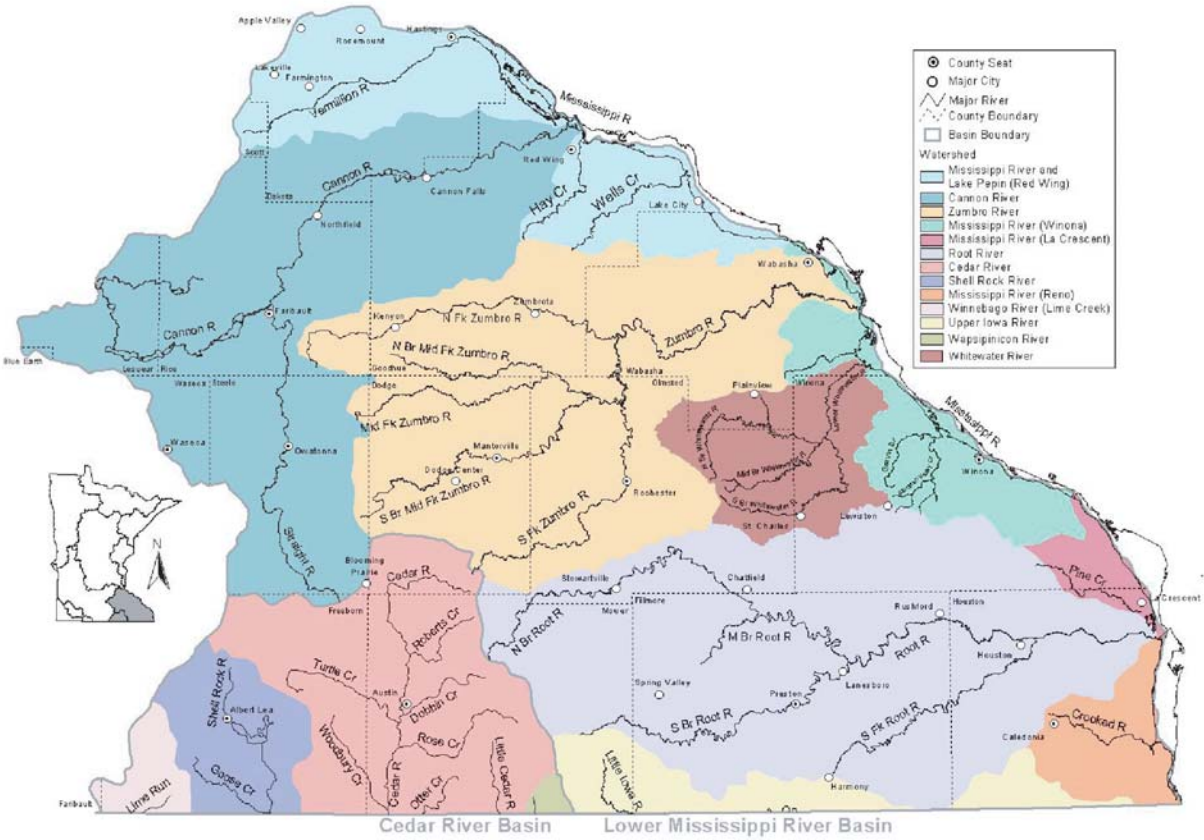
LOWER

Mississippi River

2001 Basin Plan Scoping Document



Balmm

Basin Alliance for the Lower Mississippi
In Minnesota

Lower Mississippi River Basin Planning Scoping Document

June 2001

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Basin Alliance for the Lower Mississippi in Minnesota

About BALMM

A locally led alliance of land and water resource agencies has formed in order to coordinate efforts to protect and improve water quality in the Lower Mississippi River Basin. The Basin Alliance for the Lower Mississippi in Minnesota (BALMM**)** covers both the Lower Mississippi and Cedar River Basins, and includes a wide range of local, state and federal resource agencies. Members of the Alliance include Soil and Water Conservation District managers, county water planners, and regional staff of the Board of Soil and Water Resources, Pollution Control Agency, Natural Resources Conservation Service, U.S. Fish and Wildlife Service, University of Minnesota Extension, Department of Natural Resources, Mississippi River Citizen Commission, the Southeastern Minnesota Water Resources Board, the Cannon River Watershed Partnership, and others. BALMM meetings are open to all interested individuals and organizations. Existing staff from county and state agencies provide administrative, logistical and planning support. These include: Kevin Scheidecker, Fillmore SWCD, Chair; Norman Senjem, MPCA-Rochester, Basin Coordinator; Clarence Anderson, Rice SWCD, Area 7 MASWCD Liaison; Bea Hoffmann, SE Minnesota Water Resources Board Liaison.

This Basin Plan Scoping Document is the fruit of a year-long effort by participants in BALMM. Environmental Goals, Geographic Management Strategies and Land-Use Strategies were developed by either individual BALMM members or strategy teams. An effort was made to involve those who will implement the strategies in developing them. Each strategy was presented at least once at a monthly BALMM meeting, and subsequently revised based on comments received, before being included in this draft document. Other parts of the document were prepared by the Basin Coordinator, who drew on a multitude of published sources to describe the basin's geology, water quality, and land-water relationships.

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I: Introduction

In the summer of 1999 an ad-hoc group of county, state and federal agency representatives started meeting to discuss the possibility of creating a basin plan for the Lower Mississippi River and Cedar River Basins in southeastern Minnesota. Shortly thereafter, Governor Jesse Ventura launched the Water Unification Initiative, as a result of which seven Basin Teams composed of state and federal agency representatives were appointed to assist in the development of the next state water plan, called "Water Plan 2000" (the title was later changed to "Watermarks"). Thus two basin planning groups became established at roughly the same time in the Lower Mississippi and Cedar River Basins, with similar purposes and overlapping membership.

The Basin Team[1] produced a report that was provided to the State Planning Agency in February 2000 for inclusion in Watermarks. It focused on water quality goals, objectives and indicators for the basin. Watermarks was published in September 2000. Over the next two years, the seven Basin Teams will be responsible for developing strategies whereby the environmental goals and objectives outlined in Watermarks can be achieved. These will be included in a statewide plan scheduled to be published in September 2002.

The ad-hoc basin planning group that started meeting in August 1999 contributed to the development of water quality and land use objectives in Watermarks and, since February 2000, has been developing strategies by which these goals and objectives can be accomplished over the next decade. The planning group calls itself the Basin Alliance for the Lower Mississippi in Minnesota (BALMM). It meets monthly and is staffed informally by Kevin Scheidecker, Fillmore Soil & Water Conservation District Manager, who serves as chair; and Norman Senjem, MPCA-Rochester, who serves as basin coordinator. A secretarial position staffed by BWSR-Rochester currently is vacant. Membership includes most of those who belong to the Basin Team, in addition to representatives of many local, state, regional and federal agencies.[2]

[1] Members of the original Basin Team were: Norman Senjem, Minnesota Pollution Control Agency (co-chair); Mark Dittrich, Minnesota Department of Agriculture (co-chair); Larry Gates, Department of Natural Resources; John Nicholson, Natural Resources Conservation Service; Art Persons, Minnesota Department of Health; Dave Peterson, Board of Water and Soil Resources, Judy Sventek, Metropolitan Council-Environmental Services; Allene Moesler, executive director, Cannon River Watershed Partnership; and Bea Hoffmann, executive director, Southeastern Minnesota Water Resources Board.

[2] Participants in BALMM include counties, Soil and Water Conservation Districts, University of Minnesota-Extension, Minnesota Pollution Control Agency, Minnesota Department of Agriculture, Minnesota Department of Natural Resources, Board of Water and Soil Resources, Natural Resources Conservation Service, US Fish and Wildlife Service, Minnesota Department of Health, Minnesota-Wisconsin Boundary Area Commission; Prairie Island Indian Community; St. Mary's University Resource Studies Center, Southeastern Minnesota Water Resources Board, Cannon River Watershed Partnership and the Whitewater River Watershed Project.

In addition to the BALMM activities, two public forums were conducted by the MPCA to seek advice and comment on water quality goals and strategies. The first was held Feb 7, 2000, and the second on Nov. 8, 2000, in Rochester. Citizens who had participated in the May 1999 "The Governor's Forums: Citizens Speak Out on the Environment" in Rochester were invited to attend a similar event to provide input into Watermarks on Feb. 7, 2000. County commissioners and water planners also were invited, as were members of the public through a widely distributed news release. Thirty-six people participated in the first forum, which made use of keypad technology to provide instant feedback on how the group voted on specific questions. Demographically, the group was evenly split among urban, rural-farm and rural-non-farm. Forty-six percent were citizens, 34 percent government staff, and 20 percent elected officials. Using the document *Water Plan 2000 Objectives: Lower Mississippi/Cedar River Basins*, the group evaluated the adequacy of the Water Quality and Ecosystem objectives as a whole, and then evaluated each of the land-use objectives from the standpoint of both *effectiveness* in accomplishing environmental objectives, and the *feasibility* of implementing them. In addition, the group suggested several additional objectives to add to the report, two of which were subsequently added to the Basin Plan Scoping Document Geographic Management Strategies: Groundwater Recharge Areas; and Floodplain Management). Comments also were used to modify existing objectives and indicators.

The second public forum was held on Nov. 8, 2000, to provide the public an opportunity to comment on the Draft Basin Plan Scoping Document. An informal Open House was combined with a keypad voting session similar to that used at the first forum. Once again, the discussion and voting focussed on both the effectiveness and feasibility of each strategy. Forty-two individuals participated, including citizens (61%); government staff (27%) and elected officials (12%). Results of the Citizens Forum were reviewed at the next BALMM meeting, and were used to revise the Basin Plan Scoping Document.

The final strategies for land-use, geographic management and monitoring included in this Basin Plan Scoping Document will be provided to the Basin Team for inclusion in the "Strategies" portion of Watermarks. In addition, they will be further refined and developed by BALMM sub-teams and through interaction with basin citizens and stakeholders to develop a final Basin Plan.

