provided below summarizes the goals and milestones identified in the preceding sections. Many of the 2013 through 2017 milestones listed below, as well as the implementation of specific projects, are contingent upon adequate funding and local involvement.

Goal 1: Improve interagency coordination in the development and implementation of statewide policies and programs concerning agricultural erosion and sediment control.

Milestones (Action Steps)	13	14	15	16	17	Funding Source(s)	Lead Agency(ies)
1. Continue to pursue the development and implementation of a comprehensive strategy for integrating federal farm policy and programs into state and local policy and programs to increase the use of ag erosion and sediment control practices.	X	X	X	X	X	State general fund, Clean Water Fund	Board of Water and Soil Resources (BWSR), Minnesota Department of Agriculture (MDA), and the USDA State Technical Committee (STC)
2. Meet and confer on technical and policy issues, share relevant information, coordinate regulatory and other activities and collaborate on strategic and locally directed planning associated with agricultural erosion and sediment control.	X	X	X	X	X	State general fund, Clean Water Fund	BWSR, MDA, University of Minnesota (U of M) and the USDA STC

Goal 2: Improve technical assistance and education associated with the application and adoption of best management practices (BMPs) for agricultural erosion and sediment control.

Milestones (Action Steps)	13	14	15	16	17	Funding Source(s)	Lead Agency(ies)
1. Identify needs and develop training programs for individuals planning and applying BMPs.	X	X	X	X	X	State general fund and fee supported, Clean Water Fund	BWSR, U of M, MDA and the NRCS
2. Provide the on-going support of current training programs developed in recent years via Section 319 funds.	X	X	X	X	X	State general fund and fee supported, Clean Water Fund	BWSR, U of M, MDA, MPCA and the (NRCS)
3. Increase the number of certified conservation planners on the USDA technical service provider registry.	X	X	X	X	X	319, State general fund, Clean Water Fund	BWSR, NRCS, MDA, U of M, MN Project

Milestones (Action Steps)	13	14	15	16	17	Funding Source(s)	Lead Agency(ies)
4. Education focused on comparative economics, emphasizing management packages for whole tillage systems.	X	X	X	X	X	State general fund, 319, LCCMR, Clean Water Fund	U of M, MDA, BWSR, NRCS
5. Develop and distribute informational materials and conduct associated workshops.	X	X	X	X	X	State general fund and fee supported, Clean Water Fund	U of M
6. Develop and implement a process to evaluate the effectiveness of information and education programs.	X	X	X	X	X	State general fund, 319, Clean Water Fund	U of M

Goal 3: Continue to improve the reliability and accuracy of decision-making tools associated with agricultural erosion and sediment control.

Milestones (Action Steps)	13	14	15	16	17	Funding Source(s)	Lead Agency(ies)
1. Increase the level of associated technical evaluation and research.	X	X	X	X	X	State general fund, Clean Water Fund	U of M, Science Museum of Minnesota
2. Continue to develop, promote and integrate the Local Annual Reporting System (eLINK) with other agencies.	X	X	X	X	X	State general fund, 319, Clean Water Fund	BWSR, MPCA, MDNR, MDA
3. Evaluate the environmental and economic effectiveness and adoption rates of agricultural erosion and sediment control BMPs.	X	X	X	X	X	State general fund, 319, Clean Water Fund	BWSR, U of M and MPCA
4. Investigate different techniques of gathering and displaying soils information.	X	X	X	X	X	State general fund, Clean Water Fund	BWSR, NRCS and U of M
5. Evaluate and develop hydrologic modification BMPs addressing the impacts of: a. drainage (subsurface and surface); b. effects on wetland habitats and flow; and c. effects on streambank and lakeshore stability.	X	X	X	X	X	State general fund, LCCMR, 319, Clean Water Fund	U of M, MDA, BWSR, MPCA
6. Update and redevelop eLINK project tracking system.	X	X				State general fund, Clean Water Fund, 319	BWSR

Goal 4: Increase the adoption and effectiveness of agricultural erosion and sediment control BMPs.

Milestones (Action Steps)	13	14	15	16	17	Funding Source(s)	Lead Agency(ies)
1. Develop and implement demonstration projects to illustrate how agricultural erosion and sediment control BMPs can be integrated into different farm-scale production systems.	X	X	X	X	X	State general fund. 319, Clean Water Fund	BWSR and U of M
2. Promote the use of crop residue management	X	X	X	X	X	State general fund and EQIP, Clean Water Fund	BWSR, NRCS and U of M
3. Monitor, model and evaluate the effectiveness of BMPs at various watershed scales.	X	X	X	X	X	State general fund, 319, Clean Water Fund	MPCA, U of M, USGS, BWSR
4. Conduct research for improved field and watershed scale estimation of sediment loading from stream bank erosion.	X	X	X	X	X	State general fund, Clean Water Fund	U of M, Science Museum of Minnesota
5. Develop a better understanding of the effect of sediment in water.	X	X	X	X	X	State general fund, Clean Water Fund	U of M and MPCA

Goal 5: Focus agricultural erosion and sediment control activities in watersheds contributing the most sediment.

Milestones (Action Steps)	13	14	15	16	17	Funding Source(s)	Lead Agency(ies)
1. Encourage local governments to use watershed assessments and prediction models in the development of their County Local Water Management Plans.	X	X	X	X	X	State general fund, Clean Water Fund	BWSR
2. Develop and distribute guidance for targeting agricultural erosion and sediment control BMPs at the sub-watershed or smaller scale.	X	X	X	X	X	State general fund, Clean Water Fund	U of M, MDA, BWSR
3. Emphasize the use of targeting efforts in the completion of TMDLs and following implementation plans	X	X	X	X	X	State general fund, 319, Clean Water Fund	MPCA

Chapter 9 Agricultural Nutrients

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Introduction
Impact of Agricultural Nutrients on Health and Minnesota's Water Resources

Human Health

Nitrogen (N) and phosphorus (P) are significant water quality pollutants. Excessive concentrations of Nitrate-Nitrogen (NO_3-N) are toxic to both humans and animals. The U.S. Environmental Protection Agency's (USEPA) Maximum Concentration Level (MCL) standard for nitrate-N is 10 milligrams per liter (mg L^{-1}). Humans, particularly infants, exposed to concentrations in excess of the MCL can develop methemoglobinemia. Methemoglobinemia is a blood disorder in which the ability to convert methemoglobin to hemoglobin is deficient. Methemoglobin does not carry oxygen; consequently, humans with methemoglobinemia may have episodes of breathing trouble and develop bluish mucous membranes. The most recent reported case of methemoglobinemia in Minnesota was a non-fatal case that occurred in 1979. However, the number of reported cases is probably underreported because the state does not have a methemoglobinemia medical registry. Studies in Spain, China, and Taiwan have linked gastric cancer to long-term exposure of elevated nitrate-N concentrations in adults (Xu et al., 1992; Morales-Suarez-Varela et al., 1995; Yang et al 1998).

Excessive concentrations of P in drinking water do not pose a direct human health risk. The chlorination process used to treat eutrophied water bodies resulting from excessive P loads does provide precursors for the formation of Trihalomethanes that do have known carcinogenic and mutagenic properties (Martin and Cooke, 1994).

Ground Water

A number of monitoring networks maintained by various state agencies provide information on nitrate-N tends in Minnesota's ground water. Interpretations of nitrate-N contamination in ground water must account for differing sampling objectives, field and laboratory methodologies, temporal sampling variation, and data management procedures that characterize existing databases. The primary impetus for extensive ground water sampling is that approximately 73 percent of Minnesota's population relies on ground water aquifers for its water supply. Ninety-nine percent of the state's 1,700 public supply systems[1] and an additional 450,000 private wells utilize ground water aquifers as a primary source of drinking water.

1 MDH categorizes public water supplies into two broad groups: Community and Non-Community systems. Community (Residential) systems include 700 Municipal (Cities) and 300 Non-Municipal suppliers (mobile home parks, etc). Non-Community systems include 750 Non-transient (schools, daycare centers, etc). See Mulla et al (1999) for additional details.

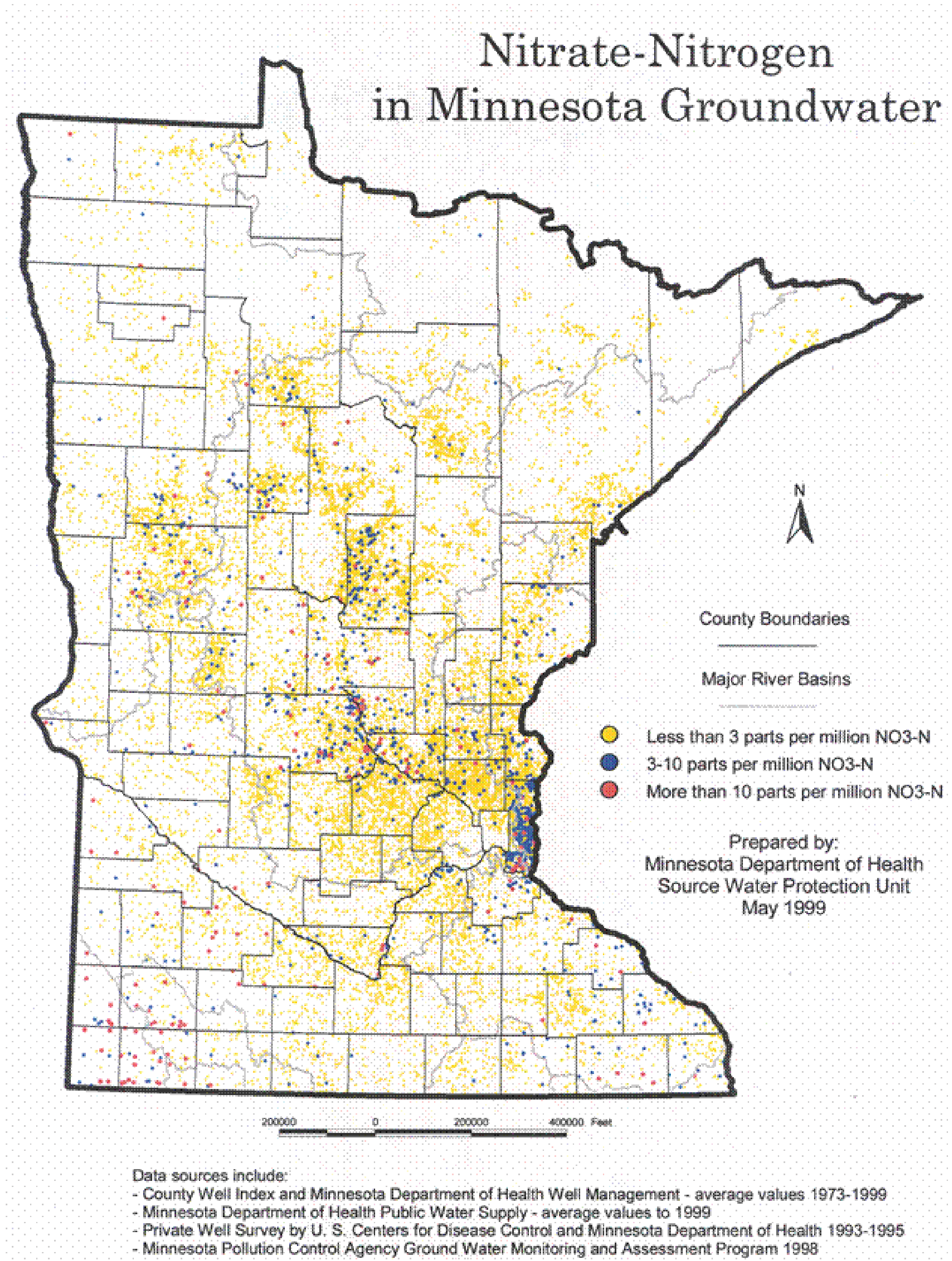


Figure 1. Nitrate-N concentrations from the County Well Index and various monitoring programs that have been operational since the 1970's.

Less than one percent of the public water supplies exceed the MCL for nitrate-N. Based on a data set maintained by the Minnesota Department of Health (MDH), seven percent of all public and private wells exceed the MCL (Figure 1). The combined database includes over 31,000 wells from the MDH Well Management Program (28,000 wells), Minnesota Geological Survey County Well Index (2000), MDH Public Water Suppliers (1,000), the MDH and U.S. Centers for Disease Control and Prevention Private Well Survey (750), and the Minnesota Pollution Control Agency's (MPCA) Ground Water Monitoring and Assessment Program. The data set does not include any representation from the 8,000 non-community wells classified as transient (campgrounds, churches, etc). A majority of the private wells included in this database are probably biased toward lower nitrate-N concentrations because the well drillers are familiar with the depth and aquifer needed to obtain acceptable drinking water (Wall and Montgomery, 1991). In some areas, such as the southeastern Karst region, new well construction in the shallower aquifers is prohibited. This caveat also applies to the information obtained from the MDH Public Water Suppliers as municipal wells are typically installed deeper than private wells and are constructed of steel or plastic casing materials to reduce the risk of ground water contamination. Results based on 52,000 wells (1995-2005) from the Minnesota Department of Agriculture's (MDA) Nitrate Water Testing Program[2] show that ten percent exceed the MCL (Figure 2; *www.mda.state.mn.us/* or *www.mda.state.mn.us/news/publications/protecting/waterprotection/clinicstats.pdf.* This data set is characterized by a broader age of wells and types of well construction (including sand points, dug wells and other non-approved construction methods) than the MDH database. These results also represent diverse geologic conditions and land use since 40 to 50 counties across the state participate in this program each year. However, the clinics tend to be conducted in areas vulnerable to nitrate-N contamination, and it is possible that well owners with more vulnerable wells participate in the voluntary clinics. This bias is offset by

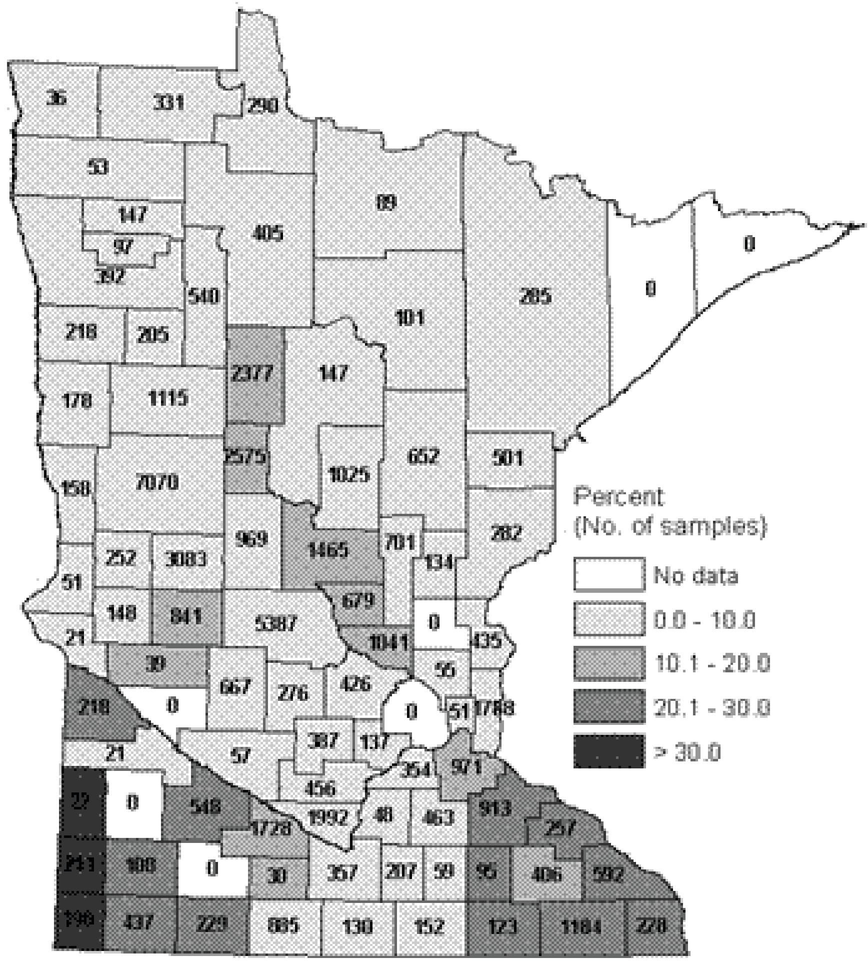


Figure 2. Results from the MDA's Nitrate Water Testing Program from 1993 to 2005 as expressed by the number of wells exceeding the 10 mg L^{-1} nitrate-N standard. Numeric values within each county represent the total number of samples analyzed (Counties in white did not participate in the program).

2 Funded in part by the Legislative Commission on Minnesota Resources (1997-1999); EPA 319 (1997-2000) and the MDA Fertilizer Account.

the fact that 40 to 50 percent of the clinic participants have either never tested their drinking water supply or have not tested their supply in less than 10 years.

Surface Water

Rivers and Streams

Twenty-seven percent (1.2 million) of Minnesotans rely on surface waters for their drinking water supply. There are 24 communities (Figure 3) that use surface water supplies; however, five of them deliver to large population bases (Twin Cities, Moorhead, St. Cloud, Mankato, and Duluth). The remaining systems serve small to medium-sized communities with many located along the Lake Superior shores[3]. Heiskary and Tomasek (2000) reported that there are approximately 64 transient non-community water suppliers that use surface waters.

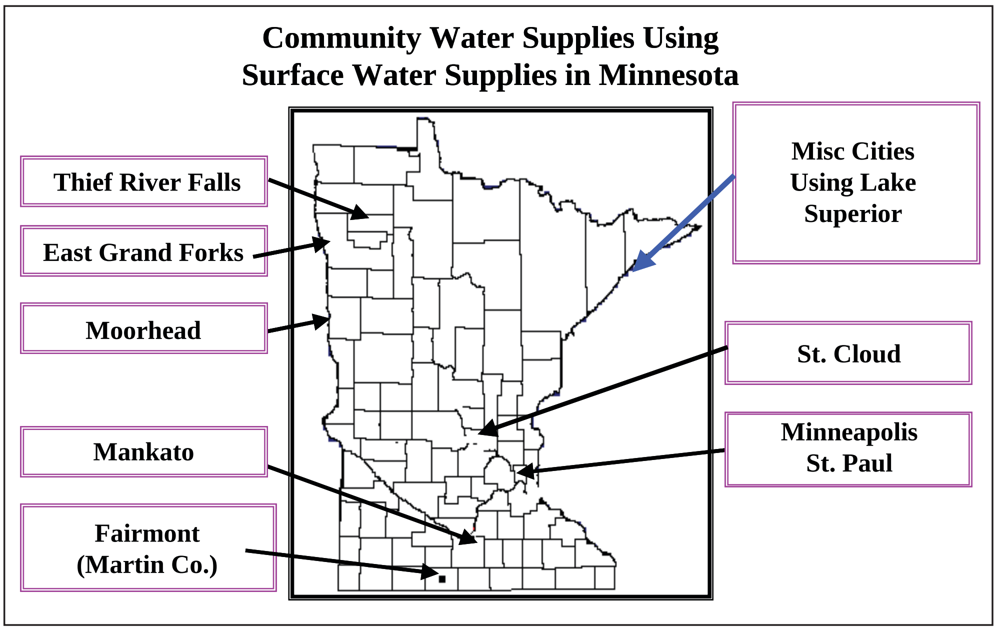


Figure 3. Locations of the population centers that rely on surface waters for drinking water. Generally community water suppliers are more concerned with pathogens than excessive nutrient concentrations. Cities that rely on water from the Minnesota River such as Mankato do face problems associated with elevated levels of N and P. From 1964 to 1994, 10 percent of the samples between St. Peter and Jordan exceeded the MCL for nitrate-N (Mulla, 1997). The long-term (1979-1992) average annual P load measured in the Minnesota River Basin is about 1,500 tons (Kroening and Andrews, 1997). There is also evidence that the streams and rivers from the southeast Karst regions of the state contain elevated nitrate-N levels. The Middle Branch of the Whitewater River has been reported to contain annual, flow-weighted concentrations of nitrate-N between 8 to 9 mg L^{-1} during 2000 to 2003 (Wotzka, 2005).

Transport of nutrients to surface water bodies can lead to the production of algal blooms. In freshwater systems P is typically limiting for algal biomass production (Schindler, 1977). Excessive inputs of P to water bodies can lead to eutrophication resulting in deleterious effects on water quality (Rast and Thornton, 1996). Symptoms of eutrophication include depleted oxygen levels due to the decomposition of algae, fish kills, increases in toxin-producing microorganisms, and reduced aesthetic value of lakes and streams. Eutrophication represents one of the most prevalent water quality impairments in the United States (USGS, 1999).

At a national scale, eutrophication is responsible for the hypoxic zone in the Gulf of Mexico which is a condition caused by stressful levels of oxygen deficiency. Hypoxia appears seasonally and has resulted in an inability to harvest fish, shrimp, and crabs in bottom-dragging trawls near the seabed (Renaud, 1986). In 2001 and 2002 the hypoxic zone reached record extents of more than 7,990 square miles (Rabalais et al., 2002).

3 Several communities in northeastern MN use abandoned taconite mine pits for water supplies.

The formation of the zone is linked to a two to seven-fold increase in N loading over the past century from the Mississippi River Basin. In addition to N, inputs of silicon (Si) and P are also implicated in the formation of the hypoxic zone with changing balances of N, Si, and P affecting marine food chains (CAST, 1999).

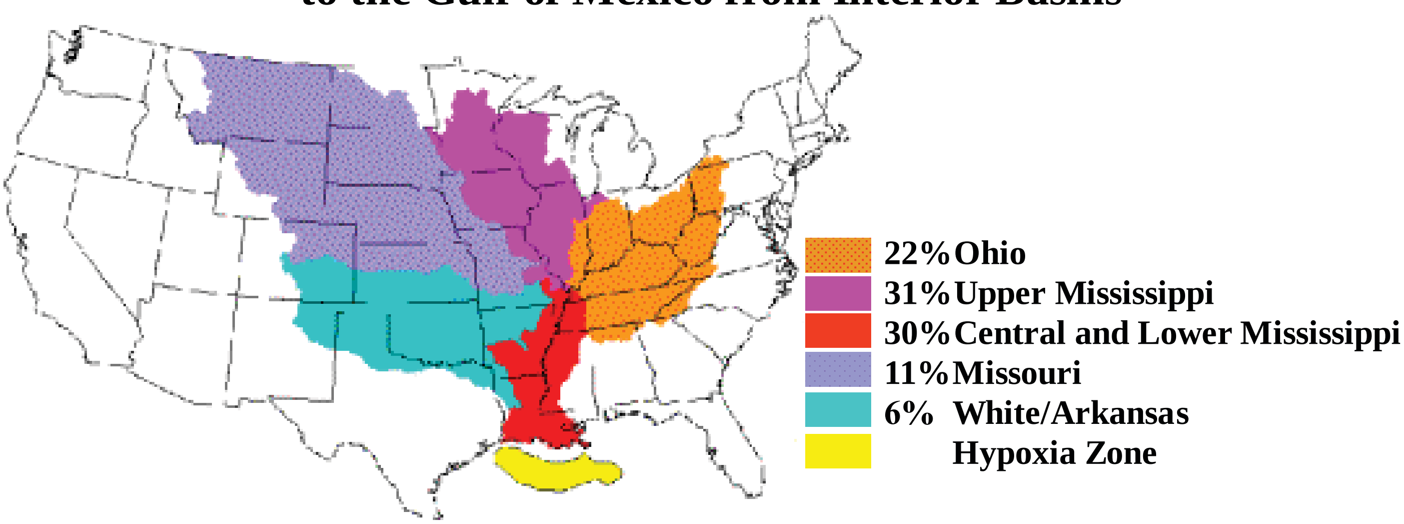
A series of comprehensive national reports covering a multitude of hypoxia-related issues are available (Brezonik et al., 1999; Goolsby, et al., 1999; Mitsch et al., 1999; and Rabalais et al., 1999).

Goolsby et al. (1999) estimated that the upper Midwestern states (portions of Iowa, Illinois, Wisconsin and Minnesota) contribute over one-third of the N loading to the Gulf of Mexico (Figure 4).

The Upper Mississippi Basin, which drains a large amount of Minnesota and western Wisconsin, accounts for approximately ten percent of the nitrogen flux to the Gulf of Mexico. Mulla et al. (1999) estimated that five and one percent of the national N loading into the Gulf of Mexico originated from the Minnesota and the Upper Mississippi Rivers (upstream from the Twin Cities), respectively. Mulla (1997) determined that over 60 percent of the N loading from the Minnesota River originates in the Blue Earth, Watonwan and Le Sueur.

Figure 4. The Upper Midwest Contributes 1/3 of the Nitrogen to the Gulf of Mexico
Percentages of total N flux to the Gulf of Mexico from the major interior basins of the Mississippi Watershed (Goolsby et al., 1999).watersheds. Minnesota contributes approximately 4 percent of the total P flux to the Gulf of Mexico. Recently, the scientific community has urged the USEPA to address P loading to the Gulf of Mexico and its role in the formation of the hypoxic zone.

Percentage of the Mississippi River Total Nitrogen Flux to the Gulf of Mexico from Interior Basins



Courtesy of Mulla and Randall. University of Minnesota

Lakes

Within this Nonpoint Source Management Program Plan (NSMPP), Anderson and Heiskary (2006) provide an excellent overview of lake ecology and its relationship with various land uses. Sediment, due to the fact that it is responsible for most phosphorus loss, was identified as the potential greatest single threat to the state's lakes. Both urban and agricultural exports can be significant. The reader is encouraged to review Chapter 4.2 "Lakes Strategy" for more information about lake water quality.

General Strategies for Addressing Agricultural Nutrient Issues

The implementation of Best Management Practices (BMPs) that maintain economic viability and minimize the impact of agricultural nutrients on water quality are needed to address Minnesota's water quality issues highlighted in the previous section. An overview of how this can be accomplished is described below with a more detailed explanation of the action steps provided in the Needs, Priorities, and MilestonesTable.

Education and Outreach

Effective implementation of BMPs entails that the stakeholders responsible for agricultural nutrient management are informed of current research and technologies and engaged as partners in finding solutions to agricultural nutrient issues. This requires that mechanisms such as conferences, workshops, publications, and conservation programs be developed and promoted for educating relevant stakeholders such as producers, agricultural retailers, crop advisors, and various agency personnel.

Research

The National Research Council reports that one of the primary needs of the Total Maximum Daily Load (TMDL) program is information on BMP effectiveness for improving the nation's water quality (USEPA 2002). This requires continued research and refinement of existing BMPs related to nutrient management, as well as, the exploration of new technologies such as drainage water management and wetland restoration. A greater understanding of nutrient cycling, transport, and fate at multiple scales is also needed. Risk assessment tools based on these principles of nutrient delivery are needed for identifying and implementing BMPs where they will have the greatest potential impact on water quality. Lastly, economic evaluations are needed to understand the costs that could potentially impede or enhance BMP implementation.

Metrics of Water Quality Improvement

Metrics of water quality improvement are needed to determine whether water quality goals are being met. These metrics include the use of multi-agency monitoring networks to measure long-term water quality trends. Other metrics include tools that serve as surrogates of water quality improvement such as surveys of BMP adoption rates in geographic areas that have been targeted for education and promotion. These efforts need to be coordinated among multiple stakeholders and agencies and enhanced to further document the progress of BMP implementation strategies and programs. One example is a tool called eLINK that enables state and local agencies to access, document, and manage individual water quality and soil conservation projects throughout the state. Further information on this tool is available at: *www.bwsr.state.mn.us/outreach/eLINK/*

The United States Department of Agriculture-Natural Resources Conservation Service (USDA-NRCS) also maintains an online service called Toolkit that allows users to view conservation planning data that has been uploaded to the National Conservation Planning Database at: *www.itc.nrcs.usda.gov/toolkit/default.htm*.

Policies

Minimizing the impact of agricultural nutrients on Minnesota's water resources requires effective statewide policies. One of the most important policies currently in existence is the Nitrogen Fertilizer Management Plan which was mandated through the 1989 Comprehensive Ground water Protection Act. Further development of guidelines for the implementation of various phases of the plan is needed to maximize the effectiveness of this important policy. Guidelines should incorporate long-term monitoring data, FANMAP surveys, and other metrics of BMP implementation. Currently, no equivalent policy exists for surface water nor does any current legislation address P management strategies. These areas represent significant needs for agricultural nutrient management.

Current Understanding of Pathways and Sources of Agricultural Nutrient Delivery to Minnesota's Water Resources

The 2000 National Water Quality Inventory attributes 48 percent of impaired river miles to agricultural nonpoint source pollution (USEPA, 2000). In Minnesota, 40 percent of the surveyed rivers and streams and 37 percent of the surveyed lakes have been classified as impaired. *(www.mda.state.mn.us/agdev/impairedwater/brochure.pdf)*

In 2004, Lake Pepin was placed on the list of impaired waters for phosphorus and turbidity. A TMDL study is being conducted to establish a single TMDL for both of these impairments by December of 2008. This process will have significant implications for the management of agricultural nutrients and sediment in the Upper Mississippi, St. Croix, and Minnesota River Basins.

The MPCA estimates that 26.4 percent of the total P delivered to Minnesota surface waters are attributed to surface runoff from cropland and pastureland during average flow conditions (Table 1. Agricultural tile drainage, feedlots, and atmospheric deposition accounted for 1.8, 1.0, and 13.1 percent of the total P contributions during the average flow years, respectively. Furthermore, the study attributes 4.8 percent of the total P in the statewide surface waters to urban runoff during average flow years.

A number of studies have attempted to examine N budgets for the Mississippi River Basin (Goolsby et al., 1997; Burkart and James, 1999; Goolsby et al., 2000; Carey et al., 2001). Despite disagreement regarding model assumptions, a common theme among each of the studies is that agricultural N remains a major component of total N export to rivers in the basin.

Relationships between ground water quality and land-applied agricultural inputs are difficult to interpret due to confounding factors related to land use, ground water flow hydraulics, ground water chemistry, geologic stratigraphy, well depth, and well construction methods (Wall and Montgomery, 1991; Richards et al., 1996).

However, a report by Wall and Montgomery summarizing more than 25,000 well observations in geologically sensitive areas associated with agricultural production determined that 27 to 44 percent of the wells exceeded the drinking water standard for nitrate-N. An understanding of the pathways and sources of agricultural nutrient delivery is needed to address their impact on water resources. The following section highlights current research and BMPs for reducing delivery of nutrients to water bodies while maintaining agricultural economic viability

Pathways

Nitrogen loss from the soil system to surface and ground waters occurs via two main pathways: leaching and drainage (O'Leary et al., 2002). Leaching is a physical process by which nitrate-N is transported with soil water below the root zone where it potentially enters the ground water or is intercepted by subsurface tile drainage to surface water. Drainage of agricultural land is a practice that has been used in Minnesota since the mid-1800's (Payne, 1994). Improved drainage is very important to the state's agricultural economy because it enables producers to raise crops in areas that would otherwise be marginal for crop production.

One of the primary factors determining the magnitude of N losses to surface waters is the amount of water transported from the landscape which is a function of climate and soil properties. The temporal distribution of rainfall throughout the year also influences the amount of N transported to surface waters. Rainfall events that occur in the spring when the soil profile is near field capacity under bare ground conditions will result in greater drainage than the same amount of rainfall that occurs in the middle of summer under drier antecedent moisture conditions and a more developed crop canopy cover.

Randall (2004) found that 68 to 71 percent of the annual flow and 71 to 73 percent of the annual nitrate-N loss from tile drainage occurred from April to May during a 15-yr study at Waseca, MN. At a basin scale, four watersheds located in the wetter, eastern portion of the Minnesota River accounted for 75 percent of the total nitrate-N load from 1977 to 1994 despite accounting for 31 percent of the total basin area (Randall and Mulla, 2001).

Nitrogen can also be lost through soil erosion and runoff particularly following a surface application of manure or fertilizer. Nitrogen losses from this pathway are typically small compared to leaching or drainage losses. The relationship between soluble and “fixed” nutrients in surface and subsurface waters is illustrated by research conducted on corn-soybean rotations throughout the Corn Belt (Table 2).

Employing drainage water management practices represents one way to reduce nitrate-N losses from agricultural landscapes. This practice entails using a water control structure to artificially set water levels at the drainage outlet. The purpose of this practice is to reduce nitrate-N loads by reducing drainage volumes. Research suggests that average annual nitrate-N loads can be conservatively reduced by 30 percent (Cooke et al., 2005). This system is best suited for flat (<1 percent slope gradient) fields comprised of poorly drained soils requiring drainage.

Restored wetlands sited to intercept tile drainage also have the potential to reduce nitrate-N loads by 40 to 90 percent (Crumpton, 2005).

The key to employing this practice is to restore wetlands that maximize the volume of drainage intercepted in order to effectively impact the water quality of the receiving stream. In Iowa, wetland restoration efforts have focused on sites with wetland to watershed ratios of 0.5 to 2.0 percent.

Phosphorus transport from the landscape occurs via two primary mechanisms: erosion and runoff. Erosion dictates the amount of particulate P (PP). Particulate P can be transported from eroding surface soil, plant materials, stream banks, and channel beds. The magnitude of PP movement is dependent upon the factors that control soil erosion including rainfall, irrigation, runoff, and crop management practices. The P concentration of the eroded particulate material can be significantly greater than the source material because the preferentially transported fine particles have a greater affinity for P compared to coarse materials (Sharpley et al., 1993) Dissolved P movement (DP) occurs as a function of surface runoff from rainfall or snowmelt. The concentration of DP in runoff is dependent on such factors as desorption, dissolution, and extraction of P from soil and plant material.

Soil test P (STP) can account for 58 to 98 percent of the variability in the DP concentration of runoff (Sharpley et al., 1996). Leaching of P through the soil profile is generally limited because P deficient subsoils sorb the P from solution (Sharpley et al., 1993). Sand and peat soils can be susceptible to P leaching due to a low P fixation capacity. Subsurface losses of P can also occur where tile drainage and macropores are prevalent.

Phosphorus losses from erosion and runoff pathways can be reduced by increasing the crop residue cover on the soil surface using conservation tillage practices. Filter strips can also reduce edge of field P losses. Research indicates that filter strips have total P trapping efficiencies of 27 to 96 percent (Helmers et al., 2005). Trapping efficiencies are dependent on the integrity, density, and continuity of the filter strip. Studies also suggest that concentrated flow entering a buffer will reduce the trapping efficiency in which case a dense stand of vegetation can assist in distributing the flows in these situations (Dosskey et al., 2002).

Table 1. Example concentrations of N and P in soil or soil water, and in surface runoff, subsurface drainage, and sediment (Baker et al., 2005).

Nitrogen (N)			
Soluble	Soil[1] Water	Surface Runoff	Subsurface drainage
		mg L^{-1}	
NH_4-N	1.0	0.5	0.1
NO_3-N	50.0	4.0	15.0
Solid/Adsorbed			
	Soil	Sediment	
		ppm	
NH_4-N	15	20	
NO_3-N	0	0	
Organic-N	1500	2000	
Phosphorus (P)			
Soluble	Soil[1] Water	Surface Runoff	Subsurface Drainage
		mg/L	
Reactive-P	0.6	0.2	0.050
Total-P	0.9	0.3	0.075
Solid/Adsorbed			
	Soil	Sediment	
		ppm	
Available-P	30	40	
Total-P	600	800	

1 Top 12 inches of soil; 3% organic matter

Sources

Annual N input (plant available forms) on a statewide basis was originally estimated between 1.4 to 1.8 million tons (Montgomery, 1991). The relative magnitude[4] of the various individual sources was also estimated; these estimates included contributions from soil organic matter, agricultural inputs, municipal treatment output and atmospheric deposition. Agricultural inputs from fertilizer, manure, and legume credits account for approximately half of the total statewide inputs. After excluding inputs over which there is little direct human control (atmospheric deposition and organic matter contributions), the reexamined budget loads indicate that over 99 percent of the N added to the soil environment originates from agricultural sources. Estimates of the relative contributions from the primary agricultural N sources including fertilizer, manures, and legumes are 68 percent, 14 percent[5] and 18 percent, respectively, based on data from the 2002 census of agriculture (Figure 5; NASS, 2005a).

4 The application of these estimates is only appropriate as a statewide overview with the recognition that the magnitude of an individual source is not necessarily directly related to the source's impact on water quality.

5 Manure N contributions were calculated based upon the 2002 animal census for various species of livestock and poultry using nutrient output estimates from the Midwest Planner (Midwest Plan Service, 1985). Output numbers are then reduced by 50% recognizing that there are significant storage and application losses due to gas emission losses of ammonia, uncollected manure

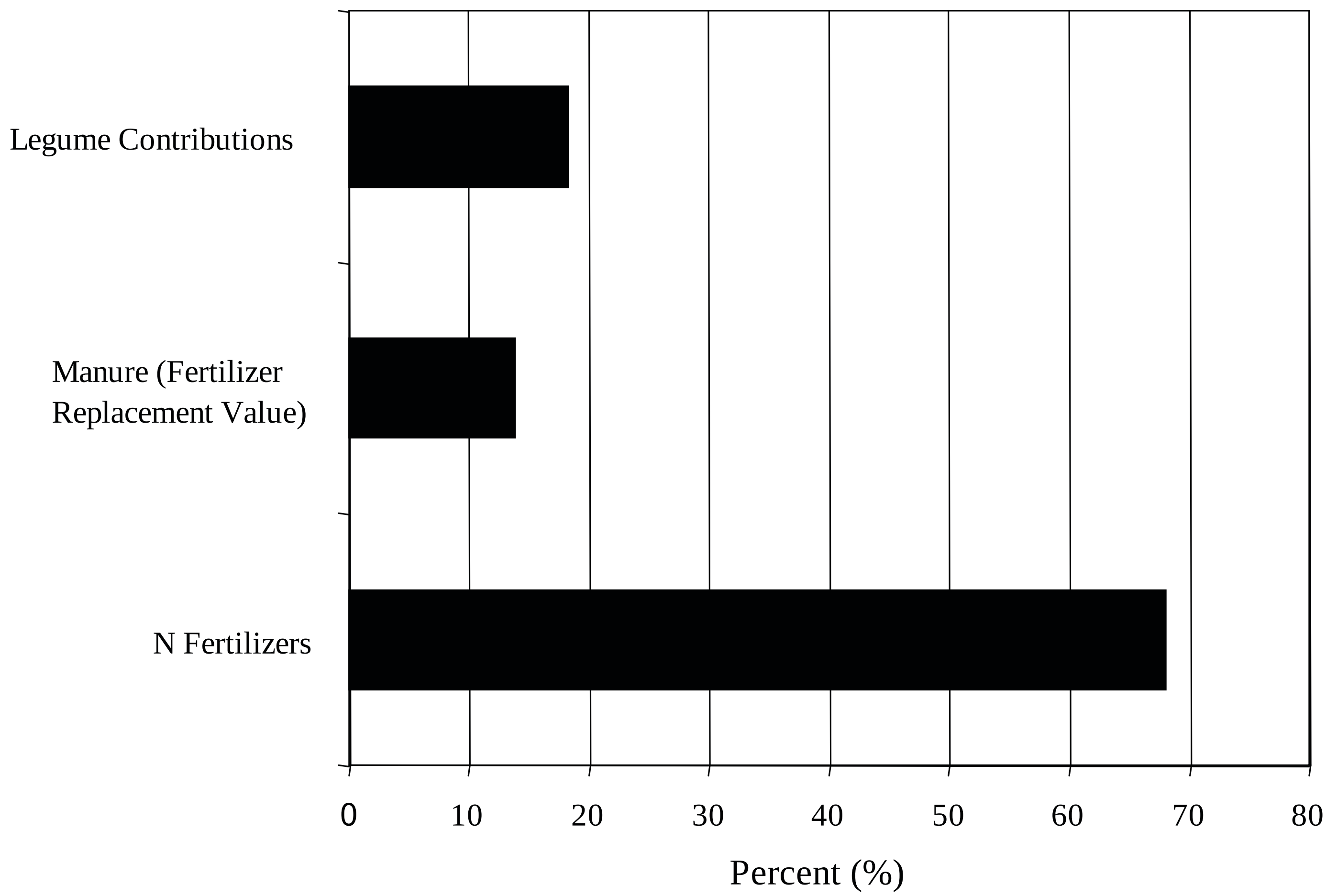


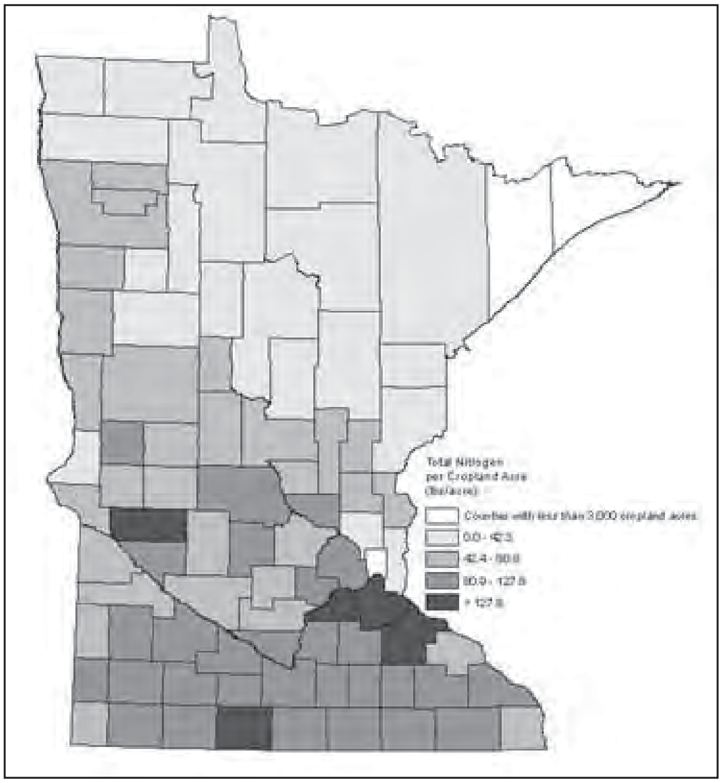
Figure 5. Comparison of the major agricultural nitrogen sources based upon the 2002 Census.