Purpose of Basin Planning

To an ever-increasing extent, water quality protection and improvement efforts in Minnesota are being organized by major drainage basin. Public and private funding sources are showing a growing preference for working through basin initiatives rather than funding a host of separate, uncoordinated efforts within the same basin. The purpose of BALMM is to create an organized, unified effort in the Lower Mississippi/Cedar River basins that will:

1. Make the case to the public, elected officials and funding sources for giving priority attention to water quality

restoration and protection in southeastern Minnesota;
2. Establish ongoing coordination of local, state, tribal and federal agencies to plan and implement water quality protection and restoration activities that are economically and environmentally sustainable and reflect local and downstream issues and priorities.

The Basin Plan Scoping Document is a guide toward the pursuit of these broad goals that the BALMM has developed in its first year. As such, it will be used by Alliance members to guide and coordinate implementation activities in the basin, even as it continues to be refined and elaborated into a more complete Basin Plan. This approach suits the implementation orientation of Alliance members while conforming to the state's schedule for the development of basin plans in the context of Watermarks.

Making Connections

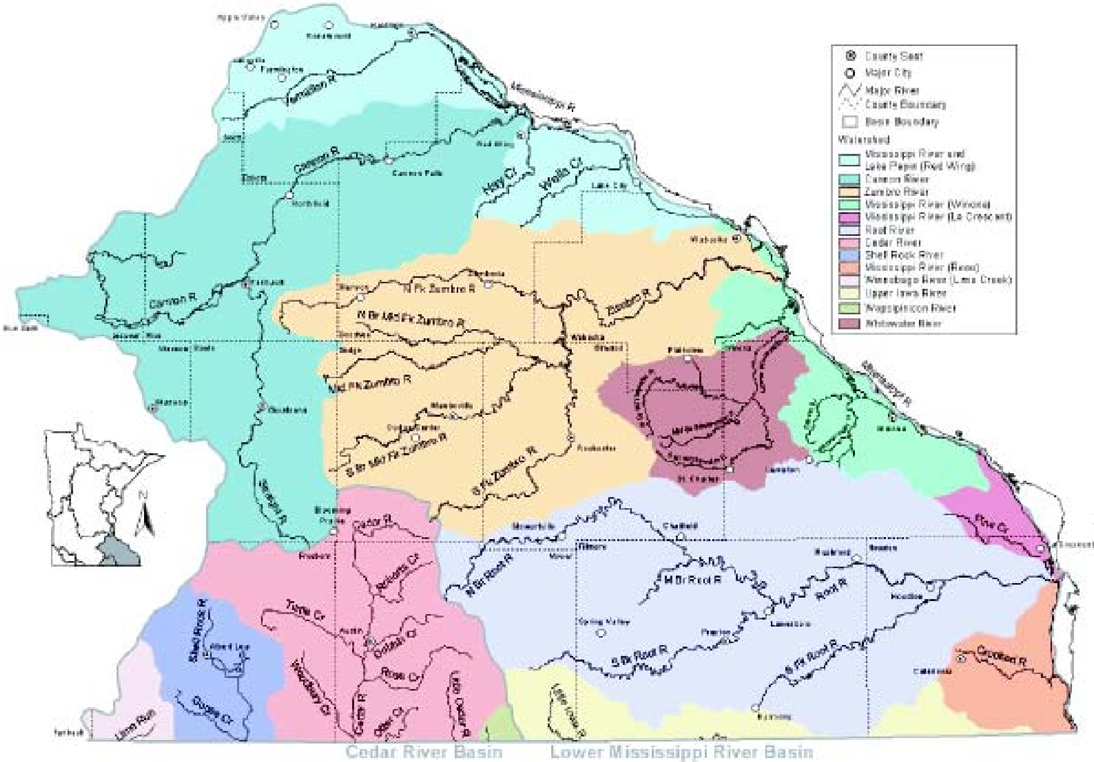
The core of the Scoping Document is found in the strategies that have been developed by Alliance members to manage the land in the context of watershed management, aquifer protection and floodplain management to achieve environmental goals and objectives. Goals for Water Quality and Quantity and Ecosystem Health are described in Part IV, while strategies for attaining these goals are described in Parts V and VI. Strategies have been developed at the basin scale, for use throughout the Lower Mississippi River Basin, but with a view to making connections with land-use planning activities at both smaller and larger geographic scales. Accordingly, goals and objectives from comprehensive local water plans from counties within the basin were collected, organized, and distributed to Alliance members to help guide the development of strategies. This should help to ensure that activities undertaken at the basin scale are compatible with and supportive of land-use activities undertaken by counties.

Similarly, an attempt has been made to relate strategies developed for southeastern Minnesota to those being developed for the larger, 189,000 square mile Upper Mississippi River Basin, defined as the drainage area upstream of Cairo, Illinois, where the Ohio River joins the Mississippi River. Toward this end the Alliance has reviewed the recently published strategy by the Upper Mississippi River Conservation Committee, entitled "A River that Works and A Working River: A Strategy for the Natural Resources of the Upper Mississippi River System." This strategy lists nine objectives for the river system as a whole, which includes the drainage basin as well as the main channel and its floodplain. In particular, improving water quality for all uses (Objective 1), Reduction in erosion and sediment impacts (Objective 2), and Manage channel maintenance and disposal to support ecosystem objectives (Objective 7) are explicitly supported by the BALMM strategies. Other objectives, which deal with particular aspects of managing the Mississippi River and its floodplain, appear to be less directly related to the land-use management activities of local and state government participating in the Alliance.

In addition, the Alliance is keeping abreast of developments concerning hypoxia in the Gulf of Mexico, its relationship to nutrient inputs to the Mississippi River originating in Minnesota, and the “Draft Action Plan for Reducing, Mitigating and Controlling Hypoxia in the Northern Gulf of Mexico” that was developed by the Mississippi River/Gulf of Mexico Nutrient Task Force. Concern about nitrate-nitrogen contamination of ground water is high in southeastern Minnesota’s karst region of fractured, porous bedrock. Because of the close interaction between surface water and ground water in karst geology, this concern extends to the trend of steadily increasing concentrations of nitrate-nitrogen in the region’s rivers. Reversing this trend is a key water quality goal for the basin that is seen as supporting efforts to reduce nutrient loads to the Gulf of Mexico.

Pool Planning

An attempt will be made also to relate the management of tributary watersheds to goals established for the main channel and backwaters of specific navigation pools, through pool planning. Pool plans are being developed for Pools 1-10 by the Fish and Wildlife Work Group, a sub-group of the U.S. Army Corps of Engineers St. Paul District’s River Resources Forum.


County Seat
Major City
Major River
County Boundary
Basin Boundary
Watershed
Mississippi River and Lake Pepin (Red Wing)
Cannon River
Zumbro River
Mississippi River (Winona)
Mississippi River (La Crescent)
Root River
Cedar River
Shell Rock River
Mississippi River (Reno)
Winnebago River (Lime Creek)
Upper Iowa River
Wapsipinicon River
Whitewater River
Cedar River Basin
Lower Mississippi River Basin

II: Basin Description

A: Overview

The Lower Mississippi River Basin, which includes the Cedar River Basin for planning purposes, is located in southeastern Minnesota. It includes all or part of 17 counties and has 12 major watersheds covering about 7,266 square miles (4,650,100 acres). Land use is diverse. On the western side lands are primarily cultivated, while the eastern landscapes are dominated by steep forested hill slopes. About two-thirds of the land in the basin is under cultivation, while about 13 percent is forested. Roughly 17 percent of the land use is open or pasture lands. Major agricultural crops include corn, soybeans and hay. Animal production includes dairy and beef cattle, hogs, sheep and lambs. Major population centers include the southern Metropolitan area of Dakota County in addition to Austin, Albert Lea, Faribault, Owatonna, Rochester, Red Wing and Winona. These and other urban areas are experiencing rapid population growth and commercial development.

The basin's population grew 11.9 percent between 1990 and 1998, from 539,787 to 603,997, according to Minnesota Planning. Most of the growth has been in Dakota (23.3 percent), Dodge (10 percent), Olmsted (11.8 percent) and Rice (10 percent) counties.

Beautiful bluffs, springs, caves and numerous trout streams abound in the eastern basin, where steep topography and erosive soils increase the potential for pollutant runoff and sedimentation of streams. Sinkholes and disappearing streams highlight the close connection between surface water and groundwater in this part of the basin. The presence of fractured limestone bedrock lying close below the land surface, which is often referred to as karst topography, [3] presents a widespread risk of groundwater contamination in the eastern basin. In the southwestern basin, Mississippi tributaries emerge as small streams out of a prairie landscape once rich in wetlands but now extensively drained to support a productive agriculture. Further to the north, in the western Cannon River Watershed, remnants of the Big Woods hardwood forest intermingle with mixed crop and livestock farming in a rolling terrain interspersed with lakes and wetlands. On the basin's eastern border, the Mississippi River is shaped by the lock-and-dam system, which converted a free-flowing meandering river into a series of navigation pools with a nine-foot-deep channel for barge traffic.

The character of rivers and streams in the Lower Mississippi River Basins changes considerably along the main direction of flow, west to east. The Cannon River originates in the lake area of eastern Le Sueur and western Rice County, a farming region of glacial drift and moraines. A major tributary, the Straight River, has its marshy beginnings near Owatonna. The headwater tributaries of the Zumbro, Root and Cedar Rivers ooze from till

[3] Karst is a geologic term used to describe a landscape created over soluble rock with efficient underground drainage. The underlying rock dissolves over time as surface water percolates through the soil and carbon dioxide from the air and from biological activity in the soil combine with the water. The water and carbon dioxide chemically form a weak carbonic acid that reacts with calcite and dolomite, causing the rock to dissolve slowly to produce joints and cracks.

plains and moraines of Steele, Dodge, Mower and Freeborn counties once rich in wetlands, now extensively drained for agriculture.

The extent of presettlement wetlands in Lower Mississippi Basin counties has been estimated to be approximately 880,000 acres. Good estimates of remaining wetland acreage are not available, but considerably less than half of the original wetlands are believed to exist today (Anderson and Craig, 1984). The vast majority of original wetland acreage is located on the western side of the basin in Dodge, Freeborn, Mower, Steele and Waseca counties. Seventy-nine percent of the landscape in southeastern Minnesota is classified as well-drained, and much of the land that was poorly drained has been tiled for agricultural production.

After leaving the till plains, the Cannon, Zumbro and Root drop down into deeper valleys starting near Northfield (Cannon), Zumbrota (Zumbro) and Spring Valley (Root). Hereafter the network of rivers and tributaries is fed by ever-deeper reserves of ground water. In certain streams, a combination of swiftly moving current, streambeds formed of boulders, cobble and gravel, and stable flows of cool, oxygen-rich waters support trout and the aquatic insects on which they feed. Deep pools and undercut banks provide refuge during sunny days and low waters, while riffles provide a continuing source of food.

Stream gradients become steeper as the rivers approach the Mississippi Valley. The upper stream valleys in this driftless area, which the last glaciation did not reach, are formed by vertical limestone bluffs, the product of millenia of erosion through highly soluble limestone. Snowmelt and heavy rainfall can induce flash floods in this topography. Finally, the rivers near the Mississippi Valley begin to slow down, lose energy and drop their load of sediment in alluvial floodplains that have been inching higher ever since glacial times. In recent decades, however, dikes along the lower reaches of the Root and Zumbro have disconnected the rivers from their alluvial floodplains, making farming of the rich soil possible, at the cost of increased sedimentation of the Mississippi and the degrading of a rich ecosystem.

B: History

The Mississippi River valley is the product of thousands of years of glacial activity and water and wind erosion. The first people that lived along the Upper Mississippi River Valley (the stretch between Lake Itasca and the confluence with the Missouri River above St. Louis) arrived 12,000 years ago. These early inhabitants were followed by a succession of native cultures that lived near the Mississippi and relied on the river for food.

Some later cultures also farmed on the Mississippi floodplains and islands. For example, early European explorers wrote of native farming practices on Prairie Island, Minnesota. These early explorers also documented the bounty of the Mississippi River in terms of fish and game:

> “Radisson went with hunting parties, and traveled "four months...without doing anything but go from river to river." He was enamored of the beauty and fertility of the country, and was astonished

> at its herds of buffaloes and antelopes, flocks of pelicans, and the shovel-nosed sturgeon, all of which he particularly described. Such was the first year, 1655, of observations and exploration by white men in Minnesota, and their earliest navigation of the upper part of the Mississippi River."
> (Collections of the Minnesota Historical Society, Volume 10, Part 2, pp. 462-463)

Following the early exploration of the Mississippi River in what is now Minnesota, additional Europeans began to trickle into this part of the continent. Eventually that trickle became a flood, and European settlers became the predominant residents of the river valley.

<u>Land-Use Changes</u>

As European immigrants advanced across the U.S., they left changing landscapes in their wake. In Minnesota, settlers plowed under the prairie and cut down the forests. Outposts, then towns, then cities grew up on riverbanks. Industry was established on the banks of the Mississippi in St. Anthony/Minneapolis, then in St. Paul. All of these activities took their toll on the health of the Mississippi River.

European settlers weren't the only sources of landscape changes in the Lower Mississippi River basin, however. Pollen analysis of sediment cores taken from Lake Pepin shows an increase in "Big Woods" plant species such as sugar maple and basswood trees long before the arrival of most Europeans. This landscape change is associated with a climatic shift to cooler, wetter conditions that occurred several hundred years before Europeans began to settle this part of the continent.

During European settlement, the landscape changed again. Pollen analysis (again on Lake Pepin sediment cores) shows a shift from primarily pine, oak, birch, and big woods species to greatly increased amounts of pollen from plants like ragweed, which grows well in open fields and cleared areas (Engstrom and Almendinger, 2000). While the exact timing of this shift is not known, the co-occurrence of this change with the first appearance of corn and wheat pollen suggests that it happened at about the same time that widespread cultivation came to Minnesota, in the 1850's.

At roughly the same time that agricultural activities were changing the landscape of southern Minnesota, logging was altering the Mississippi and St. Croix River basins to the north, both of which flow into the Lower Mississippi. Massive logging operations were active in the Upper Mississippi basin between about 1870 and 1915 (Sterner and Nunnally, 1999). Hundreds of thousands of board feet of logs and lumber were sent down the Mississippi to the mills of St. Anthony and even farther downstream each year. The St. Croix River was also a thoroughfare for the logging industry, and large mills were built at Stillwater and beyond. The intensive logging left the land susceptible to erosion, and waste products from the mills were disposed of in the rivers.

Finally, the advent of commercial navigation on the Mississippi River above St. Louis, Missouri impacted the basin as well, both directly and indirectly. The arrival of the first steamboat at Fort Snelling in 1823 heralded a new era in river transportation in Minnesota, and enormous changes for the river itself.

Navigation and the River

It is difficult to over-state the impact of navigation on the Mississippi River. The advent of commercial navigation, and the ensuing channel modifications and lock and dam system, transformed the Mississippi River above St. Louis, Missouri, from a free-flowing river to a system of reservoirs interrupted by stretches of altered river. These changes had a profound impact on the river's ecology. Today, the existence of the navigation system places boundaries on the extent to which the river can be restored and managed.

The changes wrought on the Mississippi between St. Anthony Falls and the Minnesota-Iowa border due to navigation began almost as soon as the first steamboat maneuvered upstream to Fort Snelling and later the falls of St. Anthony. Wood was scavenged or cut from the banks of the river to feed the steam engines. This activity had a significant impact on the Mississippi River near St. Louis. On the Minnesota stretch of the river, early steamboat traffic was limited to high-water periods when the boats could navigate the shallow Mississippi depths. But that limitation was soon to change.

Recognizing that steamboat traffic upstream of the confluence of the Mississippi and Missouri Rivers (below which the river became more navigable) would increase if the river channel was "improved," the U.S. Army Corps of Engineers (USACE) began altering the Mississippi River channel as early as 1838. In 1878, Congress authorized the USACE to create a 4.5-foot navigation channel through a combination of dredging and clearing snags from the river. According to the report *Ecological Status and Trends of the Upper Mississippi River System 1998*:

> "Snag clearing … contributed to the instability of the river bank because trees were removed 100 to 200 feet (30 to 60 m) back from the shoreline to reduce future hazards." (p. 3-5)

Wing dams were another tool used by the USACE to enhance navigability. These long fingers of rock and willow mats (and later concrete) extended from the shoreline out into the river channel, focusing much of the water flow into the center channel where it would scour out accumulated sediment and debris. The wing dams also served to raise the water level in the main channel. Closing dams were also constructed on side channels, to focus the river flow into the main portion of the river.

It didn't take long before the 4.5-foot channel was seen as inadequate, and in 1907 Congress authorized a six-foot channel project. This was followed by a nine-foot channel project in 1930 that led to the system of locks and dams that exists on the river today.

Today, 26 locks and dams aid Mississippi River navigation between Minneapolis and the confluence of the Missouri and Mississippi Rivers below Alton, Missouri. Eight of these locks and dams are located in Minnesota, between Minneapolis and the Minnesota-Iowa border.

Ecological Impacts

All of the historical changes in the Lower Mississippi River Basin have impacted this area's ecological systems. For example, intensive agriculture and logging left vast tracts of bare land susceptible to soil erosion. Wind and water erosion sent thousands of tons of sediment and associated nutrients into the Mississippi River and its tributary streams each year.

Agriculture and logging were not the only sources of nutrient inputs to the river. Untreated sewage and industrial wastes from the cities of Minneapolis and St. Paul were disposed of in the river until the Pig's Eye Treatment Plant — now called the Metro Plant — was constructed in 1933. This contributed to downstream nutrient loading and other problems. For example, a 1927 report of the U.S. Public Health Service and the U.S. Bureau of Fisheries indicated that pollution from the Twin Cities was so severe that a 45-mile stretch of the river below St. Paul could not support fish during August 1926 due to low dissolved oxygen levels.

This increased flux of sediment and nutrients into the Lower Mississippi River can be seen in sediment core samples taken from Lake Pepin. Between shortly after the onset of European settlement (approx. 1830) and today, sediment loading to Lake Pepin increased by an order of magnitude, and the lake experienced a more than 15-fold increase in phosphorus accumulation in the bottom sediments. These changes are also reflected in a shift in diatoms, a type of algae, from species associated primarily with clear water to those more commonly seen in nutrient-enriched lakes. These changes began during European settlement and have continued at varying rates into the present, with the greatest changes in nutrient and sediment loading occurring after 1940 (Engstrom and Almendinger, 2000).

The burgeoning population living along the river took its toll in other ways, as well. Over-fishing led to the near elimination of some large fish species (Lubinski et. al., 1998, p. 3-6), and native mussel beds were decimated by pearl hunting and the harvesting of shells for the active button industry that grew up along the river. (For details on over-harvesting of the mussel beds, see *Great River: The Environmental History of the Upper Mississippi, 1890-1950*, Philip V. Scarpino, University of Missouri Press, 1985, Chapter 3.)

Navigation, and the accompanying river channel alterations, has also altered the ecology of the river. The ecological impacts of first the wing dams and closing dams, and then the lock and dam system has been dramatic. The construction of closing dams cut off side streams and backwater areas of the river. No longer exposed to periodic flushing by higher water flows, the backwater areas began to fill with sediment, a problem that was exacerbated by increased sediment loading to the river from upstream logging and agricultural activities (USGS, 1998, p. 3-4).

Dredging was also done to increase the depth of the main river channel. Dredge spoils were piled to create channel border islands, and also deposited in shallow areas near the riverbanks, covering those aquatic habitats (USGS, 1998, p. 4-11). Levees were also built to protect the floodplains—which had become farmlands and cities—from seasonal floodwaters.

All of this added up to habitat changes for the Mississippi River. Fish spawning areas were lost, and native mussel beds either scoured away or silted over. As mentioned earlier, fisheries were also impacted. In addition, the floodplain forests experienced a decrease in diversity and a shift to a system dominated by silver maple (Yin and Nelson, 1995, p. 5).