Nitrogen and P inputs to agricultural cropland, using the 2002 Census data, have been estimated on a county basis (Figures 6 and 7); values reflect the summation of fertilizer sales, manure[6] and legume inputs distributed evenly across all cropland regardless of the type of cropping system. Because the commercial fertilizer tonnages are based upon "point of sale" rather than the county where the product is actually used, this information should only be used to provide the reader with a method of comparing relative inputs on a cluster of counties rather than on an individual basis. The value of nutrient budgets for environmental implications is greatly enhanced when conducted on a localized level and budgets must consider a variety of factors such as yield goals, manure management techniques, timings, and crop rotations.

under pastured conditions and other losses. These adjusted values represent the land-applied portion of manure that ultimately becomes available for plant uptake and is referred to as the "fertilizer replacement value of manure".

6 "Fertilizer replacement" value as previously defined for nitrogen. Phosphate contributions from manure are converted to replacement values by multiplying by 80%.

Figure 6.



Nitrogen input estimates based on 2002 Census data for county nitrogen fertilizer sales (point of sale), “fertilizer replacement” credits from manure and legume contributions. Inputs are averaged across all cropland acres within each county.In addition to inputs of agricultural nutrients, cropping systems also have a significant impact on losses of N and P from agricultural landscapes. A four-year study conducted at Lamberton Minnesota showed that annual, flow-weighted nitrate-N concentrations from drainage water averaged between 14 and 40 mg NO_3-N L^{-1} for row crops (continuous corn and a corn-soybean rotations) compared to perennial crops with values of 4 mg NO_3-N L^{-1} or less. (Table 3). Table 4 shows a similar trend for P losses with losses of total P exceeding 13 lbs P ac^{-1} for conventional corn compared to less than 2 lbs P ac^{-1} for a wheat-summer fallow cropping system

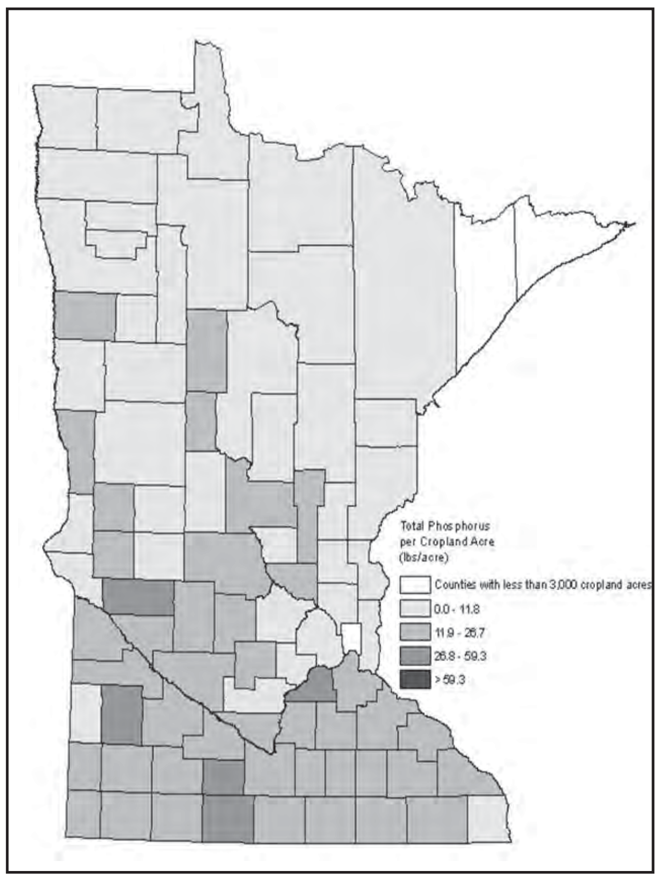


Figure 7.
Phosphorus input estimates based on 2002 Census data for county fertilizer sales and “fertilizer replacement” values from manure contributions. Inputs are averaged across all cropland acres within each county.

Table 2. Comparison of flow-weighted annual nitrate concentrations among different cropping systems (Randall et al., 1997a).

Crop system	Year 1990	1991	1992	1993
		mg NO_3-N L^{-1}		
Continuous corn	30	39	40	20
Corn-soybean	22	29	26	14
Soybean-corn	26	38	27	13
Alfalfa	–	4	4	1
CRP[1]	–	4	1	0.3

1 Conservation Reserve Program

Table 3. Phosphorus losses from different cropping systems (Rehm et al., 1998).

Crop system	Soluble	Sediment	Total
		lbs P ac^{-1}	
Grass	0.45	6.60	7.05
No-till corn	0.98	1.90	2.94
Conventional corn	0.27	13.48	13.75
Wheat-summer fallow	0.18	1.25	1.43

Commercial Fertilizer Contributions

Nitrogen and phosphorus application rates

Table 4. University of Minnesota guidelines for use of nitrogen fertilizer for corn grown on soils considered to be highly productive (Rehm et al., 2006).

N price/crop value ratio	Corn-corn		Corn-soybeans	
	MRTN[1]	Acceptable range	MRTN[1]	Acceptable
		lb N ac^{-1}		
0.05	155	130 – 180	120	100 – 140
0.10	140	120 - 165	110	90 – 125
0.15	130	110 – 150	100	80 – 115
0.20	120	100 - 140	85	70 – 100

Fertilizer application rates directly impact nutrient losses from agricultural landscapes. Buzicky et al. (1983) compared N application rates of 120 and 180 lb N ac^{-1} over a six year period on continuous corn at Waseca, Minnesota. Averaged over the fall and spring applications, yields and N losses from drainage water were 17 and 30 percent higher for the 180 lb N ac^{-1} application rate. Using simulation modeling of this region, Davis et al. (2000) determined that N losses in tile drainage were very sensitive to application rate, determining that an increase of 50 percent (from 179 to 268 lb N ac^{-1}) increased N losses by 84 percent.

Based on studies conducted throughout the state, the University of Minnesota (U of M) has recently changed the concept used for N rate guidelines for corn that will be effective beginning in January of 2006.

Data showed that there is no relationship between the economic optimum N rate (EONR) for spring fertilizer applications and the optimum yield of corn.

Rather than using yield goals, the new guidelines are related to the productive potential of the soils and the ratio of fertilizer N price to crop value. For each N price/crop value ratio, the N rate that produces the Maximum Return To Nitrogen (MRTN) has been calculated based on numerous studies conducted throughout the state (Table 5). The ratio for spring of 2006 is 0.15 based on an N price of \$0.35 lb^{-1} N for anhydrous ammonia and a corn price of \$2.30 bu^{-1}. The guidelines allow for flexibility based on the grower's fertilizer management strategy. Growers concerned with reducing the risk of nitrate-N losses to subsurface drainage may want to use rates corresponding to the bottom of the acceptable range.

Growers wanting to obtain high yields every year at a risk of slight reductions in net profit may choose to use rates at the higher end of the acceptable range. Statewide fertilizer sales provide an indication of N rates used by producers. Over the past 40 years, N sales have flourished as producers discovered the economic returns of fertility management, introduction of more productive corn hybrids, and more land has been converted into annual crop production. Nitrogen fertilizer usage rapidly increased from approximately 40 lb N ac^{-1} from 1965 to 110 lb N ac^{-1} in 1988 (Tennessee Valley Authority, 1988). Total annual N sales in Minnesota during the same time period increased from 100,000 to 600,000 tons. More recently, N sales generally range from 600,000 to 700,000 tons for all N using crops (Figure 8). Figure 9 illustrates N use in the Upper Midwest. Minnesota traditionally ranks sixth nationally in commercial nitrogen fertilizer sales following Iowa, Illinois, Texas, Nebraska and Kansas

Commercial Nitrogen Fertilizer Sales Trends in Minnesota: 1965-2004

Data Source: MDA, TVA and AAPFCO

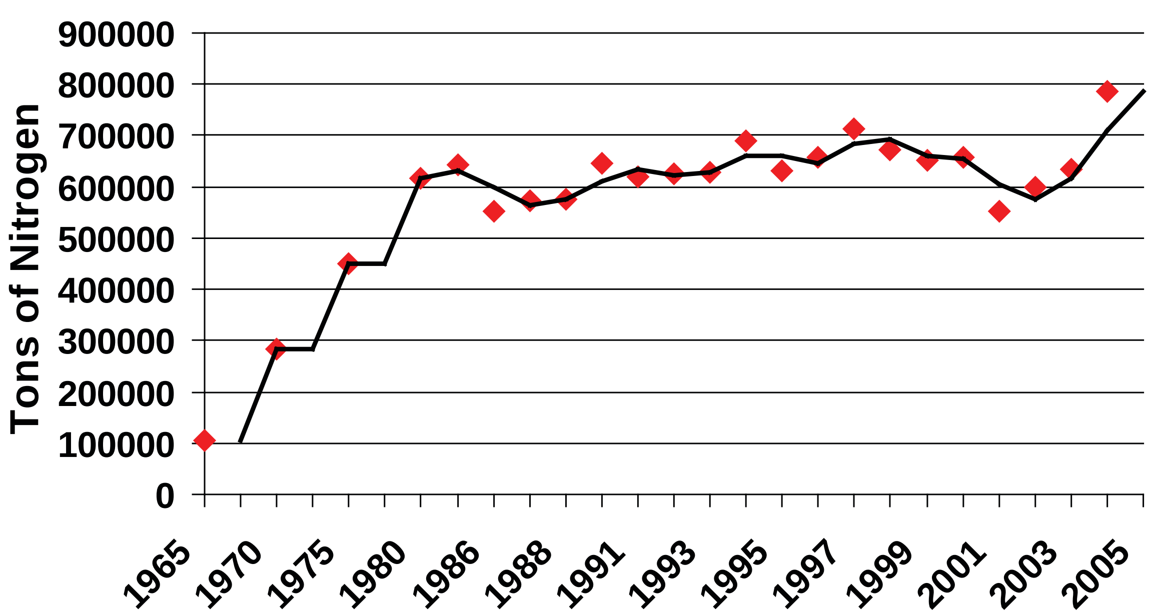


Figure 8. Minnesota's nitrogen fertilizer sales from 1965 to 2004

Fertilizer Products Sold in Upper Midwest States 1990-2004

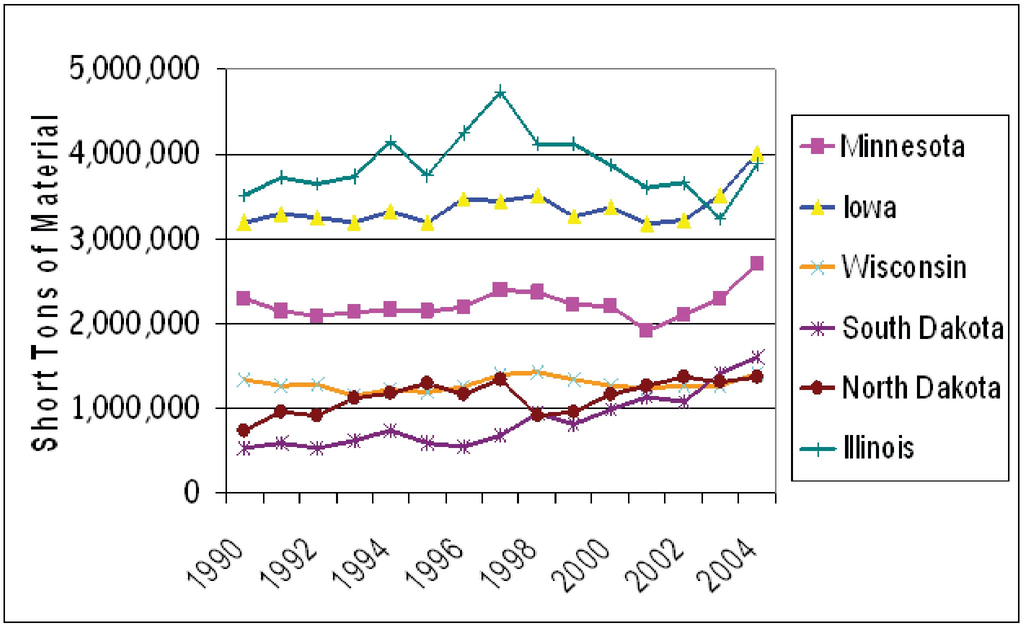


Figure 9. Trends in nitrogen fertilizer sales in Minnesota and its neighboring states from 1990 to 2005.

Despite the slight growth in fertilizer sales, data collected on a statewide basis do not indicate a correlation with increased application rates on a per-acre basis. The average nitrogen application to corn during the period 1993 to 2003 was 113 lb N ac^{-1} with no significant increasing or decreasing trends (USDA-ERS, 2005). The increased fertilizer N sales can be attributed in part to changes in cropping systems. Since the late 1970's, small grain production has decreased trends with a corresponding increase in acres being converted to corn production which would entail greater fertilizer N sales over time (Figure 10). Another measure of statewide N application rates for corn is a comparison of corn yields with corresponding N sales applied to corn. Data obtained from the Minnesota Agricultural Statistics Service shows overall increasing corn yields since 1986 (Figure 11). This trend is attributed to such factors as improved hybrids, favorable weather conditions, and improved management methods. During this time period, estimated N sales for corn have remained stable. These trends suggest improved N efficiency resulting in reduced excess N application rates that could be lost from the landscape (Figure 12).

Long-Term Trends for Major Nitrogen Demanding Crops:1921-2004

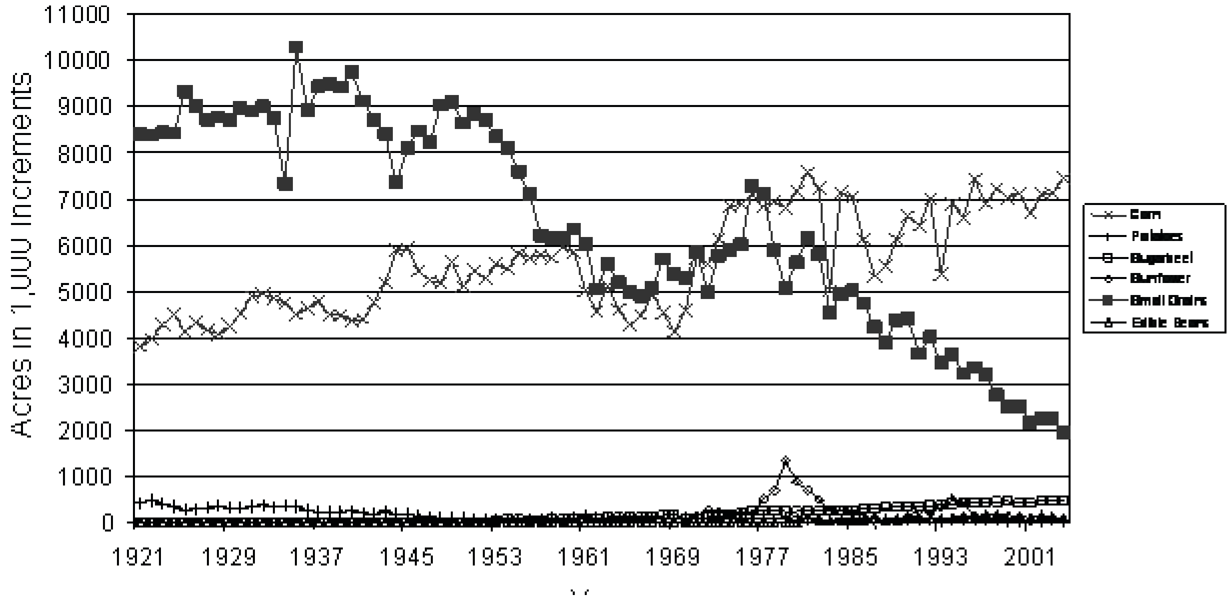


Figure 10. Acreage changes since 1921 on the major Minnesota crops that account for the majority of the state's nitrogen demand.

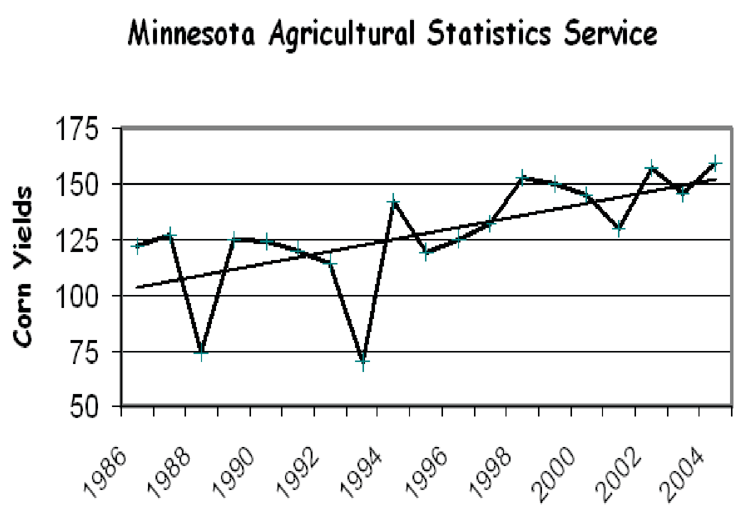


Figure 11. Statewide Corn Yields from 1986 to 2004.

Minnesota Corn Production and Nitrogen Fertilizer Use 1986 - 2004

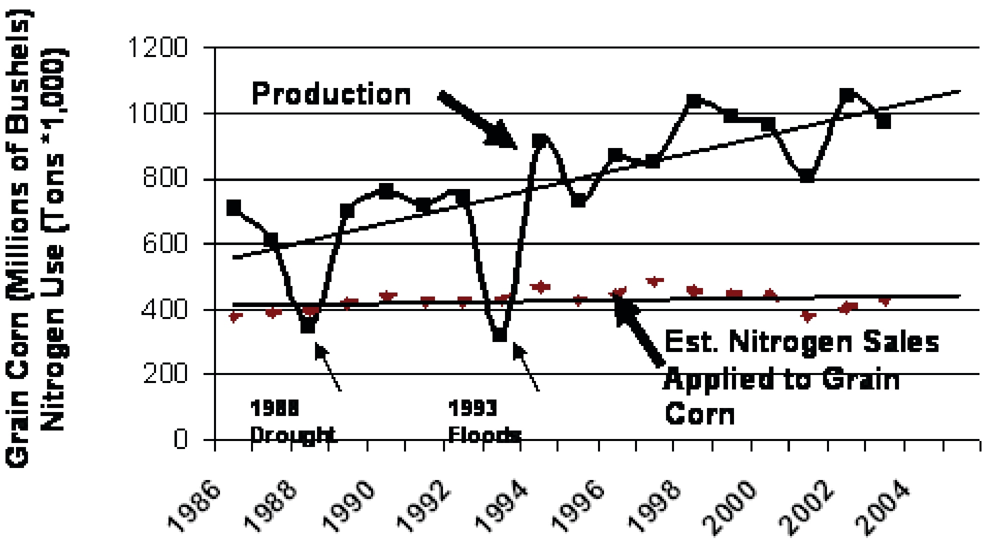


Figure 12. Statewide trends in N efficiency based on nitrogen fertilizer sales and corn yields.

The relationship between fertilizer P application rates and losses to water bodies is a function of direct losses and changes to Sewage Treatment Plant (STP) levels. Romkens and Nelson (1974) observed a linear relationship between incorporated P added as superphosphate and soluble orthophosphate or sediment extractable P levels in runoff. The study corresponded to spring conditions in the Midwest when the soil is wet and bare with a high erosive potential from storm events. Research suggests that losses of P can account for up to ten percent of the P applied when a rain event occurs shortly after a surface application of P (Baker and Laflen, 1982; Edwards and Daniel, 1992; Sharpley and Rekolainen, 1997). Phosphorus losses are also related to STP levels. However, there are limitations to using STP laboratory and sampling methods intended for agronomic purposes rather than environmental intentions (Sharpley et al., 1996; Sharpley et al, 1999). Generalized relationships between DP loss in surface runoff and STP levels are difficult to develop because P losses to runoff are also influenced by soil characteristics.

Application rates of P can vary significantly depending upon the management plan adopted by the producer. The U of M guidelines are based on a correlation/calibration method for corn and soybeans (Rehm et al., 2001). Phosphorus application rates are based primarily on STP and yield goals. Phosphorus fertilizer is not recommended for soils with a STP value higher than 25 ppm Bray and 20 ppm Olsen for corn production.

A second approach is to apply P based on the crop removal rates from the harvested grain. Rehm (2004) conducted a five-year study of a corn-soybean rotation at Waseca and Morris, Minnesota on soils with a STP rating of medium. Two P application rate approaches were compared, one based on estimates of crop removal of P and the other to match either the band or broadcast guidelines from the U of M. There was no significant fertilizer effect on yield measured at the Waseca site, but there was a statistically significant response measured at the Morris site (Table 6). The study did not observe differences in yield that could be attributed to the differing phosphate (P2O5) application rates that were based on crop removal compared with U of M guidelines. The primary difference between the treatments was a larger increase in STP at the end of the study for the plots receiving crop removal rates (33.5 to 37.8 ppm) compared to plots receiving rates based on U of M guidelines (16.5 to 22.5 ppm). The results suggest that P application rates using a crop removal strategy for medium testing soils can be expensive compared to use of U of M guidelines.

Another important consideration with respect to the relationship between P application and STP levels are rates of incline and decline for STP. Randall et al. (1997b) conducted a 20-year study on a Webster clay-loam and an Aastad clay-loam at Waseca and Morris, Minnesota, respectively, to address these issues. For the Webster clay-loam with an initial Bray-P value of 22 ppm, the study observed STP increases of 0.42 and 1.92 ppm yr-1 when fertilizer was applied over a 12-year period at rates of 50 and 100 lb P2O5 ac-1, respectively (Fig. 13). Rates of decline over the following eight years were 1.9 and 2.5 ppm yr-1 with initial STP levels of 22 and 40 ppm, respectively. For the Aastad clay-loam with an initial Bray-P value of 10 ppm, the study observed STP increases of 0.69 and 2.49 ppm yr-1 when fertilizer was applied over a 12-year period at rates of 50 and 100 lb P2O5 ac-1, respectively (Fig. 13).

Rates of decline over the following eight years were 1.6 and 2.7 ppm yr-1 with initial STP levels of 23 and 38 ppm, respectively. Broadcast applications of P did not increase corn and soybean yields when STP was greater than 13 and 19 ppm for the Webster and Aastad soil, respectively. These rates of decline imply that P application may not be necessary for row-crop production for many years when STP levels exceed agronomically optimum levels.

Table 5. Summary of phosphate study conducted at Waseca and Morris 1999-2003 (Rehm, 2004).

Treatment	Phosphate used	1998 Soil test P[1]	2004 Soil test P[1]	Avg. corn yield	Avg. soybean yield	Cost[2]
	lb ac^{-1}	ppm	ppm	bu ac^{-1}	bu ac^{-1}	\$ ac^{-1}
Waseca						
Control	0	~ 15.0	12.3	167.4	52.7	–
Crop removal, annual	270	~ 15.0	33.5	171.1	53.9	67.50
Crop removal biennial	270	~ 15.0	37.8	167.9	53.7	67.50
U of M broadcast	150	~ 15.0	22.5	166.7	53.8	37.50
U of M band	120	~ 15.0	16.5	166.5	53.4	30.0
Morris						
Control	0	8.6	7.0	169.0	50.5	–
Crop removal, annual	255	11.8	11.3	174.0	52.1	63.75
Crop removal biennial	255	15.1	12.8	174.0	50.1	63.75
U of M broadcast	125	10.5	9.0	174.0	52.7	31.25
U of M band	95	8.5	8.0	175.1	52.1	23.75

1 Bray test used at Waseca and Olsen test at Morris.
2 Assumed $0.25 lb-1 P2O5.

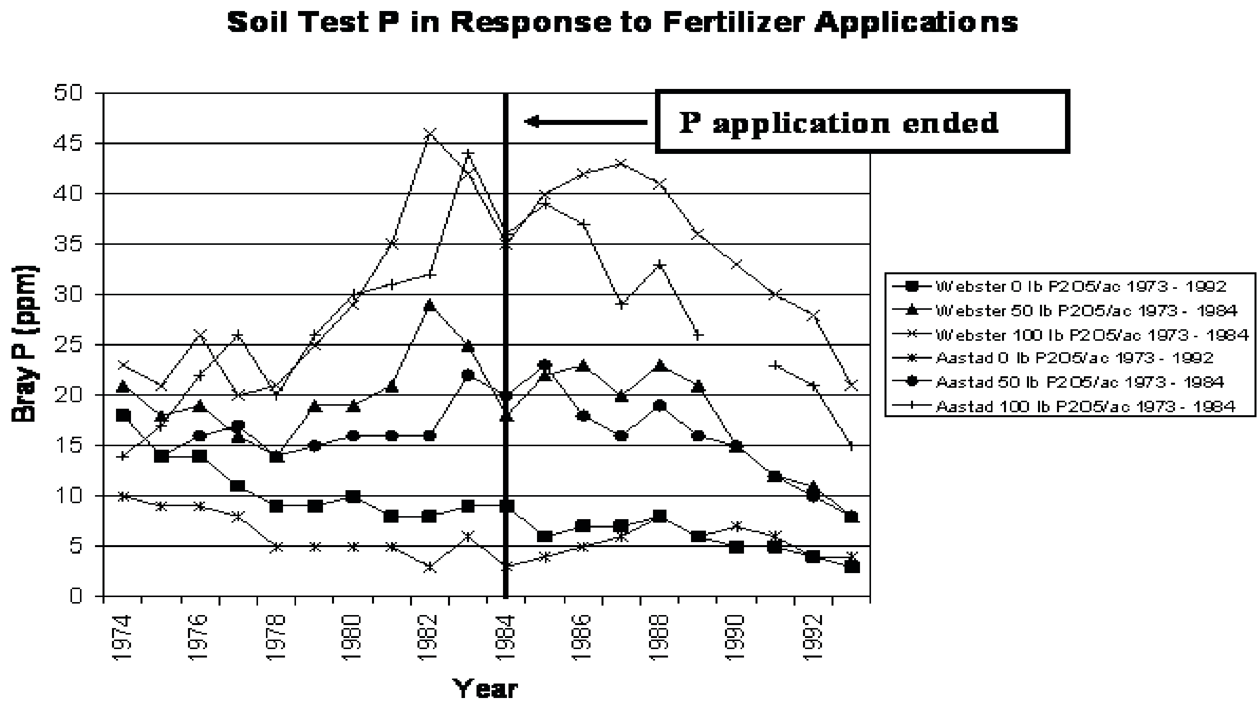


Figure 13. Trends in soil test phosphorus over a 20-year period for Webster and Aastad soils (Randall et al., 1997b).

Phosphate sales and inputs (per acre) have varied little since the 1960's. Annual sales range from 240,000 to 295,000 tons of phosphate per year (Figure 14). Despite recent increase in sales, average annual application rates from 1993 to 2003 have remained at 51 lb P_2O_5 ac^{-1} (USDA-ERS, 2005). The sales trends could be a product of the market with both farmers and timing of fertilizer N applications can have a significant effect on losses. Vetsch and Randall (2004) observed N losses from fall applied anhydrous ammonia that were 46 lb ac^{-1} higher than N losses from spring applied anhydrous ammonia when precipitation for April and May exceeded the 30-year normal by 5.2 in and temperatures exceeded the 30-yr normal by 7° F. Corn grain yield and N uptake from the fall N application were reduced by 20 and 27 percent compared to the spring application. Nitrogen recovery was 87 and 45 percent for the spring and fall applied N, respectively. The preceding differences were not detected when moisture conditions in April and May were below normal or cooperatives stockpiling phosphate fertilizer in response to potential shortages. Statewide STP levels reported from soil testing laboratories suggest that STP levels are declining. Forty-seven percent of the samples collected in the fall of 2000 and spring of 2001 tested medium or lower for P; however, these reports may be biased by nitrogen and phosphorus timing, forms, and methods of application to P deficient soils in western Minnesota. (Fixen, 2002) Summaries reported on a regional or county basis would provide a better understanding of the STP trends throughout the state. Large landscape variability in STP levels can exist due to soil texture, organic matter, and drainage characteristics. These characteristics can have direct impacts on P variability due to P availability properties or indirectly through P removal differences attributed to yield. Manure management can also lead to significant spatial variability in STP levels. Studies indicate that variable-rate fertilization can reduce STP variability and minimize P application to high-testing areas within a field (Mallarino and Bundy, 2005) normal. Despite the yield and environmental benefits to spring applications, fall applications of N are generally preferred by producers due to economic and logistical factors (Randall and Schmitt, 1998). Though statewide information on timing of N fertilizer applications is limited, statewide sales trends of the three primary N sources used in corn production can be used as a surrogate. Urea and urea-ammonium nitrate solution (UAN) are more suitable for spring application compared to fall application based on yield and nitrogen recovery rates (Randall and Sawyer, 2005). Consequently, the statewide increase in sales of urea and

UAN with corresponding sales reductions in anhydrous ammonia, suggests a trend in increasing rates of spring application of N fertilizers (Figure 15). Studies indicate that the use of nitrification inhibitors such as nitrapyrin can also affect nitrate-N losses. In a 12-year study of a corn-soybean rotation, Randall and Vetsch (2005a) observed nitrate-N losses in subsurface drainage that were 14 percent lower for spring applications of N (2.45 lb ac-1 in-1) and 10 percent lower for fall applications of N with nitrapyrin (2.54 lb ac-1 in-1) compared to fall applied N without the use of the nitrification inhibitor (2.84 lb ac-1 in-1).

Phosphate (P_2O_5) and Potassium (K_20) Sales in Minnesota from 1990 - 2004

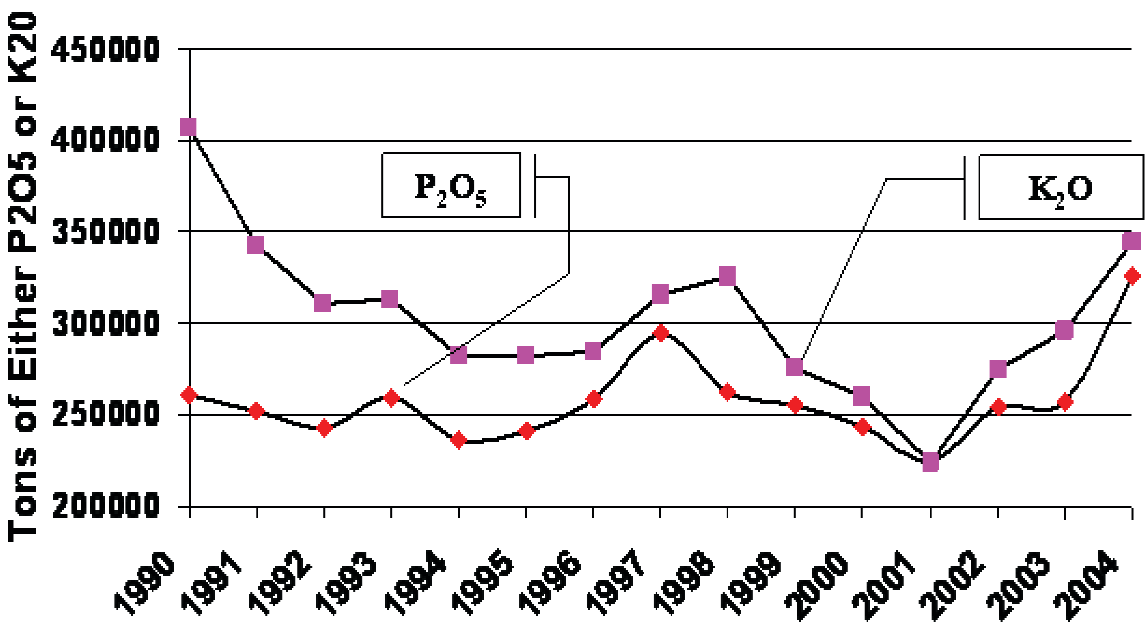


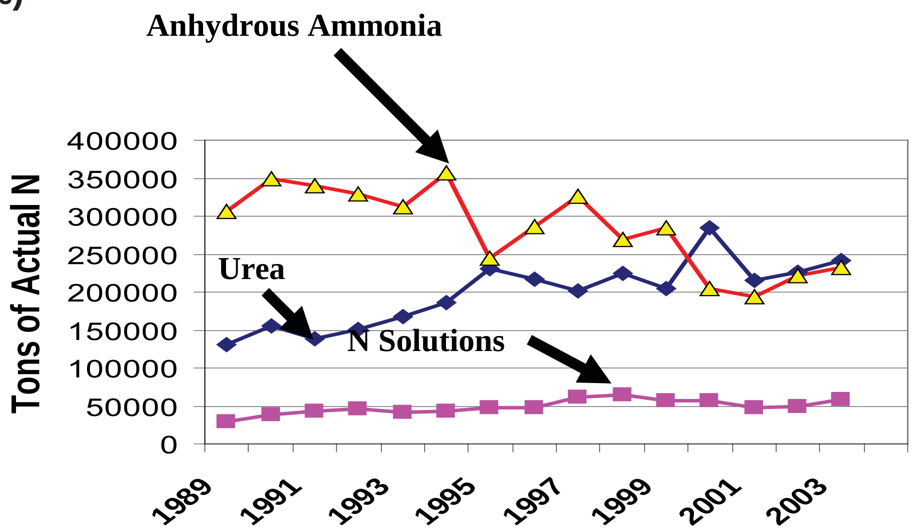
Figure 14. Phosphate fertilizer sales from 1990 to 2004.

(Figure 15). Studies indicate that the use of nitrification inhibitors such as nitrapyrin can also affect nitrate-N losses. In a 12-year study of a corn-soybean rotation, Randall and Vetsch (2005a) observed nitrate-N losses in subsurface drainage that were 14 percent lower for spring applications of N (2.45 lb ac-1 in-1) and 10 percent lower for fall applications of N with nitrapyrin (2.54 lb ac-1 in-1) compared to fall applied N without the use of the nitrification inhibitor (2.84 lb ac-1 in-1).

Studies in the Corn Belt suggest that timing of P application is not as influential for row-crop production as N, because P is relatively immobile in soils of the region.

Randall et al. (1997b) found that annual and bi-annual P applications for corn-soybean rotations have similar yield responses. Phosphorus application method can have a significant impact on losses from fertilizer sources. Baker and Laflen (1983) observed DP losses in runoff that were more than seven times greater for P applied on the surface compared to point injected methods at a rate of 24 lb P ac-1. Research suggests that crop responses to banded versus broadcast P applications are more common when STP ratings are low (Randall et al, 1985; Randall and Hoeft, 1988).

Trends in the Three Major N Sources used in Minnesota (Anhydrous, Urea, Solutions)



These 3 sources account for 83-84% of the N sales

Figure 15. Trends in major fertilizer nitrogen sources used in Minnesota.

Manure Contributions

This section provides a brief overview of the relative importance of the nutrient contributions of land-applied manure. Runoff and seepage problems associated directly with feedlots and manure storage structures are addressed in Chapter 7.

Nitrogen and Phosphorus Application Rates

Research suggests that liquid manure and commercial fertilizer sources of N can be managed similarly with respect to potential losses from the field. Randall et al. (2000) did not observe statistically significant different N losses from subsurface drainage between incorporated liquid dairy manure and urea applied at an average rate of 166 lb available N ac-1 over a four-year period.

Relationships between P loss and manure application rates are complicated by the influence of tillage method on P losses. Tillage method will be reviewed later; however, Gessel et al. (2004) showed that total P losses from rainfall runoff were similar among different application rates of incorporated liquid swine manure. Losses of DP did increase with increasing manure application rate during the spring snowmelt period.

Many studies suggest that applications of solid manure actually reduce sediment and total P losses from a field due to increased infiltration rates (Mueller et al., 1984; Ginting et al., 1998; Gilley and Risse, 2000; Zhao et al., 2001; Andraski et al., 2003). Gessel et al (2004) also observed reduced annual runoff and sediment losses from incorporated liquid swine manure applications.

Statewide animal populations, based upon animal units[7], have decreased slightly since the mid-1960s (Figure 16). The most obvious changes over the past 40 years are the significant decreases in dairy numbers and increases in hog production. It is also worth noting that the number of livestock producers managing these important manure resources has decreased.

7 For purposes of calculating relative manure production from a variety of different domesticated farm animals, state feedlot rules assume that manure production from one animal unit is equivalent to that produced by one mature cow (milked or dry) weighing less than 1000 pounds.

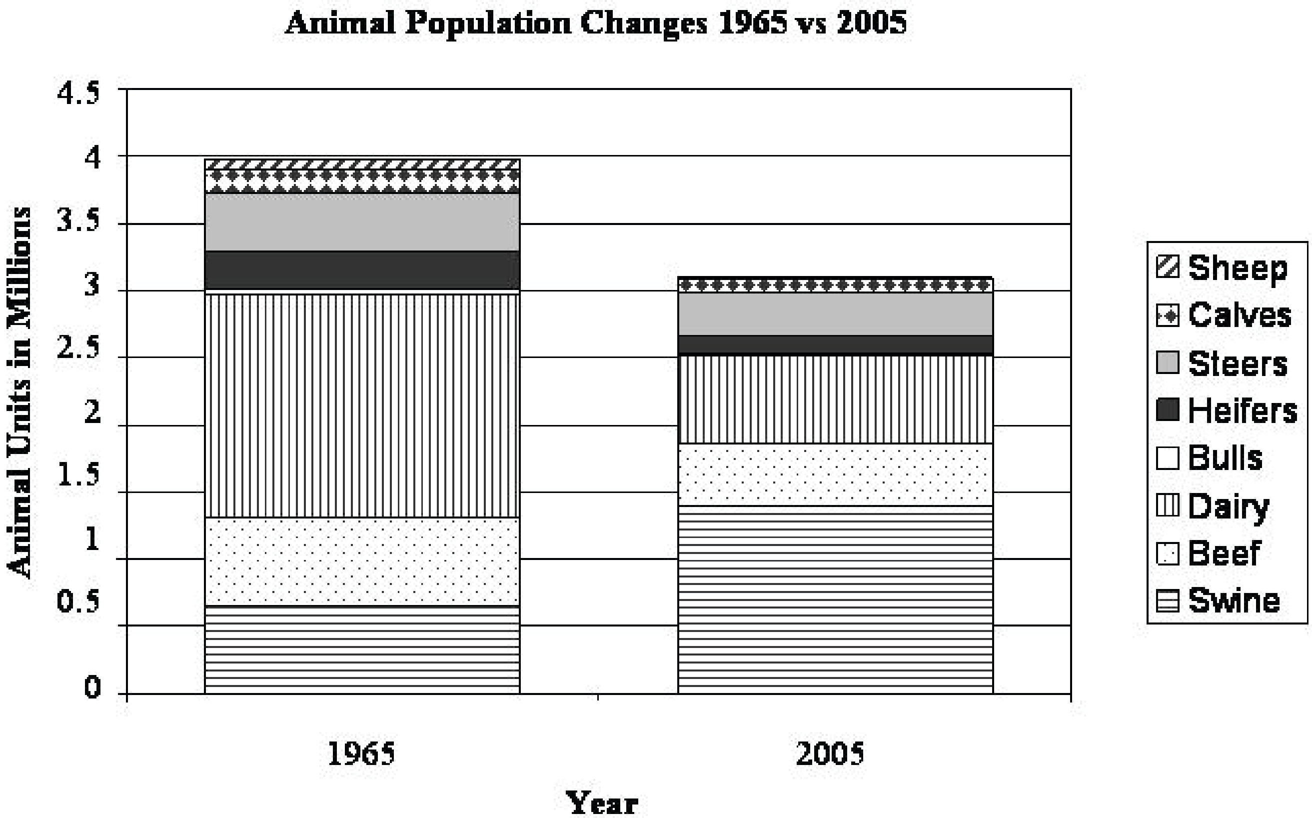


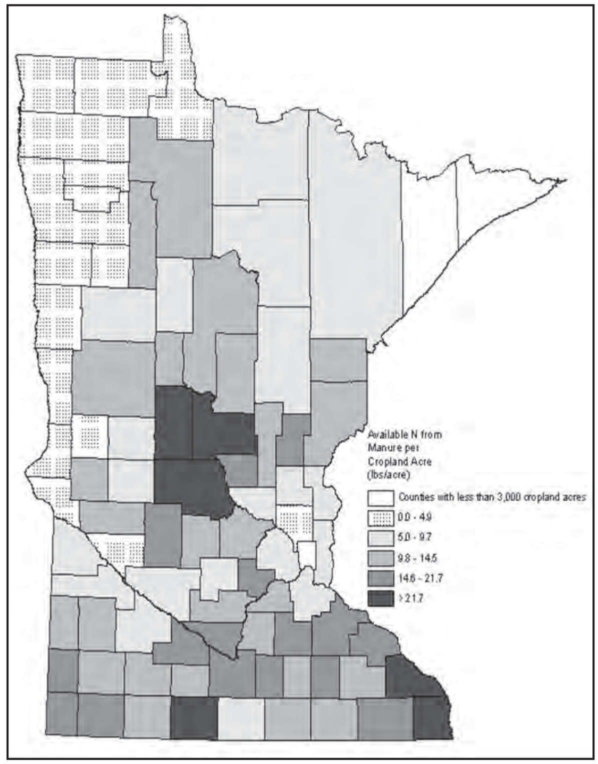
Figure 16. Comparison of animal units for the major domestic species from 1965 to 2005 (NASS, 2005b).