The construction of the lock and dam system in the 1930s brought more changes. The dams slowed flow velocities, raised water levels and inundated adjacent floodplains. Many islands disappeared below the rising water levels, and those that remained experienced increased wave erosion. Larger pool areas in the river meant a larger surface area for the wind to blow across, spurring wave action that stirs up sediment, leading to decreased water transparency and declines in aquatic plants.

Not all of the changes led to a decrease in habitat and diversity. New backwater areas were created as a result of the dams, and some now support diverse plant and animal communities. New wetlands were created as well. However, at least some of these habitats are slowly filling with sediment deposited by the river, and there is concern that eventually these areas will be lost.

The River Today

Today, advances in wastewater treatment and best management practices have led to water quality improvements. Fish and mayflies have returned to the Mississippi River below St. Paul, and numerous bald eagles return to the river near Lake Pepin and Wabasha each year. However, challenges remain. The current lock and dam system limits the impact of "re-setting events"—like floods and droughts—that once maintained the ecological system. Toxic pollutants, while decreasing, still pose a threat to human health and wildlife. Nutrient levels remain elevated in Lake Pepin. These and other problems must be addressed if the Lower Mississippi River Basin is to thrive into the future.

C: Geology

The Lower Mississippi River Basin comprises an area of 5,708 square miles in southeastern Minnesota. The Vermillion, Cannon, Zumbro and Root Rivers drain most of the basin. Annual precipitation ranges from 28 to 31 inches and increases toward the southeast. Annual runoff ranges from 5.5 to about 8 inches, increasing from west to east. The topography varies from gently rolling in the west to plateaus with deeply-incised bedrock valleys in the east. Row crop agriculture is the primary land use in upland areas, valley slopes are forested, and river valleys have a mixture of agriculture and forest.

Bedrock geology consists of alternating layers of shale, sandstone, and carbonates of Paleozoic age. These deposits have been eroded from west to east so that individual formations vary in their vertical position. Where carbonate bedrock is the first bedrock, it may be highly dissolved. The uppermost bedrock unit is generally fractured.

Much of the basin has been glaciated, but glacial deposits vary in thickness from several hundred feet in the west to less than 50 feet in the east. Bedrock is often exposed along the major rivers. Des Moines Lobe till associated with the Bemis moraine and the Altamount moraine occur in the extreme west. Most of the western half of the basin is covered with old gray till. Alluvial and colluvial deposits occur along the major rivers in the east. A loess cap occurs throughout most of the basin.

The hydrogeology of the area has been extensively studied. Despite this, mechanics of flow are not completely understood because of the complexities of flow within fractures and solution channels. Aquifers are generally recharged where they are exposed or have a thin cover of unconsolidated material. Ground water flows toward the major rivers. Vertical mixing of aquifers is most likely in areas where there are steep hydraulic gradients, such as along rivers and in buried bedrock valleys. Fractured flow and local heavy pumping also may lead to vertical mixing between aquifers.

The Cedar River Basin comprises an area of approximately 1,200 square miles in south central Minnesota. The Cedar and Shell Rock Rivers and smaller streams drain southward into Iowa and eventually into the Mississippi River. Annual precipitation ranges from 30 inches in the northern part of the basin to 31 inches in the south. Average annual runoff varies from 5.5 inches in the west to about 6.5 inches in the east. The area consists primarily of a flat undulating plain. Row-crop agriculture is the primary land use.

Glacial deposits overlie the entire watershed and consist of pre-Wisconsin drift in the eastern half of the basin and Wisconsin drift in the western half. Glacial deposits range in thickness from less than 100 feet in the south central to more than 200 feet in the northeast and northwest. Few wells are completed in drift materials because supplies are not dependable, the aquifers are susceptible to contamination, and concentrations of dissolved solids are very high, particularly in deposits of the Wisconsin drift.

The Upper Carbonate bedrock units have typically been classified as a single aquifer. They consist of the Cedar Valley, Maquoketa, Dubuque, and Galena formations. Upper Carbonate deposits underlie the entire basin. Ground water within these formations drains toward the major rivers and streams in a general southward direction. Recharge to the ground water system occurs in upland areas. Water infiltrates through glacial deposits and moves into the bedrock units. Bedrock deposits are fractured and have many solution channels. Flow can thus be very rapid within the bedrock aquifers. The rate that water percolates through the glacial deposits and the chemistry of glacial deposits exert strong controls on water quality of the bedrock aquifers. Recent investigations indicate there may be confining bedrock units within the Upper Carbonate deposits. In many portions of the basin, the Upper Carbonate aquifer is not considered an acceptable drinking water sources due to actual or potential contamination.

<u>D: Land Use, Landscape Features and Water Quality</u>

Steep-sloping land, often under intensive cultivation or development, is located in close proximity to streams in many parts of the basin. This is especially true of the blufflands on the eastern side of the basin and the rolling moraine landforms on the western edge of the basin, as well as less extensive steep areas located in between. Approximately 11 percent of the land is next to permanent streams and about 29 percent next to intermittent streams. This indicates a very high potential for sediment delivery to streams as a result of erosion and runoff.

The National Resource Inventory, a statistical land-use survey conducted every five years by the Natural Resources Conservation Service, indicates that soil erosion is evenly distributed across highly erosive and moderately erosive fields. Erosion rates are described relative to the amount of erosion that land can tolerate (T) without impairing its productive capacity. Land eroding at "T" , which usually amounts to about 3 to 5 tons per acre, is thus able to maintain its productive capacity.

Results of the 1997 NRI indicate that 61,200 acres of cultivated cropland in the Lower Mississippi River Basin are eroding at a rate of 4T or greater. This land comprises only 2.2% of the cultivated cropland in the basin, but accounts for 16% or the total water erosion in the region from cultivated cropland. Also according to the 1997 NRI, 154,700 acres of cultivated cropland in the Lower Mississippi River Basin are eroding at a rate of 2T - 4T. This land comprises only 5.5% of the cultivated cropland in the basin, but accounts for 19% of the total soil loss from water erosion from in the region from cultivated cropland. However, the majority of soil erosion – an estimated 65% -- comes from the remainder of cropland which erodes at moderate and low rates of soil loss – an estimated 2,597,000 acres. Collectively, it appears that these moderately eroding acres contribute the bulk of agricultural sediment to the region's streams.

Soil erosion and runoff are greatly affected by land use – particularly, how the land use affects surface roughness and the ability to infiltrate water. Well-managed pasture and hay land provide vast areas where rainfall and snowmelt can infiltrate the soil and recharge shallow groundwater rather than running off the surface and carrying high water volumes and pollutants to streams.

Data from the NRI show a steady decline in pastureland and erratic fluctuations in noncultivated cropland from 1982 to 1997. Together, acreage in these two land-use categories declined from 628,000 acres in 1982 to 448,000 acres in 1997, a decline of 180,000 acres, or 28 percent. Forested acreage increased slightly over the same period, from 574,000 to 590,000 acres.

Although reasons for declining acreage of pasture and noncultivated cropland were not identified in the NRI study, conversion from mixed crop/livestock farming to larger, more specialized row-crop operations appears to be playing a major role. In Olmsted County, for example, data from the Minnesota Agricultural Statistics Service indicate that major crop acreage has changed significantly over the past 25 years. There has been a shift from a forage-small grain-corn rotation to a corn-soybean rotation. From 1975 to 1998, soybeans have replaced one-third of the alfalfa hay acres and more than eighty percent of the harvest oats acreage. Soybean acres have increased from 29,900 in 1975 to 67,600 acres in 1998 (Wotzka and Bruening).

<u>Sources: Section II</u>

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III: Water Quality

A: Basinwide Surface Water Quality Conditions and Trends

Summary:

Water quality monitoring data from the Mississippi River and its tributaries in southeastern Minnesota present a somewhat mixed picture. The current condition of surface water in the basin must be described as impaired and in need of restoration with regard to several types of pollutants – mainly those for which numerical water quality standards exist. A review of historical water quality monitoring data in the basin has identified widespread impairments indicated by exceedences of the water quality standards for turbidity[4] and fecal coliform bacteria[5], and isolated exceedences of the standard for un-ionized ammonia.[6]
Of 42 stream reach impairments on the Section 303(d) list[7], 20 are for fecal coliform bacteria, 19 are for turbidity, and four are for un-ionized ammonia.

The MPCA is required under the Clean Water Act to publish a list of stream segments which have impaired uses, and for which the MPCA proposes to complete total maximum daily load (TMDL) studies. TMDL studies define the maximum amount of each pollutant which can be released and assimilated in the receiving water from point and nonpoint sources and still allow the receiving water to achieve water quality standards. The MPCA is required to list and prioritize stream segments. The 1998 list of impaired waters is based on a relatively small number of monitoring stations whose locations were determined by specific needs not necessarily related to watershed assessment. Thus, the list of impaired waters did not result from a comprehensive survey of water quality. Prioritization decisions are based on problem severity, relative importance of the stream segment, and availability of resources to conduct the TMDL work. As the basin planning process is launched in the Lower Mississippi River basin, water quality problems will be identified and prioritized, resulting in possible modifications of the list below:

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[4] The ambient water quality standard for turbidity (Minnesota Rules Chapter 7050.0222) for most waters is 25 nephelometric turbidity units (NTUs); for cold-water streams (Class 2A) the standard is 10 NTUs.

[5] The ambient water quality standard for fecal coliform bacteria (Minnesota Rules Chapter 7050.0222) for most waters of the state applies between April 1 and October 31 and is divided into two parts: 1) 200 organisms per 100 milliliters (not to exceed a geometric mean of not less than 5 samples per calendar month, or 2) 2000 organisms per 100 milliliters (no more than 10 percent of the samples per calendar month can individually exceed.)

[6]

[7] The 303(d) list of Impaired Water Bodies is a reporting requirement of Section 303(d) of the Clean Water Act. The MPCA generates this list every two years, based on an evaluation of water quality monitoring data in STORET. The Clean Water Act requires the U.S. EPA and states to develop a pollution budget, or Total Maximum Daily Load, for each listed impairment.

303(d) IMPAIRED WATERS 1998 LOWER MISSISSIPPI RIVER BASIN					
Mississippi River, Pine Cr. to Root R.					
	07040006-001		Aquatic life	Ammonia[5, 6]	2004//2007
Mississippi River, LaCrosse R. to Pine Cr.					
	07040006-002		Aquatic life	Ammonia[5, 6]	2004//2007
Reach	River Reach#	Lake #	Affected use	Pollutant or stressor	Target start//completion [7]
UPPER MISSISSIPPI RIVER BASIN, Lower Portion (cont'd)					
Mississippi River, Trimble R. to Cannon R.					
	07040001-006		Aquatic life	Ammonia[5, 6]	2004//2007
Garvin Brook, Headwaters to Mississippi R.					
	07040003-023		Swimming	Fecal Coliform[3]	2002//2006
Root River, S. Fk. Root R. to Mississippi R.					
	07040008-001		Swimming	Fecal Coliform[3]	2001//2005
***	07040008-002		Swimming	Fecal Coliform[3]	2001//2005
Straight River, Maple Cr. to Crane Cr.					
	07040002-021		Swimming	Fecal Coliform[3]	2003//2007
Zumbro River, South Fork, Cascade Cr. To Middle Fk. Zumbro R.					
	07040004-016		Swimming	Fecal Coliform[3]	2000//2004
Whitewater River, South Fork, Source to Split at 122 S. Fk. Whitewater R.					
	07040003-222		Swimming	Fecal Coliform[3]	2002//2006
Robinson Creek, Headwaters to N. Br. Root R.					
	07040008-418		Swimming	Fecal Coliform[3]	2001//2005
Prairie Creek, Headwaters to Cannon R.					
	07040002-033		Swimming	Fecal Coliform[3]	1999//2003
Salem Creek, Split at 220 to S. Fr. Zumbro R.					
	07040004-120		Swimming	Fecal Coliform[3]	2000//2004
Whitewater River, North Fork, Unnamed Cr. to Middle Fk. Whitewater R.					
	07040003-120		Swimming	Fecal Coliform[3]	2002//2006
Vermillion River, Headwaters to S. Br. Vermillion R.					
	07040001-312		Swimming	Fecal Coliform[3]	2003//2007
Vermillion River, S. Br. Vermillion R. to the Hastings Dam					
	07040001-212		Swimming	Fecal Coliform[3]	2003//2007
Cannon River, Pine Cr. To Mississippi R.					
***	07040002-002		Swimming	Fecal Coliform[3]	2003//2007
	07040002-001		Swimming	Fecal Coliform[3]	2003//2007
Mississippi River, La Crosse R. to Root R.					

***	07040006-001		Swimming	Fecal Coliform[3]	2004//2008
	07040006-002		Swimming	Fecal Coliform[3]	2004//2008
Mississippi River, Root R. to Coon Cr.					
	07060001-021		Swimming	Fecal Coliform[3]	2004//2008
Garvin Brook, Headwaters to Mississippi R.					
	07040003-023		Aquatic life	Turbidity	2002//2006
Mississippi River, Hay Cr. to Lake Pepin					
	07040001-204		Aquatic life	Turbidity	2003//2007
Root River, Thompson Cr. to Mississippi R.					
	07040008-001		Aquatic life	Turbidity	2001//2005
Reach	River Reach#	Lake #	Affected use	Pollutant or stressor	Target start//completion [7]
UPPER MISSISSIPPI RIVER BASIN, Lower Portion (cont'd)					
Mississippi River, L&D #3 to Trimble R.					
	07040001-108		Aquatic life	Turbidity	2003//2008
Mississippi River, Trimble R. to Cannon R.					
	07040001-006		Aquatic life	Turbidity	2003//2008
Mississippi River, Coon Cr. to L&D 8					
	07060001-217		Aquatic life	Turbidity	2004//2008
Zumbro River, Indian Cr. to Mississippi R.					
	07040004-001		Aquatic life	Turbidity	2000//2004
Vermillion River, Dam to Mississippi R.					
	07040001-112		Aquatic life	Turbidity	1999//2003
Mississippi River, Lk. Pepin to Rush R.					
	07040001-104		Aquatic life	Turbidity	2003//2008
Cannon R, Belle Cr. to Mississippi R.					
	07040002-001		Aquatic life	Turbidity	1999//2003
Mississippi River, Root R. to Coon Cr.					
	07060001-021		Aquatic life	Turbidity	2004//2008
Whitewater River, Whitewater R., N.Fk. to Mississippi R.					
	07040003-018		Aquatic life	Turbidity	2002//2006
Whitewater River,N. Fk., Unnamed Cr. to Middle Fk. Whitewater R.					
	07040003-120		Aquatic life	Turbidity	2002//2006
Mississippi River, Zumbro R. to Whitewater R.					
	07040003-008		Aquatic life	Turbidity	2004//2008
CEDAR-DES MOINES RIVER BASIN					
Des Moines River Below Windom Dam, Windom Dam to Jackson dam					
	07100001-101		Aquatic life	Ammonia[4,5]	2004//2007
Shell Rock River, Albert Lea Lake to Goose Cr.					
	07080202-009		Aquatic life	Ammonia[5]	2004//2007

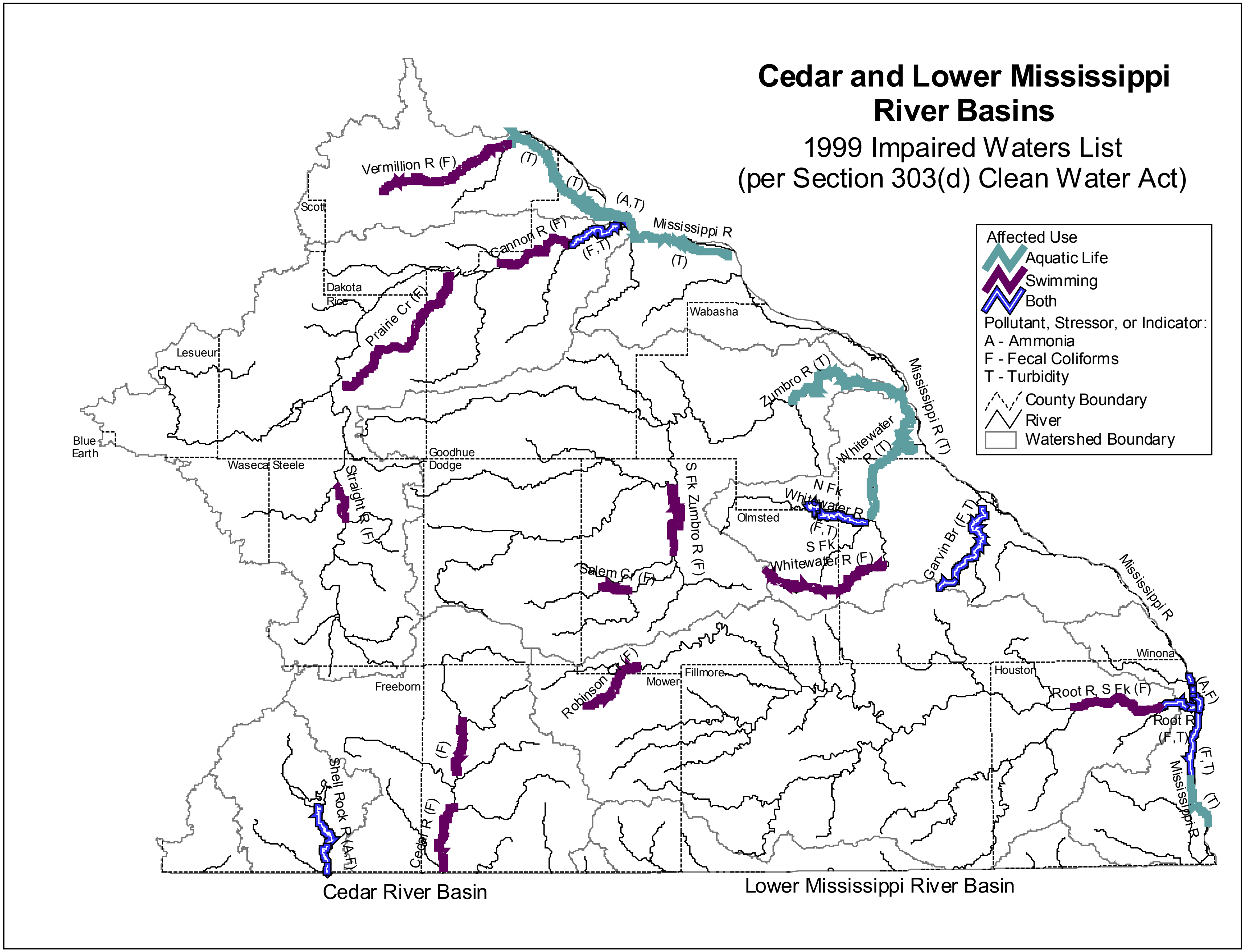
Des Moines River, Windom Dam to Jackson Dam					
	07100001-101		Aquatic life	Low Oxygen[2]	2002//2007
Cedar River, Roberts Cr. to Austin Dam upper					
	07080201-321		Swimming	Fecal Coliform[3]	2004//2007
Cedar River, Rose Cr. to Woodbury Cr.					
	07080201-016		Swimming	Fecal Coliform[3]	2004//2007
Shell Rock River, Albert Lea Lk. to Goose Cr.					
	07080202-009		Swimming	Fecal Coliform[3]	2004//2007
Des Moines River, Windom Dam to Jackson Dam					
	07100001-101		Aquatic life	Turbidity	2002//2007

In addition, 17 lakes in the basin are impaired by severe algae blooms that result from excess nutrients. Nutrient levels in streams are monitored, but the lack of numeric ambient water quality standards makes it difficult to evaluate whether monitored concentrations are causing impairments. Impairments for both fecal coliform bacteria and turbidity frequently occur in the lower reaches of the basin's major tributaries as well as far upstream in the watersheds.