Using the 2002 Census animal populations and similar calculation methods as used in Schmitt and Rehm (1993), the most recent annual fertilizer contributions from manure are 120,000 tons of nitrogen and 121,000 tons of phosphate. For purposes of this report, the "nitrogen fertilizer replacement value" is considered to be approximately 50 percent due to storage and application losses. The "phosphate fertilizer replacement" value is frequently calculated as 80 percent of the total phosphate generated. Nitrogen fertilizer replacement contributions from manure vary greatly by county, ranging from one to 34 pounds per cropland acre (Figure 17).

Phosphorus contributions[8] across all cropland acres can be as high as one to 16 pounds per cropland acre (Figure 18). While these numbers are relatively small in comparison to fertilizer inputs, manure applications tend to be concentrated on a small percentage of Minnesota's cropland.

8 Note that the units in Figure 18 are expressed in phosphorus units rather than phosphate. To convert from P to P_2O_5, multiply by 2.29.

Figure 17. Nitrogen "fertilizer replacement values" from manure based on animal populations from the 2002 Census. Inputs are averaged across all cropland acres within each county.



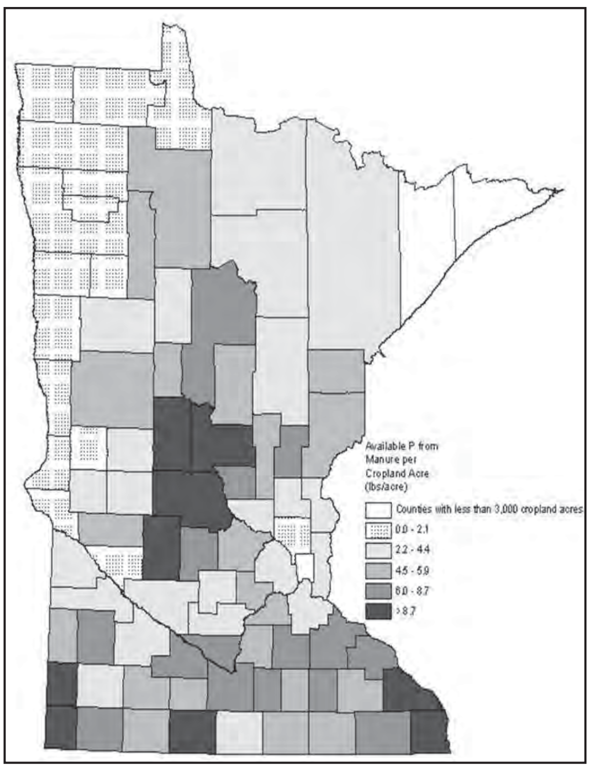


Figure 18. Phosphorus "fertilizer replacement values" from manure based on animal populations from the 2002 Census. Inputs are averaged across all cropland acres within each county.

Nitrogen and Phosphorus Timing and Method of Application

The timing of manure application influences nutrient delivery from the field as observed with commercial fertilizer. A higher risk of nutrient losses, particularly P, is associated with manure applications that occur when conditions are conducive to surface runoff, including spring snowmelt and planting periods when antecedent moisture conditions are high, infiltration rates are low, and the ground is bare (Mueller et al., 1984; Edwards and Daniel, 1994; Pote et al., 2001).

Studies addressing the effect of manure application method on N loss are limited; however, Zhao et al. (2001) observed losses of nitrate-N in surface runoff from unincorporated manure that were six times more than losses from incorporated manure. The mass of nitrate-N loss in surface runoff was less than 0.2 lb N ac^{-1} with a majority of the nitrate-N losses occurring in subsurface tile drainage. Relationships between P loss and manure application are site specific. Some studies report similar or higher total P losses from incorporating manure compared to broadcast applications due to soil disturbance associated with tillage (Ginting et al., 1998; Bundy et al., 2001; Gessel et al., 2004). Other studies report lower total P losses in runoff water due to the removal of a P source from the thin surface layer that interacts with rainfall runoff (Baker and Laflen, 1982; Mueller et al., 1984; Zhoa et al., 2001; Tabbara, 2003). Each of the preceding studies generally observed a larger fraction of the total P in the form of sediment-bound P for incorporated manure compared with higher losses of DP associated with broadcast applications of manure.

Legume Contributions

Subsequent nitrogen credits from past legume crops (primarily soybeans and alfalfa) contribute approximately 18 percent of the current N agricultural inputs to Minnesota's cropland (Figure 4). Most producers can realize a 40 lb ac^{-1} reduction in commercial N fertilizer input requirements to corn following soybeans; producers on coarse-textured soils should realize a 20 lb ac^{-1} reduction under non-irrigated conditions (Rehm et al., 2001). Nitrogen credits for forage legumes are dependent upon the population density prior to termination and credits typically range from 75 to 150 lb ac.

Long-Term Trends in "Legume" Crops (All Hay and Soybeans during 1921 - 2004

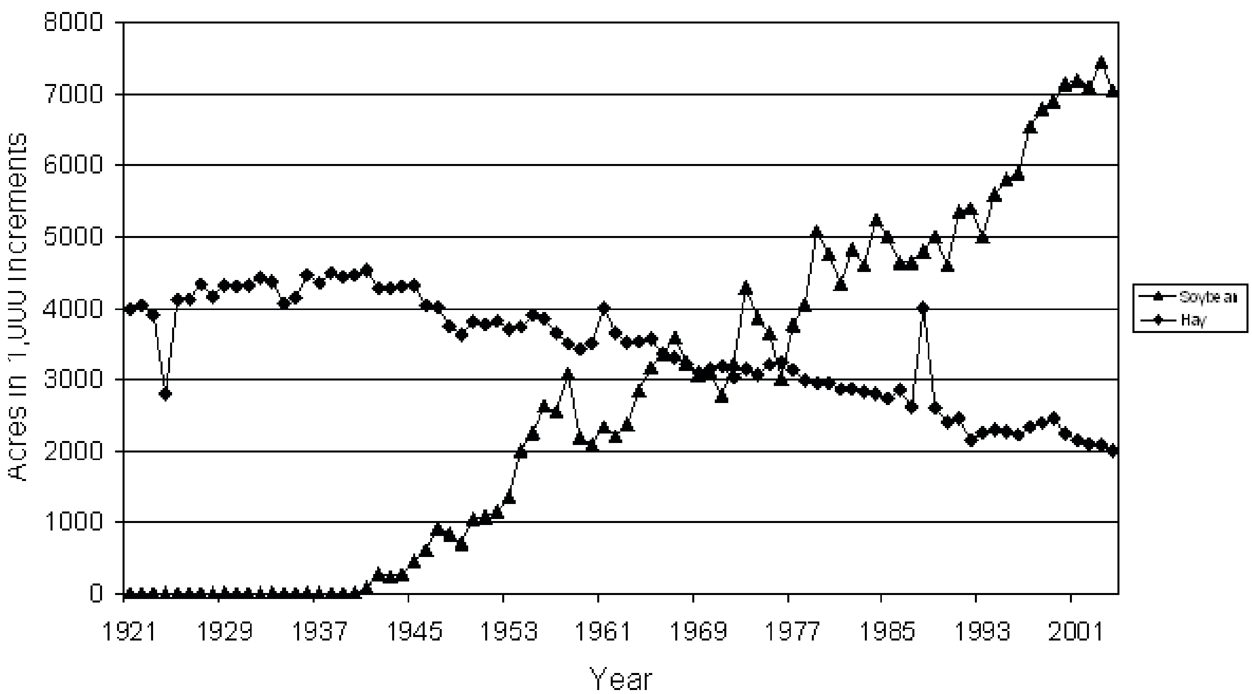


Figure 19. Acreage changes for soybeans and forage legume crops since 1921.

Soybean production has steadily risen throughout 1990's, and annual production levels now total over seven million acres (Figure 19). These changes correspond to steady decreases in wheat and hay (alfalfa and clover) production in many regions throughout the state. These reductions have occurred, in part, as a result reductions in dairy operations. Insufficient crediting of perennial forages can result in N applications in excess of crop needs. As noted in an earlier section, the benefits to water quality of perennial forages can be significant (Randall et al., 1997a; Russelle et al., 2001)

Targeting Impacted Agricultural Areas for Implementation of Best Management Practices

Source Water Protection Areas

Various state and local agencies have worked jointly with the MDH in implementing federal and state Source Water Protection (SWP) programs as they relate to agricultural nutrients. A prioritization and ranking system for public water supplies (PWSs) has helped to focus interagency efforts on those geographical areas and Source Water Protection Areas (SWPAs) where nitrate concentrations in ground water exceed or threaten to exceed the health standard. In addition to the formal PWS ranking process (driven by broad geologic mapping units, ambient ground water data and potentially affected population), geographic areas of concern have also been identified through state and local activities (via Nitrate Water Testing Clinics or other monitoring efforts) or through the MDH (via SWPA contaminant source inventories or other monitoring efforts).

The goals of the SWP Program and the state's Nitrogen Fertilizer Management Plan have been combined in an effort to promote the adoption of U of M-developed nitrogen BMPs. Local implementation of the BMPs is necessary in order to gauge their effectiveness on local landscapes, soils, crops, climatic patterns, irrigation and drainage practices and geology.

The following summaries highlight examples of educational and demonstration efforts being conducted to promote BMP adoption in PWSs responding to nitrate-N problems:

City of St. Peter SWPA: The city of St. Peter has observed increasing nitrate-N levels in vulnerable wells since the 1980's. A nitrate removal system was rejected due to the high cost, so water is blended from various wells to produce a finished water supply with a nitrate-N concentration of four to five ppm. Local farmers, county health staff, extension agents, city water planners, and state agencies developed a wellhead protection plan that was approved in 1998 to develop a strategy for protecting the city's drinking water supply from nitrate-N contamination. Many activities related to BMP implementation have been conducted as a result of these efforts and are outlined at *www.mda.state.mn.us/news/publications/protecting/waterprotection/waterstpeter.pdf*

City of Perham SWPA: The city of Perham has considered a nitrate-N removal system due to the occurrence of nitrate-N concentrations that exceeded the drinking water standard in various city wells. Because deeper aquifers with lower nitrate-N levels contain high levels of iron, finding adequate supplies of drinking water will be challenging. The city developed a wellhead protection plan to address potential nitrate leaching from cropland, lawns, septic tanks, and feedlots. Several action steps have been implemented since the development of the wellhead protection plan and can be reviewed at *http://www.mda.state.mn.us/news/publications/protecting/waterprotection/waterperham.pdf*.

Lincoln-Pipestone Rural Water System (LPRWS) SWPA: LPRWS manages the Verdi and Holland well fields which supplies water to 27 communities and 3000 rural households in southwestern Minnesota. Water from these wells has elevated nitrate-N concentrations because they are located in shallow aquifers which forced the Holland well field to purchase a $2,000,000 nitrate-N removal system. Many of the steps carried out to protect the existing water supplies can be found at *www.mda.state.mn.us/news/publications/protecting/waterprotection/waterlprw.pdf*

Tools for Targeting BMP Implementation

Minimizing the impact of agricultural nutrients on the state's water resources entails identifying vulnerable areas and implementing the appropriate practices to reduce the risk of transport. This requires the development of risk assessment tools that are based on principles of nutrient delivery to water resources. The following section explores two tools available to water planners that can be utilized to prioritize BMP implementation and effectively improve water quality.

Agroecoregions

Using watersheds as management units for statewide water resource management presents many challenges. Watersheds at this scale integrate many variable landscape characteristics that influence water quality such as precipitation, geomorphology, slope, subsurface drainage, and cropping systems. As a result, the U of M developed agroecoregions on behalf of the MDA to minimize the variability associated with these landscape characteristics for agricultural and nonpoint source pollution management applications. Thirty-nine agroecoregions cover the state ranging in size from 80,443 to 4,905,884 acres.

Studies suggest that agroecoregions are effective for characterizing regional lake water quality trends and identifying homogeneous regions in the state with elevated nitrate-N concentration in wells (Birr and Mulla, 2002).

Monitoring data indicates that elevated nitrate-N concentration occur in the north-central portion of the state corresponding to the Alluvium and Outwash and Drumlin agroecoregions. The Rochester Plateau and Blufflands agroecoregions corresponding to the Karst region in the southeast portion of the state are also vulnerable to nitrate-N contamination. Many of the shallow alluvial aquifers in the southwestern portion of the state also contain elevated nitrate levels.

Currently an ad hoc panel of scientific-technical water quality experts have begun the process of developing a catalog that rates the effectiveness of various BMPs for each agroecoregion based on water quality problems associated with the agroecoregion. The ultimate goal of these activities is to use this information to target funds obtained from legislation and conservation programs designed to improve water quality.

Phosphorus Index

The Minnesota Phosphorus Index (PI) is a risk assessment tool designed to identify sites within a watershed where excess P is being exported (Moncrief et al., 2004; *http://www.mnpi.umn.edu/*). The PI also evaluates alternative management practices to determine the most effective strategy for reducing the risk of P transport from a field. The PI does not provide an actual estimate of P delivered from the site nor does it consider the economic costs associated with BMPs.

The PI provides a relative risk value for P delivery from a field based on user provided information on land, crops, P applications, and tillage.

The PI framework is made up of three independent pathways used to characterize P delivery to a surface water body. The three pathways include 1) sediment-bound P from rainfall runoff, 2) soluble P from rainfall runoff, and 3) soluble P from snowmelt runoff. Typically, a majority of the overall risk of P loss is associated with one of the pathways. Consequently, management practices that address that pathway will be the most effective strategy for reducing the overall risk of P delivery from the site.

Technical Support and Programs for BMP Promotion and Implementation Including Recent Activities and Accomplishments

A number of organizations and state agencies are available to stakeholders to provide technical assistance on issues related to management of agricultural nutrients. Many of these entities offer programs that provide financial assistance for implementing BMPs designed to minimize the impact of agricultural nutrients on the state's water resources. This section provides a brief overview of these organizations and the programs they administer. A more detailed report of the recent activities of many of these groups are highlighted in *Needs, Priorities, and Milestones* of this Nonpoint Source Management Program Plan.

University of Minnesota and the University of Minnesota Extension Service

Technical expertise related to the management of agricultural nutrients is primarily available within the College of Agriculture, Food, and Environmental Science (COAFES) and Minnesota Agricultural Experiment Station at the U of M. Water quality research is also conducted within the Colleges of Natural Resources and Biological Sciences.

The U of M Extension Service represents the outreach unit of the university and delivers educational programs related to the research.

Educational programs cover such diverse topics as agricultural N BMPs to the proper location, construction, and maintenance of individual sewage treatment. Other topics covered by the U of M Extension Service include soil and manure testing, BMPs for P management, and crediting of manure and legumes. Specific nonpoint pollution educational efforts are targeted to agricultural chemical dealers, consultants, local resource managers and producers.

A number of publications have been released from the U of M related to nutrient management BMPs including:

- Tillage Best Management Practices for Water Quality Protection in Southeastern Minnesota (Randall et al., 2002; *www.extension.umn.edu/distribution/cropsystems/DC7694.html*
- Validating N Rates for Corn on Farm Fields in Southern Minnesota (Randall et al., 2003; *www.extension.umn.edu/distribution/cropsystems/DC7936.html*
- Fertilizing Corn in Minnesota (Rehm et al., 2006; *www.extension.umn.edu/distribution/cropsystems/DC3790.html*
- A bulletin series on agricultural drainage issues (Busman and Sands, 2002; *www.extension.umn.edu/distribution/cropsystems/DC7740.html*

Board of Water and Soil Resources (BWSR)

BMPs are promoted through BWSR programs and its local government clientele, which includes Soil and Water Conservation Districts (SWCD), county government, watershed districts, and water management organizations. The BWSR administers the comprehensive local water planning program, which includes components dedicated to the prevention of nonpoint source pollution from agricultural nutrients. The BWSR, the SWCDs and local units of government that directly or indirectly address nonpoint source pollution from agricultural nutrients through the following programs:

State Cost-Share Program

Provides funds to local SWCDs for conservation projects that protect and improve water quality by controlling soil erosion and reducing sedimentation.

Reinvest in Minnesota Reserve Program (RIM)

Designed to retire private land from agricultural production to restore previously drained wetlands.

Conservation Reserve Enhancement Program (CREP)

This land retirement program combines the USDA-NRCS Conservation Reserve Program (CRP) with RIM to protect environmentally sensitive cropland.

Nonpoint Engineering Assistance Program

Provides engineering assistance to private landowners for a variety of nonpoint water quality management practices.

Minnesota Department of Agriculture (MDA)

The MDA is the lead state agency for all aspects of pesticide and fertilizer environmental and regulatory functions as described in Minnesota Statutes §§ 18B, 18C, 18D, and 103H. Programs developed and administered by the MDA focus on nonpoint source chemical fertilizer contamination of the state's rural and urban surface and ground water resources.

Activities conducted by the MDA include the Farm Nutrient Management Assessment Program (FANMAP). This program conducts surveys of farmers to provide baseline information for measuring the effectiveness of educational programs as well as provide insight for the design of educational programs.

The MDA also conducts monitoring of the state's surface and ground waters for the presence of pesticides and agricultural nutrients. The Monitoring and Assessment Unit maintains a network of over 80 wells throughout the state and conducts automated sampling of surface water in select watersheds.The MDA also works closely with the Minnesota Department of Health to assist Wellhead Protection planners in developing strategies to protect water resources from potential nonpoint source contamination from fertilizer. The following section highlights some of the MDA's programs developed to carry out the authority granted under the Minnesota Statutes. Additional information can be accessed online at *www.mda.state.mn.us*, *www.mda.state.mn.us/chemicals/pesticides/maace.htm*, *www.mda.state.mn.us/chemicals/fertilizers/nutmgmt.htm*.

Soil Testing Lab Certification and Manure Testing Lab Certification Programs

The Soil Testing Lab Certification is a voluntary MDA program to ensure accurate and credible soil test results for Minnesota producers, and promotes use of soil testing and use of U of M fertilizer recommendations in nutrient management planning. Participating laboratories must maintain standards for equipment, facilities, personnel, record keeping, methods and procedures. Soil analysis must follow uniform reporting methods. Soil fertility recommendations made by the laboratory must include land grant university soil fertility recommendations as a basis for comparison by the crop producer. More information is available at *www.mda.state.mn.us/index.htm*, *www.mda.state.mn.us/licensing/pestfert/soilabs.htm*

The Manure Testing Laboratory program is similar to the soil testing laboratory certification program and was developed in response to economic and environmental concerns related to land application of animal manures. Most producers do not test their manure on a regular basis, in part due to concerns about the value of the testing. Use of MDA-certified laboratories will be required for development of manure management plans by certain livestock producers under provisions of the new state feedlot rules; however, testing is recommended regardless of whether a producer is required to conduct manure analysis. Currently, there are 42 MDA certified laboratories located in the United States and Canada (Figure 20). More information on the program can be reviewed online at *www.mda.state.mn.us*, *http://www.mda.state.mn.us/licensing/pestfert/manurelabs.htm*, *www.mda.state.mn.us/licensing/pestfert/mnrcertfaq.htm*

Commercial Animal Waste Technician Licensing Program

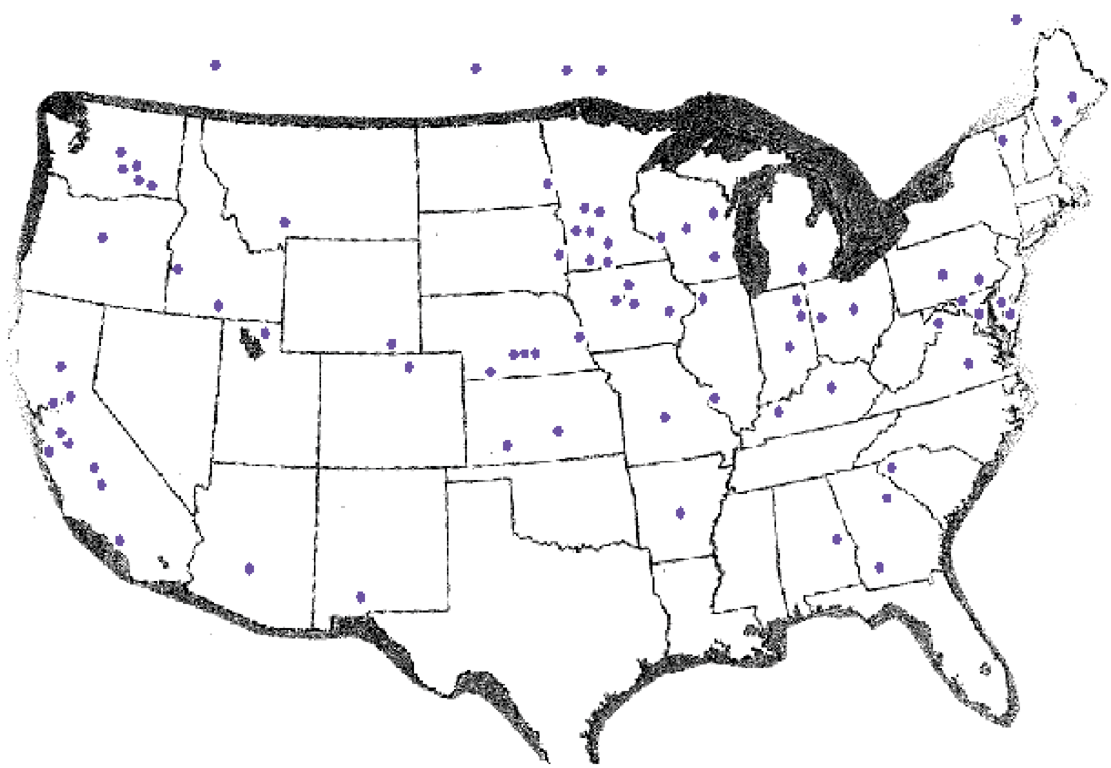
In response to requests from the professional associations representing commercial applicators of liquid and solid manure in Minnesota, the 1998 legislative session (Minn. Stat. § 18C.430) established a licensing program for Commercial Animal Waste Technicians. As of 2000, over 160 businesses are now licensed through the MDA.

Certified Crop Advisor Program (CCA)

This program is a membership service of the American Society of Agronomy (ASA). Any public, commercial or independent adviser, who counsels farmers, ranchers or other agricultural entities can participate in the program. The requirements of certification include passing a comprehensive exam that covers four topics: soil fertility, soil and water management, integrated pest management and crop production. Members must maintain 40 hours of continuing education every two years.

Agricultural BMP Loan Program

The MDA AgBMP Loan Program provides low-interest loans to counties, SWCDs and Joint Power Boards. These funds are provided for the implementation of select agricultural BMPs addressing infrastructure needs



and certain farm management practices that reduce or prevent nonpoint environmental degradation from farm fields and farmyards. Funds are provided for agricultural waste management, structural erosion control measures, conservation tillage and manure handling equipment, individual sewage treatment system upgrading or replacement, and proper sealing of abandoned wells. The BMPs must be identified as priorities by local units of government in their water planning activities, including Wellhead Protection Program (WHP) plans.

Figure 20. Location of MDA certified manure testing laboratories.

Nitrogen Fertilizer Management Plan

Minnesota Statute 1989, Chapter 326, Article 6, Section 33, Subd. 2b, also known as the 1989 Comprehensive Ground water Protection Act (the Act) directed a nitrogen fertilizer task force to develop recommendations for a Nitrogen Fertilizer Management Plan (NFMP) for the prevention, evaluation and mitigation of nonpoint source occurrences of N fertilizer in waters of the state. The NFMP was finalized in August of 1990 and includes components that promote the prevention of contamination of water resources by inorganic nitrogen and responses to the detection of inorganic nitrogen from fertilizer sources in ground or surface water. Although the Act and the associated NFMP have laid the foundation for protection of the state's water resources from agricultural nonpoint source pollution, there was no related funding provided with enactment of the legislation, leaving state agencies to compete for limited federal funds and a variety of state funding programs originally designed for other environmental protection efforts.

The Act mandates that the NFMP contain both a voluntary BMP component and a component that allows for regulatory action in the form of Water Resource Protection Requirements (WRPRs).

The voluntary BMPs, developed jointly by the U of M Extension Service and the MDA, were an outgrowth of the Act and were developed through public participation and notice in the state register. Statewide BMPs outline broad-based recommended practices, while regionally specific BMPs account for variable soil and climatic conditions. Special situation BMPs (e.g., for irrigated, coarse textured soils, and for potatoes) were developed based on emerging issues.

The NFMP structure for responding to nitrogen fertilizer nonpoint contamination is as follows:

BMP Promotion Phase: Promotion of voluntary adoption and implementation of BMPs. BMP development and promotion is considered an ongoing process;

BMP Evaluation Phase: Evaluation of the adoption and effectiveness of voluntary BMPs. The state is currently developing and implementing BMP evaluation efforts in a limited number of areas of critical concern (e.g., Source Water Protection Areas); and

Response Phase: Response to instances wherein voluntary BMPs have not been adopted (despite promotion) or are ineffective at mitigating the occurrence of nitrate in local ground or surface water. The Response Phase is implemented when initial attempts to resolve nitrogen contamination problems through voluntary action fail. Regulation governing nitrogen fertilizer use in vulnerable areas is possible after a series of intense BMP and ground water monitoring efforts justifies rule writing. The Response Phase (which incorporates additional BMP promotion and evaluation efforts) is comprised of the following steps:

Special BMP Promotion Areas – Before regulatory action can be taken at the local level, the MDA, SWCD and the county water planning authority must designate a localized "Special BMP Promotion Area" in which various evaluation efforts must occur.

Time must be allotted for producers to implement the BMPs and then a reasonable amount of time needs to be factored in for observing potential water quality changes.

Nitrogen Management District

If, after the creation of the localized Special BMP Promotion Area, agricultural sources of nitrate in drinking water remain problematic for at least a four-year period, the area should be reclassified as a Nitrogen Management District. The establishment of the district initiates a process of change from a voluntary to a regulatory situation.

Water Resource Protection Requirements

If BMP adoption and water quality remain unacceptable in the Nitrogen Management District after annual reviews, the MDA shall commence the promulgation of localized Water Resource Protection Requirements through rule-making.

Details of the NFMP are provided in the *Recommendations of the Nitrogen Fertilizer Task Force on the Nitrogen Fertilizer Management Plan to the Minnesota Commissioner of Agriculture,* August 1990, available from the MDA *www.mda.state.mn.us*

Currently, the response phase of the NFMP has not been carried out anywhere throughout the state. In July of 2005, the Legislature approved a $0.15 per ton increase in fertilizer tonnage fees. The increase in funding allowed three water quality specialists to be hired within MDA. The increased staffing will enable the MDA to more effective employ the NFMP and address water quality concerns at a local level in sensitive geographic areas impacted by agricultural nutrients.

Minnesota Department of Health The Source Water Protection Program

The federal Safe Drinking Water Act [CFR 40, Part 141, Section 1428] and the state Wellhead Protection Rule [Minn. Rules, §§ 4720.5100 to 4720.5590] jointly require that source water protection measures be established for all public water supply wells. Both programs are administered by the MDH. The MDA has developed a Memorandum of Understanding with the MDH to coordinate source water protection activities related to nonpoint source pollution from agricultural nutrients. The MDH also conducts its own monitoring and education programs related to nitrate contamination of public and private drinking water wells. The MDA in conjunction with the MDH have been involved in many cooperative projects related to source water protection including *www.mda.state.mn.us:*

- publication of wellhead protection case studies
- release of a series of drinking water protection fact sheets
- release of a funding and technical assistance matrix that outlines cost share and funding programs for adoption of BMPs
- development of an interactive mapping program that identifies vulnerable protection areas
- assist local wellhead teams with implementation objectives
- on-farm demonstrations of U of M BMPs
- maintain “one on one” contact with producers and ag-professionals in protection areas

Minnesota Pollution Control Agency

The MPCA is involved in the monitoring of lakes, streams and ground water and contributes to assessment of current conditions, trends and causative factors related to agricultural nutrients and nonpoint source pollution based on the Chapter 7050 Water Quality Standards. Through the Chapter 7020 Feedlot Rules, the MPCA evaluates and permits feedlot design and operation, including manure management plans. Through the Clean Water Partnership, and Minnesota River project, the MPCA facilitates the implementation of numerous projects striving to minimize agricultural nutrient transport to water resources. MPCA also serves as the lead state agency in the development of TMDLs.

Clean Water Partnership and Clean Water Act Section 319 Programs

The state Clean Water Partnership (CWP) Program, administered by the MPCA, will provide grants, loans, and technical assistance to local units of government to address agricultural nonpoint source pollution. CWP Phase I grants are awarded for diagnostic projects in which the type and extent of nonpoint source pollution in a lake, river or aquifer are determined and response/implementation plans are developed. CWP Phase II grants or loans are awarded to implement practices to improve or protect water resources identified in the CWP Phase I report or an equivalent diagnostic and planning process.

The Clean Water Act Section 319 Program has also been used to implement activities to reduce agricultural nonpoint source pollution. Grants have funded various implementation activities including development of specific farm surveys, interviews with producers, demonstration projects, other educational activities, and various agricultural BMPs. Funds have also been used to conduct monitoring that assesses the effectiveness of BMPs.

USDA-Natural Resources Conservation Service (NRCS)

The NRCS provides technical and financial assistance to land owners and resource managers to conserve soil, water, and other natural resources. The NRCS administers a number of programs designed to manage nutrients and improve water quality.

Conservation Reserve Program (CRP)

A program administered by the Farm Service Agency (FSA) to provide long-term rental payments and cost-sharing assistance for establishing a vegetative cover on cropland and marginal pasture land for protection from soil erosion and nutrient transport in runoff.

Wetlands Reserve Program (WRP)

Provides technical and financial assistance to landowners to restore, enhance, and protect wetlands. The program is offered on a continuous sign-up basis and is designed to restore the function of wetlands in the landscape.

Conservation Security Program (CSP)

Provides payments to producers who already employ BMPs on agricultural lands and provides incentives for those interested in doing more. The program is eligible to all farms within selected watersheds and offers three tiers of enrollment based on the degree of conservation practices adopted for the operation.

Environmental Quality Incentives Program (EQIP)

Provides technical, financial and educational assistance related to cropping, tillage and nutrient management and environmental protection practices in designated priority areas.

EQIP education grants have funded demonstration projects, workshops, farm surveys and cost-sharing grants used to provide incentives to producers to implement environmentally beneficial improvements to infrastructure or for nutrient, pest and grazing land management plans and practices.

Best Management Practices

The following general list of BMPs is commonly used to reduce nonpoint source pollution from use of agricultural nutrients. This list is not comprehensive and does not suggest that other BMPs would have no benefit.

Please refer to Part I Agricultural BMPs and Part II Erosion and Sediment Control BMPs in an Appendix of this document for definitions of the following BMPs.

Part I Agricultural BMPs:

Chapter 9 Agricultural Nutrients

Needs, Priorities and Milestones

The action plan provided below summarizes the goals and milestones identified in the preceding sections. Many of the milestones listed below, as well as the implementation of specific projects, are contingent upon adequate funding and local involvement.

Goal 1: Accelerate and enhance education and outreach of BMPs related to the management of fertilizers, manure, and organic sources of agricultural nutrients. Promote programs related to BMP implementation. Focus BMP education and implementation efforts on rulnerable areas Identified using monitoring data.

Milestones (Action Steps)	13	14	15	16	17	Funding Source(s)	Lead Agency(ies)
1. Enhance mechanisms for delivering current research to stakeholders and promote/develop synergistic relationships among stakeholders (i.e., use of existing conferences that bring together researchers, producers, agricultural retailers, and agricultural advisors, such as nutrient efficiency conferences).	X	X	X	X	X	Rapid Response Fund (U of M), EQIP, 319, State, Commodity Orgs, Ag Fertilizer Research and Education Council (AFREC), CWF	U of M, MDA, USDA- Agricultural Research Service, SWCD, NRCS, MPCA. Working with Ag Water Resource Center and MN Crop Production Retailers
2. Education and outreach topics							
a. Promote the principles of nutrient management, alternative cropping systems, and drainage technology and the associated environmental and economic aspects of these areas. Provide tools and technical assistance to the agricultural community to accelerate practice implementation (i.e. Nutrient Management Initiative) Launch new Educational efforts based on the revised Nitrogen Fertilizer Management Plan and Agriculture Water Quality Certainty Program.	X	X	X	X	X	CIG1-NRCS, 319, State, MLICA2, BWSR Clean Water Fund Implementation Grants, Commodity Groups	U of M, MDA, USDA- Agricultural Research Service, SWCD, NRCS, BWSR, ISU

Milestones (Action Steps)	13	14	15	16	17	Funding Source(s)	Lead Agency(ies)
b. Promote the principles of manure management including such topics as nutrient availability associated with manure storage and application methods, proper crediting, spreader calibration and uniformity. Promote livestock industry's environmental quality assessment and water quality certification programs. Provide tools and technical assistance to the agricultural community to accelerate the development and implementation of nutrient management plans.	X	X	X	X	X	319, Livestock Commodity Orgs, EQIP, State, BWSR Clean Water Fund Implementation Grants, Commodity Groups	U of M, MDA, USDA- Agricultural Research Service, SWCD, NRCS, MPCA, BWSR
c. Provide technical training to agricultural service providers through "traditional" programs such as the Certified Crop Advisors, NRCS Technical Service Providers and the Commercial Manure Applicators as well as one-on-one consultations and distance-based methods including the Internet, software, and other "state-of-the-art" technology.	X	X	X	X	X	Various Public and Private Funds, 319	Various Boards, U of M, MDA Certification Programs, NRCS, Multi-Agencies, Private Organizations, USEPA
d. Maintain appropriate consistency in recommendations from manure and soil testing labs through approved laboratory methods, reporting units and subsequent fertilizer recommendations using such certification programs as Certified Manure Testing Labs and Certified Soil Testing Labs. Maintain efforts in consolidating manure-testing programs on a national level to reduce conflicting individual state programs.	X	X	X	X	X	Livestock industry, USEPA, State, Testing Labs	MDA, U of M, North American Proficiency Testing
e. Promotion of irrigation water scheduling and nutrient management in Source Water Protection Areas and other areas at risk from nitrate contamination of drinking water supplies.	X	X	X	X	X	Local water plans, 319, BWSR Clean Water Fund Implementation Grants, CWF	U of M, SWCD, NRCS, MDA, MDNR, BWSR

Milestones (Action Steps)	13	14	15	16	17	Funding Source(s)	Lead Agency(ies)
3. Establish demonstration projects of research-proven effective BMPs related to nutrient management to validate BMPs in physiographic settings that differ from the conditions in which the BMPs were researched and developed (i.e. on-farm research and demonstration projects) and to provide opportunities for BMP education and promotion.	X	X	X	X	X	319, MDH, State, EQIP, Commodity Orgs, Surface Water Assessment Grants, CWF, Commodity Groups	U of M, Center for Ag Partnerships, MN Corn Growers, MDA, USDA-Agricultural Research Service, Southern Minnesota Beet Sugar Cooperative, Northwest Research and Outreach Center, Discovery Farms, MN Ag Water Resources Center, Local Watershed Groups
4. Develop and promote innovative programs designed for BMP implementation and adaptive management with a particular focus on environmentally sensitive areas. Develop on-farm support network to aid producers in conducting their own in-field testing of BMPs. Support the 4-R Plant Nutrition Program and further explore the On Farm Network basal stalk nitrate test.	X	X	X	X	X	CIG, 319, LCCMR and other state sources	MDA, NRCS, BWSR, SWCD, Local Watershed Groups, U of M
5. Clean Water Fund Project Implementation and Adoption: In 2008, the State's electorate voted for an increase of State's sales tax of which a portion goes to projects that help restore and protect MN waters. BWSRs Clean Water Fund appropriation will be utilized for grants to local units of government to implement projects that mitigate and prevent the leaching and runoff of nutrients into MN surface and groundwater resources. These projects will include funds for project development and siting, technical assistance and engineering/design needs, and structural and vegetative practices construction and installation.	X	X	X	X	X	BWSR Clean Water Fund, MDA Ag BMP Loans	BWSR, MPCA, MDA, MDH, MDNR

Goal 2: Continual research, development and refinement of BMPs that minimize nutrient losses from agricultural systems. Evaluate BMP effectiveness and long-term sustainability. Continual research of nutrient sources and transport mechanisms in agricultural systems for the development of tools for resource planners/managers to prioritize BMP implementation and selection. Provide guidance to the agricultural Community for proper selection of BMPs and expected performance/outcomes.

Milestones (Action Steps)	13	14	15	16	17	Funding Source	Lead Agency(ies)
1. *Research BMP effectiveness for water quality improvement. Research should address BMPs related to nutrient management, manure management, drainage (i.e. "conservation drainage," controlled drainage, etc.), ditch water management, cover crops, precision agriculture, water treatment systems (i.e. wetlands, riparian treatment, linear wetlands, control structures, etc), irrigation management, and alternative cropping systems. Techniques should include the use of validated computer simulation models, long-term demonstrations (via paired watersheds, drainage lysimeters, "model farm concepts") and other proven methods. Research should be evaluated on a field-scale basis when possible and developed for different regions/sensitive areas of the state with unique climatic, topographic, and soil characteristics.*	*X*	*X*	X	X	X	Commodity Groups, Proposed Ag Fertilizer Research and Education Council (AFREC), USDA, USEPA, LCCMR, MN Land Improve-ment Contractors of America (MLICA), State CWF Research Grants	U of M, USDA-ARS, MDA, MPCA, NRCS, Discovery Farms, MN Ag Water Resources Center, Multi-Agencies
2. Research and quantify nutrient sources, losses, and mechanisms of transport at different scales (plot, field, and watershed). Develop and validate different tools to assist resource managers/planners to identify priority areas for BMP implementation.	X	X	X	X	X	319, CWP, LCCMR, Commodity Groups, Proposed AFREC, CWF	U of M, USDA-ARS, MDA, MPCA, NRCS, Multi-Agencies
3. Identification of economic, social, and technological barriers that impede transfer of existing BMPs and technologies.	X	X	X	X	X	State, 319	U of M, MDA

Goal 3: Provide accurate assessments of BMP adoption rates and performance through surface and ground water monitoring as well ws "Performance Indicators" such as survey instruments.

Milestones (Action Steps)	13	14	15	16	17	Funding Source(s)	Lead Agenc(ies)
1. Assessment of BMP adoption using survey methods in geographic areas where BMP education, promotion, and programs have been focused.	X	X	X	X	X	319, CWP, State, CREES, CWF	MDA, UM, National Agricultural Statistics Service[5], State Agencies, USDA-NRC
2. Establish groundwater and surface water monitoring networks to evaluate BMP effectiveness at landscape scales and identify environmentally sensitive areas. Promote and coordinate monitoring activities among multiple agencies.	X	X	X	X	X	State, 319, CWP, CREES, CWF	MPCA, MDA, MDH, MDNR, NRCS, SWCD
3. Develop additional performance indicators of water quality impacts to supplement traditional survey and monitoring techniques.	X	X	X	X	X	State, 319, CWF	MDA, BWSR, UM, USDA-NRCS
4. Evaluate the costs of BMP related activities on a per unit basis and associate with water quality improvements to determine the per unit costs of water quality improvements. Consider coordinating economic evaluations with other performance indicators (i.e. survey instruments) to obtain the information needed for economic analysis. Further develop the BMP cost optimization framework spreadsheet for nitrogen and develop a similar spreadsheet for phosphorus BMPs.	X	X	X	X	X	State, LCCMR, 319	U of M, MDA
5. Develop a standardized record keeping tool for farmers that includes information required for enrollment in various conservation programs (i.e. Conservation Measurement Tool, Nutrient Tracking Tool, CSP, CRP, EQIP) and could be used for risk assessment tools (i.e. PI, RUSLE2, manure management planner, etc).	X	X	X	X	X	CIG, NRCS	USDA-NRCS, MDA

Goal 4: Develop effective statewide policies for decreasing the transport of agricultural nutrients to the state's water resources and improve the coordination framework necessary to accomplish these policies.

Milestones (Action Steps)	13	14	15	16	17	Funding Source(s)	Lead Agency(ies)
1. Finalize and begin implementing the state's revised Nitrogen Fertilizer Management Plan.	X	X	X	X	X	State	MDA, Local SWCDs, MPCA
2. Seek legislative approval for the MDA and U of M to formally develop BMPs for a phosphorus management plan using a similar process as nitrogen.	X	X	X	X	X	State	U of M, MDA
3. Finalize and Implement Minnesota's State-level Nutrient Reduction Strategy, including adopting and improving state-level programs, tracking progress, and assisting local watershed planning and adoption.	X	X	X	X	X	State, 319	Multi-Agency

[1] Conservation Innovation Grants (Natural Resource Conservation Service)
[2] Minnesota Land Improvement Contractors of America
[3] Clean Water Partnerships
[4] Ag Fertilizer Research and Education Council" Pending legislative approval in the spring of 2006.
[5] National Agricultural Statistics Service

Chapter 10 Pesticides

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Introduction

For both urban and rural landowners, the term “pest” describes many different threats to crops and lawns, including insects, rodents, weeds, and a variety of plant diseases. To manage this vast array of pests effectively, urban and rural landowners use a variety of pest control tools and management strategies. One strategy, known as integrated weed or pest management (IWM or IPM), can include precise timing and application of pesticides, as well as crop rotations, adjustments of planting dates, weather monitoring, introducing natural enemies of particular pests, the use of resistant varieties of plants and crops, as well as non-chemical approaches to pest management.

To protect farm fields, home lawns and turf, landowners consider many different pest control options, and one of these options is the responsible use of pesticides. In farm fields, pesticides may help protect crops and increase yields. In landscaped areas, pesticides may help protect shrubs, trees, lawns and gardens. Finding the balance between the responsible use of pesticides and the protection of water resources is an ongoing challenge. While certain areas of the state - including the central sand plains and the karst regions of southeast Minnesota are particularly vulnerable to water resource contamination, all surface water and ground water resources need to be protected from the potential risk of contamination by pesticides. By finding the balance, pesticides can continue to be available as a tool for protecting crops, shrubs, trees, lawns and gardens from pests, while water resources are protected to the greatest extent possible.