On the positive side, a long-term evaluation of the MPCA's 16 Minnesota Milestone monitoring sites in the Lower Mississippi/Cedar River basins shows significant improvements in the concentration of certain pollutants and no trend in others over the past three decades.

- Un-ionized ammonia concentrations decreased at all 16 sites.
- Biochemical oxygen demand (BOD) concentrations decreased at all but one site (on the Vermillion River);
- Total Phosphorus decreased at 11 sites and remained unchanged at 5 sites.
- Fecal Coliform Bacteria concentrations declined at 8 sites and showed no trend at 8 sites.
- Total suspended Solids (TSS) concentrations showed no trend at 11 sites, declined at 4 sites and showed an increase at two sites (both on the Mississippi River)
- Nitrate Nitrogen concentrations showed an increasing trend at 12 sites and no change at four sites.

Many of these positive trends likely have resulted from the installation of secondary (biological) or further treatment for point source dischargers in the basin. However, despite these positive and neutral trends, concentrations of many pollutants remain high enough to cause widespread water quality impairments. The ubiquitous and substantial increases in nitrate nitrogen concentrations is thought to be related to manure and commercial nutrient applications to row-cropped fields. Many fields have been extensively drained with subsurface tile, which act as efficient conveyors of nitrate nitrogen to surface water. In addition, wastewater treatment facilities with ammonia effluent limits convert ammonia to the nitrate form of nitrogen.


Cedar and Lower Mississippi
River Basins
1999 Impaired Waters List
(per Section 303(d) Clean Water Act)
Affected Use
Aquatic Life
Swimming
Both
Pollutant, Stressor, or Indicator:
A - Ammonia
F - Fecal Coliforms
T - Turbidity
County Boundary
River
Watershed Boundary
Vermillion R (F)
(T)
(T)
(A,T)
Mississippi R
(T)
Cannon R (F)
(F,T)
Scott
Dakota
Rice
Prairie Cr (F)
Lesueur
Blue Earth
Waseca
Steele
Goodhue
Dodge
Wabasha
Zumbro R (T)
Mississippi R (T)
Whitewater R (T)
N Fk Whitewater R
(F,T)
Olmsted
S Fk Whitewater R (F)
Straight R (F)
S Fk Zumbro R (F)
Salem Cr (F)
Garvin Br (F,T)
Mississippi R
Winona
Houston
Root R, S Fk (F)
Root R
(F,T)
(A,F)
(F,T)
(T)
Mississippi R
Robinson Cr (F)
Mower
Fillmore
Freeborn
(F)
Cedar R (F)
Shell Rock R (A,F)
Cedar River Basin
Lower Mississippi River Basin

B: Mississippi River Water Quality

Water quality in the Mississippi River varies considerably along the 146.5 river miles between confluence with the St. Croix River just southeast of St. Paul, southward to the Iowa border. Several complicating factors make this stretch of river unique and challenging to describe with simple measurements of water quality.
The first, and most obvious, is the lock-and-dam system that forms nine navigation pools adjacent to Minnesota (29 for the entire Upper Mississippi River) within which a nine-foot-deep navigation channel is maintained to support commercial barge traffic. This system, installed in the 1930s, has fundamentally changed the river and its potential uses by converting a free-flowing river meandering through a broad floodplain, into a series of pools that cover the floodplain with slackwater. Within the navigation pools it is useful to distinguish between the flowing water of the main channel, and the side channels and backwaters, when describing water quality and its connection to aquatic life support.

A second structural factor that greatly influences water quality of the Mississippi is the presence of Lake Pepin, which was formed naturally from alluvial sediment deposits at the mouth of the Chippewa River. Because Lake Pepin acts as a settling basin for sediments and attached contaminants, water quality differs quite dramatically upstream and downstream of Lake Pepin.

1. Water Quality: Lake Pepin and the River Upstream

Two dominant influences on water quality in the 60 river miles between Lake Pepin and upstream through Pool 2 are the Minnesota River and the Metropolitan Twin Cities area. The Minnesota River contributes more than 80 percent of the average annual sediment load to Lake Pepin, and is chiefly responsible for the filling-in of the lake at a rate roughly 10 times that which prevailed in pre-settlement times (before 1840). Approximately 17 percent of the lake volume in 1830 has been replaced by sediment. If current rates of sedimentation continue, Lake Pepin will fill in after approximately 340 years rather than 4,000 years without accelerated sediment loading. In less than a century the upper third of Pepin will be filled in. The rate of phosphorus accumulation has increased 15-fold over the same period. Currently, the Minnesota River contributes approximately half the load of phosphorus and viable chlorophyll a (a measure of algae) to Lake Pepin on an average annual basis. During low flow periods of concern, half the load of chlorophyll comes from the Upper Mississippi River Basin. This contributes to chronic problems associated with algal production. Upstream of Lake Pepin, sediment from the Minnesota River makes the Mississippi River much more turbid than it otherwise would be, limiting the diversity of aquatic life including mussels and submersed aquatic vegetation.

The Metropolitan Twin Cities area also exerts a powerful influence on the Mississippi River through Lake Pepin. This is a result of the density of population (more than 3 million) combined with the relatively small discharge of the river in the metropolitan area (310 cubic meters per second on average, compared to 520,000 cubic meters per second near the mouth of the Mississippi River). This produces a "population stress" level of about 10,000 people per square meter of river flow per second, the highest of any point on the Mississippi River.

The 60-mile reach downstream of the Metropolitan area was polluted with sewage for many decades. This resulted in frequent depletion of dissolved oxygen, which adversely affected fish and other pollution-sensitive organisms. This situation prevailed until the mid-1980s, after which time improvements in the Metro Plant, the state's largest sewage treatment facility, were introduced. The Metro Plant was built to provide primary treatment in 1938; secondary treatment was added in 1978. More recently, additional treatment for ammonia was added; and biological phosphorus removal is being introduced at the Metro Plant and other facilities operated by the Metropolitan Council in the near future. The separation of storm water from the sanitary sewage collection system completed in 1995 has further reduced pollution pressure by virtually eliminating the need for sewage treatment bypasses during storm events in the Metro area.

Ammonia toxicity problems have diminished in frequency as a result of these improvements, and it is hoped that phosphorus reductions from the Metro Plant, combined with planned reductions from point and nonpoint sources in the Minnesota River, will help to reduce algal bloom frequency and duration in Lake Pepin, especially in vulnerable low-flow periods when point sources provide the bulk of phosphorus to the river. The last such period was summer 1988, when a severe drought resulted in very low flows, algal blooms, oxygen depletion and resulting fish kills in Lake Pepin.

Toxic chemicals became a major pollution problem in the Mississippi following World War II, when the synthetic-organic chemical industry rapidly expanded and introduced thousands of new chemicals, which eventually found their way into the nation's rivers. By 1950, the Mississippi River had been significantly degraded by chemicals such as mercury and polychlorinated biphenyls (PCBs). Following the banning of PCBs in the 1970s, concentration in sediments decreased greatly. Bed sediments deposited during the 1950s and 1960s retain extremely high levels of PCBs (2000 to 3000 nanograms per gram) in Pool 2; thus, contaminated sediments could remain a problem for years to come. USGS sampling from 1987 to 1992 showed that bed-sediment concentrations of mercury in Lake Pepin exceeded 0.18 micrograms/gram, a level that has been shown to increase the mortality rates in fish, embryos, eggs and larvae[8]. In surficial bed sediments, PCB concentrations are high below the Twin Cities, reach a peak in Lake Pepin, and decline sharply downriver.

High organic-carbon concentrations in the presence of mercury in the bed

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[8] Birge, W.J., Block, J.A., Westerman, A.G., Francis, P.C., and Hudson, J.E., 1977, Embryopathic effects of waterborne and sediment-accumulated cadmium, mercury and zinc on reproduction and survival of fish and amphibian populations in Kentucky: US Department of Interior, Research Report 100, Washington, D.C., 28 p.

sediments increase the methylation rate of mercury and subsequently increase the absorption and retention of mercury in fish and human tissues. The Mississippi River between Lake Pepin and the Twin Cities is one of the areas where this is most likely to occur.

Recent water quality monitoring data show that the Mississippi River upstream of Lake Pepin is impaired by turbidity and ammonia. The MPCA lists the Mississippi River from Lock and Dam 3 through Lake Pepin as impaired by turbidity. The lower reach of the Vermillion River, which at higher flows exchanges water with the Mississippi, also is listed as impaired by turbidity. In addition, a short reach between the Trimbelle River and the Cannon River is impaired by un-ionized ammonia.

USGS monitoring from 1987 to 1992 showed that average concentrations of herbicides were below maximum contaminant levels of drinking-water standards established by the US EPA. However, it is not known whether agricultural chemicals and their metabolites adversely affect aquatic life. Concentrations of dissolved heavy metals are well below maximum contaminant levels, but concentrations in suspended and deposited sediment often exceed maximum contaminant levels, and toxics accumulated in bed sediments remain a potential threat to riverine biota.

The Wisconsin Department of Natural Resources' Mississippi-Lower St. Croix Team has identified positive trends in several water quality parameters after examining two decades of monitoring data. In the last 20 years, significant decreasing trends were noted for fecal coliform bacteria, un-ionized and total ammonia nitrogen in the upper study area (Lock & Dam 3 and 4). Dissolved oxygen concentrations and dissolved oxygen saturation exhibited a small increasing trend over the same period. Municipal point source pollution abatement activities, particularly in the Twin Cities Metropolitan Area, were likely important management activities influencing these positive improvements. However, nitrite+nitrate nitrogen concentrations and loading increased significantly at Lock and Dam 3 and 4. But when all forms of inorganic nitrogen were considered, only a small increasing trend was observed at Lock & Dam 4.

A Water Quality Assessment Report published in 1999 by the Wisconsin Department of Natural Resources indicates that concentrations of PCBs have been gradually decreasing at monitoring sites near Lock and Dam 3 and Lock and Dam 4 on the Mississippi River. This assessment is based on long-term monitoring of suspended sediment contaminant concentrations at these two sites since 1987. Suspended sediment contaminant trends for lead and mercury are less obvious, although there appears to be a decline in lead and mercury concentrations at Lock and Dam 3. These trends in contaminant reduction were credited to past pollution abatement efforts to reduce the use or discharge of these contaminants.

Suspended sediment in river water represents a major portion of contaminant transport, especially in turbid rivers such as the Mississippi River. Organic chemicals that do not dissolve readily in water (such as PCBs, organochlorine pesticides and heavy metals) adsorb to fine-grained suspended sediment particles, especially those high in organic matter content. Some sources of contaminant input include runoff from urban and agricultural land use, deposition from coal and waste incineration, resuspension of contaminated bed sediments, and wastewater discharges.

Concentrations of PCBs, lead and mercury in suspended sediments normally were higher in samples collected from Lock and Dam 3 than at Lock and Dam 4. This is due to the closer proximity to the Twin Cities Metropolitan area, a major source of these contaminants. Lake Pepin acts as a natural sediment trap, which results in decreased transport of these contaminants downstream.

2. Water Quality Downstream of Lake Pepin

In some respects the Mississippi River “starts over” at Lake Pepin. As noted above, concentrations of heavy metals drop sharply. Nutrient enrichment and consequent hyper-eutrophication is not a recurring, widespread problem, as it is in Lake Pepin and further north in Spring Lake. Impairments for ammonia, fecal coliform bacteria and turbidity are clustered toward the southern stretches of the river, between the confluence with the LaCrosse River and the Iowa border.

Sediment is a widespread and recurring problem both in the main channel and slackwater areas of all navigation pools. Continual deposition of large-particle sediments (sand) in the main channel necessitate regular dredging and a massive river channel maintenance program to maintain the 9-foot navigation channel. Much of the large-particle sediments originate in Chippewa River. Other tributaries and upstream river channel scouring also are sources of large-particle sediment. Dredging itself as well as related activities such as transport and storage and dewatering of dredge spoils within the flood plain, are potential sources of pollution.

Finer-particle sediments (silt and clay) from tributaries and points upstream (the Minnesota River, for example) tend to settle out in side-channels and backwater areas where water moves very slowly. In the decades since the Lock-and-Dam system was constructed, backwater areas that once were lakes, old river channels, oxbows and wetlands, have been filled in with several feet of fine-particle sediment from upstream sources. The surficial sediments are not consolidated, and are easily resuspended by wind or turbulence caused by recreational and commercial boat propellers.

Many backwater areas of the Mississippi supported dense beds of aquatic plants before an abrupt decline in the late 1980s. High levels of turbidity continue to hinder the re-establishment and recovery of submersed aquatic vegetation in these areas by keeping light from penetrating to the river bed. Continued deposition and resuspension of sediment in backwaters also has tended to produce a uniform depth of water which results in a less diverse biological community. A recent increase in submersed aquatic vegetation in Pools 5-9 has been accompanied by an apparent decline in turbidity.

The rapid spread of zebra mussels into the Upper Mississippi River is quickly becoming a major water quality issue. Zebra mussels were first discovered near La Crosse in 1991. Since then, the population and distribution of zebra mussels have expanded greatly. The highest concentrations have been found on hard substrates in flowing water with moderate to low suspended solid concentrations. Densities exceeding several thousand individuals per square meter have been found in some portions of the river. Zebra mussel populations upstream of Lake Pepin are very low and are likely negatively affected by high suspended solid concentrations from the Minnesota River.

Unusually low dissolved oxygen concentrations were detected in parts of the Mississippi River where zebra mussel populations were high, during early summer periods of 1997and 1998. Water clarity improved dramatically in portions of the river in late summer 1997, which may have resulted from the filter-feeding activity of zebra mussels. Perhaps the most serious impact of zebra mussels is on native mussel populations in the river. Native mussels are being smothered by high concentrations of zebra mussels that attach themselves to the native mussel's shell. This greatly reduces the ability of native mussels to filter-feed. In addition, waste products from zebra mussels may be harmful to native mussels.

C: Water Quality of Major Mississippi Tributaries

The major tributaries to the Mississippi are listed north to south, accompanied by a brief summary of water quality resource issues:

Vermillion River: This stream originates in the south metro area near Lakeville, and discharges into the Mississippi near Redwing. The headwaters area of the Vermillion includes reaches classified for a trout fishery, which are threatened by urban development, lack of shading, high temperature and unstable hydrology. The Vermillion is impaired by excess levels of fecal coliform from the headwaters to the dam in Hastings, and by excess turbidity in the lower reach that runs parallel to the Mississippi River. Sediment exchange between the Vermillion and Mississippi Rivers at high flow complicates the turbidity problem. Recent monitoring shows that riverine lakes along the lower reach of the Vermillion are impacted by excess phosphorus. Urbanization, stream corridor protection from agricultural practices and development, and the Metropolitan Council's Empire wastewater treatment facility are among the most significant concerns. Long-term monitoring of the Vermillion four miles northeast of Farmington indicates decreasing concentrations of total suspended solids and un-ionized ammonia, and increasing concentrations of BOD_5 and nitrate-nitrogen.

Cannon River: The Cannon River enters the Mississippi River immediately upstream of Lake Pepin. Riverine reservoirs including Cannon Lake and Lake Byllesby often suffer from hyper-eutrophication, the result of excessive loads of phosphorus from point and nonpoint sources. The latter include feedlots, excess fertilizer and manure use, and soil erosion. Riverine lakes at the mouth of the Cannon also may be impacted by phosphorus. Fecal coliform bacteria levels are high throughout the Cannon River and its major tributaries. The northern portion of the watershed is experiencing rapid urban development, partially a result of more Twin Cities commuters. The lower reach of the Cannon is impaired by excess turbidity, which is likely a result of excessive soil erosion from the surrounding hilly terrain combined with streambank erosion. The Straight River, a major tributary that runs parallel to the developing Interstate 35 corridor, is impaired by fecal coliform bacteria. Long-term monitoring at the mouth of the Cannon show decreasing concentrations of BOD_5, un-ionized ammonia, total suspended solids, total phosphorus and fecal coliform bacteria over past decades.

U.S. Geological Survey monitoring from 1984 to 1993 was evaluated for the National Water Quality Assessment Program (NAWQA) in the Cannon River. The assessment showed that the greatest loads and yields of nitrate nitrogen and total phosphorus in both the Straight River (near Faribault) and Cannon River (near Welch) occurred in spring and summer. Nitrate nitrogen concentrations exceeded the Maximum Contaminant Level of 10 milligrams per liter on the Straight River during spring and summer of 1990. The Straight River, a large tributary that enters the Cannon River at Faribault, was found to contribute disproportionately to nutrient loads in the Upper Mississippi. Yield of total nitrite plus nitrate nitrogen was 8.22 tons per square mile per year, on average, more than twice the amount estimated for the Minnesota River and seven times the amount for the Vermillion River. The yield of total phosphorus was 0.30 tons/square mile/year, three times that of the Minnesota River, and six times the level in the Vermillion River. In an Upper Mississippi River Basin NAWQA Study of snowmelt runoff, concentrations of nitrate nitrogen, dissolved ammonia nitrogen and total phosphorus in the Cannon River watershed were among the highest in the study area.

Zumbro River: Like the Cannon River, the Zumbro River is impaired throughout by excessive concentrations of fecal coliform bacteria. Zebra mussels were detected in Lake Zumbro in September 2000, the first time this exotic species has been found in Minnesota outside of the Mississippi River and the Duluth-Superior harbor where it is a major nuisance. Lake Zumbro also suffers from hyper-eutrophication, but has improved somewhat since phosphorus controls were introduced at the Rochester Water Reclamation Plant. Additional reductions from point and nonpoint sources are needed. The Zumbro also is considered a source of nitrates that contribute to the contamination of the aquifer that supplies drinking water to the City of Rochester. A Clean Water Partnership for the South Fork was initiated to address this problem. The lower Zumbro is impaired by high suspended sediment concentrations. Sediment and phosphorous discharged from the Zumbro at times may impair aquatic vegetation in Weaver Bottoms in the Mississippi. Long-term monitoring of the south fork of the Zumbro downstream of Rochester shows decreasing concentrations of BOD_5, un-ionized ammonia and total phosphorus, and an increasing trend in nitrate-nitrogen concentrations over past decades.

Whitewater River: The Whitewater River supports a healthy population of brown trout, and is the centerpiece of one of the state's most popular parks. Impairments from excessive sediment and bacteria limit its uses. The MPCA, Natural Resources Conservation Service and other state and federal agencies are assisting local government in a major watershed improvement effort focused mainly on sediment reduction and habitat improvement. These efforts will also help to protect the Weaver Bottoms in the Mississippi River. Long-term monitoring indicates that average concentrations of BOD_5 and un-ionized ammonia have been decreasing over past decades, while nitrate nitrogen concentrations have been increasing. In the 1990s decade, the mean concentration of nitrate nitrogen was 8.90 mg/l, the highest level recorded at long-term monitoring stations in the basin.

Root River: The Root River originates in the Western Corn Belt Plains ecoregion dominated by intensive agricultural land uses, and flows into the Driftless Region which is more wooded, rolling karst terrain where groundwater flows provide stream temperatures suitable for trout. High concentrations of fecal coliform bacteria and sediment impair the Root River, limiting its suitability for recreation and for aquatic life support. The mean concentration of total suspended solids at the mouth of the river was 99 mg/l during the 1990s, more than twice as high as any other monitored major tributary in the basin. Concentrations of BOD_5, Total Phosphorus, un-ionized ammonia and fecal coliform bacteria have been decreasing over past decades, while nitrate-nitrogen concentrations have been increasing.