The state’s largest potential impacts to water resources come primarily from land-applied pesticides, typically herbicides used to control weeds in farm fields, orchards, rights-of-way and landscapes. Home and structural applications of pesticides to control insects, mold and disease-causing organisms are less likely to reach water resources.

During the planning stages for the Nonpoint Source Management Program Plan, the Minnesota Pollution Control Agency, the U.S. Environmental Protection Agency and the Minnesota Department of Agriculture (MDA) agreed that use of the state’s 2005 revised Pesticide Management Plan (PMP): A Plan for the Protection of Ground water and Surface Water (the PMP) was appropriate as the template for this chapter. Thus, this chapter is a summarized version of the PMP. The PMP is the state’s guidance document for the prevention, evaluation and mitigation of nonpoint source pesticide impacts to water resources.

Minnesota Pesticide Management Plan (PMP)

Because some pesticides can leach through soil to ground water, or be lost from fields in surface water runoff, the commissioner of the MDA was directed in 1989 to develop a pesticide management plan for the prevention, evaluation, and mitigation of occurrences of pesticides or pesticide breakdown products in ground waters and surface waters of the state.

The Minnesota Pesticide Management Plan is designed to guide the MDA, its stakeholders, and other state agencies in efforts to coordinate activities necessary to protect Minnesota's ground water and surface water resources from pesticide contamination. Many of the steps outlined in the PMP are directly linked to the statutory requirements and guidance in the Pesticide Control Law (Minn. Stat. Chapter 18B) and the Ground water Protection Act (Minn. Stat. Chapter 103H). In addition, the commissioner of agriculture has broad authority to take action, both within and separate from the PMP, to take any actions necessary to protect public health and the environment from harmful exposure to pesticides, and to prevent unreasonable risk to humans or the environment. The PMP for water resource protection focuses primarily on agricultural use of pesticides; however, many of the concepts and policies are equally applicable to other uses, including urban pest management, forestry, rights-of-way use, and structural pest control.

The current plan reflects revisions to a previous version of the PMP (October 1998). The revisions are designed to reflect: the changes in MDA program resources; the need for greater clarity in PMP references to ground water vs. surface water statutes and programs (including new Federal Clean Water Act program activities in Total Maximum Daily Load assessments); changes to the scope of federal pesticide management plan requirements; and changes in various technical references, the MDA monitoring program, and other outdated information.

The purpose of the PMP is to carry out requirements of Minnesota Statutes § 18B.045, which direct the commissioner to develop a pesticide management plan for the prevention, evaluation, and mitigation of occurrences of pesticides or pesticide breakdown products in ground waters and surface waters of the state. The pesticide management plan must include components promoting prevention, developing appropriate responses to the detection of pesticides or pesticide breakdown products in ground water and surface waters, and providing responses to reduce or eliminate continued pesticide movement to ground water and surface water. The commissioner must submit a biennial status report on the plan to the state's environmental quality board for review and then to the state House of Representatives and Senate committees with jurisdiction over the environment, natural resources, and agriculture. The statute further directs that the PMP shall be coordinated and developed with other state agency plans and with other state agencies through the state's environmental quality board. In addition, the University of Minnesota extension service, farm organizations, farmers, environmental organizations, and industry shall be involved in the pesticide management plan development.

Minn. Stat. Ch. 103H (the Ground water Protection Act) serves as the foundation of the PMP's ground water activities, while Minn. R. part 7050.0150 and Minn. R. part 7050.0185 serve as the foundation of the PMP's surface water activities.

The PMP is a generic plan that provides the framework and process for protecting both ground water and surface water from pesticide contamination. Within the PMP is a process for pesticide-specific responses that may change in any given year.

The PMP:

- Guides the MDA in its efforts to coordinate activities necessary to protect Minnesota's ground water and surface water resources from pesticide contamination
- Is limited to the terrestrial "use" of pesticides (as opposed to pesticide misuse or spills), focusing initially on agricultural use yet recognizing that the concepts and policies presented in the PMP are applicable to other types of uses (e.g., urban, structural, forestry, and rights-of-way). Pesticide "use" means activities conforming to product labeling which include mixing, loading, disposal, application, and storage of pesticides
- Guides the MDA in the development of pesticide Best Management Practices (BMPs) or other necessary responses in a framework containing prevention, evaluation and mitigation components

The PMP does not focus on:

- The use of aquatic pesticides (products labeled for specific use in water)
- Non-labeled, non-target uses of pesticides

- MDA's response to spills, incidents, or fires
- Promote or discourage differing philosophies on pest management, although these may be part of specific BMPs

Water Resource Monitoring Goal

It is the goal of MDA water resource monitoring to provide information on the impacts of the routine use of pesticides on the state's ground and surface water so pesticide use may be managed to prevent or minimize degradation of the state's water resources.

Additional information on PMP activities related to pesticide use, water quality standards, and other issues can be accessed by downloading the complete PMP at *www.mda.state.mn.us*

Ground water Monitoring Objectives

The objectives of ground water monitoring for pesticides at the MDA are to:

1. determine statewide and regional differences in pesticide concentrations and occurrence
2. determine long-term trends in pesticide concentrations over time
3. monitor for significant changes in pesticide concentrations and occurrence over time
4. provide analysis of land use, pesticide management, and hydrologic and geologic attributes that may result in water resource degradation
5. provide the basic information from which the overall efficacy of pesticide management strategies may be determined
6. provide the information extracted from the monitoring data to information users, policy makers, scientists, and interested citizens

Ground Water Monitoring Network Design

Three ground water monitoring projects have been designed to meet the various objectives of the monitoring program. The three projects are a ground water monitoring well network, a regional ground water sampling program, and a drinking water well survey. Networks are designed based on specific information needs of each program coupled with the physical characteristics of specific land forms of interest including soils, geology and topography.

To fulfill program objectives the state has been divided into ten pesticide monitoring regions (Figure 3) based on soils, hydrology, cropping patterns and the associated agro-ecoregions. No quantitative measures were attempted in drawing the regional boundaries.

Landscape units with a large percentage of acreage in row crops, sandy soils, surficial sand and gravel aquifers, and relatively large amounts of irrigation are given the highest priority for monitoring ground water. The highest priority has been given to the sand plain regions because of the value of these aquifers for shallow rural wells, the limited adsorption capacity of the soils, the high water transmission rates of the soil and vadose zone material, and the results of previous monitoring that showed relatively high frequency of pesticide detections in ground water of the area. These sand plain areas primarily consist of large outwash plains in the central part of the state, although smaller sand plains and coarse grained alluvial river valley aquifers are included as well. Karst bedrock areas have the next highest priority due to the rapid recharge of water to the aquifers through sinkholes and solution channels, shallow soil with little adsorptive capacity, and the widespread use of the aquifers as domestic drinking water supplies. Alluvial river valley aquifers with finer textured geologic materials, fractured crystalline bedrock aquifers, and buried sand aquifers are also of interest to the program, and will be monitored as time and resources permit.

General Network Design Concepts

The current MDA ground water monitoring well network is located in the central sands region of Minnesota and utilizes small diameter observation wells. The primary objective of the ground water monitoring well network is to describe the temporal trends and peaks in contamination levels of the network as a whole, and at individual wells. New monitoring wells were installed by the MDA or cooperators in areas where no well existed at the time of network development. The network is sampled quarterly although an individual well may not be sampled more than once in a given year. Monitoring well locations are selected systematically so the network as a whole will appropriately represent the average condition of the entire network area. Well sites are selected by overlying an appropriate sized, randomly initiated grid across the area of interest. The central sand plain portion of the monitoring well program has been developed, wells have been installed and sampling began in January of 2000.

The drinking water well survey is short term in nature and is used to determine and confirm areas in the state where pesticides are impacting drinking water supplies, and which pesticides may be of concern. Data from the drinking water well survey is utilized for evaluating the general quality of ground water used as drinking water, and to focus expansion of the more scientifically rigorous ground water monitoring well network. The MDA recognizes the need for careful screening of drinking water wells to ensure they represent actual ground water conditions. Wells for the drinking water survey were selected from those previously sampled by the Ground water Monitoring and Assessment Program of the Minnesota Pollution Control Agency (MPCA), the non-community transient drinking water well list of the Minnesota Department of Health (MDH), or the state's county well index, in that order of priority. The first samples from the drinking water well survey were collected in January and February of 2004. The objectives of the regional ground water sampling program are to track changes within and between the various MDA monitoring regions (Figure 6), and to provide information useful for implementing and assessing BMPs.

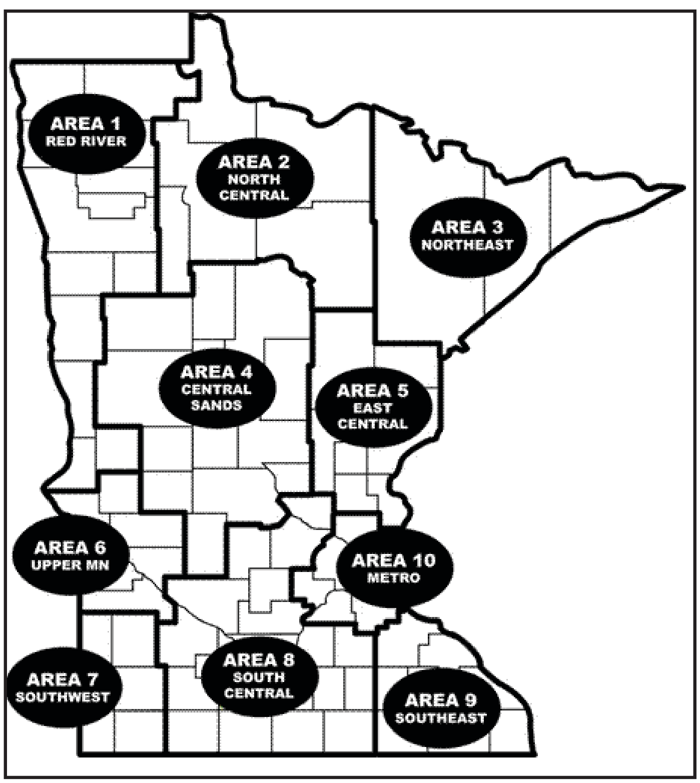

Figure 3: Pesticide Monitoring Regions Map

The regional monitoring program will be long term in nature with sampling conducted twice each year; once in winter and six months later during summer. The best available, relatively vulnerable source of ground water in the regions will be utilized as sample points. In some cases this will be existing monitoring wells although drinking water wells of various types may also be utilized. In the southeastern region of the state (characterized by karst limestone geology), naturally occurring springs are being used as ground water sample points. These springs emerge from bedrock formations and are generally considered to accurately represent regional ground water conditions.

Surface Water Monitoring Objectives

The objectives of surface water monitoring for pesticides at the MDA are to:

1. determine statewide spatial differences in pesticide concentrations and occurrence
2. determine pesticide concentration and loading in selected streams
3. monitor for changes in pesticide concentration and loading over time
4. determine the characteristics of pesticide water quality monitoring data
5. provide analysis of land use, pesticide management, and hydrologic attributes that may result in water resource degradation
6. provide the basic information from which the efficacy of pesticide management plans may be determined
7. disseminate the information extracted from the monitoring data to the appropriate information users, policy makers, scientists, and interested citizens

Surface Water Monitoring Network Design

The surface water monitoring program is divided between two distinctly different components. The primary component of MDA's surface water monitoring program provides detailed monitoring of pesticide loading within select watersheds in the state. The selected watersheds are continuously monitored during the months when the streams are unfrozen. These watersheds are instrumented with automatic sampling stations that collect water samples in response to increases in river levels during and following a rainfall event. The event is continuously monitored and estimates of loading from the storm are determined. These watershed monitoring stations have been established to assist in determining measures by which to evaluate the effectiveness of BMPs and other efforts as part of the pesticide management plan.

MDA's water quality monitoring program intentionally samples during spring runoff in order to determine which pesticides leave the point of application and enter the surface water system. Not all pesticides leave the point of application. MDA's water quality monitoring program collects samples at times and locations where pesticides that leave the point of application will be detected and also collects samples at times when pesticides would not be expected to run off from the ground surface.

The determination of which pesticides to monitor for is based on several factors including: the extent of use in an area; the chemistry of the compound; environmental fate data; and the laboratory's ability to analyze for the compound. The water quality monitoring program targets pesticides largely based on the resources available, practicality, and the appropriateness of analysis.

The second major component of MDA's surface water monitoring program consists of a grab sampling survey of approximately 15 stream or river locations in the state. These samples are analyzed for a suite of pesticide parent materials and breakdown products. This sampling program is designed to determine which pesticides occur in Minnesota and where they occur. The data is analyzed to determine whether there has been a change in the pesticides that are being detected, and whether there is a difference in where the detected pesticides are occurring. The data is also used in determining the need for BMPs.

Non-MDA Water Quality Data Collection Activities

It is the responsibility of the commissioner of agriculture to collect information on the occurrences, concentration, and use of pesticides in Minnesota. Several other organizations also monitor for pesticides in water. Each organization has different program goals and procedures. These organizations include but are not limited to:

Minnesota Department of Health (public water supplies)
Minnesota Pollution Control Agency (surface water, ground water)
United States Geological Survey (surface water, ground water, precipitation)
United States Fish and Wildlife Service

Other States
Local Units of Government
Pesticide Registrants

The information provided may or may not be useful to the MDA. The MDA evaluates water quality data collected from other organizations, public or private, and determines if it is applicable and meets MDA quality control standards. The MDA will consider data from other states but will not use that data as the primary criteria for making a determination that a pesticide is commonly detected in ground water or a surface water pesticide of concern.

The commissioners of the MDA, MPCA and MDH have signed an interagency cooperative ground water monitoring agreement. This agreement will help coordinate monitoring and data management activities among the three agencies.

Water Quality Data Collection as a Decision-Making Tool

Water quality data and information is a tool to aid in wise decision-making. MDA's pesticide management programs are established accordingly. In this context water quality data will be reviewed on an annual basis by the MDA. A report will be prepared that covers data from the previous year's monitoring efforts. The report will discuss the compounds detected in Minnesota, typical concentrations, geographic locations, criteria and benchmarks for evaluation, and the likelihood of further detections in Minnesota. The MDA will continually modify and evaluate the monitoring program so that it provides the flexibility needed to implement and assess the PMP.

For the purposes of the PMP, monitoring information from all readily available sources will be analyzed to determine if pesticide detections (including parent compounds and/or breakdown products) are a result of normal applications or a unique or unusual circumstance. Detections and respective concentrations of a pesticide which are determined after investigation and analysis to be the result of routine use will be evaluated for common detection in ground water or for designation as a surface water pesticide of concern. Detections determined to be the result of an unusual or unique situation will be further evaluated to develop an appropriate response.

Focused management activities may be appropriate in regions where use of the compound is more frequent. Additional resources may be necessary to expand the water quality monitoring program to include monitoring networks for specific pesticides placed in common detection status. Chemical-specific monitoring may be focused in special BMP promotion areas to help determine the effectiveness of specific BMPs.

Prevention Goal

The prevention goal of the PMP is to promote prevention of occurrences of pesticides or pesticide breakdown products in ground waters and surface waters of the state. It is intended that this prevention be accomplished while promoting practices that consider economic factors, availability, technical feasibility, implementability, effectiveness, and environmental effects, and in consideration of the beneficial uses of pesticides and applicable water quality standards.

Prevention Approach

The prevention goal of the PMP will be accomplished through:

1. utilizing analysis tools to focus resources in scientifically defensible ways and in high risk areas;
2. establishing an Education and Promotion Team to assist the MDA in coordinating prevention activities;

3. developing, adopting, and implementing effective strategies for prevention education and promotion through:
   a. applicator training and certification/licensure
   b. BMP research and development
   c. education program development and coordination
   d. demonstration projects
   e. Integrated Pest and Weed Management promotion
4. integrating prevention actions, where appropriate, into other natural resource management efforts, to support identified alternative pest management systems, and data collection activities

Prevention Objective 1

Key target groups are educated on issues associated with land use, land management, community health, crop production, economic profitability, and risks versus benefits, relevant to pesticide use as it impacts water quality in Minnesota. Target groups include pesticide users, policymakers, landowners, retailers, general public, crop consultants, institutions, financial institutions, agencies, and residents.

Prevention Objective 2

Effective prevention strategies are encouraged through education and promotion, including adoption of BMPs by pesticide users considering all management tools available and supported by proper pesticide distribution, storage, handling, use and disposal, and crop specific management strategies.

Recommended Actions to Accomplish Prevention Goal

See *Needs, Priorities and Milestones, Action Plan, Goal 1, Milestones (Action Steps)*

Evaluation Goal

The evaluation goal of the PMP is to evaluate detections of pesticides and pesticide breakdown products in water resource monitoring data, and to evaluate the adoption, validity and effectiveness of prevention and management strategies, including pesticide BMPs.

Evaluation Approach

The evaluation goal of the PMP will be accomplished through:

1. establishing a Pesticide Management Plan Committee (PMPC) to support MDA evaluation activities
2. annual review of detections of pesticides and pesticide breakdown products in water resource monitoring data
3. assessing, evaluating, and validating
   a. changes in management practices
   b. resource impacts and trends
   c. delivery systems to local interests and stakeholders
   d. economic impact of implementing prevention steps
4. using evaluation findings to refine practices and management strategies

Recommended Actions to Accomplish Evaluation Goal

See *Needs, Priorities and Milestones, Action Plan, Goal 2, Milestones (Action Steps)*

Mitigation Goal

The mitigation goal of the PMP is to reduce or eliminate continued movement of pesticides or pesticide breakdown products to ground water and surface water.

Mitigation Approach

The mitigation goal of the PMP will be accomplished by:

1. intensifying and targeting education and outreach (preventative) efforts; refining or developing BMPs, incentives or regulatory options; and considering the cost versus benefit and technical feasibility of mitigation measures; and
2. if necessary, exercising regulatory authority through mandatory use changes by adoption of water resource protection requirements or the restriction or cancellation of product registration.

Recommended Actions to Accomplish Mitigation Goal

See *Needs, Priorities and Milestones, Action Plan, Goal 3, Milestones (Action Steps)*

Figures 1 and 2 below illustrate the general processes for prevention, evaluation and mitigation decisions for pesticides in ground water and surface water.

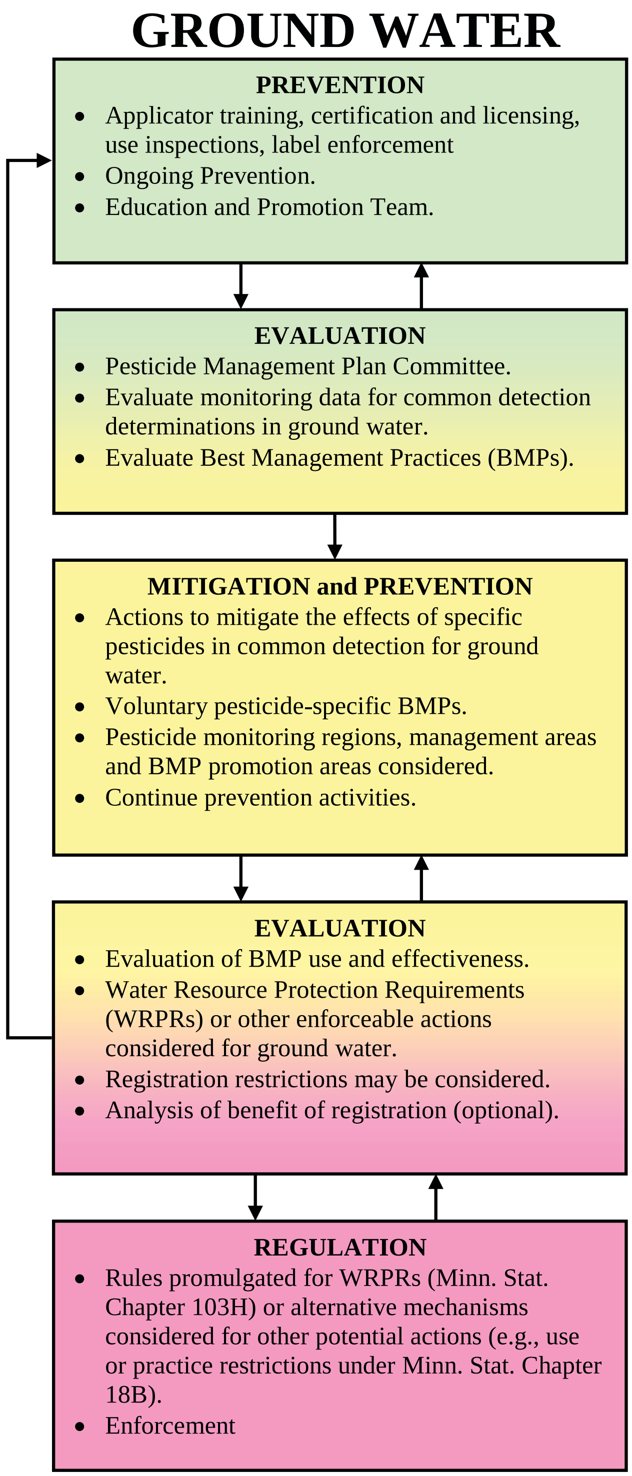

Figure 1: Minnesota Pesticide Management Plan - General Process Schematic for Ground Water Decisions

SURFACE WATER

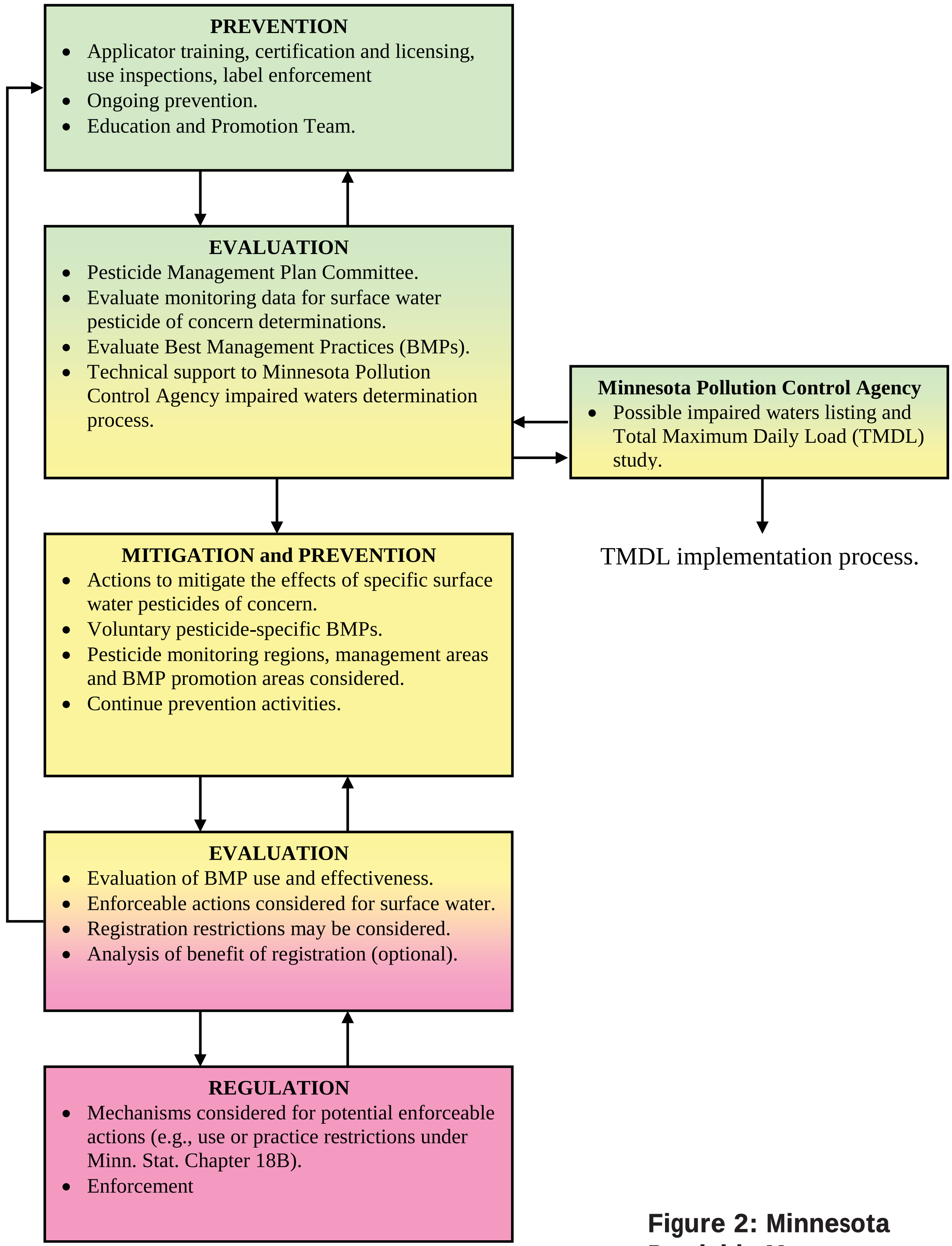

Figure 2: Minnesota Pesticide Management Plan - General Process Schematic for Surface Water Decisions

Pesticide Best Management Practices Development and Adoption

The MDA will use the Ground water Protection Act's definition of BMPs and its consultative requirements in the development of BMPs for both ground water and surface water. Under the Ground water Protection Act, the MDA is responsible for coordinating the development and implementation of ground water BMPs for pesticides and pesticide breakdown products defined as pollutants, while under the Pesticide Control Law, the MDA is responsible for prevention, evaluation and mitigation efforts (all of which could include BMPs) related to occurrences of pesticide and pesticide breakdown products in both ground water and surface water.

As a preventative measure, the MDA will coordinate the development, promotion and maintenance of generic pesticide BMPs for pesticide distribution, storage, handling, use and disposal. Currently developed generic BMPs can be accessed via the internet at *www.mda.state.mn.us.* Natural Resources Conservation Service (NRCS) national standards can be the starting point for development of generic BMPs. BMPs developed may go beyond conservation compliance plans (expanding on NRCS technical standards). These practices in turn may be considered for use by NRCS. Efforts are coordinated between MDA and NRCS programs.

The MDA may develop and adopt additional generic BMPs that serve as core practices to address potential water resource impacts or concerns for specific classes of pesticides (e.g., insecticides, herbicides, fungicides). Currently developed core practices can be accessed via the internet at *www.mda.state.mn.us*.

Additionally, when pesticides are determined to be common detection in ground water or a surface water pesticide of concern, specific BMPs will be developed to address the pollutants. Currently developed pesticide-specific practices can be accessed via the internet at *www.mda.state.mn.us*.

Best Managment Practices development efforts include consultation with local water planning authorities (as required in Minn. Stat. § 103H.151 subd. 2), and as part of their development, the MDA will solicit and consider input from farm organizations, interested groups and the public.

The University of Minnesota will be asked to assist the MDA with periodic literature reviews of pesticide research that can be used as the basis for generic or specific pesticide BMPs in Minnesota. Such reviews should address the issues of pesticides in Minnesota water resources, both surface waters and ground waters. Such reviews should include, but not be limited to a literature review of pertinent pest management research, evaluation of the research and recommendations for future action.

Best Management Practices Education and Promotion Program: Development and Coordination

After BMP development, the MDA will seek assistance from organizations that can provide resources to promote the BMPs. Soil and Water Conservation Districts (SWCDs) can provide a local coordination role, especially in areas where ground or surface water are significantly impacted by contamination. This is consistent with Minn. Stat. § 103H.151, subd. 3.

The promotion of BMPs, whether generic or pesticide-specific, will use existing delivery mechanisms whenever possible. It is understood that different individuals and user groups are more receptive to certain information sources than others. By providing a number of channels for education and information dissemination, there is an increased likelihood that most pesticide users will be reached.

In addition to pesticide applicator training sessions, the MDA will seek assistance in promoting BMPs from pesticide dealers, the University of Minnesota (U of M), pesticide registrants, SWCDs, NRCS, Board of Water and Soil Resources (BWSR), crop consultants, Department of Natural Resources (DNR), industry trade associations, commodity groups, and environmental groups. In order to effectively promote BMPs to the urban landowner/manager, when appropriate, the MDA will encourage participation from local units of government, garden centers, block clubs, the master gardener program, park and recreation boards, and commercial and non-commercial applicators.

Statewide/Pesticide Management Area BMP Promotion

Generic BMPs and certain pesticide-specific BMPs are likely to be applicable to the majority of the state. Through the MDA's Education and Promotion Team (EPT), campaigns can be designed to promote BMPs through the following groups or mechanisms:

1. Pesticide Dealers
   Pesticide dealers have been shown to be a primary source of information for pesticide applicators. Promotion information can be developed for generic and pesticide-specific BMPs. Under the direction of the MDA, pesticide-specific BMP promotional packets can be developed by the registrants and distributed to the dealers. Dealers will be encouraged to distribute BMP promotional information.
2. University of Minnesota: Soil, Water and Pesticide Research; University of Minnesota Extension Services (UMES); and Agricultural Experiment Stations
   University of Minnesota's researchers, extension specialists, and extension educators can inform pesticide users of pertinent BMP information. Several program areas within the U of M can be used to promote BMPs, including integrated pest management, water quality, and pesticide impact and analysis (e.g., basic research and modeling on pesticide-soil-water-crop interactions).
3. Pesticide Applicator Training (PAT)
   The MDA and UMES will cooperate in the development of training materials for BMPs which are applicable on a statewide level. These will be distributed at private PAT sessions by county extension educators. Information will be delivered at commercial and non-commercial applicator recertification workshops. BMP information will also be included in MDA newsletter mailings to private and commercial/non-commercial applicators.
   In situations where WRPRs are adopted (see Chapter 10 – Mitigation), relevant training materials will become mandatory in addition to Environmental Protection Agency (EPA)-required materials. Questions on WRPRs will be included in the original certification test and at all recertification workshops.
4. Urban BMP Promotion
   Presently, several organizations exist, appropriate to the BMPs developed, with whom the MDA will encourage cooperative relationships in order to more effectively promote BMP educational information to the urban landowner/manager. These include local units of government, garden centers, block clubs, the master gardener program, park and recreation boards, and commercial and non-commercial applicators. In addition, when conducting inspections, MDA's agricultural chemical investigators can distribute BMP promotional materials to urban pesticide distribution centers such as garden centers, hardware stores, and department stores.
5. Other BMP Promotional Opportunities
   Other BMP promotional opportunities can be developed with environmental organizations, the pesticide industry, and state and local agencies. The MDA's EPT will consider other efforts and will cooperate with other groups to ensure that the most effective methods to deliver and promote BMP implementation are achieved. These may include public service announcements, demonstration plots, brochures, displays and events. The EPT will strive to coordinate these efforts to ensure that the message delivered to producers is consistent with the BMPs.
   Pesticide-specific BMPs can be incorporated into many promotional strategies including those for crop, cultural, or pest management. These complementary strategies may be promoted by agricultural or community organizations.

Local BMP Promotion

The MDA will seek assistance in promoting BMPs from organizations which reach pesticide applicators on a local level. These groups include commodity groups, township boards, local citizens, the UMES, NRCS, SWCDs, BWSR, pesticide dealers, and U of M Agricultural Experiment Stations.

BMP Promotion Areas

Special attention and efforts may be focused within areas where significant pesticide contamination of ground water or surface water exists or could potentially exist in geographically contiguous areas, and where the source is thought to originate from normal (labeled) use of pesticides.

These areas may be recognized as warranting concern for several possible reasons including:

1. existing monitoring data either collected by or provided to the MDA which indicates a water quality problem due to pesticide use
2. areas indicated by a vulnerability assessment as being highly sensitive to contamination whether documented or not
3. designation as a Wellhead Protection Area by the Minnesota Department of Health

The MDA will evaluate the situation in consultation with the local SWCD and the appropriate water planning authorities and where necessary will designate a special BMP promotion area.

Integrated Pest and Weed Management

Opportunities exist to incorporate into prevention activities various strategies for Integrated Pest and Weed Management that directly relate to water quality protection.

Minn. Stat. § 18B.063 encourages state agencies (e.g., Minnesota Department of Natural Resources, Minnesota Department of Agriculture, University of Minnesota, and the Minnesota Department of Transportation) to use Integrated Pest and Weed Management techniques in its management of public lands. Such techniques might be used to protect water resources.

In addition, Minn. Stat. § 17.114, subd. 4: *Integrated Pest Management* states: “the state shall promote and facilitate the use of integrated pest management through education, technical or financial assistance, information and research”.

The MDA develops and implements statewide strategies for the increased use of Integrated Pest and Weed Management on private and state managed lands. Some of the Integrated Pest and Weed Management program activities include generating information via newsletters for growers, producers and land managers which inform them of relevant issues and can help them make alternative choices in their pest management decisions; developing school programs to educate school districts on Integrated Pest and Weed Management and how to implement its use; providing funding for research; and providing information to the general public.

Various programs at the MDA, University of Minnesota, and within local, state and national commodity and industry groups promote the development and implementation of Integrated Pest and Weed Management. MDA programs have been established to respond to the statutory directives cited above, and include: the provision of funds for demonstration grants; a low-interest loan program to support farmer transition to more environmentally sound, profitable practices; whole farm planning decision-making assistance; on-farm research in practical farming alternatives; a Conservation Reserve Program Project to identify the Conservation Reserve Program (CRP) lands most critical to preserving Minnesota’s soil and water quality; an Integrated Pest Management program concerned with developing and implementing state-wide strategies for the increased use of IPM on private and state managed lands; and organic farming technical assistance and advice on conversion to organic methods, certification and marketing of crops and livestock. In addition, the MDA conducts field days, workshops and assembles speakers on diverse topics with farmer, agency, academic, non-profit and local partners.

Such programs and related activities can be considered by the EPT as it assists the MDA with review and design of educational and promotional strategies for the prevention of water resource impacts from pesticides.

Additional information, fact sheets and management practices promoted by MDA’s Integrated Weed and Pest Management Programs can be accessed via the internet at:

www.mda.state.mn.us/ipm/, www.mda.state.mn.us/weedcontrol/, www.mda.state.mn.us

Chapter 10 Agricultural Pesticides

Needs, Priorities and Milestones, Action Plan

The action plan provided below summarizes the goals and milestones identified in the preceding sections. Many of the milestones listed below, as well as the implementation of specific projects, are contingent upon adequate funding and local involvement.

Goal 1: Promote prevention of occurrences of pesticides or pesticide breakdown products in ground waters and surface waters of the state. It is intended that this prevention be accomplished while promoting practices that consider economic factors, availability, technical feasibility, implementability, effectiveness, and environmental effects, and in consideration of the beneficial uses of pesticides and applicable water quality standards.

Milestones (Action Steps)	13	14	15	16	17	Potential Funding Source(s)	Lead Agency(ies)
1. Utilize analysis tools to focus agency operating staff resources in scientifically defensible ways and in high risk areas; Utilize available databases, maps and analytical procedures to evaluate potential pesticide loss and water resource impacts based on hydrogeology, soil and pesticide properties.	X	X	X	X	X	Minnesota Pesticide Regulatory Account USEPA-MN FIFRA Cooperative Agreement CWA Section 319, LGUs	MDA, MPCA, MDNR, U of M Extension, Private Organizations Local Units of Government
2. Utilize the Pesticide Management Plan (PMP) Education & Promotion Team (EPT) to assist the MDA in coordinating prevention activities.	X	X	X	X	X	See Above	MDA, MPCA, DNR, BWSR, NRCS, SWCDs, U of M Extension, Local Units of Government
3. Develop, adopt, and implement effective strategies for prevention education and promotion.	X	X	X	X	X	See Above	MDA, MPCA, DNR, BWSR, NRCS, SWCDs, U UM-Extension, Private Organizations, Local Units of Government

Milestones (Action Steps)	13	14	15	16	17	Potential Funding Source(s)	Lead Agency(ies)
4. Incorporate into pesticide applicator certification and training the various prevention activities and strategies developed and recommended by the EPT, and all BMPs developed as part of MDA's general prevention activities or in response to common detection pesticides in ground water or to surface water pesticides of concern.	X	X	X	X	X	See Above	MDA, MPCA, DNR, BWSR, NRCS, SWCDs, U UM-Extension, Private Organizations, Local Units of Government
a. Conduct periodic literature reviews of available pesticide ground water and surface water research data, and to facilitate the development of scientifically-based prevention activities and programs, including BMPs. Such reviews can also be used to determine opportunities for research, demonstration projects and education.						See above	MDA, U of M Extension
b. Develop and adopt Pesticide BMPs to address general pesticide distribution, storage, handling, use and disposal. Develop and adopt additional generic BMPs to serve as core practices to address potential water resource impacts or concerns for specific classes of pesticides (e.g., insecticides, herbicides, fungicides). Develop and adopt chemical-specific BMPs for pesticides (or their breakdown products) determined to be common detection in ground water or to be surface water pesticides of concern.						See above	MDA, NRCS, SWCDs, U of M Extension, Local Units of Government, Stakeholders
c. Develop, coordinate and extend BMP educational programs to include training for dealers, crop consultants, agronomists, SWCD and NRCS staff and pesticide users. Assistance with these educational programs would be sought from the UME, registrants and dealers, and others.						See above	MDA, U of M Extension, Registrants, Stakeholders

Milestones (Action Steps)	13	14	15	16	17	Potential Funding Source(s)	Lead Agency(ies)
d. Incorporate results of BMP research into ongoing MDA-UME applicator training and certification/licensure programs.						See above	MDA
e. Develop demonstration projects to show the potential effects of BMPs and alternative pest management systems (Integrated Pest and Weed Management, crop diversification, etc.) on changes in water quality over time.						See above	MDA, MPCA, DNR, BWSR, NRCS, SWCDs, U of M Extension, Private Organizations, Local Units of Government
f. Promote and coordinate Integrated Pest and Weed Management activities related to water quality protection with the University of Minnesota and Registrants/Dealers.						See above	MDA, U of M Extension, Private Organizations, Local Units of Government
g. Encourage state agencies (e.g., Minnesota Department of Natural Resources [DNR], MDA, University of Minnesota, and the Minnesota Department of Transportation) to use Integrated Pest and Weed Management to protect water resources.						See above	MDA, DNR, U of M, MNDOT, Local Units of Government
h. Identify alternative pest management systems and determine efficacy by working with the University of Minnesota, registrants, and other interested parties.						See above	MDA, U of M Extension, Registrants, Private Organizations
i. Educate on and promote the adoption of effective BMPs by pesticide users considering all management tools available including pesticide distribution, storage, handling, use, disposal, and crop-specific strategies.						See above	MDA, MPCA, BWSR, SWCDs, U of M Extension, Stakeholders

Milestones (Action Steps)	13	14	15	16	17	Potential Funding Source(s)	Lead Agency(ies)
j. Utilize the available data collection activities of the MDA – Minnesota Agricultural Statistics Service, UME, and other interested organizations and encourage coordination of state task forces, working groups, and agencies in gathering and issuing data.						See above	MDA, MASS, U of M Extension, Stakeholders

Goal 2: Evaluate detections of pesticides and pesticide breakdown products in water resource monitoring data, and evaluate the Adoption, validity and effectiveness of prevention and management strategies, including pesticide BMPs.

Milestones (Action Steps)	13	14	15	16	17	Funding Source(s)	Lead Agency(ies)
1. Utilize a PMP Committee to review the collection and analysis of information on detections of pesticides and pesticide breakdown products for potential common detection determinations in ground water and surface water pesticide of concern determinations in surface water.	X	X	X	X	X	See Above	MDA, MPCA, DNR, MDH, U of M Extension, Farm Organizations, Farmers, Environmental Organizations, Industry, additional academic expertise
2. Develop potential pesticide management and monitoring areas based on land form units, agro-ecoregions, watersheds and other factors.	X	X	X	X	X	See Above	See below
a. Conduct water monitoring in each monitoring region.						See above	MDA, U of M Extension, additional academic expertise
b. Delineate BMP promotion areas based on land form units or watersheds.						See above	MDA, U of M Extension, additional academic
c. Develop a strategy to evaluate the effectiveness of pesticide or crop-specific pesticide management strategies for best management practices promotion areas.						See above	MDA, MPCA, DNR, BWSR, NRCS, SWCDs, U of M Extension, Stakeholders

Milestones (Action Steps)	13	14	15	16	17	Funding Source(s)	Lead Agency(ies)
3. Assess, evaluate, and validate:	X	X	X	X	X	See Above	MDA, MPCA, DNR, MDH, U of M Extension, Farm Organizations, Farmers, Environmental Organizations, Industry, additional academic expertise, SWCDs, NRCS, Local Units of Government
a. changes in management practices						See above	See above
b. resource impacts and trends						See above	See above
c. delivery systems to local interests and stakeholders						See above	See above
d. economic impact of implementing prevention steps						See above	See above
4. Use evaluation findings to refine practices and management strategies.	X	X	X	X	X	See Above	MDA, MPCA, DNR, MDH, U of M Extension, Farm Organizations, Farmers, Environmental Organizations, Industry, additional academic expertise, SWCDs

Goal 3: Reduce or eliminate continued movement of pesticides or pesticide breakdown products to ground water and surface water.

Milestones (Action Steps)	13	14	15	16	17	Funding Source(s)	Lead Agency(ies)
1. Intensify and target education and outreach (preventative) efforts; refine or develop BMPs, incentives or regulatory options; and consider the cost versus benefit and technical feasibility of mitigation measures.	X	X	X	X	X	See Above	MDA, MPCA, DNR, MDH, U of M Extension, Farm Organizations, Farmers, Environmental Organizations, Industry, additional academic expertise, SWCDs, NRCS, Local Units of Government
2. If necessary, exercise regulatory authority through mandatory use changes by adoption of water resource protection requirements or the restriction or cancellation of product registration.	X	X	X	X	X	See Above	MDA, MPCA

Goal 4: Promote the development and implementation of integrated pest and weed management as they pertain to water quality protection.

Milestones (Action Steps)	13	14	15	16	17	Funding Source(s)	Lead Agency(ies)
1. Provide funds for demonstration grants that affect water quality.	X	X	X	X	X	See Above	MDA
2. Utilize low-interest loan program to support farmer transition to more environmentally sound, profitable practices that reduce pesticide impacts to water resources.	X	X	X	X	X	See Above	MDA
3. Assist with whole farm planning decision-making and on-farm research in practical farming alternatives that minimize pesticide impacts to water resources.	X	X	X	X	X	See Above	MDA
4. Promote and supplement the technical and financial assistance offered by several Farm Bill Conservation Title programs to help landowners implement and maintain IPM practices.	X	X	X	X	X	See Above	MDA, USDA, Farm Services Agency, NRCS, USFWS, BWSR, DNR, SWCDs, U of M Extension, Private Organizations, Local Units of Government

Milestones (Action Steps)	13	14	15	16	17	Funding Source(s)	Lead Agency(ies)
a. Promote and/or supplement Environmental Quality Incentives Program (EQIP) incentive payments and technical assistance for implementing integrated pest and weed management on cropland (MN NRCS Conservation Standard 595 Pest Management) or pasture (Standard 528a Organic Prescribed Grazing) on eligible acreage;						See above	See above
b. Promote and/or supplement Conservation Security Program (CSP) enhancement payments for one or more pest management activities to protect water quality, whether already regularly practiced by the landowner or to be started. Includes pest scouting to minimize and target pesticide applications; band, split, spot or variable rate application; one or more non-chemical controls as the primary method of weed control; crop rotations including small grains and/or hay; or use of pest management products that meet USDA organic farming requirements.						See above	See above
5. Promote Integrated Pest Management programs, develop and implement state-wide strategies for the increased use of IPM on private and state managed lands.	X	X	X	X	X	See Above	MDA and Private Organizations
6. Provide organic farming technical assistance on conversion to organic methods, certification and marketing of crops and livestock.	X	X	X	X	X	See Above	MDA

Chapter 11 Urban Runoff

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Introduction

Urban runoff is runoff from developed or developing urban areas wherever they may be found in the state.

What are the issues and trends associated with urban runoff? Many reports by the Center for Watershed Protection, and others, have summarized the impacts of urbanization. The two main issues can be summarized as quantity and quality. Properly addressing these issues can be hampered by such things as a lack of knowledge of these impacts, development restrictions, or assessing Better Site Design techniques. The U.S. Environmental Protection Agency (USEPA), Metropolitan Council, the U.S. Geological Survey (USGS), the Minnesota Pollution Control Agency (MPCA) and others have documented the impacts of urbanization.

Many of the issues described below are highlighted by the reports of these agencies.

Role of this Report

The Section 319 Nonpoint Source Management Program Plan (NSMPP) is responsible for implementing programs for problems not covered by National Pollutant Discharge Elimination System (NPDES) stormwater permits. Activities supported through Section 319 funding, therefore, are limited to issues and areas not covered by stormwater permits. However, Section 319 funds can be utilized to support innovative source control activities or practices that serve to educate others, even in areas covered by stormwater permitting. Activities that may be eligible for Section 319 funding include:

- technical support to stormwater permit writers
- problem identification and quantification
- source control best management practices (BMPs) implementation (non-permit)

- runoff control BMPs implementation (non-permit)
- information and education programs
- technology transfer and training

Other Sources of Information

The “Minnesota Stormwater Manual”, hosted on the Minnesota Pollution Control Agency’s Web site, is the primary source for stormwater management in the state of Minnesota. The initiation of this manual and ongoing updates is overseen by the Stormwater Steering Committee. This committee is made up of approximately 40 represented groups including state and local governments, business, environmental groups, and other stormwater interest groups.

Another source of information is the EPA’s “National Management Measures to Control Nonpoint Source Pollution in Urban Areas” (November 2005).

Both of these sources directly influenced the Needs, Priorities, and Milestones section of this chapter and provide more information than can be provided in the following pages.

Urban Runoff Pollution

The latest 2000 USEPA 305b report shows urban runoff as the third leading source of pollutants nationally causing impairment of lakes, ponds, and reservoirs behind agriculture and hydromodification (EPA 2000).

Quality of Runoff

Urban surfaces are subject to the deposit of contaminants, which are then subject to wash-off by rainfall or snow melt. Typical contributors to pollutants in runoff include vehicular traffic, industry, power production, lawn care, pets, eroded sediments and vegetative litter.

The major urban runoff pollutants include sediment, nutrients, oxygen-demanding substances, toxic chemicals, chloride, bacteria, parasites and viruses, temperature changes and floatable trash and litter. Each of these pollutants is discussed below.

Sediment

Suspended sediment is made up of tiny soil particles from natural soils, metal particles from streets and parking lots, and sand and grit associated with snowmelt. These particles are washed and blown into lakes and streams. Sediment is considered one of the more damaging pollutants in Minnesota, and it is the major pollutant by volume in the state’s surface waters and at one point slowed barge traffic down in the rivers. The issue is being dealt with. For example, the state’s first Conservation Reserve Program has reduced annual runoff into the Minnesota River by 470,000 tons of sediment and 580,000 pounds of phosphorus (McAuliffe 2001).

Nutrients: Phosphorus and Nitrogen

In Minnesota, the effects of nutrients are a major concern for surface water quality. Many naturally occurring materials - especially phosphorus and nitrogen - are essential for life, and are therefore termed “nutrients.” However, as with the quantity of nutrients, a proper balance is needed. An excess of some nutrients can lead to explosive growth of noxious life, such as algae, or can be toxic to some forms of aquatic life (as is the case with ammonia).

Nutrients can cause algal blooms and excessive aquatic plant growth. Of the two nutrients, phosphorus is usually the limiting nutrient that controls the growth of algae in lakes. As phosphorus loading rises, the potential for algae blooms and accelerated lake eutrophication also increases.

Of particular concern for receiving waters are nutrients that are increased in urban runoff from such sources as lawn care products, and vegetative and animal debris. Nitrate nitrogen, most commonly from fertilizer overuse, can adversely impact ground water when concentrated to high-enough levels. Nitrate may also have toxic effects on some aquatic life such as mollusks.

Oxygen-Demanding Substances

While land animals extract oxygen from the air, aquatic life depends on oxygen dissolved in water. When aquatic microorganisms consume organic matter, dissolved oxygen is depleted. Following a rainfall, urban runoff can deposit large quantities of oxygen-demanding substances in lakes or streams. The BOD of typical urban runoff is about as large as that of effluent from an efficiently run secondary wastewater treatment plant (USEPA, December 1983). A “pulse” of high oxygen demand can be created during storm runoff that can totally deplete oxygen supplies in shallow, slow-moving or poorly flushed waters. Oxygen depletion is a common cause of fish kills. In urban areas, spills, pet wastes, street litter and organic matter are common sources of oxygen-demanding substances.

Toxic Chemicals

Many of the everyday activities in urban areas also contribute substantial amounts of toxic substances to receiving waters. Essentially, anything that is applied to the land or emitted from fertilizer or pesticide applications, a smokestack or a vehicle’s tailpipe can be deposited on, and washed off, impervious urban surfaces. Some of the toxics substances of concern are trace metals and hydrocarbons. Seventeen pesticides and five metabolites were detected at all monitored sites in a USGS report (99-4247).

Chloride

In Minnesota, a tremendous amount of salt is used each year to melt ice from roads, parking lots and sidewalks. From 1984 to 1994 average salt usage was approximately 157,000 tons per year. Over 1989 to 1994 usage increased to an average of 181,000 tons per year. Because it is extremely soluble, almost all salt applied ends up in surface or ground water (Pitt, 1995). If the concentration of chloride becomes too high, it can be toxic to many freshwater organisms. There have been many cases of surface and ground water contamination caused by runoff from inadequately protected stockpiles of salt and sand-salt mixtures (Blaha, Cherryholmes, unpublished MPCA data).

Bacteria, Parasites and Viruses

High concentrations of many bacteria and viruses are found in urban runoff. Apparently, soil can act as a source of bacteria even when it is very unlikely that the high levels are of human origin or that they indicate significant human health risk (Barrett *et al.*, 1996). For example, coliform contaminates 25 sections of the Minnesota River and its tributaries (Meersman 2002). Levels of coliform measured were up to 300 times the water quality standard along Shakopee Creek and other rivers in western Minnesota (Meersman 1999). The coliform bacteria that are detected may not be a health risk in themselves, but are often associated with pathogens that are. The sources of pathogens can include sanitary sewer leaks, pets, failing septic systems, livestock, wildlife and discarded infected material. The result of contact with these pathogens can be disease.

Temperature Change

Temperature changes, from sources such as impervious surfaces or even ponds, can significantly impact streams, especially trout streams. Various types of temperature criteria can affect the success and mortality of organisms in waterways. Temperature changes that occur over a short period can have a shock effect, resulting in their death. There can also be long-term temperature effects, which cause changes in the growth, reproduction or mortality of organisms. These mean and maximum temperature levels vary from organism to organism and can be different for even the same organism in a different waterway. In Minnesota, the water quality standards reflect daily maximum average temperatures for most waterways, or changes above the ambient which are limited to a few degrees on a monthly average basis (Minn. R. ch. 7050).

Floatable Trash and Litter

Many of the state's river and stream reaches are degraded to varying degrees by floatable trash and litter of human origin. There are many sources and modes of transport for these materials, but the problem is generally most serious within and downstream from urban, commercial, and industrial land use types. Trash can be directly deposited in the water or on streambanks by water users, flushed in by storm sewers or overland runoff, and in some cases wind blown. Many of these materials are nonbiodegradable and will persist in the environment for many decades until removed or in some cases buried through sedimentation processes within the floodplain. In many areas, increasing volumes of litter are accumulating throughout riparian areas with annual highwater events. It is not a practical assumption to consider that clean-up volunteers can effectively address any more than the immediate stream corridor of a small percentage of Minnesota's 92,000 miles of river habitat. There are also serious ethical questions about shifting the responsibility for this problem to environmentally concerned citizens when education, enforcement, and structural source controls for abatement are deficient or absent. Trash and litter constitute a major impairment to the recreational use and esthetic appreciation of many reaches of the states' rivers and streams and can be hazardous to humans and wildlife.

The issue of trash and litter defiling the nation's waters has received surprisingly little attention from the responsible local, state, and federal agencies with mandates to protect these natural resources in the public interest. This is perhaps an artifact of the priorities established early in the process of implementing the intent of the Federal Clean Water Act. In Minnesota, awareness of the problem resulted in a request for study by the MPCA and Department of Natural Resources in 1987. With a grant and coordination from the Local Road Research Board of the Department of Transportation, a consultant study was undertaken to attempt a characterization of the floatable trash and litter problem in the Mississippi River within the Minneapolis and St. Paul area. A principal focus was to gain some quantification of these materials that were delivered to the river by storm sewer systems. The study was limited in area and time but results are considered to be representative for this metropolitan area. The final study results show that small man-made floatable litter (MMFL) is the majority of the volume of total MMFL in the river and that storm sewers contribute most of that material. The results underestimate the actual volumes due to information and sampling constraints. Nonetheless, it has been shown that a single rain event delivers large volumes of a persistent and objectionable class of pollutant to waters of the state.

Cleanup is underway in the state. For example, in the 2003 International Coastal Cleanup (ICC), Minnesota cleanup of waterways collected almost 12,000 debris items weighing in at over 5,000 pounds (Mascarenhas 2003). Recreational activities accounted for 45 percent of the litter and smoking activities made-up over 50 percent of the collected material. Cigarettes, food wrappers and glass bottles accounted for 72 percent of the debris (Mascarenhas).

In Minnesota there are 260 registered Adopt-a-River groups that do smaller clean-up events throughout the year. Since the program's creation in 1989, these groups removed about 175,000 pounds of trash from the state's waterways every year and have removed about 4.7 million pounds total (Horgen 2005).

Quantity of Runoff

An emerging issue in water quality that needs to be addressed is that of hydromodification, which involves changes in flow patterns in natural waterways such as rivers or streams and wetlands. Hydromodification is also one of the major urban runoff issues. As noted above, the 2000 USEPA 305b report shows hydromodification as the second leading cause of impairment of fresh waters (EPA 2000).

While climate and rainfall patterns may or may not have been affected by human activity, it is clear that runoff has changed significantly with human development. In the presettlement Midwest, entire watersheds were in vegetative cover (*e.g.*, prairie, oak savanna), with maximum infiltration and minimum runoff. With the massive conversion of the landscape to agricultural and urban uses came substantial changes in runoff to wetlands, lakes and streams.

Removal of perennial vegetation led to a decrease in infiltration and an increase in the volume of runoff. Exposing soils to wind and water increased sediment loads carried by runoff. Impervious surfaces and artificial drainage systems increased the volume of runoff and accelerated the rate at which water was removed from the landscape. Impervious surfaces in urban areas also transported pollutant carrying runoff more rapidly and in greater volumes than before development.

There is an emerging understanding of the many ways that land use practices negatively affect the quality of instream habitat. Anything that is done to alter the diversity and stability of naturally occurring stream habitats inevitably affects the aquatic community of organisms residing in streams. Also, because streams are flowing, interconnected systems, any alterations that occur in the upstream headwaters will eventually be reflected in the lower stream reaches. Stream habitat may be compromised by altering the stream's natural morphology through ditching and channelization or through land use practices that occur outside of the stream channel, such as removal of the riparian vegetation, storm sewer drainage, and residential development.

Existing stream characteristics are a reflection of past conditions in the watershed. Urbanization will increase the runoff volume from each storm event, and may overload the natural drainage systems. The frequency of bank-full events increases with urbanization, causing the stream to enlarge its channel to reach a new equilibrium with the increased flows. Increased flow volumes increase the erosive force of the flows in the channel and can significantly upset the sediment load equilibrium that was established over many years.

Base flow, or low flow, in streams is also affected by changes in hydrology from urbanization because a large part of base flow comes from shallow infiltration. Impervious cover reduces infiltration, reducing the volume of water available for base flow in streams. These changes in hydrology can have a dramatic effect on the ecosystem of urban streams and wetlands. Studies of streams affected by urbanization have shown that fish populations either disappear or are dominated by species that can tolerate a lower level of water quality (Klein, 1979).

Hydromodification as a Pollutant

Minn. Stat. § 155.01, subd. 13 (b) define pollution of waters as "the alteration made or induced by human activity of the chemical, physical, biological, or radiological integrity of waters of the state." The basis for the provisions of this statute is that human activity, such as hydromodification, affects these waters in many adverse ways. For example, if the land around a small stream is developed from a natural state to parking lots, roads, and rooftops, that stream may experience

- larger volumes of water during rain events
- scouring, eroding, and straightening of the stream channel,
- dry periods due to reduced ground water inflow from the surrounding "capped" land
- change in stream habitat and ecology

Under natural conditions and at bank-full capacity, studies have shown that streams can handle a flow approximately equal to the historic 1.5- to 2-year frequency peak discharge within their banks (Rosgen, 1994; Leopold et al., 1964). After urbanization, increased runoff can cause bank-full flow to be exceeded several times each year. In addition to increased flooding, this condition causes previously stable channels to erode and widen. Much of the eroded material becomes bed load and can smother bottom-dwelling organisms.

In this process, stream habitat diversity is damaged or lost. Water that was once slowed by bends, pools, and woody debris in the water column moves faster and with greater volume cutting into the bed and eroding the banks. This faster flowing water carries with it an increased sediment load, some of which is deposited in the downstream reaches. Many fish and invertebrate species cannot use substrates that are laden with excessive silt for reproduction, feeding, or cover. Riffles and pools become scarce or absent as the stream is converted from riffle, run, pool sequences to long runs or pipes. Not only is habitat diversity affected but the stream hydrology becomes inherently less stable. As water leaves the system faster, the natural hydrologic timing is altered. The overall effect is an increase in the intensity of the high flows and decreased duration of low flow events. If the water is stored to prevent increased peak flows, then the flow duration is extended. Streams in which the surrounding vegetation has been removed or altered are usually compromised by an increase in the amount of silt-laden runoff. Also, water temperatures within the stream may rise as the overhead canopy is removed exposing the stream to full sunlight.

Urbanization also changes the extent and duration of inundation in wetlands, which can modify the established wetland vegetation. Measures to control discharges to wetlands must control the peaks and volume of flow to wetlands, if they are to be protected. This also means that reduced surface and ground water flow caused by diversion to storm sewers is also an area of concern, especially for sensitive wetlands.

Hydromodification of Small Events

Urbanizing areas increase runoff from small events in greater proportion than large events. This is important because, in Minnesota, more than 90 percent of the precipitation events are less than 1.0 inch. These rainfall events also account for approximately 65 percent of the cumulative runoff quantity in urban areas and proportionately large amounts of the pollutant loading associated with these rainfall events (Pitt, 1998). While the significance of large flood events should not be underestimated, the smaller flows with an approximately nine-month to two-year return period frequency are probably as important or more important to overall water quality. These flows can be very erosive and can be the major source of increased pollutant loading. Pollutant loading is more closely associated with total runoff volume than with peak runoff rates. Utilizing methods to maintain volumes and peaks closer to those that originally shaped the channel can reduce the channel reshaping process in a watershed. Examples of appropriate management techniques are the volume reduction that results from the use of swales instead of curb and gutter, reduced impervious surfaces or infiltration structures.

Wetland and upland vegetation can affect or be significantly affected by hydrologic changes. For example, drainage can obviously change the vegetation at a site, but increased water that drains from a project area into an off-site drainage basin can impact trees and other vegetation, including wetland vegetation. In such cases, water itself is the damaging agent even if it is clean. The increase in water level, both surface and subsurface, can result in the death of roots. Roots require oxygen from the air, and saturated soils create an anaerobic condition that will eventually kill the roots. A case in point is a tamarack swamp that receives water from several developments. As water levels increase through the swamp, the increased flow depth results in the death of many of the tamarack trees, even though they are tolerant of wet conditions. In Minnesota, we have several tree species that tolerate short periods of flooding, but we should be encouraging diversity and be mindful of sensitive areas downstream. Likewise vegetation in upland areas can change the infiltration capacity or evapotranspiration capacity of a watershed. By using native plantings that have denser canopies and/or deeper root networks the storage capacity of the upland areas are significantly increased in reducing run-off volumes, especially in the smaller storms.

Regulations for Urban Runoff Controls

The above list of water quality impacts are reduced and minimized by effective implementation of management measures including regulatory and voluntary programs. Both regulatory and voluntary programs utilize the same basic BMPs, but differ in administrative opportunities and education efforts to protect the resources in Minnesota. The following text identifies how key programs or policies in Minnesota are implemented.

Point Source Urban Runoff

In Minnesota, the primary regulatory program for stormwater runoff is the NPDES stormwater discharge program under Section 402 of the 1987 Clean Water Act. The MPCA is the state agency responsible for administering this point source urban runoff stormwater permitting program.

The MPCA requires stormwater discharges to be authorized under an NPDES/SDS (State Disposal System) Permit for the following municipal, industrial, and construction activities:

1. Municipal includes publicly owned storm sewer systems, not combined with sanitary sewer systems (known as municipal separate storm sewer systems or MS4s), under the following conditions:
   - MS4s characterized in federal law as ‘medium’ or ‘large’ (having a population larger than 100,000 as of the 1990 Census). For Minnesota, communities that qualify under this provision are Minneapolis and St. Paul.
   - Small MS4s include:
     - MS4s located in an ‘Urbanized Area’ as defined by the Federal Bureau of Census
     - MS4s designated by the state under Minn. R. ch. 7090, including cities and townships with a population of 10,000 or greater or those with populations of 5,000 or greater that discharge to an Outstanding Resource Value Water, Trout lakes or streams, or an impaired water
     - MS4s designated by the Commissioner of the MPCA
     - MS4s petitioned to be covered by permit and approved by the Commissioner of the MPCA
2. Industrial activities divided into ten categories based on Standard Industrial Classification (SIC), including manufacturing, mining, transportation, hazardous waste facilities, power plants, landfills, recycling facilities and wastewater treatment plants (over 5,000).
3. Construction activities which disturb at least one acre of land or a site which is part of a common plan of development that in total disturb over an acre of land. Construction activities include clearing, grading, grubbing, excavation, road building, demolition activity, and construction such as residential houses, office buildings, commercial facilities and industrial buildings.

Nonpoint Urban Runoff

The NPDES program is the statewide “regulatory”, or point source program, addressing stormwater runoff from municipal, industrial and construction site activities. For nonpoint source activities, the local governments and watershed management organizations (WMO) are the primary implementing bodies. The Minnesota Board of Water and Soil Resources (BWSR) has the responsibility for overseeing the state water management plans, utilizing Minn. Stat. ch. 103B (formerly 509) planning process. Cities and townships within the Metro Area have adopted regulatory controls through their local water management plans for activities such as erosion from construction sites, and are responsible for implementing these regulatory controls.

Metropolitan Area

State 103B watershed management planning has been done by watershed management organizations created either by a joint powers agreement under 103B or as a watershed district under 103B and 103D. As a result of the 103B planning effort in the Metro Area, there are 23 WMOs and 14 watershed districts in the area that plan and carry out authorities under this statute. Carver and Scott counties have assumed water-planning responsibilities of WMOs within their jurisdiction, and Dakota has assumed one watershed in the county.

Previously there were as many as 37 joint powers agreement WMOs. However, due to their lack of levying authority, levy limits placed on cities and other reasons, many joint powers agreement WMOs have dissolved and watershed districts have been formed or counties are conducting the water management planning. The lack of funding and administration has been the downfall of several joint powers agreement WMOs due to a small geographic size and low tax base.

The content and implementation programs of the first generation plans varied in scope and content due to a number of variables, including but not limited to: development pressure, geographic size, funding, tax base, local administrative pressure and lack of comprehensive requirements for the plans. The cost of first generation plans varied, from $15,000 in rural areas to as high as $150,000 in urban areas, with the average costs from $50,000 to $60,000 in the urban areas.

The second generation plans are much more consistent and of higher quality than the first generation plans due to state rules (Minn. R. ch. 8410). Second generation plans require local controls to regulate erosion from construction sites per approved BMP manuals in use in the Metro Area. They also require standards for stormwater design, must be consistent with state and regional water management goals, provide detailed accountability and establish measurable goals for a number of specific stormwater management issues. Some second-generation plans have cost a quarter of a million dollars and the average is well over $100,000.

For cities and townships in the Twin Cities Metropolitan Area, Local Water Management Plans are required that have to be consistent with the WMO's plans through Minnesota Rules Chapter 103 B and the Metropolitan Land Planning Act. The local water plans are reviewed by the Metropolitan Council and approved by the watershed organizations that the local government falls under.

Rural Areas

Outside of the seven-county metropolitan area where watershed districts and joint powers watershed management organizations conduct water planning, each of the 80 remaining counties have adopted a comprehensive local water plan. Further, the state has approved each of these 80 county comprehensive local water plans.

Local water planning at the county level works because of funding, land use authority, local coordination and the state-local partnership. The state has continually appropriated funding for this effort. Often the state appropriation has been over five million dollars a year. The average annual state contribution is $30,000 per county and the average annual county contribution is $95,000. Additional funding and grants from various sources have also been utilized.

Local coordination and communication may be the most visible of the program's successes. In all 80 counties, the local task forces that formed to develop the plans continue to meet after plan approval to aid in plan implementation. These task forces ensure that the plans consistently reflect local priorities. In addition, frequent meetings provide a forum to coordinate the variety of resource-related activities that various levels of government and other groups may be performing, thus avoiding duplication.

Stormwater Management Plans

As local governments develop their stormwater management plans, in response to the state planning requirements, they must develop comprehensive programs to manage stormwater for aesthetics, flood control, pollution control and all other appropriate purposes. Planning should involve public and intergovernmental participation. In developing local goals, local government should analyze the system-wide needs of the community, addressing the appropriate measures for the site, watershed, region or water body. Selection of the optimal mix of BMPs, including educational and structural measures such as stormwater ponds, depends on the goals that are established for the system, the nature of the project site, the nature of the watershed, and the pollutants to be addressed.

Important factors to consider include, but are not limited to:

- **Environmental Goals**
  pollutant-removal targets and levels of removal: phosphorus, total suspended solids, metals, sediments temperature changes Channel erosion protection Wetland creation Wildlife habitat Aesthetics Swimmable waters
- **Community Goals**
  development needs Community amenities such as open space, parks, trails, etc.
  stormwater BMP safety risks, construction, maintenance, and land-consumption costs
- **Nature of the Watershed**
  developed: retrofit options Undeveloped: planning for future development
  sensitive areas: special protection
- **Selection of Proper Prevention and Treatment System**
  avoidance policies
  selection of primary treatment systems
  selection of associated BMPs

Resource Protection Policies

Controlling stormwater discharges to water bodies should be the primary objective of the comprehensive stormwater and surface-water runoff-management plan developed by local units of government. Requirements of the Metropolitan Area Surface Water Management Act and other applicable planning requirements should form the basis for comprehensive review of stormwater and water body plans. As with all plans, the first step should be a survey of existing information, including mapping of all the water bodies in the watershed and associated normal flow paths.

Resource Inventory

It is recommended that the local unit of government complete the inventories of existing resources. Existing information, such as the Protected Waters Inventory (PWI/MDNR) and the National Wetland Inventory, U.S. Fish and Wildlife Service (NWI/USF&WLS) or the Watershed Heritage Program (WHP/MDNR) can be used as a starting point for these inventories. Any survey information must be field verified. Much of the original aerial photography was made over 15 years ago, so the surveys can be used only as a guide to field activities. Field visits are necessary to verify NWI information. Wetlands should be identified in the inventory and classified according to their appropriate wetland sensitivity group (Eggers, 1997; Minnesota, State of, June 1997). The size should be estimated and the surface hydrologic connections should be recorded for each water body identified on the inventory.

Significant Resources

Water bodies that have been designated by local, state or federal action as providing unique qualities, such as recreational, scientific, educational or aesthetic uses, should be considered significant resources. Other significant water bodies should include those that have been restored for specific purposes, such as water quality improvement or wildlife, industrial or agricultural uses. Water bodies known to be important to local recreation activities, such as hunting, fishing or bird watching, and water bodies occurring within parks, shoreland areas and conservation corridors would also be considered to be significant resources. Forested areas may also be considered significant resources and should be designated for protection from destruction by removal, inundation and flooding.

Excellent-quality water bodies of all types are very rare and becoming rarer as time and development goes on. Every effort to protect these waterbodies should be made. Providing off-site compensation does not easily mitigate for destruction or degradation of these types of water bodies.

Sensitive water bodies should be protected. Highly sensitive water bodies, even of moderate quality, are a concern because of the care that must be taken to preserve them. Importantly, they often cannot be easily mitigated, restored or created due to their special nature.

Other Water Bodies

Because of their position in the watershed, morphology, surface-flow connections or other physical attributes, some waterbodies play an important role as part of a hydrological system. The role of the waterbody in the hydrologic or ecological system should be highlighted in the inventory when these functions are believed to be important.

Maintaining and improving public uses and values is a very important component of maintaining or improving the entire function of a watershed. Piecemeal destruction or alteration of minor water bodies and/or changes in the hydraulic regime can significantly damage the entire system through changes in hydrology, erosion, nutrients or other pollutant loading on the system.

Resource Quality and Condition

An assessment of water body quality and condition is probably best conducted using a methodology that evaluates the condition of the biological community. The functioning of many water body uses is directly related to the biological integrity, since the biota will reflect the overall health of the system. Therefore, an assessment of the condition of a water body is best based on an evaluation of the relative “biotic impoverishment” (such as provided by Karr, 1993).

Policies for Urban Runoff

Avoidance Policies

It is important to avoid impacts at the outset if at all possible. The best way to minimize adverse impacts of development on runoff and water quality is to develop policies that avoid any construction activity in the most sensitive areas. Given the open-space requirements found in most zoning codes, this is a real option which is still too often overlooked.

Avoid:

- destruction of natural vegetation
- sitting improvements along the shoreline of lakes or streams
- constructing in natural drainageways
- areas dominated by steep slopes, dense vegetation or erodible soils

Vegetation

Avoid the loss of vegetation whenever possible. Delineate important vegetation and protect it from development activities.

Shoreline

Runoff from construction close to the receiving waters is hard to clean up before it reaches the receiving water, making measures to reduce pollutant delivery much more difficult and expensive. Measures to avoid the runoff are the best choice. Vegetated shoreline is a critical part of nature's system for cleansing runoff water of pollutants. Also, once the vegetation is disturbed, shoreline erosion from running water and wave action is dramatically increased.

Natural Drainageways

Construction in natural drainageways destroys the natural vegetation that protects the soil from erosion and, with it, the filtering capacity of the vegetation. This type of vegetation is among the most difficult to reestablish. Natural drainageways contribute a large percentage of runoff going directly to receiving lakes or streams, and once disturbed, they become high-energy, high-volume conduits for moving massive amounts of pollutants to receiving waters. Site plans that disturb these areas result in much larger volumes of water to manage and treat (and much greater costs for pipes and BMPs) than would be required by using other areas of the site for the same purpose.

Steep Slopes

Generally, the steeper the slope, the greater the erosion hazard. This is because the angle of repose on steep slopes means it takes less energy for water to dislodge and transport soil particles. Development often results in making flat areas for such things as roads, buildings and lawns. Creating flat areas on steep slopes exposes more soil surface area to erosion during construction than the same action on flat slopes. Good site planning avoids placing buildings and roads on steep slopes.

Erodible Soils

When denuded of vegetation, areas with easily eroded soils yield greater volumes of transported soil than those with erosion-resistant soils. Proactive planning can avoid disturbing erodible soils in the land development process, so that erosion and sedimentation problems will be avoided.

Impervious Surfaces

While population density is important for many planning and zoning regulations, imperviousness and the way impervious surfaces drain is the critical environmental planning consideration with reference to urban runoffs.

Impervious surface area is the portion of the land where water cannot infiltrate to the subsurface. Instead, water is conducted by gravity on the surface as overland flow. Impervious systems generally consist of roads, parking lots, sidewalks, rooftops and other impermeable surfaces of the urban landscape. While imperviousness is fairly easy to define, it may be hard to identify in practice. While asphalt and concrete are generally impervious, they have been found to allow infiltration under some conditions. Gravel surfaces can be pervious, but if they contain a high percentage of fines, they may become impervious. Lawns are considered pervious, but disturbed urban soils may allow only minimal infiltration (Pitt, 1994).

Imperviousness is still a very useful indicator by which to measure the impacts of land development on aquatic systems. Research conducted in many geographic areas and employing many different methods of analysis has led to similar conclusions regarding the nature of impervious surfaces and stream degradation: Stream degradation occurs at levels of imperviousness from as low as approximately 10 to 20 percent of the watershed (Schueler, Fall 1994).

Local Planning and Zoning Methods

If municipalities have addressed the problem of impervious surface at all, they have often addressed it by setting the maximum density for an area based on building units. The transport component is generally not addressed. However, transport-related imperviousness often exerts a greater hydrological impact than building-related imperviousness. Runoff from rooftops can be spread over pervious areas, such as open fields and grassed waterways, whereas roads and parking lots are usually directly connected to the storm-drain system.

Not only are roads generally connected to the drainage system, they also have the effect of producing secondary development, with a multiplying effect on the impacts to the watershed system. Because impervious surfaces place greatly increased total flow and loadings on waterways and on aquatic systems, it is very difficult to eliminate the impacts of the impervious surfaces by BMPs. BMPs that provide stable channels, reduce pollutant loading and reduce impacts to benthic biota may raise the allowable imperviousness. However, even when effective practices are widely applied, the threshold of imperviousness is eventually crossed, which results in a degraded condition. It is, therefore, critical that local government units (LGUs) address the impacts of imperviousness very early on by aggressive land use policies.

There are many policies that can be adopted on a local level to reduce the impacts of imperviousness. These policies can be adopted in local codes or ordinances to be applied to new developments. When techniques such as preserving natural areas, disconnecting and distributing runoff, and reducing impervious cover are applied to individual sites, stormwater runoff volumes can be reduced and reduce the size or number of conveyance systems and BMPs to mitigate the effects of runoff. These techniques, known as Better Site Design, are promoted in the Minnesota Stormwater Manual (Chapter 4). In incorporating Better Site Design into local codes and ordinances, local governments should consider working with stakeholders and identifying barriers to these policies. Barriers may be able to be addressed or it may be found that the benefits outweigh the problems with implementation.

Better Site Design can have many benefits besides reducing the environmental impacts of new development. It can result in savings for the developer and long term maintenance savings for the local government. It will also improve the quality of life for residents and increase property values.

Ground Water

When development occurs, the problems of runoff need to be addressed; often this is by "Better Site Design" or "infiltration devices." Better Site Design includes reducing impervious surfaces, discharging impervious surfaces over pervious areas, disconnecting roof drains from the stormwater system or other measures. Better Site Design policies are encouraged and are essential; however, general policies may require special consideration for potential hotspots such as in industrial areas or other unusual cases.

The other category of activity is called *infiltration devices*. This is everything from filter strips and swales to large infiltration ponds or infiltration trenches, tubes or other devices that conduct the runoff into the ground. Care needs to be taken to ensure that these devises do not bypass the zone of aeration above the ground water table (vadose zone) and conduct surface runoff directly into the ground.

Infiltration reduces stormwater flows in surface waters and replenishes ground water through recharge.

Summary of Authorities and Programs

Many other state and local agencies have leadership responsibilities in stormwater pollution control. The primary role of the involved agencies can be summarized as follows:

Minnesota Pollution Control Agency

- apply effluent and water quality standards for stormwater, erosion and sediment control where applicable

- adopt and provide technical assistance on acceptable technical standards and BMPs as permit requirements and as accepted tools in nonpoint source (NPS) watershed programs
- coordinate review and approval of local programs
- provide technical assistance and administrative assistance for NPS watershed projects under the Clean Water Partnership (CWP) program
- provide educational and technical assistance to locals developing pollution prevention plans for compliance with the state's stormwater permitting program
- provide water quality certification of 404 wetlands permits process and other federal permit certification
- provide BMPs for urban areas including

Nonstructural BMPs focus on changing behavior and management. These measures can be described as "good common sense" and can include such practices as street cleaning, education on lawn and garden practices, moving materials inside to reduce exposure, prohibiting certain practices, training, and employing spill-prevention plans.

Structural BMPs are measures that control or manage stormwater runoff and drainage. Examples of structural BMPs include enclosures used for covering exposed significant materials, swales, dikes, or stormwater treatment basins and wetland restoration.

- The MPCA also has many regulatory and pollution-prevention programs that can affect stormwater, such as the hazardous waste program, the aboveground and underground tanks programs, spills response programs and even air quality rules. Many fact sheets have been developed to help individuals, industries and local governments to develop their pollution-prevention programs.

Board of Water and Soil Resources

- review, comment, and approval of local comprehensive watershed planning
- provide cost share funding for local water planning and plan implementation
- oversee Minnesota's Wetlands Conservation Act.
- provide assistance to Local Governmental Units (LGUs) for complying with water planning laws
- provide oversight for local watershed plan implementation
- hear and rule on appeals alleging failure to implement local water management plans
- periodically review and update rules relating to comprehensive local water planning
- provide technical assistance

BWSR and MPCA

- develop model ordinances
- develop acceptable technical standards and Urban BMPs
- ensure interagency coordination
- provide information and education programs
- review local programs

Minnesota Department of Natural Resources

- Provide technical assistance on stormwater runoff control.
- Enforce Protected Waters Permit regulations.
- Enforce Shoreland Management Act provisions.
- Has developed and led public awareness and cleanup programs such as the "Adopt A River Program".

Metropolitan Council

- review water quality plans for the Metropolitan Area as mandated by USEPA through Clean Water Act (Section 208) and by the state Legislature through Minn. Stat. ch. 473
- implement a NPS control strategy through the local comprehensive plans of local units of government via the Metropolitan Land Use Planning Act

- provide technical planning assistance to local units of government and watershed managers, and participate in multi-agency efforts to solve water quality problems
- conduct research on the behavior and management of urban NPS pollution

Minnesota Department of Transportation

- designs, builds and maintains stormwater conveyance and treatment systems for transportation projects
- coordinates transportation project design with local units of government, WMOs, state and federal agencies
- provides standards and specifications for materials and techniques used in BMPs
- provides formal and informal research of stormwater quality BMPs
- provides standards and specifications for integration of biological systems with engineering principles, leading to functional succession of green spaces
- partners with others for research and development of appropriate seed mixes reflecting Minnesota's ecological regions for vegetative establishment associated with transportation projects
- provides systematic life-cycling approaches for the use of new products, BMPs, and designs for reducing impacts of stormwater
- provides technical assistance, training and education for the management of stormwater during and after construction

Minnesota Department of Agriculture

- coordinate the development of pesticide and fertilizer BMPs
- assess current pesticide and fertilizer management practices
- promote the use of BMPs and alternative management approaches for pesticides and fertilizers
- provide direction/guidance in the development of local Integrated Pest Management (IPM) programs
- enforce violations of state and federal pesticide and fertilizer laws

Minnesota Department of Health

- responsible for drinking water issues

Minnesota Department of Labor and Industry

- responsible statewide for regulation of stormwater conveyance systems for public, commercial, and industrial facilities. Responsibilities include review and approval and inspections of installations of building storm drains and storm sewers within the property lines for those facilities, although cities of the first class provide their own review and inspection services

Soil and Water Conservation Districts

- act as technical resource to local government and perform inspections as requested
- review and comment on local programs

Local Governmental Units

- adopt and implement local ordinances, including zoning
- install, operate and maintain BMPs
- administer and enforce local controls

Other Programs and Requirements

University of Minnesota

- conducts performance research on stormwater BMPs and develops assessment protocols on the same
- conducts research on impact of urban landscape management on urban water quality

- provides professional training on construction site erosion and sediment control and post-development stormwater management
- Provides professional and landowner training on landscape management for water quality, including turfgrass management
- Provides professional and landowner training on shoreland protection and restoration
- Assists local units of government in designing and implementing stormwater pollution prevention education programs for the general public, elected officials, professionals, and trades

Class 5 Wells

Under federal laws, "Class 5 wells," which are essentially any stormwater infiltration device that is deeper than it is wide, are required to be inventoried by reporting to the USEPA and the MPCA.

Minnesota Rules Chapter 7060

Minnesota state laws (Minn. R. ch. 7060) prohibit the direct discharge of untreated stormwater to the saturated zone if the discharge threatens ground water from potential pollutants. There could be liability if it is determined that a discharge has introduced contaminants into ground water in violation of state law. Treatment before infiltration is a suggested means to discourage the possible introduction of pollutants into the ground water.

Wellhead and Source Water Protection Plans

For stormwater systems located in defined wellhead and source water protection areas, the local unit of government must develop a "Wellhead or Source Water Protection Plan" in accordance with state laws and requirements. Special attention should be given to injection wells or infiltration basins and trenches which may pose a high risk to the wellhead, especially for drinking water wells classified by the Minnesota Department of Health as vulnerable to contamination.

Best Management Practices (BMP)

Best Management Practices are commonly used to reduce nonpoint source pollution from Urban Runoff sources. For listing and selection of BMPs, see the "Minnesota Stormwater Manual" and sources referenced within that manual.

Chapter 11 Urban Runoff

Needs, Priorities, and Milestones, Action Plan

The action plan provided below summarizes the goals and milestones identified in the preceding sections. Many of the milestones listed below, as well as the implementation schedules of specific projects, are contingent upon adequate funding, data, preceding projects, and local involvement.

Goal 1: Jurisdictions responsible for unregulated small municipal separate storm sewer system (MS4) develop comprehensive runoff management programs (see USEPA's *National Management Measure to Control Source Pollution from Urban Areas*).

Milestones (Action Steps)	13	14	15	16	17	Funding Source(s)	Lead Agency(ies)
1. Evaluate or develop and implement a runoff management program framework in local jurisdictions: a. establish legal authority through local codes or ordinances b. establish program funding c. establish program staffing	X			X	X	State, Local, 319	MPCA, MDNR, Met. Council, BWSR, MDH
2. Identify areas needing protection or restoration: a. state recognized outstanding resource value water and other special waters b. locally recognized special waters and ground water used for recreation, drinking water supplies, etc. c. state listed impaired waters d. locally recognized waters that are threatened with urban runoff.	X	X	X	X	X	State, Local, 319	MPCA, MDNR, Met. Council, BWSR, MDH
3. Develop and implement a program to address runoff from new development: a. maintain predevelopment site hydrology b. protect erodable or areas benefiting water quality c. limit impervious areas d. limit land disturbances e. preserve natural areas and vegetation	X	X	X	X	X	State, Local, 319	MPCA, MDNR, Met. Council, BWSR. MDH
4. Develop and implement a program to address runoff during construction: a. sediment b. erosion c. chemical control	X	X	X	X	X	State, Local, 319	MPCA, MDNR, Met. Council, BWSR, UM

Milestones (Action Steps)	13	14	15	16	17	Funding Source(s)	Lead Agency(ies)
5. Reduce pollutant runoff through pollution prevention measures for: household chemicals, lawn, garden, and landscaping commercial activities parking lots and roads, trash, pet/animal waste, municipal operations/good housekeeping	X	X	X	X	X	State, Local, 319	MPCA, MDNR, Met. Council, BWSR, MDA, UM
6. Evaluate, identify, or develop ordinances and/or stormwater fee incentives to require/encourage BMP installation, especially during redevelopment. a. limit impervious areas b. increase natural areas c. increase opportunities for on-site infiltration	X	X	X	X	X	State, Local, 319	MPCA, MDNR, Met. Council, BWSR, MDH
7. Perform maintenance, clean-out, and repair of structural BMPs owned by the community and insure maintenance of private BMPs flowing into the communities system. a. assess maintenance needs and costs within a LGU jurisdiction b. evaluate, identify or develop long term funding mechanisms to address clean-out of ponds or other structural BMPs c. evaluate, monitor, or compare maintenance techniques for cost effectiveness and for minimizing release of contaminates from structural BMPs	X	X	X	X	X	State, Local, 319	MPCA, MDNR, Met. Council, BWSR, MDH

Goal 2: Additional best management practices (BMPs) and low impact development techniques are advanced in Minnesota (see the Stormwater Steering Committee's Minnesota Stormwater Manual).

Milestones (Action Steps)	13	14	15	16	17	Funding Source(s)	Lead Agency(ies)
1. Overcome barriers to Low Impact Development a. research local codes and ordinances b. identify stakeholders c. conduct roundtable discussions to reach consensus d. implement code and ordinance changes			X	X	X	State, Local, 319	MPCA, MDNR, Met. Council, BWSR, MDH, MnDOT
2. Evaluate and implement BSD through education/behavior change, incentive programs, or ordinances.				X	X	State, Local, 319	MPCA, MDNR, Met. Council, BWSR, MDH, MnDOT, UM

Milestones (Action Steps)	13	14	15	16	17	Funding Source(s)	Lead Agency(ies)
3. Evaluate and implement new and innovative BMPs such as rain gardens, porous pavement, green roofs, etc. that are located closer to the source of runoff.	X	X	X	X	X	State, Local, 319	MPCA, MDNR, Met. Council, BWSR, MDH, MnDOT, UM
4 Evaluate and implement infiltration to also include ground water recharge.	X	X	X	X	X	State, Local, 319	MPCA, MDNR, Met. Council, BWSR. MDH, MnDOT, UM
5. Evaluate and incorporate into codes or ordinances unified sizing criteria (see Minnesota Stormwater Manual).				X	X	State, Local, 319	MPCA, MDNR, Met. Council, BWSR, MDH
6. Model and evaluate potential impacts of proposed BMPs for site specific watersheds, neighborhoods, and water bodies.					X	State, Local, 319	MPCA, MDNR, Met. Council, BWSR, MDH, UM
7. Evaluate proper utilization and combinations of urban BMPs as appropriate with varying sets of circumstances within watersheds, such as: a. pond design b. outlet flow controls c. wetland pretreatment and use d. wetland construction e. housekeeping f. erosion controls	X	X	X	X	X	State, Local, 319	MPCA, MDNR, Met. Council, BWSR, MDH, MnDOT, UM
8. Develop a program of stormwater credits which may include: a. natural area conservation b. site reforestation/prairie restoration c. drainage to buffers (stream, wetland or shoreline) d. surface impervious cover disconnection e. rooftop disconnection f. use of grass channels			X	X	X	State, Local, 319	MPCA, MDNR, Met. Council, BWSR, MDH,

Goal 3: Address load allocation reductions for total maximum daily loads established due to stormwater runoff Impacting impaired water or maintain water quality of a water body threatened by urban runoff.

Milestones (Action Steps)	13	14	15	16	17	Funding Source(s)	Lead Agency(ies)
1. Coordinate LGUs and stakeholders to assess and address threats to a water body within a watershed		X	X	X	X	State, Local, 319	MPCA, Met Council
2. Implement structural or non-structural BMPs					X	State, Local, 319	MPCA, Met Council
3. Monitor or evaluate effectiveness of BMPs					X	State, Local, 319	MPCA, Met Council, UM
4. Track BMP use within a watershed					X	State, Local, 319	MPCA, Met Council
5. Develop guidance options to allocate urban runoff inputs to water quality for Total Maximum Daily Loads (TMDLs).	X	X	X	X	X	State, Local, 319	MPCA, Met Council

Goal 4: Establish an effective technical assistance and education delivery system.

(To Achieve Maximum Effectiveness, Technical Assistance, Education and Information Delivery will prioritize and focus on needs for a particular watershed or runoff concern, target appropriate audiences, address barriers and benefits to implementation, and foster and measure behavior change. The following milestones are best done as a group.)

Milestones (Action Steps)	13	14	15	16	17	Funding Source(s)	Lead Agency(ies)
1. Delivery systems are focused with clear goals			X	X	X	State, Local, 319	MPCA, MDNR, Met. Council, BWSR, MDH, MnDOT
2. Benefits and barriers to achieving the desired goal are identified prior to implementation a. benefits are reinforced, created, or recommended to be enacted b. barriers to meeting the goals of the education or technical assistance are addressed			X	X	X	State, Local, 319	MPCA, MDNR, Met. Council, BWSR, MDH, MnDOT
3. Educational materials take into account age, cultural, ethnic, language and other audience differences as needed.				X	X	State, Local, 319	MPCA, MDNR, Met. Council, BWSR, MDH, MnDOT, UM
4. Outcomes of the education or technical assistance delivery system are measured to determine effectiveness of meeting the desired goals.			X	X	X	State, Local, 319	MPCA, MDNR, Met. Council, BWSR, MDH, MnDOT, UM

Goal 5: Promote the improvement of urban water quality through education and technical Assistance programs on the application of urban runoff best management practices consistent with Goal 4 and Chapter 6 of this plan.

Milestones (Action Steps)	13	14	15	16	17	Funding Source(s)	Lead Agency(ies)
1. Education of children through such methods as school curriculum or water festivals.	X	X	X	X	X	State, Local, 319	MPCA, MDNR, Met. Council, BWSR, MDH, EdMN, UM
2. Expand and develop certification/ training programs to address contractors, administrators and installers/inspectors. (319 funds would not be used for actual inspections, but for training).	X	X	X	X	X	State, Local, 319	MPCA, MDNR, Met. Council, BWSR, MDH, MnDOT, UM
3. Pool resources within a watershed or region for more effective outreach efforts.	X	X	X	X	X	State, Local, 319	MPCA, MDNR, Met. Council, BWSR, MDH, MnDOT
4. Expand and develop both informational materials and educational workshops related to pollution prevention plans for education about compliance with the NPDES stormwater program. Workshops would be targeted toward providing technical assistance to NPDES industrial, construction and MS4 permittees.	X	X	X	X	X	State, Local, 319	MPCA, MDNR, Met. Council, BWSR, MDH

Milestones (Action Steps)	13	14	15	16	17	Funding Source(s)	Lead Agency(ies)
5. Improve public education efforts related to urban impacts through such delivery channels as neighborhood networks, demonstrations, media coverage, advertisement, public service announcements, publications, and videotapes. Initial areas of emphasis would include: a. storm sewers (where they discharge to) b. lawn and garden chemical use, composting and debris disposal c. construction (BMPs and erosion control d. material handling (tanks, spills, hazardous materials solid waste, etc.) e. animal waste f. public participation g. litter (source controls, collection and prevention) h. imperviousness and the; need to mitigate runoff by running water over pervious surfaces or other measures i. water collection and treatment system especially swales, sewers, and ponds j. evaluating educational tools	X	X	X	X	X	State, Local, 319	MPCA, MDNR, Met. Council, BWSR, MDH, MnDOT, UM, MDA
6. Provide education to elected officials, their staff and consultants on impacts of land use on water resources and Low Impact Design Principles	X	X	X	X	X	Local, State, 319	MPCA, MDNR, Met Council, BWSR, UM

Goal 6: Minnesota stormwater runoff stakeholders work together to address and prioritize runoff needs for the state.

Milestones (Action Steps)	13	14	15	16	17	Funding Source(s)	Lead Agency(ies)
1. Stakeholders address and prioritize runoff needs including: a. education b. research c. coordination	X	X	X	X	X	State, 319.	MPCA, MDNR, Met. Council, BWSR, MDH, MnDOT, MDA, UM
2. Continue to revise state manuals to reflect the findings of studies and experience gained locally and throughout the nation and publicize and document the work of the group.	X	X	X	X	X	State, 319.	MPCA, MDNR, Met. Council, BWSR, MDH, MnDOT, MDA, UM

Milestones (Action Steps)	13	14	15	16	17	Funding Source(s)	Lead Agency(ies)
3. Encourage the involvement of associations and non-governmental units in utilizing grant opportunities	X	X	X	X	X	State, 319.	MPCA, MDNR, Met. Council, BWSR, MDH, MnDOT, MDA

Goal 7: Research the effectiveness of urban runoff best management practices (see Appendix K of the Minnesota Stormwater Manual).

Milestones (Action Steps)	13	14	15	16	17	Funding Source(s)	Lead Agency(ies)
1. Evaluate BMP life cycles a. long-term effectiveness b. costs including c. maintenance d. acceptance of urban BMPs				X	X	319, State, Federal.	MPCA, MDNR, Met. Council, BWSR, MDH, MnDOT, UM
2. Research the performance of emerging and nontraditional BMPs including but not limited to: a. bioretention b. pervious pavement c. green roofs d. infiltration e. proprietary sediment removal devices f. long term performance data		X	X	X	X	319, State, Federal	MPCA, MDNR, Met. Council, BWSR, MDH, MnDOT, UM
3. Assess the impacts of freezing, snow and snowmelt on the operation and effectiveness of existing and potential BMPs (BMP assessment).		X	X	X	X	319, State, Federal	MPCA, MDNR, Met. Council, BWSR, MDH, MnDOT, UM
4. Develop cold climate simulation tools		X	X	X	X	319, State, Federal	MPCA, MDNR, Met. Council, BWSR, MDH, MnDOT, UM
5. Research BMP effectiveness in contaminate removal for pathogens, toxins, and other emerging issue contaminates.		X	X	X	X	319, State, Federal	MPCA, MDNR, Met. Council, BWSR, MDH, MnDOT, UM

Milestones (Action Steps)	13	14	15	16	17	Funding Source(s)	Lead Agency(ies)
6. Research infiltration techniques including: a. soil amendments and deep ripping to increase infiltration b. effectiveness in cold conditions c. monitor, evaluate, identify or develop BMPs that protect ground water where it may be detrimentally impacted		X	X	X	X	319, State, Federal	MPCA, MDNR, Met. Council, BWSR, MDH, MnDOT, UM
7. Develop stormwater runoff demonstration sites for research, monitoring and educational purposes. Publicizing of the sites can be done through being open to the public, published in sources such as the Minnesota Stormwater Manual, and/or cited in training materials.	X	X	X	X	X	State, Local, 319	MPCA, MDNR, Met. Council, BWSR, MDH, MnDOT, UM
8. Research low impact development and Low Impact Development techniques			X	X	X	State, Local, 319	MPCA, MDNR, Met. Council, BWSR, MDH, UM
9. Research on salt contamination: a. salt management including storage and application b. BMPs c. alternative methods and products	X	X	X	X	X	State, Local, 319	MPCA, MDNR, Met. Council, BWSR, MDH, MnDOT, UM
10. Evaluate, identify or develop BMPs on ways to mitigate artificially extended “bankfull” flow in developed areas.	X	X				319, State, Federal	MPCA, MDNR, Met. Council, BWSR, MDH, MnDOT, UM

Chapter 12 Forestry

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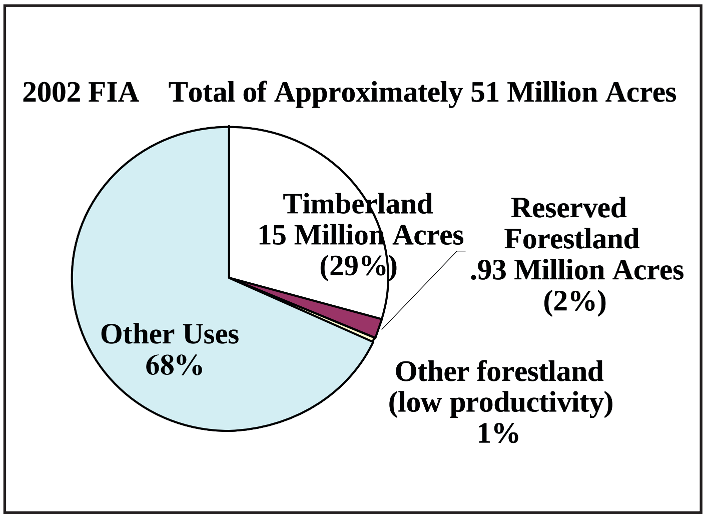
Introduction

Minnesota is blessed with vast acreages of forestland and an abundance of high quality water. Forest management activities are extensive and often take place in close proximity to or adjacent to water resources, or in wetland areas. Sustainable forest management is only possible when all the needs of society are balanced with maintaining diverse, healthy forest ecosystems. Therefore, forest managers, landowners and operators must ensure that all forest management activities are accomplished in a manner that minimizes impacts to the environment and water quality. The total land area of the state is 51 million acres. Of this total, 16.3 million acres are forested, most of which is contained in the northern half of the state. More than one million acres of forest are within scientific and natural areas or the Boundary Water Canoe Wilderness Area, where no harvesting is permitted. Another 800,000 acres are unproductive forestland (Figure 1). The remaining productive or commercial timberlands available for timber management totals 15 million acres. More than twenty-six percent of the state's timberland is wetland forest types (Figure2) such as ash-elm, black spruce, tamarack, and white cedar. Management activities in these types require extra caution to minimize impacts to their biologic and hydrologic functions. The aspen forest type covers the largest acreage, nearly thirty-seven percent, and is where the most timber harvest activity has occurred over the last thirty years (Figure 2). While aspen remains the dominant species harvested, harvest pressure on all other forest types is approaching levels comparable to the aspen type due to increased worldwide demand.

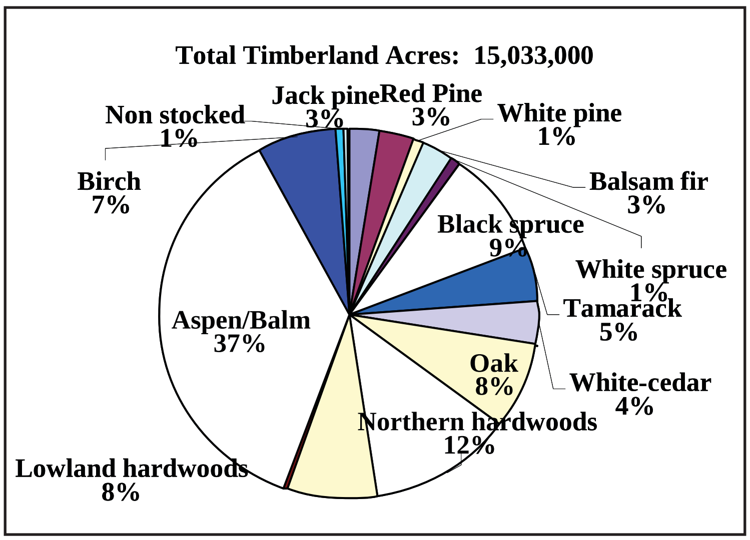
Figure 1 Minnesota Land Use



Source: Minnesota FIA 2002 Eastwide Database Provided by USFS North Central Forest Experiment Station

Figure 2 Timberland Cover Type Acres

Cover Type: A classification of forestland based on the species forming a plurality of live tree stocking. **Source:** Minnesota FIA 2002 Eastwide Database Provided by USFS North Central Forest Experiment Station. It is worthwhile to note that aspen is by far the largest cover type in Minnesota.



Prior to 1990, public agency lands provided the majority of timber harvested in Minnesota, despite the fact that the largest acreage of forest types containing the species most in demand are located on Non-Industrial Private Forest (NIPF) lands.

(Figure 3). This was because:

- public forest management agencies are required to actively manage their lands on a sustainable basis,
- demand for wood was well below the harvest levels these agencies identified as desirable in their management plans,
- and stumpage prices were too low to encourage NIPF landowners to market their wood.

As worldwide demand has increased, the state's forest industry has grown.

The demand for all species, particularly aspen, now exceeds the volume available from public lands. As a result, harvest levels on NIPF lands increased dramatically in the early 1990s (Figure 3).

This shift of harvest to NIPF lands is a significant concern for the protection of water quality. Public agencies own and manage fifty-four percent of the commercially available forestland. (Figure 4).

Figure 3 Estimated Volume of Timber Sold by Ownership

Source: Public Lands: Public Stumpage Price Review. Industry Lands: Minnesota Forest Industries survey. Private Lands = An estimate figured as follows: Total estimated harvest, minus public volume sold, minus industry volume harvested.

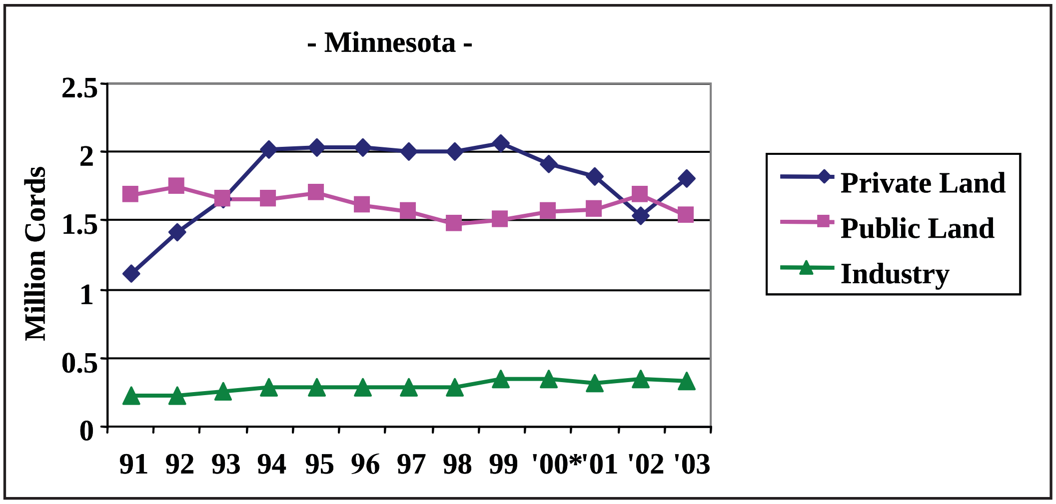
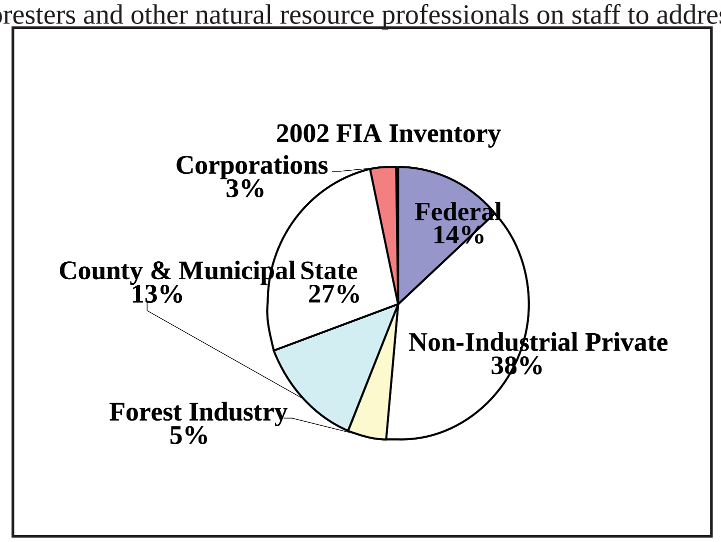


Figure 4 Minnesota Timberland Acres by Ownership

Source: Minnesota FIA 2002 Eastwide Database Provided by USFS North Central Forest Experiment Station

These agencies have foresters and other natural resource professionals on staff to address nonpoint source



(NPS) pollution through the adoption of appropriate organizational policies and regulations. Many forest product companies also have professional forest management staffs. Public agencies and forest product companies are also subject to ongoing legislative and public scrutiny to assure they adhere to high standards of resource protection. One response has been the involvement of the organizations of forest certification programs. Public agencies and forest industry are leading the way.

The Minnesota Department of Natural Resources (MDNR), which administers 4.9 million acres, received its Forest Stewardship Council (FSC) and Sustainable Forestry Initiative (SFI) certificates in December 2005.

County forestlands have also been pursuing certification from FSC, SFI, or both. St. Louis County is SFI certified, Aitkin and Cass County are FSC certified, and six additional counties are preparing to be certified. Potlatch Corporation and UPM Blandin Paper lands are certified under both FSC and SFI, and Forest Capital Partners lands are SFI certified.

In contrast to public agencies, NIPF landowners, who control thirty-eight percent of Minnesota's timberland, often do not utilize professional natural resource assistance. Prior to 1990 the MDNR, Division of Forestry estimated that only about twenty percent of the estimated 139,000 NIPF landowners utilized a forestry professional to help plan their forest management activities. Developing incentives and an effective education program to encourage implementation of Best Management Practices (BMP) on NIPF lands has been a major challenge.

Offering ways to participate in a certification program is one approach to this. Private landowners have many choices if they wish to certify their lands. Consulting foresters, accredited by FSC, are available to assist those who wish to be certified at a reasonable cost. Timber harvested from a certified Tree Farm can be marketed as SFI certified wood. Minnesota also offers landowner assistance through Forest Stewardship planning, cost share programs, and special property tax treatment for lands managed under a qualified plan.

Geographic Areas of Concern

Much of Minnesota's forestland has gentle topography and stable soils where impacts to water quality from erosion and sedimentation attributed to silvicultural activities are generally not severe. It is important to recognize, however, that an extremely high proportion of high quality waters (e.g., designated trout streams, designated trout lakes, and Outstanding Resource Value Waters) occur or originate in the forested areas of Minnesota.

Several forested areas of Minnesota are particularly susceptible to erosion and sedimentation. Additionally, NIPF landowners generally own small parcels of timberland, and have limited awareness of low impact land-use practices. Because their timberlands are interspersed with public and forest industry lands, a complex mosaic of ownership exists that greatly complicates coordination of forest management on a landscape scale.

Regional landscape planning committees, made up of stakeholders from all segments of the regions' population, have been established to begin addressing the complicated issues that this mosaic of ownership creates.

Currently Applied BMPs

Minnesota has had voluntary water quality BMPs to address nonpoint source pollution since 1990. These were revised in 1994, based on new scientific information and the results of implementation monitoring in 1991, 1992, and 1993. Wetland BMPs were incorporated at that time to better address the intent of the Federal Clean Water and Coastal Zone Management Acts and to address the requirements of the state's new Wetland Conservation Act. Visual Quality BMPs were also developed in 1994 as a result of collaboration initiated by the resort and forest product industries of Minnesota. Implementation monitoring of the revised water quality and new wetland and visual quality BMPs was conducted in 1995 and 1997.

The focus of Minnesota's forestry BMPs has been, and continues to be, at the site level for all forest ownership across the state. These site level practices have been expanded and integrated with guidelines intended to enhance or minimize impacts to riparian areas, site-specific wildlife habitat, soil productivity, and cultural and historic resources. The water quality, wetland, and visual quality BMPs were incorporated into the *Voluntary Site-Level Forest Management Guidelines, Sustaining Minnesota Forest Resources*, published in 2000, with a revised edition released in the fall of 2005. The forest management guidelines or BMPs found in this Manual are incorporated by reference into this Plan. Additional efforts to address forest management issues at a landscape level are also continuing. The entire program remains voluntary for the landowner/manager to the extent practical within the constraints of existing federal, state, and local laws and regulations. This provides important flexibility to meet variations across landscapes, in on-site conditions, available equipment and technology, and management goals.

The expanded forest management guidelines have been adopted as operational policy on state, national forest, county, and industry forest lands. They are also an integral part of the forest certification programs in which many of the agencies and companies are participating.

Members of the Minnesota Logger Education Program (MLEP) are required to take forest management guideline training and are encouraged to include compliance with the guidelines in their contracts with NIPF landowners. MLEP has more than 400 member companies representing more than 90 percent of the timber harvested in Minnesota. MLEP is expanding their program to include logger certification. In order to qualify for this higher credential, loggers will have to agree to third party audits of their harvest operations, which will include assessment of their application of the forest management guidelines.

Minnesota's Forest Stewardship Program, which extends professional assistance to NIPF landowners through consultants, industry foresters, Soil and Water Conservation District (SWCD) staffs, environmental groups, and state natural resource professionals, requires all individuals wishing to qualify as Forest Stewardship plan writers to take forest guideline training. The plan writers are also required to incorporate the appropriate guidelines, including water quality protection strategies, in the plans they write for NIPF landowners. And the landowners are also required to utilize the guidelines for all projects involving cost-share funding.

The forestry BMP guidebook provides recommendations to protect water quality for the following activities:

1. General Practices:
    - fuel, lubricant and equipment management
    - riparian management zones and filter strips
    - follow-up evaluations
2. Forest Roads:
    - design recommendations, considerations for alignment, water crossings and approaches, winter roads, and drainage
    - construction recommendations for clearing, excavation, surfacing, drainage, and soil protection
    - maintenance recommendations activities for all roads in general, specific considerations for active roads, and inactive roads
3. Timber Harvest:
    - planning considerations for reconnaissance, timber sale plans, design and layout, harvesting and follow up, and leave trees
4. Mechanical Site Preparation:
    - planning considerations
    - recommended prescriptions for shearing and raking, discing, patch and row scarification
5. Pesticides:
    - planning considerations for integrated pest management, use of licensed pesticide applicators, pesticide selection, and response to spills
    - procedures for pesticide handling during transportation, storage, mixing, loading, application, equipment cleanup, and container and waste disposal
6. Prescribed Burning:
    - planning considerations, recommended prescriptions, and maintenance after fire

Due to increasing demands for energy and wood fiber, the MN Forest Resources Council (MFRC) has initiated development of additional forest management guidelines for recovery of biomass from brushlands and logging residues. Concurrently, the MN DNR Division of Trails and Waterways is developing guidelines for recreational trails in response to concerns over the impacts of all terrain and off highway vehicles (ATVs and OHVs).

Waterbodies Addressed

The wetland and water quality BMPs apply to all perennial and intermittent streams, lakes, open and non-open water wetlands including seasonal ponds (types 1-8 Circular 39 wetlands), seeps and springs, sink holes, and ground water.

Pollutants

Erosion and subsequent sedimentation is the principal water quality impairment associated with silvicultural practices in Minnesota (Generic Environmental Impact Statement, Draft, 1993). Other pollutants commonly associated with forest management activities include dissolved nutrients, organic debris, pesticides, petroleum products, and thermal effects. Changes in the pattern of water movement above and within the soil (hydrologic flow) are another potential impact that can affect water quality biologic function at the site level and beyond. While some erosion and sedimentation within forested lands occurs naturally, most is attributable to poor design, placement, and maintenance of forest roads and trails. Other silvicultural activities that have the potential to generate these pollutants include:

- mechanical site preparation resulting in sedimentation and dissolved nutrient losses
- soil compaction and rutting that results in increased surface flow of water off site or that interrupts normal lateral water movement in the soil
- spills of fuel and lubricants due to breakdowns or during equipment maintenance
- harvesting trees along the banks of waterbodies, resulting in increased water temperatures and reduced bank stability which can degrade the stream channel and increase long-term sedimentation
- slash burning resulting in nutrient loading to streams
- extensive clearcutting within a drainage basin which can result in increases in stream peak flows, and a corresponding increase in the amount of sediment movement within stream channels
- regeneration and pest control activities that involve pesticide use or chemical management
- fire breaks resulting in sedimentation and dissolved nutrient losses.

Seasonal changes and fluctuating climatic conditions often complicate these activities

Program Description:

Implementation of the forest management guidelines is monitored by field audits of a sample of recent forest management activities on all forested ownership in Minnesota. Information gained from the field audits is used to:

- evaluate the degree of implementation of the guidelines
- identify needed modifications to guidelines
- focus technical assistance and education efforts on problem areas identified in the field audits

Our goal has been, and continues to be, to randomly sample a sufficient number of timber harvest sites to statistically assess overall guideline implementation on all ownerships. Our primary limitations are funding and design of a timely way to obtain an unbiased sample of forest management sites, particularly for NIPF ownership.

For the monitoring conducted from 1991 through 1997, minimal funding restricted us to requesting the cooperation of state, county, federal, forest industry, and tribal forestry organizations to self-identify sample sites. We attempted to obtain the same information for NIPF lands, but were severely limited because less than 20 percent of such activity was accomplished with the assistance of a professional forester. No records were available for activities on the other 80 percent.

The self-selection process for public agencies and industry, and the lack of an effective means of identifying the majority of activity on NIPF lands were significant limitations for the credibility of our monitoring results from 1991 through 1997. Beginning in 2000 we attempted to improve the credibility of our site selection process and resolve some of the staffing and logistical complexities of the monitoring effort. This included:

- hiring biometricians to design a statistically valid system of randomly selecting townships in the forested regions of the state, for which aerial photography was flown, as an unbiased way to identify a pool of sample sites
- hiring a private contractor to audit the sites
- instituting a quality control process to ensure the contractor accurately evaluates the sites
- initiating development of a computer program intended to permit entry of data in the field

Since 2004, monitoring sites have been identified by randomly selecting 270 forest disturbances identified by comparing satellite imagery of the state from two different years. Low-level aerial photography is taken of these 270 sites, the photos analyzed to determine that the sites are timber harvests, and landowners are identified. A pool of approximately 180 to 200 sites normally remains after this process. From the remaining pool, ninety sites are then randomly selected for on-site monitoring.

Specific Accomplishments

The MFRC has published 4,000 copies of the 2005 edition of the integrated forest management guidebook titled, "*Voluntary Site-Level Forest Management Guidelines, Sustaining Minnesota Forest Resources.*" More than 2,000 loggers, foresters, wildlife managers, recreation specialists, hydrologists, and other natural resource managers have received basic guideline training through programs offered by MLEP and the Minnesota Extension programs. Additional, more specialized guideline training on such subjects as recreational trails, road maintenance, and prescribed burning will be offered in the future. Training on the forest management guidelines has also been given to more than 500 volunteer "woodland advisors" through program organized by the Minnesota Forestry Association (MFA) and the Minnesota Extension program. These are private individuals with an interest in forest and wildlife management who receive eighty hours of training on general forestry and wildlife topics and the types of professional services available to private landowners. These people then provide advice to their neighbors, and encourage them to seek appropriate assistance.

Many forest management agencies and companies select a set of standardized forest statements to incorporate forest management guidelines, including specific water quality guidelines, into their timber sale permits and other forest management project contracts to improve the consistency and clarity of the wording and make the regulations more easily enforced. Field foresters also have the flexibility to write project regulations customized to address unique site conditions.

Many have also developed checklists to assist documentation of preharvest meetings, permit supervision, and project closure inspections. This documentation will enable

- identification of the types of problems that arise
- evaluation of the appropriateness of
- project regulations
- comparison of agency results with the statewide monitoring results

Research efforts have also been conducted and continue to be developed to evaluate the effectiveness, cost, and benefits of individual guidelines.

Substantial joint efforts are being made by local, state, and federal agencies to restore riparian vegetation, particularly forest cover, along some of Minnesota's most polluted waterbodies. The MDNR, Division of Forestry has hired three full-time foresters to accelerate this effort in the Minnesota River drainage area. They are working with a number of programs to provide incentives to farmers to take floodplain fields out of crop production and plant forest cover.

One of the most important programs is the Conservation Reserve Enhancement Program (CREP), which allows a landowner to extend their Conservation Reserve Program (CRP) contract by five years if they plant trees. Several field demonstration of a variety of small-scale logging equipment were held to introduce loggers, foresters, and landowners to equipment options that may be better suited to thinning, small acreages, and minimization of harvest impacts on sensitive sites. MFA, Minnesota Extension, DNR Forestry and County SWCDs organized these programs.

Goals

The forestry community will continue to develop, evaluate and improve education programs for loggers, landowners and resource managers. Education efforts will continue to target woodland advisory committees, woodland owner groups and other NIPF landowners.

The MDNR, Division of Forestry, Minnesota Extension Service, and United States Department of Agriculture (USDA)Forest Service are pursuing research funds to continue and expand research on light-on-the-land logging technologies and to expand the evaluation of the effectiveness, costs, and benefits of individual guidelines.

Under the state's Sustainable Forest Resources Act, Minnesota's forest management guidelines will remain a voluntary program for the landowner/ manager. The majority of public forest agencies and forest industry, loggers and many NIPF landowners are strongly committed to the effective utilization of the guidelines. Evaluation and revision of the guidelines and the entire program remains a process involving multiple stakeholders and extensive scientific and public review. Minnesota is promoting and encouraging the continued development of sustainable forest management programs through forestland certification (i.e., Sustainable Forestry Initiative, Forest Stewardship Council) and implementation of a Master Logger program. Central to these programs is the adoption and use of the timber harvesting and forest management guidelines. Certification and Master Logger programs encourage sustainable forestry practices that are scientifically sound and economically, environmentally, and socially responsible. The MFRC guidelines are a core component of these programs and their use is required to help sustain, maintain, and protect critical resources. In 2004, the MFRC appointed an interdisciplinary Riparian Science Technical Committee of nine scientists to thoroughly review the science related to evaluating impacts of managing forested riparian areas. The information from this review will inform the discussions within the MFRC on proposed revisions to the guidelines for incorporation into the second revision of the timber harvesting and forest management guidebook.

Programs, Roles and Authorities

The Minnesota Department of Natural Resources, Division of Forestry is the lead agency for implementing the forestry section of the NPS Management Plan. The Minnesota Pollution Control Agency (MPCA) is the agency designated to oversee the Section 319 activities and will be involved in coordination of forestry NPS activities with the overall NPS Management Program. As needed, memoranda of agreements will be developed between implementing agencies. Other federal, state and local agencies and organizations and individuals, which have roles and programs, related to improving the water quality of Minnesota's forestlands through the use of appropriate silvicultural practices, include:

- USDA/FSA/NRCS: Conservation Reserve Program
- USDA: Stewardship Incentives Program
- Natural Resources Conservation Service (NRCS)/SWCDs: Preparation of conservation plans for erosion and sedimentation control (i.e., field windbreaks)
- US Forest Service (USFS): National Environmental Policy Act of 1969 (NEPA) - USFS: Forest Legacy
- USDA/FSA: Forestry Improvement Program
- MDNR: Private Forest Management/Stewardship Programs, Forestry Communication and Education Program, Forest Guideline
- Implementation Monitoring Program, Utilization and Marketing Program
- U of M College of Natural Resources (CNR) and Extension: Forestry education for landowners, natural resources professionals, loggers, and others

- Private Industry: Provide forest stewardship planning to private landowners
- Consulting Foresters: Provide forest stewardship planning to private landowners
- MFA: Woodland Advisor training and NIPF landowner outreach
- MLEP: Loggers education and certification programs and cooperative training to other natural resource professionals

A more detailed description of these programs, including the major program components, the funding source, lead agency and resource information can be found in Chapter 2, Programs and Funding for Implementing NPS Program, of this Nonpoint Source Management Program Plan (NSMPP).

Best Management Practice (BMP)

The following guidelines are recommended to reduce nonpoint source pollution from forestry activities. This list is not comprehensive and does not suggest additional measures would have no benefit but is provided to highlight commonly employed practices. Appendix B of this NSMPP provides definitions of best management practices for a broad range of NPS sources. The forestry guideline book provides recommendations to protect wetlands and water quality for the following areas of concern:

1. General Practices:
    - timing of activities
    - fuel, lubricants, and equipment management
    - petroleum product spills
    - filter strips and riparian management zones
    - protection of normal hydrologic flow of streams and wetlands
    - protecting wetland inclusions and seasonal ponds
    - coarse woody debris
    - follow-up evaluations of sites
2. Forest Roads:
    - location and alignment
    - references back to general practices for protection of wetlands and bodies of open water
    - design recommendations for:
        - season of required access, long term access needs, topography, soil type
        - surface drainage erosion control
        - approaches to and crossing of wetlands and bodies of open water
    - construction recommendations for
        - clearing and excavation,
        - soil stabilization, and disposal of clearing debris
        - approaches to and crossing of wetlands and bodies of open water
    - maintenance recommendations for roads while in use and when temporarily closed
    - recommendations for permanent closure of roads
3. Timber Harvest:
    - utilization of aerial photography, topographic maps, wetland inventory maps, and other aids when planning and designing timber sales
    - recommends field reconnaissance for preparation of harvest plans and prior to the start of harvest operations
    - recommends a written harvest plan and on-site review of that plan with the logger prior to the start of operations
    - location of landings and skid trails
    - references back to general practices for protection of wetlands and bodies of open water
    - skid trail approaches to and crossing of wetlands and bodies of open water; and documentation, supervision, and follow-up evaluation of desired outcomes

Milestones (Action Steps)	13	14	15	16	17	Funding Source(s)	Lead Agency(ies)
4. Promote and supplement the technical and financial assistance offered by several Farm Bill Conservation Title programs to help landowners implement and maintain IPM practices.	X	X	X	X	X	See Above	MDA, USDA, Farm Services Agency, NRCS, USFWS, BWSR, DNR, SWCDs, U of M Extension, Private Organizations, Local Units of Government
a. Promote and/or supplement Environmental Quality Incentives Program (EQIP) incentive payments and technical assistance for implementing integrated pest and weed management on cropland (MN NRCS Conservation Standard 595 Pest Management) or pasture (Standard 528a Organic Prescribed Grazing) on eligible acreage;						See above	See above
b. Promote and/or supplement Conservation Security Program (CSP) enhancement payments for one or more pest management activities to protect water quality, whether already regularly practiced by the landowner or to be started. Includes pest scouting to minimize and target pesticide applications; band, split, spot or variable rate application; one or more non-chemical controls as the primary method of weed control; crop rotations including small grains and/or hay; or use of pest management products that meet USDA organic farming requirements.						See above	See above
5. Promote Integrated Pest Management programs, develop and implement state-wide strategies for the increased use of IPM on private and state managed lands.	X	X	X	X	X	See Above	MDA and Private Organizations
6. Provide organic farming technical assistance on conversion to organic methods, certification and marketing of crops and livestock.	X	X	X	X	X	See Above	MDA

Chapter 12 Forestry

Needs, Priorities and Milestones, Action Plan

The Action Plan Provided Below Summarizes the Goals and Milestones Identified in the Preceding Sections. Many of the Milestones Listed Below, The Implementation of Specific Projects, are Contingent Upon Adequate Funding and Local Involvement.

(P) Private (S) State (F) Federal

Goal 1: Education: Improve adoption and use of BMPs through effective educational programs.

Milestones (Action Steps)	13	14	15	16	17	Funding Source(s)	Lead Agency(ies)
1. Woodland owner education: Curriculum development and delivery with local partners (i.e. county woodland committees, woodland advisors).	X	X	X	X	X	General Fund (S), Stewardship Education Fund (S), Extension (S).	MDNR, Forestry, MFA, U of M Extension
2. Develop early education curriculum in cooperation with professional associations (i.e. Project Wet, Project Wild, Project Learning Tree, Natural Resources in the Classroom)	X	X	X	X	X	General Fund (S), Association Funds (P).	MDNR Forestry, MDNR Waters, Wildlife Society, Society of American Foresters, U of M Extension.
3. Document benefits of the guideline education programs based on workshop evaluations and landowner surveys		X			X		MDNR Forestry, MFA, U of M Extension.
4. Document benefits of the guideline education programs based on evaluation of implementation field monitoring results.	X	X	X	X	X	General Fund (S).	MDNR Forestry.
5. Develop demonstrations of practices and equipment to reduce impacts and improve the efficiency and cost effectiveness of forest operations.	X	X	X	X	X	General Fund (S), S&PF (F), Grants (P), MLEP (P).	MDNR Forestry, U of M Extension.
6. Continue training programs for loggers and foresters and expand to include other natural resource professionals.	X	X	X	X	X	General Fund, (S), MLEP (P).	MFRC
7. Agroforestry education to promote crop diversification and use of woody perennials for phytoremediation and wellhead protection.	X	X	X	X	X	UMN CNR and Extension (S), NRCS (F), RC&Ds (F)	U of M CNR and Extension, NRCS
8. Support statewide initiative to promote third-party certification of Minnesota's private woodlands	X	X	X	X	X	Blandin Fdn. (P), LCMR (S), Extension (F, S), MDNR (S)	U of M CNR and Extension, MFA, Blandin Fdn.

Goal 2: Monitoring: Evaluate and quantify implementation of BMPs

Milestones (Action Steps)	13	14	15	16	17	Funding Source(s)	Lead Agency(ies)
1. Continue guideline implementation monitoring.	X	X	X	X	X	General Fund (S)	MDNR Forestry
2. Improve implementation monitoring process design.	X	X	X	X	X	General Fund (S)	MFRC
3. Adequate sampling of critical activities.	X	X	X	X	X	General Fund (S)	MFRC
4. Identify meaningful sampling criteria.	X	X	X	X	X	General Fund (S)	MFRC
5. Streamline on-site evaluation.	X	X	X	X	X	General Fund (S)	MFRC
6. Expand implementation monitoring beyond timber harvest to include permanent forest management infrastructure such as roads, water crossings, and trails.			X	X	X	General Fund (S)	MFRC MDNR

Goal 3: BMP Development and Implementation: Continue BMP development and implementation efforts to improve the effectiveness and use of BMPs and expand the protection of resources.

Milestones (Action Steps)	13	14	15	16	17	Funding Source(s)	Lead Agency(ies)
1. Revise guidelines to reflect the results of monitoring and research.	X	X	X	X	X	General Fund (S)	MFRC
2. Prioritize assistance, education, and corrective actions to address those practices identified through implementation monitoring as poorly applied, inadequately utilized, or newly developed or revised.	X	X	X	X	X	General Fund (S), Stewardship Education Fund (S), Cost Share Programs (S) (F), MLEP (P), U of M Extension (F)	MFRC
3. Increase technical assistance to NIPF landowners.	X	X	X	X	X	General Fund (S), Stewardship Funds (S).	MDNR Forestry U of M Extension
4. Evaluate the need for tax credits as incentives for guideline implementation.	X	X	X	X	X	General Fund (S)	MFRC

Milestones (Action Steps)	13	14	15	16	17	Funding Source(s)	Lead Agency(ies)
5. Establish guideline implementation recognition programs for loggers, natural resource managers, landowners, and management agencies.	X	X	X	X	X	General Fund (S), Association Funds (P).	MFRC,SAF, MLEP,MFA.
6. Support statewide logger certification initiative to increase sustainable forestry implementation and the amount of certified fiber from Minnesota's private woodlands.	X	X	X	X	X	Association Funds (P).	MLEP

Goal 4: Research: Target research efforts to evaluate costs and benefits effectiveness of BMPs in reducing negative impacts of forest management practices.

Milestones (Action Steps)	13	14	15	16	17	Funding Source(s)	Lead Agency(ies)
1. Evaluate the costs, benefits, and effectiveness of implementing specific forest management guidelines	X	X	X	X	X	General Fund (S), S&PF (F), Grants (P)	MFRC, MDNR Forestry, U of M CNR, U of M NRRI, USFS NCFES & S&PF.
2. Carry out long term research to evaluate the effectiveness of a variety Riparian Managment Zone (RMZ) configurations for; a. thermal impacts trapping b. sediments capturing or trapping nutrients c. providing critical habitats	X	X	X	X	X	General Fund (S), S&PF (F), Grants (P) (F), LCMR (S).	MFRC, MDNR Forestry, U of M CNR, U of M NRRI, USFS NCFES.
3. Evaluate soil disturbance impacts and recovery rates; a. erosion and channelization b. infiltration c. hydrologic regimes d. site productivity	X	X	X	X	X	General Fund (S), S&P (F), Grants (P) (F).	MFRC, MDNR Forestry, U of M CNR, U of M NRRI, USFS NCFES.
4. Evaluate alternative technologies to accomplish timber harvest and other forest management activities.	X	X	X	X	X	General Fund (S), S&PF (F), Grants (P) (F)	MFRC,MDNR Forestry, U of M CNR, U of M NRRI, USFS NCFES.

Goal 5: Retain and restore forest vegetation on sensitive areas to improve water quality, absorb nutrients, restore habitat, provide alternative crop, improve aesthetics, slow flood discharge, and trap Sediment.

Milestones (Action Steps)	13	14	15	16	17	Funding Source(s)	Lead Agency(ies)
1. Restore riparian forest cover to 2,000 to 6,000 acres per year utilizing native species and hybrid varieties of trees, with preference for native species.	X	X	X	X	X	RIM (S), CRP (F), CREP (F), MFA (P), EQIP (F)	MDNR Forestry, MDNR Waters, MPCA.
2. Promote easement programs or tax incentives to promote riparian cropland to forest cover.	X	X	X	X	X	RIM (S), CRP (F), CREP (F), MFA (P)	BWSR, SWCD's.
3. Research the potential value of woody perennial species for wellhead protection and phytoremediation in agroforestry applications	X	X	X	X	X	U of M CNR and Extension (F, S), MDA (S), RC&Ds (F)	U of M CNR and Extension, RC&Ds, SWCDs
4. Conduct outreach and education about the value of woody perennial (and other native) species on sensitive lands. Target crop consultants and advisors, landowners, agricultural professionals, and others as needed.	X	X	X	X	X	U of M CNR and Extension (F, S), MDA (S), RC&Ds (F)	U of M CNR and Extension, RC&Ds, SWCDs
5. Promote programs to retain existing riparian forest areas, such as conservation easements, the forest legacy program, zoning, and outright purchase	X	X	X	X	X	General Fund (S) Grants (P) (F)	MDNR Forestry

Chapter 13 Subsurface Sewage Treatment Systems

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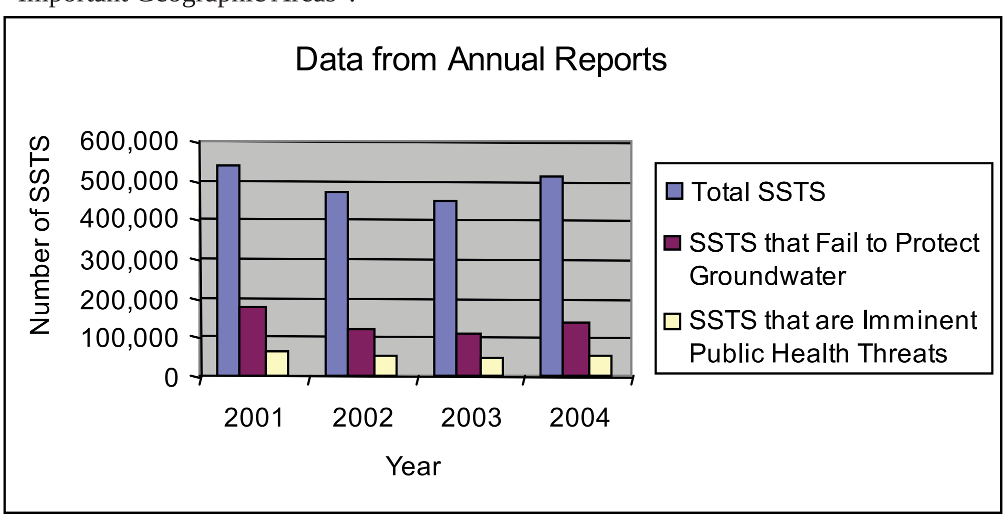
Introduction

According to data that local units of government provide to MPCA in annual reports, there are approximately 530,000 residences and other buildings served by Subsurface Sewage Treatment Systems (SSTS) in Minnesota. An informal survey of county planning and zoning administrators done by the Minnesota Pollution Control Agency (MPCA) in the 1980's indicated that 70 percent, or approximately 344,000, housing units at that time had systems that failed to provide basic sewage treatment and dispersal. Recent estimates reported to MPCA in the annual reports that local governments file have reduced that amount to approximately ten percent of all SSTS. This is a marked improvement in the number of homes discharging untreated sewage to the environment.

An estimated additional 27 percent of the current SSTS fail to protect ground water and will need to be replaced over time. It is important to note that most local governmental units (LGU) do not have accurate data, what is represented here are locally-derived estimates based on local official's experience in the area. Another important note is the qualifier that compliance rates vary widely across the state. Areas with soils that were not amenable to in-ground dispersal of treated sewage (areas with high water table and/or heavy clay soils) have more systems with surface discharges (imminent threat). This is changing now since advanced technology (sewage mounds, other advanced treatment systems) now offer more options for on-site treatment and dispersal. These areas formerly allowed discharge of sewage to drain tiles and ditches. This is now prohibited and existing surface discharges are beginning to be addressed. This is addressed in more detail later in this chapter under "Important Geographic Areas".



The large numbers of housing units that do not have adequate sewage treatment are due, in part, to:

- historic practices in onsite sewage management
- no or limited past regulation of SSTS at the local level
- local political pressure preventing proper enforcement of regulations
- lack of system maintenance and management
- minimal training of SSTS professionals

It should be noted that local units of government were not required to adopt and enforce a county-wide SSTS ordinance until 1999. The statewide SSTS licensing program began in 1996. Local units have been required to adopt an SSTS ordinance in shoreland areas for many years, with some having effective programs and others less so.

It should also be understood that nonconforming system criteria are vastly different for new systems than for existing systems. Nonconforming status for systems under construction is those systems that do not meet all code requirements such as the number of inspection pipes, cleanliness of distribution rock, etc. These nonconforming characteristics must be corrected before the SSTS is put into use.

Nonconforming status for existing systems is those systems that do not provide basic treatment and dispersal. More specifically Minn. R. ch. 7080 (Subsurface Sewage Treatment System Program) defines nonconforming existing systems as:

Systems which fail to protect ground water, including: seepage pits, cesspools, drywells, leaching pits, other pits, tanks that obviously leak below the designated operating depth, or systems with less than a 3-foot (2 foot for older systems) vertical separation distance from the system bottom to the seasonally high watertable or bedrock.

- Systems which pose an imminent threat to public health or safety. These situations include ground surface or surface water discharges and sewage backups.
- Systems which fail to perform as designed, or systems which are not monitored or failure to report monitoring (for performance and non-standard systems).

Important Geographic Areas

The majority of housing units served by SSTS are located in metropolitan suburbs, rural agricultural or remote areas, small cities, rural subdivisions and unincorporated areas of the state. In addition, numerous SSTS are used for homes and cabins on lakeshore lots, with a few located on urban lots within sewered cities.

Ground water contamination is a concern from cesspools, seepage pits and drywells. Surface water could also be impacted from the discharge of contaminated ground water. Direct surface water contamination is a concern from systems discharging to agricultural drain tile, road ditches, or to the ground surface. These concerns are magnified in areas of higher population density.

In addition to the above general areas, three areas of the state are of special concern. These areas are lakeshore areas, the Minnesota River Basin, and area covered in the Southeastern Minnesota Total Maximum Daily Load (TMDL). In many parts of the state local water planners have identified nonconforming SSTS as a priority issue in regards to lake water quality management. As an active response, many counties are undertaking surveys of SSTS in lakeshore areas and have enacted programs to bring systems into compliance. In the Minnesota River basin, it is estimated that 80 percent of systems are nonconforming, with approximately 45 percent or more discharging to draintile, road ditches or to the ground surface. This (along with feedlot discharges) has resulted in high levels of fecal organisms in the river. The Southeastern Minnesota TMDL estimates that 44 percent of rural households in this basin have inadequate sewage treatment, including individual residences and unsewered communities, both incorporated and unincorporated.

The Department of Natural Resources is developing advisory rule changes for shoreland areas as part of the Governor's Lakes Initiative in central Minnesota. These changes will not be mandatory for local units of government to adopt, but are presented as a way for local units that wish to provide greater protection for their shoreland areas.

Programs, Authorities and Best Management Practices for Implementing Subsurface Sewage Treatment System Controls

History of Program

Subsurface Sewage Treatment Systems regulation started in Minnesota in the 1960's with development of an onsite sewage treatment code by the Minnesota Department of Health. This code was not widely adopted or administered at the local level. In 1969, the Shoreland Management Act was passed that required all counties excluding municipalities to adopt shoreland management standards into their local land use controls. The act directed the Department of Natural Resources to develop appropriate standards and oversee their adoption and administration by the counties. The rules included SSTS standards for dwellings within shorelands. By 1973, most counties had adopted shoreland management controls. Later, the act was amended to include municipalities.

To assist with implementation of the shoreland management program, the University of Minnesota started a training program for the onsite sewage treatment contractors and local unit of government inspectors on the proper siting, design, construction, inspection and maintenance of SSTS.

The Minnesota Pollution Control Agency then developed a voluntary certification program for SSTS professionals and established state standards (Minn. Rules ch. 7080) in 1978. Chapter 7080 was mandatory in shoreland areas but not mandatory outside of shoreland areas. The shoreland regulations were to be administered by LGUs. Some LGUs adopted Chapter 7080 in shorelands but few provided adequate administration and enforcement. Some also adopted the standards outside of shoreland areas, but few had adequate administration and enforcement. Therefore, in a broad sense, SSTS regulation was spotty with weak administration and enforcement.

The first statewide SSTS legislation was passed in 1994 (Minnesota Laws chapter 617), codified as Minn. Stat. § 115.55. This statue contained rule requirements, inspection requirements and local ordinance requirements. The statute also contained requirements for an SSTS licensing program (Minn. Stat. § 115.56). These statutes were amended annually since 1997; as a result, the state SSTS program requirements have been under continual change since 1994. (For a detailed listing of the statutes, go to *www.pca.state.mn.us/programs/ists/*) Below are some of the major provisions of these statutes.

Ordinances

The statute requires LGUs to adopt and enforce SSTS ordinances. The deadline for adoption was January 1, 1999.

The statute requires ordinances to comply with Minn. R. ch. 7080; however, LGUs are allowed to adopt either more or less restrictive standards. The less restrictive standards are only allowed under limited conditions and must still adequately protect the public health and the environment. The changes to MR 7080 will require all counties to update their ordinances within a year of the rule's date of promulgation. Cities, towns and other non-county local units of government that regulate SSTS will need to update their ordinances to the new standards within a year of the county's update, and no later than two years after the effective date of the rules. This will result in freshly updated ordinances statewide and, at least in theory; more effective sewage treatment statewide as increased training and more rigorous standards are implemented.

Inspection

All systems under construction must be inspected. The law states that systems must be in compliance before adding a bedroom to a dwelling. In shoreland areas, systems must be in compliance before any type of permit is issued for the property. Upon property transfer in all areas, a disclosure of the status of the system must be provided between the buyer and seller. Many LGUs and lending institutions require a compliant system (or escrow funds) before a property is sold.

Upgrade Requirements

If a system is found to be an imminent threat to the public health and the environment, the statute requires an upgrade within ten months (maximum). If a system is found to be impacting ground water, the upgrade requirement is set by the local ordinance.

Licensing

Per statutory requirements, the MPCA has adopted rules to license SSTS professionals. The agency licenses designers, installers, inspectors and pumpers. Exemptions with qualifiers exist for state or local government employees; however, Chapter 7080 requires training, exam and experience requirements. License exemptions are also provided for individuals doing work on their own property and individuals performing work under a licensed person. The state licensing program includes requirements for enforcement, training, examination, experience, proof of general liability insurance, a corporate surety bond of at least $10,000 and an annual fee of $100/license category.

Roles of Each Unit of Government

Local Governmental Units

Local governmental units are responsible to adopt and enforce an SSTS ordinance. The ordinance may be either more or less restrictive than Chapter 7080. The LGU is required to issue permits and inspect for all new construction or replacement of systems and when issuing a permit for a bedroom addition.

Minnesota Department of Health (MDH)

The MDH requires compliant SSTS for establishments that require a MDH license to operate (e.g., restaurants, resorts, mobile home parks, etc.). While they do not have a program specifically for inspection of these SSTS, Health Department inspectors do require upgrades of systems that are Imminent Public Health Threats.

Minnesota Pollution Control Agency (MPCA)

The MPCA makes revisions and provides interpretation to chapter 7080; administers the statewide SSTS licensing and registration program; issues permits for SSTS with an average design flow of 10,000 gallons per day (gpd) or greater; assists the University of Minnesota (U of M) in training SSTS professionals; reviews local ordinances to determine if they adequately protect the public health and the environment; reviews annual reports submitted by the LGU and provides technical and administrative assistance to LGUs. Extensive rule changes are underway that will update technical standards and develop more specific standards for large SSTS serving clusters up to 30 homes and other establishments such as resorts, restaurants, etc.

U of M Extension Service

The U of M conducts research on new and existing SSTS and cluster technologies, provides statewide training workshops for SSTS professionals, provides education to homeowners on SSTS operation and maintenance, provides education to local decision-makers of small communities with nonconforming SSTS. The U of

M also provides technical assistance and materials to SSTS professionals, local units of government, Rural Development, homeowners and small communities.

Best Management Practices (BMP)

The following general list of BMPs is commonly used to reduce nonpoint source pollution from SSTS. This list is not comprehensive and does not suggest additional BMPs would have no benefit.

Please refer to the Part I Agricultural BMPs, Part II Erosion and Sediment Control BMPs and Part III Other Cultural and Structural BMPs in the Appendix *Best Management Practices* for definitions of the following BMPs.

Part I Agricultural Best Management Practices (BMP)

12. Fencing

Part II Erosion and Sediment Control Best Management Practices (BMPs)

1. Vegetation Establishment

12. Silt Fence

34. Topsoiling

Part III: Other Cultural and Structural Best Management Practices

56. Correct Use of Soils for Septic Systems

64. Proper Installation of Septic Tanks and Drainfields

66. Routine Maintenance of Septic Tank Systems

Chapter 13: Subsurface Sewage Treatment Systems (SSTS)

Needs, Priorities and Milestones, Action Plan

The action plan provided below summarizes the goals and milestones identified in the preceding sections. Many of the milestones listed below, as well as the implementation of specific projects, are contingent upon adequate funding and local involvement.

Goal 1: To have all counties adopt amended countywide SSTS ordinance that meets state standards of MR 7082, and to ensure that cities and towns that chose to regulate SSTS do so appropriately by February of 2014 for counties and one year later for smaller jurisdictions.

Milestones (Action Steps)	13	14	15	16	17	Funding Source(s)	Lead Agency(ies)
1. Work with Association of Minnesota counties to develop aids to facilitate county adoption of ordinances that meet state standards.	X					State Environmental Fund	MPCA, AMC
2. Provide assistance to counties individually as they develop ordinances, particularly in the area of flexibility provided in the rule and other approaches counties may take instead of adopting less restrictive standards.	X	X				SSTS Tank Fee, other state sources	MPCA
3. Review ordinances as they are completed and provide comments to the counties.	X	X				SSTS Tank Fee, other state sources	MPCA
4. Provide guidance and assistance to counties as they work with cities and towns to develop consistent ordinances.		X	X	X		SSTS Tank Fee, other state sources	MPCA
5. Use administrative and enforcement tools available to the Agency to ensure compliance by the local units of government.			X	X	X	SSTS Tank Fee	MPCA

Goal 2: Have all LGUs effectively administering their updated SSTS ordinance

Milestones (Action Steps)	13	14	15	16	17	Funding Source(s)	Lead Agency(ies)
1. Work with counties to develop criteria for evaluating program capacity through the SSTS Implementation and Enforcement Task Force.	X	X				Environmental Fund	MPCA/others

Milestones (Action Steps)	13	14	15	16	17	Funding Source(s)	Lead Agency(ies)
2. Provide oversight of local programs to ensure that cities and towns have sufficient resources to effectively administer and enforce their ordinances, and that they drop their ordinances if not.			X	X		SSTS Tank Fee	MPCA
3. Find most effective ways to improve county SSTS programs with additional funds provided through Clean Water Legacy	X				X	Clean Water Fund (CWF)	Clean Water Council

Goal 3: To effectively enforce the SSTS licensing program.

Milestones (Action Steps)	13	14	15	16	17	Funding Source(s)	Lead Agency(ies)
1. Continue communication with industry representatives to identify needed areas of license enforcement work.	X	X	X	X	X	SSTS Tank Fee	MPCA
2. Monitor complaints and assess trends to identify needed areas of license enforcement work.	X	X	X	X	X	SSTS Tank Fee	MPCA
3. Continue enhanced license enforcement efforts.	X	X	X	X	X	SSTS Tank Fee	MPCA

Goal 4: To increase the knowledge and dkill levels of SSTS professionals

Milestones (Action Steps)	13	14	15	16	17	Funding Source(s)	Lead Agency(ies)
1. Provide soils training in each of the state's major soil types.	X	X	X	X	X	Registration fees from SSTS training	U of M
2. Develop online or other remote training opportunities for SSTS professional continuing education		X	X	X	X	319	U of MN
3. Audit Type IV technology – visit installations of advanced treatment technology in SSTS and assess performance	X	X	X	X	X	319	U of MN

Goal 5: Provide technical and financial assistance to areas with inadequate Sewage Treatment (small communities, rural subdivisions, lakeshore sreas, unincorporated communities, etc.)

Milestones (Action Steps)	13	14	15	16	17	Funding Source(s)	Lead Agency(ies)
1. Request funding for wastewater treatment planning.	X	X	X			319 (for non-NPDES solutions), State MPCA, CWF	MPCA
2. Request funding for education of local leaders.	X	X				319 (for non-NPDES solutions),	U of MN and MPCA

Milestones (Action Steps)	13	14	15	16	17	Funding Source(s)	Lead Agency(ies)
3. Request funding for facilitation and technical assistance projects, such as the Southeast Minnesota Wastewater Initiative.			x	x	x	319, CWF	MPCA, SE MN Water Resources Board, BWSR
4. Request funding for technical assistance, organizational assistance, permitting, rule revision to accommodate moderate sized flows, financing assistance, enforcement of non-compliance.		X				319 (for non-NPDES solutions), CWF	U of M and MPCA.
5. Request funding for construction upgrades of failing systems.	X	X	X	X	X	319 (for non-NPDES solutions), State through Ag. BMP loans and SRF, CWF	MPCA
6. Implement expanded program.	X	X	X	X	X	319 (for non-NPDES solutions), State, CWF	MPCA

Goal 6: Provide education to local decision-makers, the public and special groups.

Milestones (Action Steps)	13	14	15	16	17	Funding Source(s)	Lead Agency(ies)
1. Request funding to increase homeowner education on the importance of proper SSTS maintenance.	X	X	X	X	X	CWF, 319	U of M
2. Develop and implement presentations to local decision makers on the importance of conforming systems.	X	X	X	X		CWF, 319	U of M
3. Provide presentations for special groups.	X	X	X	X		CWF, 319	U of M
4. Update the Homeowners Guide.	X					CWF, 319	U of M
5. Implement training for real estate agents.	X					CWF, 319	U of M
6. Develop programs for small communities on cluster and small community systems.	X	X				CWF, 319	U of M

Chapter 14 Effects of Atmospheric Pollution on Water Quality

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Introduction

The atmosphere as a significant source of pollution to surface water is a relatively recent idea, first demonstrated for acid rain (sulfur dioxide and nitrogen oxides: SO_2 and NO_x), and later for mercury, polychlorinated biphenyls (PCBs), and nutrients such as nitrogen (N) and phosphorus (P). Most pollutants in urban runoff are picked up by clean precipitation running off dirty surfaces; yet the dirt may have come from the atmosphere and the rain may already contain some of pollutants, such as phosphorus, nitrogen, mercury, pesticides, and PCBs. The development of impervious surfaces (paving, etc.) and storm sewers has the effect of increasing the efficacy of transport to surface water of deposited airborne pollutants. Consequently, impervious surfaces alone may create a nonpoint source (NPS) pollution problem for surface water, even without considering the watershed activities that contribute pollutants, such as lawn care, pet feces, eroded soil, and vegetative litter. The importance of atmospheric loading will vary, depending on the pollutant, the nature of the watershed and the water body type. In urbanized and agricultural watersheds, nutrient loading from the atmosphere may be negligible. But in the same watersheds, the atmosphere may be the main source of toxic pollutants, such as PCBs and mercury.

There are two situations where atmospheric deposition may be especially important sources of NPS pollution to surface water. First, lakes with a small watershed to lake surface area ratio can receive a large proportion of their loading from the atmosphere. For example, a study of Lake Mille Lacs suggests that precipitation (wet and dry fall) may contribute approximately 48 percent of the annual phosphorus loading to the lake. (Lake Mille Lacs occupies 53 percent of its total watershed area.) Similarly, airborne dust is thought to deliver the majority of phosphorus loading to Lake Superior. Second, some pollutants may be primarily delivered by the atmosphere even when there is significant human activity in the watershed. For instance, the geological source material in most watersheds does not contain a significant source of mercury. Mercury in a waterbody is most likely a result of atmospheric deposition. In addition, environmentally significant levels often accumulate in soils due to atmospheric deposition. If soil is eroded or inundated (say, through impoundment), there may be significant increases in mercury contamination to aquatic systems in the watershed.

Definitions

Point Source Emissions to Air can become Nonpoint Source Pollution

Atmospheric deposition of pollutants is implicitly nonpoint source pollution in this document. Yet, the emission source to the atmosphere may well be a point source such as an emission stack. It is worth pointing out that even if modeling or measurement studies verify a direct relationship between a point source of air emissions and deposition to a water body, water managers may still consider that source of pollution to be nonpoint, because it is delivered by the atmosphere.

Air managers identify three basic categories of emission: point sources, area sources, and mobile sources. Each category is further subdivided into subcategories. Point sources are permanently fixed stacks of known diameter, elevation, temperature, and exit velocity.

Area sources include windblown dust from stockpiles or tilled fields, fugitive emissions from a landfill or the numerous valves and connections at a refinery, and forest fires. Mobile sources are divided into on-road sources such as traffic emissions and dust from unpaved roads, and off-road sources such as lawn mowers, portable generators, chain saws, and snowmobiles.

Wet Deposition

Pollutants in the atmosphere can be scavenged by precipitation or act as condensation nuclei for precipitation formation and thereby be deposited to surface water and land in the form of rain or snow.

Dry Deposition

Particles in the air are deposited onto surface water and land surfaces at a rate that depends on the particle size, wind speed, and other factors. Gaseous pollutants can also be deposited to water and land.

Indirect Versus Direct Deposition

Air pollutants are not only deposited directly to the surface of waterbodies, but are also deposited to watersheds and then enter surface waters indirectly, through storm water runoff, tributaries, and ground water seepage. Where the watershed is large relative to the open water, indirect loading can exceed direct loading.

Volatilization

Previously deposited gaseous and semi-volatile chemicals, such as mercury and PCBs, can be re-emitted to the atmosphere as the result of many factors, including chemical reactions and changes in temperature or wind speed. Types of airborne pollution that can affect surface water. Any change in the physics or chemistry of the atmosphere can negatively affect surface water. For example, depletion of stratospheric ozone could increase the damage to aquatic life from increased Ultra Violet (UV) radiation. Global warming is projected to virtually eliminate the cold water fishery in Minnesota, while simultaneously reducing the duration of ice-cover and therefore winterkills.

A wide variety of materials are deposited from the atmosphere that can affect the surface water. Some airborne materials are toxic (e.g. mercury, PCBs, lead, dioxin), some are nutrients (e.g., phosphorus and nitrogen), and some interact with other pollutants (e.g., calcium carbonate in wind-blown soil can neutralize acid rain, or sulfate deposition may stimulate the methylation of mercury in low-sulfate systems).

The following is a description of the different types of changes in the atmosphere that can affect surface water.

Carbon Dioxide and other Greenhouse Gases

Scientists believe that emissions of certain gases to the atmosphere are causing warming and possibly other changes in the climate. The greenhouse gases include the naturally occurring compounds carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_2O). Humans also release synthetic greenhouse gases that contribute significantly to climate change (chlorofluorocarbons (CFCs), hydrofluorocarbons (HFCs), and perfluorocarbons (PFCs). Carbon dioxide is released to the atmosphere when solid waste, fossil fuels (oil, natural gas, and coal), and wood and wood products are burned.

Methane is emitted during the production and transport of coal, natural gas, and oil.

Methane emissions also result from the decomposition of organic wastes in municipal solid waste landfills, and the raising of livestock.

Nitrous oxide is emitted during agricultural and industrial activities, as well as during combustion of solid waste and fossil fuels. Greenhouse gases that are not naturally occurring include byproducts of foam production, refrigeration, and air conditioning called *chlorofluorocarbons* (CFCs), as well as *hydrofluorocarbons* (HFCs) and *perfluorocarbons* (PFCs) generated by industrial processes.

Each greenhouse gas differs in its ability to absorb heat in the atmosphere. Hydrofluorocarbons and PFCs are the most heat-absorbent. Methane traps over 21 times more heat than carbon dioxide, and nitrous oxide absorbs 270 times more heat than carbon dioxide.

Global warming has already caused significant reductions in the duration of ice cover in Minnesota. Models show that winterkills will get rarer. As summer temperatures rise, summer kills will become more common and in some lakes cold water fisheries will shift to warm water. It will be harder to predict effects on other temperature- and CO_2-sensitive processes, such as mercury methylation and plant growth. Since chemical reaction rates, and the growth rates of bacteria, plants, and cold-blooded animals are all highly dependent on temperature, there may be many unanticipated effects of global warming.

CFCs and other Ozone-Depleting Substances

When CFCs reach the stratosphere, the ultraviolet radiation from the sun causes them to break apart and release chlorine atoms which react with ozone, starting chemical cycles of ozone destruction that deplete the ozone layer. One chlorine atom can break apart more than 100,000 ozone molecules.

Other chemicals that damage the ozone layer include methyl bromide (used as a pesticide), halons (used in fire extinguishers), and methyl chloroform (used as a solvent in industrial processes). As methyl bromide and halons are broken apart, they release bromine atoms, which are 40 times more destructive to ozone molecules than chlorine atoms.

Reductions in stratospheric ozone levels lead to higher levels of UVB reaching the Earth’s surface. Studies have shown that in the Antarctic, the amount of UVB measured at the surface can double during the annual ozone hole. Another study confirmed the relationship between reduced ozone and increased UVB levels in Canada during the past several years.

Ozone levels vary by season and latitude. In the middle latitudes (most of the populated world), ozone levels have fallen about ten percent during the winter and five percent in the summer. Since 1979, they have fallen about five percent per decade when averaged over the entire year. Depletion is generally worse at higher latitudes, i.e. further from the Equator.

In the marine environment, solar UVB radiation has been found to cause damage to early developmental stages of fish, shrimp, crab, amphibians and other animals. The most severe effects are decreased reproductive capacity and impaired larval development. Even at current levels, solar UVB radiation is a limiting factor in some systems. It is uncertain what effect enhanced UVB radiation would have on the Minnesota environment.

Mercury

Mercury vapor emissions from combustion sources result in ambient air concentrations below those of concern for direct human health effects through inhalation. Once in the atmosphere, mercury vapor is slowly converted to a divalent form that is water soluble, and subject to wash out in precipitation. Its concentration in rain is usually above the ambient surface water quality standard of 6.9 nanograms per liter (ng/L) (1.3 ng/L in the Lake Superior basin). Some proportion (usually between 1 to 20 percent) of this mercury is converted to methyl mercury by sulfate-reducing bacteria in the aquatic system or its watershed. Methyl mercury is bioaccumulated to a great degree in the aquatic food chain. Methylation rates appear to be higher in wetlands than other environments by one or two orders of magnitude. Mercury is probably the most pervasive type of atmospheric NPS pollution in Minnesota, causing fish consumption restrictions on over 90 percent of the lakes tested in the state.

Acid Rain

Sulfuric Acid:

Sulfuric acid presents the potential for acidification of surface water, although there is no known permanent damage in Minnesota. There is evidence that increased loading of sulfate stimulates the growth of bacteria that convert sulfate to sulfide in wetlands, which also increases the proportion of mercury that is methylated.

Nitric Acid:

Nitric acid presents the potential for acidification of surface water, although there is no known permanent damage in Minnesota. Nitric acid acts as nutrient in nitrogen-poor lakes, such as oligotrophic lakes in northern Minnesota.

Wind Blown Soil

Generally, the size spectrum of wind blown soil particles is sufficiently large that it is not a human health concern for inhalation. However, some components of wind blown soil can have impact on surface water.

Calcium Carbonate

Calcium carbonate, a base, neutralizes acid rain in the atmosphere.

Calcium Sulfate

Calcium sulfate, which is pH-neutral, can contribute sulfate to sulfate-poor systems, which may stimulate the methylation of mercury.

Phosphorus

Phosphorus is held tightly by soil, so that movement of wind blown soil to surface water can contribute to eutrophication.

Mercury

Soil binds and efficiently holds mercury deposited from the atmosphere, so that the movement of soil to surface water can introduce large amounts of this metal. Lakes in agricultural areas receive high loading of mercury due to soil erosion, but it is unclear whether this mercury is always available for methylation. It is not known how much mercury is carried to lakes by wind blown soil.

Iron

Iron is a limiting nutrient in oligotrophic systems, a phenomenon well documented for the Pacific Ocean and Lake Tahoe. The oligotrophic lakes in northern Minnesota may also respond to iron additions, although the critical experiments have never been performed. Soil contains significant quantities of iron, so wind blown soil could conceivably fertilize lakes.

Anthropogenic Particulate Matter in the Atmosphere

Particulate matter is emitted by point sources, area sources, and mobile sources, and often contain materials that might affect surface waters.

Metals

Heavy metals such as cadmium, lead, and silver can be emitted in quantities that are potentially significant to surface water.

Soot

A product of incomplete combustion, soot provides a highly adsorptive surface that can scavenge pollutants such as mercury and dioxin from the atmosphere. Sources of soot include forest fires and poorly tuned combustion devices. Soot may enhance deposition of pollutants to nearby lakes.

PCBs

In earlier times, PCBs were introduced into the environment from point sources, but now PCBs cycle from water bodies to the atmosphere and back to the water. PCBs present a challenge for remediation because they are semivolatile, hydrophobic, bioaccumulate, and are extremely resistant to decay. The sale and new use of these chemicals were banned by law in 1979. The Great Lakes are at present net emitters of PCBs to the atmosphere. NPS impacts appear to be in oligotrophic lakes with long-lived lake trout, and perhaps urban areas possessing impervious surfaces that funnel deposition to surface water.

Dioxin

Dioxin (dibenzo-p-dioxins) is a product of incomplete combustion, and also can be formed in processes that utilize chlorine such as paper bleaching. Air emissions of dioxin are extremely low and atmospheric deposition has not been satisfactorily measured. Direct discharge can result in dioxin accumulation in fish in the surface water.

Pesticides

Many pesticides have the potential to cause problems in aquatic systems. Potentially damaging pesticides that have significant deposition rates from the atmosphere include chlordane, DDT/DDE, dieldrin, hexachlorobenzene, alpha-HCH, lindane, and toxaphene. Because of restrictions, none of these currently have significant sources within the United States. However, volatilization from soils or wind blown soil can deposit significant quantities of these persistent chemicals. In some cases, the compounds are currently used in other countries and transported by the atmosphere to the United States.

Chemicals that Disrupt Hormonal Function in Wildlife and Humans

Many chemicals released by human activity have the potential to disrupt the endocrine system of animals, including fish, birds, mammals, and humans. Among these chemicals are persistent, bioaccumulative compounds that include some pesticides, and industrial chemicals such as DDT, lindane, octachlorostyrene, certain PCB congeners, 2,3,7,8-TCDD and other dioxins, 2,3,7,8-TCDF and other furans, atrazine, cadmium, and mercury. The impacts include thyroid dysfunction in birds and fish, decreased hatching success in birds, fish, and turtles, gross birth deformities, in birds, fish, and turtles, demasculinization and feminization of male fish, birds, and mammals, and defeminization and masculinization of female fish and birds. Many of these compounds are delivered by the atmosphere to aquatic systems.

Ammonia

Like nitrate, atmospheric ammonia that is deposited to lakes and watersheds adds nitrogen to aquatic systems. The addition of nitrogen can contribute to eutrophication, a particular problem in N-limited, oligotrophic lakes in northern Minnesota. Additions of nitrogen may also affect species balances in other systems like prairies and wetlands. The largest sources of ammonia emissions to the atmosphere are: animal agriculture (81 percent), fertilizer application (ten percent), refrigeration (five percent), and other activities (four percent). In terms of total nitrogen emissions to the atmosphere in Minnesota, the major contributors are: animal agriculture (32 percent), mobile sources (22 percent), electric utilities (22 percent), other fuel combustion (13 percent), and nitrogen fertilizers (11 percent).

Emerging Contaminants

Two groups of persistent bioaccumulative toxic compounds, which have been categorized as emerging contaminants because scientific studies of their ecotoxicology, are perfluoroctane sulfonate (PFOS) and polybrominated diphenyl ethers (PBDE). PFOS is a perfluorinated compound produced for numerous products and has been found in the tissues of fish and wildlife in remote areas. PBDEs are brominated flame retardants used in many household products and have also been found to be bioaccumulating in fish and wildlife. PBDEs are similar in structure to PCBs, but unlike PCBs, which are decreasing in environment, PBDEs are increasing. This has been clearly demonstrated in Great Lakes fish. The dissemination of PFOS is expected to diminish. Some types of PBDEs have been banned, while others continue to be used and studied.

Geographic Areas of Concern

For most airborne pollutants, it is uncertain what factors might make some geographic regions more sensitive than others. However, it is clear that geological areas low in alkalinity are more sensitive to acid rain. For less obvious reasons, low alkalinity regions are also more sensitive to mercury deposition. These areas of Minnesota are of special concern and will be included in ongoing research into atmospheric deposition of pollutants.

Best Management Practices (BMPs)

Best Managment Practices usually control pollutants as near as reasonable to the pollution source. Atmospherically deposited pollutants generally migrate from sources outside the watershed, making the conventional concept of BMP difficult to implement. The best BMP to reduce atmospheric deposition is to halt the release of these pollutants into the atmosphere. Because of the diversity of sources, cessation of release is complicated and would require the coordination of the full spectrum of the economy, including agriculture, energy production, transportation, waste disposal, manufacturing, and government. Because the atmosphere carries some materials long distances, it may be necessary to address many of these atmospheric pollutants on a national and international basis. For instance, the MPCA estimates that 90 percent of the mercury deposited in Minnesota comes from out of state. It is therefore important to communicate the need for national level controls to the U.S. Environmental Protection Agency for mercury and other pollutants subject to long-distance atmospheric transport.

Existing BMPs for some other pollutants may lead to some surprising situations. For instance, it is increasingly common to use wetlands to trap sediments and associated nutrients in storm water before the pollutants can get to a lake or stream. However, the high biological activity of wetlands may lead to some negative consequences for persistent bioaccumulative chemicals. For instance, mercury deposited to terrestrial systems binds strongly to soil particles. Eroded soil may be caught in a wetland, where the mercury would be subject to biological activity. Because of the heightened activity of anaerobic bacteria that convert sulfate to sulfide, methylation rates are perhaps 100 times higher in wetlands than in lakes. Use of wetlands to clean runoff may therefore enhance methyl mercury loading to surface water, which would increase the concentration of mercury in fish.

Best Management Practices for a particular atmospheric pollutant should be selected only after its cycle and fate have been evaluated. Otherwise, we may find ourselves exacerbating the effects of a particular pollutant, as in the hypothetical case of mercury, above. Another example of the consequences of an incomplete understanding might be attempting to reduce PCBs in Lake Superior by reducing inputs. The PCB burden in Lake Superior is determined by volatilization back to the atmosphere, not external loading. Although research on the environmental fate and budgets of persistent chemicals may be expensive, it is less expensive than making management decisions based on erroneous assumptions, resulting in expensive but ineffective treatment.

Programs and Authorities

- National Pollutant Discharge Elimination System permits - pretreatment requirements
- pollution prevention
- water quality standards
- air emission controls
- fish consumption advisories
- recycling and product screening (e.g., Hg switches in consumer items, such as shoes)
- market incentives
- Statutes and Rules (e.g., ch. 7050)
- Minn. Stat. § 116.454, authorized the Minnesota Pollution Control Agency (MPCA) to initiate a statewide air toxics monitoring network and air toxics inventory in calendar year 1993.
- The Acid Deposition Control Act (Minn. Stat. § 116.42-116.45) was passed in 1982 and was the first of its kind in the nation; it required the MPCA to (1) identify the areas of the state containing resources sensitive to acid deposition, (2) develop a standard to protect these resources, (3) adopt a control plan to reduce sulfur dioxide emissions, and (4) ensure that all Minnesota sources subject to the control plan are in compliance by January 1, 1990.
- Minn. Stat. 116.915 subd. 1—known as the 1999 mercury reduction law called for specific mercury reductions and established mercury emission goals for 2001 and 2005; those goals were achieved.
- The Clean Water Act, Section 303(d), requiring total maximum daily loads (TMDL) for targeted impaired waters, led to the MPCA drafting a Statewide Mercury TMDL, which was approved by the U.S.Environmental Protection Agency (EPA) in March 2007 for over 500 impaired waters listings. During the development of the 2008 impaired waters list, the MPCA intends to add over 500 more mercury impairments to the TMDL.

Sequence for Implementation of NPS Effort for Atmospheric Pollutants

1	Identify water quality problem
2	Determine air pollution as the cause.
3	Determine source of air pollution (e.g., area or facility)
4	Evaluate the relative efficacy of BMPs within the watershed in contrast to air emission reductions

Chapter 14: Effects of Atmospheric Pollution on Water Quality

Needs, Priorities and Milestones, Action Plan

The Action Plan provided below summarizes the milestones identified in the preceding sections. Many of the milestones listed below, as well as the implementation of specific projects, are contingent upon adequate funding and local involvement.

Goal: To Develop a Quantitative Understanding of the Effect of Air Pollutants on Water Quality and to Develop Appropriate Best Management Practices to Minimize the Impact of Air Pollution on Water Resources.

Milestones (Action Steps)	13	14	15	16	17	Funding Sources	Lead Agency(ies)
1. Quantify deposition of metals (cadmium, lead, iron, etc.) and phosphorus in select watersheds.	X	X	X	X	X	MPCA, TMDL	MPCA
2. Develop monitoring effort for effect of global warming on surface water; ice cover times and water temperature.	X	X	X	X	X	General Fund	MDNR, MPCA
3. Quantify proportion of phosphorus and mercury deposited from atmosphere that results from wind erosion of soil.	X	X	X	X	X	TMDL	MPCA
4. Evaluate why lakes vary greatly in mercury contamination of fish, given that atmospheric deposition is relatively homogeneous.	X	X	X	X	X	TMDL, USGS	MPCA, USGS
5. Evaluate effect of sulfate loading on mercury methylation.	X	X	X	X	X		MDNR,MPCA, Science Museum
6. Quantify relationship between emissions of pollutants and deposition to surface water and watersheds.	X	X	X	X	X	General Fund	MPCA
7. Evaluate methylation of mercury in wetlands used as BMPs for trapping runoff.	X	X	X	X	X	General Fund; USEPA	MPCA
8. Investigate the impact of atmospheric deposition of endocrine-disruptive compounds on aquatic organisms.	X	X	X	X	X	General Fund	MPCA
9. Investigate whether aquatic resources near emission sources experience increased impacts.	X	X	X	X	X	General Fund	MPCA

Milestones (Action Steps)	13	14	15	16	17	Funding Sources	Lead Agency(ies)
10. Develop land-based BMPs for watersheds to minimize the impact of pollutants deposited from the atmosphere.	X	X	X	X	X	General Fund	MPCA
11. Study the effect of UV radiation on the health of aquatic organisms due to ozone depletion in the stratosphere due to air pollution.	X	X	X	X	X	General Fund	MPCA
12. Determine if non-mercury air pollutants can increase mercury in water by accelerating the atmospheric deposition of mercury.	X	X	X	X	X	General Fund	MPCA
13. Investigate if PCBs in surface waters includes “inadvertent” PCBs from ongoing generation and release or legacy PCBs from “old” PCB cycling in the atmosphere.	X	X	X	X	X	General fund, USEPA	MPCA
14. Investigate if atmospheric transport is responsible for “pseudo-persistence” of bis-phenol a (BPA) (it breaks down rapidly in bench scale tests but is found at high levels in freshwater).	X	X	X	X	X	General fund, USEPA, USGS	MPCA
15. Investigate possible atmospheric transport of chlorpyrifos, (Minn. Dept. Agriculture listed it as a “pesticide of concern” in 2012 because it is being detected with increasing frequency and at elevated concentrations in Minnesota’s surface water)	X	X	X	X	X	General fund, USEPA, MDA	MPCA
16 Monitor the presence of alkylphenol ethoxylates in air and the contribution of alkylphenol ethoxylates to lakes and rivers in Minnesota through atmospheric deposition.	X	X	X	X	X	General fund, USEPA,	MPCA
17. Develop a statewide monitoring plan for atmospherically-deposited brominated flame retardants in sediments (extremely low concentrations of brominated flame retardants are typically found in water).	X	X	X	X	X	General fund, USEPA,	MPCA
18. Develop a statewide monitoring plan for polycyclic aromatic hydrocarbons (PAHs) (PAHs are detected in all environmental media. Their presence in air and surface waters pose concerns for human health).	X	X	X	X	X	General fund, USEPA,	MPCA
19. Develop a plan to assess the extent of burn barrels as dioxin sources to the air and water in Minnesota (According to USEPA, burn barrels are the number one source of dioxin in the U.S.)	X	X	X	X	X	General fund, USEPA,	MPCA

Appendix A

Nine Key Elements of a Successful Nonpoint Source Management Program

Minnesota's Nonpoint Source Management Program Plan (NPSMPP)

Citations provided after each element, indicates where and how the NPSMPP satisfies each of the Nine Key Elements.

ELEMENT 1. *Explicit short-and long-term goals, objectives and strategies to protect surface and ground water.*

All chapters/strategies of the NPSMPP include a narrative providing nonpoint source (NPS) information for that chapter/strategy. The following items are provided at the beginning of Chapters/Strategies 4.

1. Goals
2. Needs, Priorities and Milestones
3. Action Steps recommended to be carried out during the effective time period

The combination of narratives of the chapters/strategies including Goal statements and Needs, Priorities and Milestones (Action Steps) Tables beginning with Chapters/Strategies 4, present Minnesota's strategy for protecting surface and ground water during the time period of this plan.

Minnesota's short-term goals for Minnesota's impaired waters are as follows:

Continue developing approach for performing Total Maximum Daily Load (TMDLs), focusing on encouraging local involvement and leadership in TMDL development and implementation.

Integrate TMDL and source-water protection efforts where practical. Develop sourcewater TMDL for Twin Cities and St. Cloud area bacteria impairments.

Continue to inform parties impacted by TMDLs of their implications including local water resource managers in areas where impaired waters are found, agricultural interests, industry, forestry interests, environmental advocacy groups, etc.

Continue to initiate and complete TMDL studies, followed by implementation plan development and execution.

ELEMENT 2. *Strong working partnerships and collaboration with appropriate State, interstate, Tribal, regional, and local entities (including conservation districts and special units of government such as drainage commission), private sector groups, citizens groups, and federal agencies*.

MPCA BASIN MANAGEMENT AND COORDINATION: Although the MPCA has legal responsibility for administering the Clean Water Act, the protection and restoration of the Minnesota's streams, rivers, lakes, wetlands, and shores depends on the collective efforts of citizens, businesses, tribal nations, and governmental agencies. The basin management process was designed to establish and support a strong partnership among the MPCA and other organizations responsible for managing the state's water resources. Basin management is also intended to ensure meaningful public participation in decision-making processes. As the MPCA works to involve citizens in basin planning efforts, it will ensure that public participation efforts conform to the requirements of Part 25 of 40 Code of Federal Regulations (CFR) Chapter 1.

A stakeholder is defined as any entity involved in or affected by watershed management activities. The term "stakeholder" covers a broad range of people and organizations, which can be grouped into three general categories:

Government: city, county, regional, state and federal agencies.

Business: commercial and industrial establishments; mining, agricultural and forestry operations; utilities; business groups; and trade associations.

The Public: individual residents and landowners; schools; and interest groups (including citizen, environmental, consumer and community groups).

By establishing more cooperative working relationships and providing opportunities for participation, the Basin Management approach strives to improve ways of identifying common water quality goals and problems and implementing cost-effective solutions.

Statewide for agencies and organizations concerned about watershed management-related activities across the entire state who need a statewide structure for targeting and synchronizing efforts with one another.

At the *basin level* for assessing water-quality conditions within a large basin and finding basin-specific management goals and priorities that multiple stakeholders share and want to work on together.

At the *local watershed level* to develop management strategies and plans and to rally public support and participation for protecting and restoring water quality. This means cooperatively developing and implementing plans for priority areas that incorporate both voluntary and regulatory actions.

See Chapter 3 of the Minnesota NPSMPP for more information on how collaboration on NPS issues is fostered through the watershed approach in Minnesota.

ELEMENT 3. *A balanced approach that emphasizes both statewide nonpoint source programs and on the ground management of individual watersheds where waters are impaired or threatened.*

The 319 and CWP Programs both contribute financial and technical resources to protect water resources in watershed areas. See Chapter 2 for more information on how Minnesota uses its funding programs to foster the watershed approach.

Chapter 3 Watershed Management of the NPSMPP details the relationship between resources and management of impaired or threatened water resources.

Minnesota Clean Water Partnership (CWP) Program:

The CWP program was established by Minn. Stat. §§ 103F.701 to 103F.761. The program focus is on control of nonpoint sources of pollution through watershed management to protect and improve surface and ground water in Minnesota. The CWP program provides financial assistance through matching grants, State Revolving Fund (SRF) loans, and technical assistance to LGUs to lead pollution control projects.

The Clean Water Partnership Rules (Minn. R. ch. 7076) adopted in September 1988 and revised September 1991, 1995 and 2013 define the criteria and procedural conditions under which the MPCA may award grants to local governments. The rules provide separate grants for 50 percent of the eligible costs for resource investigation projects (Phase I) and implementation projects (Phase II). Resource investigation projects are designed to complete a Phase I diagnostic study and subsequently develop an implementation plan. Phase I activities include water quality monitoring, identifying the sources of pollution and the combination of best management practices (BMPs), activities and protective measures that will be necessary to solve the identified problems. A Phase II project is designed to install the BMPs and carry out educational and other support activities identified in the implementation plan.

Federal Clean Water Act Section 319 Funding:

In 1987 the Clean Water Act was amended to include Section 319, a new section which authorized federal assistance for implementing NPS programs.

The U.S. Environmental Protection Agency (USEPA) has granted Section 319 funds by first establishing a base funding level for each state to institutionalize the program over the long term. In addition to base level funding, the USEPA regional offices allocate additional funds to each state in their region for selected NPS implementation projects. Project money is allocated competitively among the states within an USEPA Region.

Project funding is available to all state agencies or local entities that meet USEPA match requirements and USEPA/MPCA funding criteria. Project money is awarded competitively based upon project merit and consistency with Section 319 program requirements and priorities.

MPCA Watershed Approach:

The MPCA has moved toward a more integrated, water resource-based approach for its water quality management programs. This approach is referred to as the watershed approach.

Traditional water quality efforts have focused on specific pollutants and pollution sources. In contrast the watershed approach starts with a focus on the water resources themselves and considers each in terms of the cumulative effects from multiple pollution sources that may threaten or impair its use. By shifting the focus to the problems and needs of individual water resources, the watershed approach helps to link point source and NPS programs together to form a coordinated management strategy.

The MPCA's watershed approach process is intended to strengthen the connections between all water quality program activities – from monitoring and assessment to assistance and compliance. On a rotating cycle, priority water bodies are identified in each of Minnesota's ten major drainage basins. Point source and NPS program resources are then coordinated in a way that addresses the particular problems and needs of those priority water bodies. An approach is prepared that describes the condition of water bodies and identifies the priorities, sets water quality goals and describes recommended management strategies to be taken.

ELEMENT 4. *The State program (a) abates known water quality impairments resulting from nonpoint source pollution and (b) prevents significant threats to water quality from present and future activities.*

The entirety of this Nonpoint Source Management Program Plan (NPSMPP) is about how Minnesota uses a combination of approaches and programs to abate and prevent NPS pollution. The plan documents progress that has been made since previous plans were produced, and includes action strategies on how NPS pollution abatement and prevention will be carried out over the time period of this plan.

The MPCA uses its own monitoring data and data from other sources to characterize the condition of water resources in the state in preparing the CWA 305b water body assessments. The assessments characterize the conditions of monitored waters of the state and suggest possible causes of impairments for individual waterbodies, including specific types of nonpoint source pollution. From the 305b assessments, the MPCA develops its Clean Water Act (CWA) 303d list of impaired waters, or Total Maximum Daily Load (TMDL) list. The MPCA has developed a schedule for developing TMDLs for these waters and has begun work with local resource managers and citizens on several of the state's impaired waters impacted by nonpoint source pollution.

The MPCA has developed a "protection strategy" designed to ensure that unimpaired waters are not ignored as impaired waters receive focus. The strategy is currently being discussed with other state agencies.

ELEMENT 5. *An identification of waters and watersheds impaired or threatened by nonpoint source pollution and a process to progressively address these waters.*

Chapter 1 of the NPSMPP is the "Updated Nonpoint Source Assessment" Chapter where impaired waters are identified as being affected by nonpoint source pollution. Through 319 and state CWP and Clean Water Legacy Act funding, the state continues to address nonpoint source pollution.

Watershed Approach: The watershed approach emphasizes watershed protection and restoration. Key elements include watershed-based permitting, identification of goals and priorities at the watershed scale, and greater involvement by partners and the public.

The following programs are all part of the MPCA's efforts to identify impaired water resources and systematically address these resources:

Citizen Lake Monitoring Program (CLMP) and Lake Assessment Program (LAP):

Since the mid-1980s, MPCA's lake monitoring efforts have been focused on several areas, including CLMP and LAP. In the CLMP, citizens reside on or near lakes take weekly transparency measures using a secchi disk and record their perceptions of the physical appearance and recreational suitability of their lake. This program is wholly based on public participation. This information is used for problem identification and goal setting.

LAPs are more complicated. Each LAP is a cooperative study of a lake involving MPCA staff and local citizens. The studies characterize a lake's condition and how it is being affected by its watershed. They provide valuable information for local governments and others interested in protecting or improving the quality of a lake.

Continuous Planning Process (CPP):

The Clean Water Act Section 303(e) Continuous Planning Process document for the MPCA describes the processes and procedures we use for water quality planning. There are nine specific processes that must be contained in each state CPP, including water quality standards development, TMDL allocation implementation, and a process for determining the priority of permit issuance.

MPCA's CPP emphasizes water resource protection and restoration. Chapter 2 deals with geographic planning, stakeholder involvement, and water quality standards. Chapter 3 focuses on stakeholder outreach, our five-year planning cycle, and other scheduling issues. The planning cycle includes data assessment, prioritization and targeting, integrated management strategy development, and implementation. This process demonstrates strong commitment to public participation, coordination with other agencies, problem identification and implementation, the role of TMDLs, and goal setting.

Citizen Stream Monitoring Program (CSMP):

The CSMP is equivalent to Minnesota's CLMP, but focusing on streams and rivers. This program is also wholly based on public participation. A transparency tube is used instead of the secchi disk and user perception measures are gathered similar to the CLMP. The information will be used to address short term questions like seasonal differences in streams and impacts of storm events, and also be used for long term questions like trend analyses basin planning.

Clean Water Partnership Program (CWP):

Minnesota's CWP program was created to address pollution associated with runoff from agricultural and urban areas. It provides local governments with resources to protect and improve lakes, streams, and ground water. Clean Water Partnership Program projects have two phases: Phase 1 is the resource investigative phase and Phase 2 is the implementation phase. Local sponsors work with the MPCA to collect data and information on the resource and its watershed. These programs strongly emphasize public participation, problem identification, and goal setting.

Great Lakes Initiative (GLI) [Minn. R. ch. 7052]:

The process for incorporating the Great Lakes Initiative into the MPCA water quality standards [Minn. R. ch. 7052] is an excellent example of the strong commitment the agency has toward public participation and coordination with local units of government, other state agencies, and other federal and international agencies. All our major modifications to our water quality standards, such as the incorporation of toxic standards and wetland water quality standards, follow these same measures to ensure the broadest possible review.

Phosphorus Strategy:

MPCA recognizes that phosphorus is a pollutant of concern, and has developed a seven part strategy: education and outreach to the public, initiate several phosphorus forums, emphasize the watershed approach to deal with the cumulative problems associated with phosphorus, more broadly implement water quality standards, promote lake initiatives focusing on phosphorus, begin to address phosphorus impacts to rivers, and, if necessary, modify the water quality standards.

Total Maximum Daily Load (TMDL) studies:

The federal Clean Water Act requires states to adopt water quality standards to protect the nation's waters. These standards define how much of a pollutant can be in a surface and ground water and still meet its designated uses, such as for drinking water, fishing, swimming, irrigation, and/or industrial purposes. Many of Minnesota's water resources cannot meet their designated uses because of pollution problems from a combination of point and nonpoint sources.

The Clean Water Act requires states to publish a list of streams and lakes every two years that are not meeting their designated uses because of excess pollutants. The list, known as the 303(d) list, is based on violations of water quality standards, and is organized by river basin. The MPCA must complete TMDL studies for all waters on this list.

A TMDL study identifies the sources of each pollutant that result in the exceedance of water quality standards. When conducting a TMDL, all the point sources and all types of the nonpoint sources that contribute are identified. Water quality sampling and computer modeling work are done to determine how much each pollutant must reduce its contribution to assure the water quality standard is met. Individual lakes and streams may require TMDLs for more than one pollutant.

The iterative approach to creating TMDLs is to use the simplest method appropriate for the parameter of concern. For streams dominated by nonpoint source pollution that are diffuse and watershed wide in scope, a load or concentration based spreadsheet will usually be the most appropriate approach. For streams dominated by point source pollution and for those streams with a typical hydrology, a complex water quality modeling approach that is very data intensive will usually be the most appropriate approach. The actual approach taken for each TMDL will be based on reach specific concerns, including local preferences. For either approach, a pollutant reduction goal will be established. As implementation proceeds, the reach will be monitored to ensure that the water quality objectives are being achieved. If the selected approach is not succeeding, a more rigorous approach will be developed. The iterative approach to creating and implementing TMDL reduction goals is very much a dynamic process.

The state is making great strides in completing TMDL studies using funds from the state Clean Water Legacy Act.

ELEMENT 6. *The State reviews, upgrades and implements all program components required by section 319 of the Clean Water Act, and establishes flexible, targeted, iterative approaches to achieve and maintain beneficial uses of water as expeditiously as practicable.*

Minnesota's NPSMPP is updated periodically. The 1994 NPSMPP contained only the ground water strategy of Chapter 4 "Overall Strategy for Each Water Resource." Since 2001, the NPSMPP included a strategy for 4.1 Ground Water, 4.2 Lakes, 4.3 Rivers and Streams and 4.4 Wetlands thereby, providing a more comprehensive view and approach for assessing and addressing nonpoint source pollution control. Beginning with Chapter 4, the remaining Chapters provide individual time frames and goals identifying the major water quality concerns of that chapter/strategy.

ELEMENT 7. *An identification of federal lands and objectives which are not managed consistently with State program objectives.*

The Environmental Quality Board (EQB) Water Resources Committee, which includes federal government representatives, also periodically prepares a framework water plan. In May 2007, the EQB released "Protecting Minnesota's Waters: Priorities Report."

ELEMENT 8. *Efficient and effective management and implementation of the State's nonpoint source program, including necessary financial management.*

The Clean Water Council is consulted in the administration of grants and Minnesota's nonpoint source program. MPCA provides staff resources to assist grant recipients and managing day-to-day financial administration of the nonpoint program.

ELEMENT 9. *A feedback loop whereby the State reviews, evaluates, and revises its nonpoint source assessment and its management program at least every five years*.

Minnesota updates the NPSMPP in this time frame. In addition, 305(b) Assessments and Impaired Waters (303d) lists are updated in two year cycles.

Appendix B

Best Management Practices – Definitions

Minnesota's Nonpoint Source Management Program Plan (NPSMPP)

The following Best Management Practices (BMPs) are listed by title. This list includes definitions of BMPs to more fully describe BMPs and the pollutant minimized. BMPs listed in the Best Management Practices section of most chapters and in Appendix C "BMP Matrix" of this document were taken from the following list. (See Appendix C, "BMP Matrix" to see BMPs used individually or in combination for reducing Non-point Source (NPS) pollution per chapter/topic.)

Part I: Agricultural BMPs

Most agriculture BMPs used in Minnesota are based upon the Natural Resources Conservation Service (NRCS) conservation practices described in the NRCS *National Handbook of Conservation Practices*, and modifications set forth in the Minnesota NRCS *Field Office Tech Guide*.

Access Road – A road constructed to minimize soil erosion while providing needed access.

Biological Control of Pests – Use of natural enemies as part of an integrated pest management (IPM) program which can reduce the use of pesticides.

Brush Management – Management and manipulation of brush to improve or restore a quality plant cover in order to reduce soil erosion.

Conservation Crop Rotation – Growing crops in a recurring sequence on the same field to improve the soil, control erosion and pests, balance plant nutrients and provide food for livestock.

Contour Farming – Farming sloped land on the contour in order to reduce erosion, control water flow, and increase infiltration.

Correct Application of Pesticides – Spraying when conditions for drift is minimal. Mixing properly with soil when specified. Avoiding application when heavy rain is forecast.

Correct Pesticide Container Disposal – Following accepted methods for pesticide container disposal.

Critical Area Planting – Planting vegetation to stabilize the soil and reduce erosion and runoff.

Cultural Control of Pests – Using cultural practices, such as elimination of host sites and adjustment of planting schedules, to partly substitute for pesticides.

Deferred Grazing – Postponing grazing for a prescribed period to improve vegetative conditions and reduce soil loss.

Diversion and Terraces – Channels with a mound or ridge along the lower side, constructed across a slope to divert runoff water and help control soil erosion. Grassed or lined waterways and subsurface pipes are used to handle water from terrace systems.

Fencing – Enclosing a sensitive area of land or water with fencing to exclude or control livestock.

Field Border – A border or strip of permanent vegetation established at field edges to control soil erosion and filter nutrients.

Field Windbreak – A strip or belt of trees established to reduce wind erosion.

Forest Stand Improvement – Managing species composition, stand structure and stocking to achieve numerous objectives including restoration of natural communities, improvement of wildlife habitat, and increasing quantity and quality of forest products.

Grade Stabilization Structure – A structure to control the erosion in natural or constructed channels.

Grassed Waterway or Outlet – A natural or constructed waterway or outlet maintained with vegetative cover in order to prevent soil erosion and filter nutrients.

Integrated Crop Management – A crop production system that uses a combination of cultural and/or agronomic measures to produce economic returns while lowering inputs and reducing detrimental effects to the environment.

Integrated Pest Management – Managing agricultural pests including weeds, insects and disease to reduce adverse effects on plant growth, crop production and environmental resources. Management methods may be a combination of cultural, biological and chemical controls.

Irrigation Water Management – Determining and controlling the rate, amount and timing of irrigation water application in order to minimize soil erosion, runoff, water use and fertilizer and pesticide movement.

Lined Waterway or Outlet – A runoff water channel or outlet with an erosion resistant lining to prevent erosion. Applicable to situations where unlined or grassed waterways would be inadequate.

Mulching – Applying plant residues or other suitable materials to the soil surface in order to reduce water runoff and soil erosion.

Nutrient Management – Managing the amount, form, placement and timing of plant nutrient applications to maximize uses and reduce detrimental off-site effects.

Pasture and Hayland Management – Proper treatment and use of pasture land or hay land to prolong life of desirable forage species and protect the soil and reduce water loss.

Pasture and Hayland Planting – Establishing forage plants to reduce runoff and erosion and produce high quality forage.

Pesticide Selection – Selecting pesticides which are less toxic, persistent, soluble and volatile, whenever feasible.

Pond Sealing or Lining – Installing a fixed lining or impervious materials or using soil treatment to prevent excessive infiltration, water loss and to minimize the potential for ground water contamination.

Prescribed Grazing – Controlling grazing to improve plant health and vigor, reduce erosion and improve water quality.

Residue Management (no till, strip till, mulch till and ridge till) – Managing the amount, orientation and distribution of crop and other plant residues on the soil surface year-round.

Residue Management-seasonal – Managing the amount, orientation and distribution of crop and other plant residues on the soil surface during part of the year, while growing crops in a clean tilled seedbed.

Resistant Crop Varieties – Use of plant varieties that are resistant to insects, nematodes, diseases, etc., in order to reduce pesticide use.

Riparian Buffer – A strip of land varying in width, along streams and other waterbodies in which grass and trees are planted and maintained to filter pollutants from runoff.

Shade Areas – Lessening the need for animals to enter water for relief from heat by using trees or artificial shelters to provide shade at selected locations.

Slow Release Fertilizer – Applying slow release fertilizers to minimize nitrogen losses from soils prone to leaching.

Soil Testing and Plant Analysis – Testing to avoid over-fertilization and subsequent losses of nutrients to surface or ground waters.

Streambank Protection – Stabilizing and protecting banks of streams, lakes, estuaries, or excavated channels against scour and erosion with vegetative or structural means.

Stripcropping – Growing crops in a systematic arrangement of strips or bands to reduce water and wind erosion.

Timing and Placement of Fertilizers – Timing and placement of fertilizers for maximum utilization by plants and minimum leaching or movement by surface runoff.

Tree Planting – Planting trees, especially on critical or highly erodible areas, to prevent erosion, conserve moisture and reduce water quality impacts.

Use Exclusion – Excluding livestock and other activities from an area to maintain soil and water resources.

Vegetative Filter Strip – A strip of land, varying in width, along streams and other waterbodies in which a lush establishment of grass is planted and maintained to filter pollutants from runoff.

Waste Management System – A planned system to manage wastes from animal concentrations in a manner which does not degrade air, soil or water resources. Often wastes are collected in storage or treatment impoundments such as ponds or lagoons.

Waste Utilization – Crediting organic wastes for fertilizer in a manner which improves the soil and protects water resources. May also include recycling of waste solids for animal feed supplement.

Water and Sediment Control Basin – Earthen embankments constructed across a minor watercourse to form a sediment trap and detention basin.

Water/Feeder Location – Locating feeders and watering facilities a reasonable distance from streams and water courses, and dispersing them to reduce livestock concentrations, particularly near streams, and to encourage more uniform grazing.

Part II: Erosion, Sediment and Pollutant Control BMPs

Brush Barrier – A temporary sediment barrier composed of limbs, weeds, vines, root mat, soil, rock and other cleared materials pushed together to form a berm; located across or at the toe of a slope to intercept and detain sediment and decrease flow velocities.

Check Dams – Small, temporary dams constructed across a drainage ditch to reduce the velocity of concentrated flows, reducing erosion of the swale or ditch. Limited to use in small open channels which drain 10 acres or less; should not be used in live stream.

Concrete Grid and Modular Pavement – This practice involves the use of a special pervious paving material in low traffic areas. The pavement consists of concrete grids or other structural units alternated with pervious fillers such as sod, gravel or sand. The resultant pavement provides an adequate bearing surface and yet allows a significant amount of infiltration thereby reducing runoff volume, discharge rate, pollutant load and improving the water quality.

Construction Road Stabilization – Temporary stabilization with stone of access roads, subdivision streets, parking areas and other traffic areas immediately after grading to reduce erosion caused by vehicles during wet weather, and to prevent having to re-grade permanent roadbeds between initial grading and final stabilization.

Critical Area Planting – Establishment of vegetative cover by planting sprigs, stolons or plugs to stabilize fine-graded areas where especially suited to the site and establishment with sod is not preferred.

Detention Basins – This practice involves the construction or modification of surface water impoundments in a manner which will protect downstream areas from potential water quality degradation, flooding, and stream channel degradation due to upstream urban development. The objective is to detain stormwater and release it at a controlled rate. Downstream water quality is improved through sediment removal, plant uptake of nutrients, chemical transformation and other processes.

Diversion – A permanent channel with a ridge on the lower side constructed across a slope to reduce slope length and intercept and divert stormwater runoff to a stabilized outlet to prevent erosion on the slope.

Dust Control – Reducing surface and air movement of dust during land disturbance, demolition or construction activities in areas subject to dust problems in order to prevent soil loss and reduce the presence of potentially harmful airborne substances.

Exfiltration Trenches – this practice involves the excavation of pits or trenches which are backfilled with sand and/or graded aggregates. Stormwater runoff from impervious surfaces can be directed to these facilities for detention and infiltration. Permeable soils are a prerequisite. The potential for ground water pollution must also be carefully evaluated.

Fertilizer Application Control – This practice involves managing the use of fertilizer so as to keep it on the land and out of our waterways. Implementation will result in maximum effectiveness of the nutrients on vegetation and reduced nutrient loads in our waterways. The practice covers concepts such as public education, the need for soil testing, and the proper timing of fertilizer applications.

Filter Strips – This practice involves using grassed surfaces to reduce runoff velocities, enhance infiltration and remove runoff contaminants, thus improving runoff quality and reducing the potential for downstream channel degradation and sediment pollution.

Grade Stabilization Structures – A permanent structure or series of structures designed to step water flow down a slope without causing channel erosion; applicable in natural or man-made channels with long, relatively steep reaches.

Grassed Waterways or Outlets – This practice involves using grassed surfaces to reduce runoff velocities, enhance infiltration and remove runoff contaminants, thus improving runoff quality and reducing the potential for downstream channel degradation and sediment pollution.

Grassed Waterway (Swale) – This practice involves using grassed surfaces to reduce runoff velocities, enhance infiltration and remove runoff contaminants, thus improving runoff quality and reducing the potential for downstream channel degradation and sediment pollution.

Gravel Inlet Filter – The installation of various kinds of sediment trapping measures around drop inlet or curb inlet structures prior to permanent stabilization of the disturbed area; limited to drainage areas not exceeding one acre, and not intended to control large, concentrated stormwater flows.

Level Spreader – An outlet for dikes and diversions consisting of an excavated depression constructed at zero grade across a slope to convert concentrated, sediment-free runoff to sheet flow and release it onto areas of undisturbed soil stabilized by existing vegetation.

Mulching – Application of plant residues or other suitable materials to disturbed surfaces to prevent erosion and reduce overland flow velocities. Fosters plant growth by increasing available moisture and providing insulation against extreme heat or cold. Applicable to all seeding operations, other plant materials which do not provide adequate soil protection by themselves and bare areas which cannot be seeded due to the season but which still need soil protection.

Outlet Protection – The installation of paved and/or riprap channel sections and/or stilling basins below storm drain outlets to reduce erosion from scouring at outlets and to reduce flow velocities before stormwater enters receiving channels below these outlets.

Parking Lot Storage – This practice involves the use of impervious parking areas or landscape islands as temporary impoundments during rainstorms. Parking lot stormwater systems can be designed to temporarily detain stormwater in specially designated areas, and release it at a controlled rate. The objective is to protect downstream areas from increased flooding, stream channel degradation and pollutant loads caused by urban development. It is important that these facilities be designed to minimize potential safety hazards and inconvenience to motorists and pedestrians.

Paved Flume – A permanent concrete-lined channel constructed to conduct concentrated runoff from the top to the bottom of a slope without causing erosion on or below the slope.

Permanent Seeding – Establishment of perennial vegetative cover by planting seed on rough-graded areas that will not be brought to final grade for a year or more or where permanent, long-lived vegetative cover is needed on fine-graded areas.

Pesticide Use Control – This practice involves eliminating excessive pesticide use by proper application procedures and the use of alternatives to chemical pest control. The goal is to reduce the load of pesticide-related contaminants in urban stormwater runoff. The practice covers legal requirements for pesticide application, methods of application, equipment cleaning, disposal of unused chemicals and empty containers, pesticide storage, alternative pest control methodologies and public education. Both commercial-scale application and private home use are discussed.

Porous Pavement – This practice involves the use of a special asphaltic or concrete paving material which allows stormwater to infiltrate at a high rate. Infiltration water is stored below the pavement in a high-void aggregate base. This practice provides for stormwater detention and, in some cases, increases infiltration into the ground. Use of the practice can contribute to reduced sewer overflows, decreased flooding and stream channel degradation, and improved water quality. This type of pavement offers many other benefits not related to water quality, including enhanced visibility, increased safety and reduced drainage system costs.

Retention Basins – This practice pertains to the construction of infiltration reservoirs or basins (usually dry) to provide complete on-site storage of a specific volume of stormwater runoff. For pollution control purposes, these facilities are usually designed and constructed to divert and percolate runoff volume associated with the first flush of stormwater pollutants leaving the site. The practice incorporates both pollution control and ground water recharge concepts into the design. Such facilities are practical wherever permeability is sufficient to allow rapid percolation between storms. Potential ground water contamination may be a problem associated with these systems and must always be considered in their design.

Riprap – A permanent, erosion-resistant ground cover of large, loose, angular stone usually underlain by erosion mat or filter fabric installed wherever soil conditions, water turbulence and velocity, expected vegetative cover, etc., are such that soil may erode under design flow conditions.

Rooftop Runoff Disposal – This practice encourages the disposal of rooftop runoff by systems and techniques that avoid or replace direct connections of roof drainage systems to storm sewer systems. The objective is to help reduce storm sewer flows. Proposed alternatives to sewer connection include surface drainage through swales, subsurface infiltration and runoff collection and storage.

Silt Fence – A temporary sediment barrier constructed of posts, filter fabric and, in some cases, a wire support fence, placed across or at the toe of a slope or in a minor drainageway to intercept and detain sediment and decrease flow velocities from drainage areas of limited size; applicable where sheet and rill erosion or small concentrated flows may be a problem. Effective life is six months.

Sodding – Stabilizing fine-graded areas by establishing permanent grass stands with sod. Provides immediate protection against erosion, and is especially effective in grassed swales and waterways or in areas where an immediate aesthetic effect is desirable.

Sod Inlet Filter – The installation of various kinds of sediment trapping measures around drop inlet or curb inlet structures prior to permanent stabilization of the disturbed area; limited to drainage areas not exceeding one acre and not intended to control large, concentrated stormwater flows.

Solid Waste Collection and Disposal – This practice involves the routine management and handling of urban refuse, litter and fallen leaves in ways that will prevent their becoming water pollutants. Recommendations range from municipal trash and leaf collection and disposal operations to public education concerning collecting procedures and schedules to concepts such as recycling wastes. Responsibility for implementation lies equally with the municipality and the citizenry.

Source Control on Construction Sites – This practice encourages the use of good management and “housekeeping” techniques on construction sites to reduce the availability of construction-related pollutants that contaminate runoff water and, where runoff contamination cannot be avoided, to retain the pollutants and polluted water on the site. Concepts covered include erosion and sediment control, equipment maintenance and repair, storm sewer inlet protection, trash collection and disposal, the use of designated washing areas for cleaning equipment, proper material storage, dust control at demolition sites, use of proper sanitary equipment and pesticide use control.

Storage/Treatment Facilities – This practice involves the use of some water treatment unit operations applied at such a scale that they are less involved and less costly than treatment plant technology. These procedures are most applicable when used in conjunction with other BMPs to remove contaminants from collected stormwater. Unit operations considered applicable are the physical processes of settling, filtration, and screening; and the chemical processes of flocculation and disinfection.

Storm Drain Inlet Protection – The installation of various kinds of sediment trapping measures around drop inlet or curb inlet structures prior to permanent stabilization of the disturbed area; limited to drainage areas not exceeding one acre, and not intended to control large, concentrated stormwater flows.

Stormwater Conveyance Channel – This practice involves using grassed surfaces to reduce runoff velocities, enhance infiltration and remove runoff contaminants, thus improving runoff quality and reducing the potential for downstream channel degradation and sediment pollution.

Straw Bale Barrier – A temporary sediment barrier composed of straw bales placed across or at the toe of a slope to intercept and detain sediment and decrease flow velocities from drainage areas of limited size; applicable where sheet and rill erosion from low to moderate channel flows may be a problem. Effective life is three months.

Street Cleaning – This practice involves sweeping, vacuuming, flushing, or otherwise cleaning streets, parking lots and other paved vehicular traffic areas. The objective is to remove dry-weather accumulations of pollutants, especially fine particulate matter, before wash off can occur, thus reducing the potential for pollution impacts on receiving waters. In the past, street cleaning operations were conducted primarily for aesthetic purposes; however, they are now known to be an effective method for improving the quality of runoff when utilized during the appropriate time of the year.

Subsurface Drain – A perforated conduit installed beneath the ground to intercept and convey ground water. Prevents sloping soils from becoming excessively wet and subject to sloughing, and improves the quality of the vegetative growth medium in excessively wet areas by lowering the water table. Can also be used to drain detention structures.

Surface Roughening – Grading practices such as stair-stepping or grooving slopes or leaving slopes in a roughened condition by not fine-grading them. Reduces runoff velocity, provides sediment trapping and increases infiltration, all of which facilitate establishment of vegetation on exposed slopes. Applicable to all slopes steeper than 3:1 or that have received final grading but will not be stabilized immediately. Also recommended for other exposed slopes.

Temporary Diversion Dike – A ridge of compacted soil located at the top or base of a sloping disturbed area to divert off-site runoff away from unprotected slopes and to a stabilized outlet, or to divert sediment-laden runoff to a sediment trapping structure.

Temporary Fill Diversion – A channel with a supporting ridge on the lower side cut along the top of an active earth fill to divert runoff away from the unprotected fill slope to a stabilized outlet or sediment trapping structure; applicable where the area at the top of the fill drains toward the exposed slope and continuous fill operations make the use of a Temporary Diversion Dike unfeasible. Effective life is one week.

Temporary Gravel Construction Entrance – A gravel pad, located at points of vehicular ingress and egress on a construction site, to reduce the mud transported onto public roads and other paved areas.

Temporary Right-Of-Way Diversion – A ridge of compacted soil or loose gravel constructed across a disturbed right-of-way or similar sloping area to shorten the flow length within the disturbed strip and divert the runoff to a stabilized outlet. Earthen diversions are applicable where there will be little or no construction traffic within the right-of-way, and gravel structures are applicable where vehicular traffic must be accommodated.

Temporary Sediment Basin – A basin with a controlled stormwater release structure, formed by constructing an embankment of compacted soil across a drainageway, to detain sediment-laden runoff from disturbed areas greater than five acres for enough time to allow most of the sediment to settle out. Can be constructed only where there is sufficient space and appropriate topography. Effective life is 18 months unless designed as a permanent pond.

Temporary Sediment Trap – A small pond area, formed by constructing an earthen embankment with a gravel outlet across a drainage swale, to detain sediment-laden runoff from small disturbed areas for enough time to allow most of the sediment to settle out. Effective life is 18 months.

Temporary Seeding – Establishment of temporary vegetative cover on disturbed areas by seeding with appropriate rapidly-growing plants on sites that will not be brought to final grade for periods of 30 days to one year.

Temporary Slope Drain – A flexible or rigid tube or conduit, used before permanent drainage structures are installed, intended to conduct concentrated runoff safely from the top to the bottom of a disturbed slope without causing erosion on or below the slope.

Topsoiling – Preserving and using topsoil to provide a suitable growth medium for vegetation used to stabilize disturbed areas. Applicable where preservation of importation of topsoil is most cost-effective method of providing a suitable growth medium.

Tree Preservation and Protection – Protecting existing trees from mechanical and other injury during land disturbing and construction activity to ensure the survival of desirable trees where they will be effective for erosion and sediment control and provide other environmental and aesthetic benefits.

Trees, Shrubs, Vines and Ground Covers – Stabilizing disturbed areas by planting trees, shrubs, vines and ground covers where turf is not preferred. These plant materials also provide food and shelter for wildlife as well as many other environmental benefits. Especially effective where ornamental plants are desirable and turf maintenance is difficult.

Underdrain Stormwater Filter Systems – This practice usually consists of a conduit, such as a pipe and/or a gravel filled trench which intercepts, collects and conveys drainage water following infiltration and percolation through the soil, suitable aggregate and/or filter fabric. Underdrain or filtration systems may be used in combination with a variety of stormwater management measures where space, soil permeability or high water table conditions limit the magnitude of pollutant removal that can be achieved through natural percolation, sedimentation, or other means. Pollutant removal primarily occurs as the prescribed volume of stormwater passes through the sand, gravel and filter cloth which usually surrounds the conduit.

Vegetation Establishment – Establishment of vegetative cover by planting sprigs, stolons or plugs to stabilize fine-graded areas where vegetation is especially suited to the site and establishment with sod is not preferred.

Waterway Drop Structure – A permanent structure or series of structures designed to step water flow down a slope without causing channel erosion; applicable in natural or man-made channels with long, relatively steep reaches.

Part III: Other Cultural and Structural BMPs

BMPs listed under Part III are defined by their title.

Adequate Containers for On-Site Solid Waste

Aeration of Lawns

Alum treatments of lakes to stop internal loading once watershed inputs have been addressed

Compost Production and Use

Correct Use of Soils for Septic Tanks

Dry Weather Flow Testing of Storm Sewers and Ditches

Increase Flow Distances

Land idling/retirement

Lane Absorption Areas and Use of Natural Systems

Leash Laws and Clean Up After Your Pet Programs

Maintain Set Backs From Surface Waters

Maximum Recycling of Solid Waste

NPS ordinances (phosphorus fertilizer use restrictions)

Prompt Clean-Up of Chemical Spills

Proper Installation of Septic Tanks and Drainfields

Proper Maintenance of Motorized Equipment

Rock drain tile inlets

Routine Maintenance of Septic Tank Systems

Soil Testing and Plant Analysis

Stormwater chemical treatment systems (alum addition system that treats stormwater in-line using alum to remove phosphorus, or ponds that use polymer addition to bind phosphorus)

Training for Pesticide Home Applicators

Waste Treatment System, Publicly Owned Treatment Works (POTWs)

Wetland restoration

Appendix C

STATE OF MINNESOTA

OFFICE OF THE ATTORNEY GENERAL

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ATTORNEY GENERAL

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June 8, 2001

RECEIVED
JUN 11 2001

Elizabeth Shevi, Division Director
Policy and Planning Division
Minnesota Pollution Control Agency
520 Lafayette Road
St. Paul, Minnesota 55155-4194

Re: Attorney General Certification
State of Minnesota Nonpoint Source Management Program Plan

Dear Ms. Shevi:

I am the state's attorney of record in the development and adoption of the State of Minnesota Nonpoint Source Management Program Plan (NSMPP) in accordance with Section 319 of the Clean Water act. I make this certification on behalf of the State of Minnesota, by and through its Minnesota Pollution Control Agency (MPCA).

I certify that the NSMPP was duly adopted in accordance with Minnesota law, and that the state, by and through its MPCA, has adequate authority to administer and implement the standards, policies and procedures adopted therein. The applicable law includes, but is not limited to, Minn. Stat. chapters 115 and 116 and Minnesota Rules, chapters 7000, 7001, and 7050.

Thank you in advance for your cooperation and consideration in this matter.

Sincerely,

Paul Merwin

PAUL MERWIN
Assistant Attorney General

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Appendix D

2013 Minnesota Nonpoint Source Management Program Plan

Summary of Public Participation

Development of the NPSMPP

The chapters/strategies of the Minnesota Nonpoint Source Management Program Plan (NPSMPP) were developed by technical committees, chairs and co-chairs. Collectively, technical committees were comprised of over 200 members representing 50 federal and state agencies, local units of government and public and private organizations.

Noticing of the Draft Phase 1 revisions to the NPSMPP

Prior to the beginning of the public comment period, a notice was published in the *Minnesota State Register*, providing public notification that the Draft **Phase 1 revisions to the** Minnesota NPSMPP was available for public review and comment. The notice also informed the public where the document could be reviewed.

The public comment period for the Draft began August 19, 2013 and closed on September 17, 2013.

Public notices announcing the availability of the draft NPSMPP were also provided through:

- The August *Waterfront Bulletin*; to interested parties requesting information through the GovDelivery system.

MPCA statewide press releases to newspapers, radio and television stations **Format of the Draft NPSMPP.**

To encourage public outreach, the draft NPSMPP was available for public review in four formats.

- MPCA's Web site
- Compact Disk
- Paper Copies
- E-mailing of individual chapters/strategies

Appendix E

Federal Assistance Programs and Development Projects

for Consistency with the

Minnesota Nonpoint Source Management Program Plan (NPSMPP)

Executive Order 12372

The federal consistency provisions in Section 319 of the Clean Water Act (CWA) authorize each State to review federal activities for consistency with the state nonpoint source (NPS) management program in accordance with Executive Order 12372. Much of the consistency criteria pertain to use of federal lands.

The state of Minnesota has long considered consistent application of nonpoint source management practices to be critical on all lands, be they private or public lands owned by the local, state, or federal governments. As part of the process to ensure that, a number of steps have been taken. They include official interagency agreements as well as both formal and informal project coordination and review efforts.

Section 319(b)(2)(F) requires states to identify federal financial assistance programs and development projects which will be reviewed for their effect on water quality consistent with the state NPS Management Program.

At this time, the federal financial program that most clearly relates to the NPS Management Program is the Natural Resources Conservation Service (NRCS) Environmental Quality Incentives Program (EQIP). A state technical committee has been formed where consultations on EQIP activities take place.

Minnesota intends to maintain the current structure and will work with the U.S. Environmental Protection Agency, under a process separate from the Nonpoint Source Management Program Plan, if needed.

STATE OF MINNESOTA

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Paul Merwin

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Appendix F

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