Cedar and Shell Rock River watersheds. These two watersheds discharge into the Cedar River in Iowa, where the vast majority of the watershed acreage is located. Fecal coliform bacteria concentrations are high enough to cause both streams to be impaired on the Minnesota side of the border. The Cedar River is listed as impaired by nitrate-nitrogen and fecal coliform bacteria by the Iowa Department of Natural Resources. Long-term monitoring has been conducted at two sites on the Cedar River and one site on the Shell Rock River. A monitoring site north of Austin on the Cedar shows decreasing concentrations of BOD_5, total phosphorus and un-ionized ammonia. A monitoring site south of Austin, downstream, shows decreasing concentrations of BOD_5 , total phosphorus, un-ionized ammonia and fecal coliform bacteria, with an increase in nitrate-nitrogen concentrations. The Shell Rock River shows decreasing concentrations of BOD_5, total suspended solids and un-ionized ammonia, and increasing concentrations of nitrate-nitrogen.

Long-Term Water Quality Trends in the Lower Mississippi River Basin

Cannon River at Br on CSAH-7 at Welch (CA-13)	1950s	1960s	1970s	1980s	1990s	overall trend
Biochemical Oxygen Demand (5-day)	3.3	---	---	2.5	2.5	decrease
Total Suspended Solids	---	---	---	22.8	15.1	decrease
Total Phosphorus	---	---	---	0.26	0.18	decrease
Nitrite/Nitrate	---	---	---	3.00	3.90	no trend
Un-ionized Ammonia	---	---	---	0.0060	0.0040	decrease
Fecal Coliform Organisms	---	---	---	139	52	decrease

Cedar River at CSAH-4, 3 Miles S of Austin (CD-10)	1950s	1960s	1970s	1980s	1990s	overall trend
Biochemical Oxygen Demand (5-day)	---	5.2	5.8	3.1	2.4	decrease
Total Suspended Solids	---	31.0	30.5	23.4	28.8	no trend
Total Phosphorus	---	0.64	0.72	0.43	0.36	decrease
Nitrite/Nitrate	---	---	3.20	3.90	5.45	increase
Un-ionized Ammonia	---	---	---	0.0135	0.0070	decrease
Fecal Coliform Organisms	---	2,307	697	199	280	decrease

Cedar River at CSAH-2, 0.5 Miles E of Lansing (CD-24)	1950s	1960s	1970s	1980s	1990s	
Biochemical Oxygen Demand (5-day)	---	3.3	3.0	1.9	1.4	decrease
Total Suspended Solids	---	23.0	25.5	18.9	21.1	no trend
Total Phosphorus	---	0.18	0.28	0.19	0.16	decrease
Nitrite/Nitrate	---	---	---	4.40	6.55	no trend
Un-ionized Ammonia	---	---	---	0.0060	0.0030	decrease
Fecal Coliform Organisms	---	409	589	302	374	no trend

Garvin Brook at CSAH-23, SW of Minnesota City (GB-4.5)	1950s	1960s	1970s	1980s	1990s	overall trend
Biochemical Oxygen Demand (5-day)	---	---	---	1.6	1.4	decrease
Total Suspended Solids	---	---	---	85.8	35.5	no trend
Total Phosphorus	---	---	---	0.25	0.13	no trend
Nitrite/Nitrate	---	---	---	1.30	1.70	increase
Un-ionized Ammonia	---	---	---	0.0050	0.0040	decrease
Fecal Coliform Organisms	---	---	---	670	851	no trend

Units of Measurement

Biochemical Oxygen Demand (5-day)	(geomean in mg/l)l
Total Suspended Solids	(geomean in mg/l)l
Total Phosphorus	(geomean in mg/l)l
Nitrite / Nitrate	(geomean in mg/l)l
Un-ionized Ammonia	(geomean in mg/l)l
Fecal Coliform Organisms	(geomean in col/100ml)

Root River at Br on MN-26, 3 Mi E of Hokah (RT-3)	1950s	1960s	1970s	1980s	1990s	overall trend
Biochemical Oxygen Demand (5-day)	---	5.5	2.4	1.8	1.5	decrease
Total Suspended Solids	---	58.5	92.6	81.3	99.1	no trend
Total Phosphorus	---	0.16	0.26	0.18	0.17	decrease
Nitrite/Nitrate	---	---	1.90	2.65	3.90	increase
Un-ionized Ammonia	---	---	---	0.0025	0.0020	decrease
Fecal Coliform Organisms	---	1,276	703	322	615	decrease

Straight River near CSAH-1, 1 Mi SE of Clinton Falls (ST-18)	1950s	1960s	1970s	1980s	1990s	overall trend
Biochemical Oxygen Demand (5-day)	6.4	4.6	---	2.4	1.8	decrease
Total Suspended Solids	---	25.8	---	22.5	21.0	no trend
Total Phosphorus	---	---	---	0.33	0.24	decrease
Nitrite/Nitrate	---	---	---	4.90	6.20	no trend
Un-ionized Ammonia	---	---	---	0.0095	0.0030	decrease
Fecal Coliform Organisms	---	3,433	---	353	537	decrease

Mississippi River below US-14 Br at La Crosse (UM-698)	1950s	1960s	1970s	1980s	1990s	overall trend
Biochemical Oxygen Demand (5-day)	---	---	3.4	2.5	2.6	decrease
Total Suspended Solids	---	---	19.1	20.9	27.8	no trend
Total Phosphorus	---	---	0.21	0.18	0.18	decrease
Nitrite/Nitrate	---	---	0.85	0.78	1.30	increase
Un-ionized Ammonia	---	---	---	0.0055	0.0030	decrease
Fecal Coliform Organisms	---	---	50	68	101	no trend

Mississippi River at Lock & Dam #6 at Trempealeau, Wis (UM-714)	1950s	1960s	1970s	1980s	1990s	overall trend
Biochemical Oxygen Demand (5-day)	---	4.1	3.4	2.3	2.5	decrease
Total Suspended Solids	---	27.6	27.5	19.1	25.5	decrease
Total Phosphorus	---	0.21	0.24	0.18	0.20	decrease
Nitrite/Nitrate	---	---	---	0.97	1.60	no trend
Un-ionized Ammonia	---	---	---	0.0060	0.0030	decrease
Fecal Coliform Organisms	---	188	174	46	120	decrease

Mississippi River at Lock & Dam #5, 3 Mi SE of Minneiska (UM-738)	1950s	1960s	1970s	1980s	1990s	overall trend
Biochemical Oxygen Demand (5-day)	---	---	3.4	2.3	2.6	decrease
Total Suspended Solids	---	---	20.9	18.1	25.0	no trend
Total Phosphorus	---	---	0.21	0.18	0.18	decrease
Nitrite/Nitrate	---	---	0.90	1.16	2.00	increase
Un-ionized Ammonia	---	---	---	0.0070	0.0040	decrease
Fecal Coliform Organisms	---	---	66	28	63	no trend

Mississippi River at Lock And Dam #2 at Hastings (UM-815)	1950s	1960s	1970s	1980s	1990s	overall trend
Biochemical Oxygen Demand (5-day)	---	5.3	5.7	3.5	3.0	decrease
Total Suspended Solids	---	45.8	37.7	36.3	42.0	no trend
Total Phosphorus	---	0.37	0.37	0.28	0.26	decrease
Nitrite/Nitrate	---	---	---	1.40	2.80	increase
Un-ionized Ammonia	---	---	---	0.0130	0.0050	decrease
Fecal Coliform Organisms	---	3,109	114	35	50	decrease

Mississippi River at Shiely Co. Dock, Grey Cloud Island (UM-826)	1950s	1960s	1970s	1980s	1990s	overall trend
Biochemical Oxygen Demand (5-day)	---	---	4.9	3.3	2.9	decrease
Total Suspended Solids	---	---	25.7	34.1	43.1	increase
Total Phosphorus	---	---	0.33	0.26	0.26	decrease
Nitrite/Nitrate	---	---	0.96	1.60	2.70	increase
Un-ionized Ammonia	---	---	0.0125	0.0160	0.0060	decrease
Fecal Coliform Organisms	---	---	1,186	167	97	decrease

Mississippi River at Dock upstrm of Wabasha St Br, St. Paul (UM-840)	1950s	1960s	1970s	1980s	1990s	overall trend
Biochemical Oxygen Demand (5-day)	---	---	3.3	2.9	2.7	decrease
Total Suspended Solids	---	---	30.1	44.6	50.4	increase
Total Phosphorus	---	---	0.22	0.21	0.21	no trend
Nitrite/Nitrate	---	---	0.78	1.50	2.70	increase
Un-ionized Ammonia	---	---	0.0075	0.0100	0.0040	decrease
Fecal Coliform Organisms	---	---	774	265	82	decrease

Shell Rock River at Br on CSAH-1, 1 Mi W of Gordonsville (SR-1.2)	1950s	1960s	1970s	1980s	1990s	overall trend
Biochemical Oxygen Demand (5-day)	---	13.4	11.2	8.1	6.4	decrease
Total Suspended Solids	---	77.5	35.1	44.4	41.8	decrease
Total Phosphorus	---	0.52	0.73	0.91	0.41	no trend
Nitrite/Nitrate	---	---	0.33	3.95	1.95	increase
Un-ionized Ammonia	---	---	---	0.0160	0.0045	decrease
Fecal Coliform Organisms	---	140	158	175	150	no trend

Vermillion River at Br on Blaine Ave, 4 Mi NE of Farmington (VR-32.5)	1950s	1960s	1970s	1980s	1990s	overall trend
Biochemical Oxygen Demand (5-day)	---	---	---	1.1	1.4	increase
Total Suspended Solids	---	---	---	12.9	8.1	decrease
Total Phosphorus	---	---	---	0.72	0.64	no trend
Nitrite/Nitrate	---	---	---	4.50	4.40	increase
Un-ionized Ammonia	---	---	---	0.0030	0.0010	decrease
Fecal Coliform Organisms	---	---	---	129	105	no trend

Whitewater River South Fork N of Cr-115, 3.5 Mi NW of Utica (WWR-26)	1950s	1960s	1970s	1980s	1990s	overall trend
Biochemical Oxygen Demand (5-day)	---	---	2.5	1.6	1.7	decrease
Total Suspended Solids	---	---	19.0	19.3	41.7	no trend
Total Phosphorus	---	---	0.47	0.45	0.52	no trend
Nitrite/Nitrate	---	---	6.00	7.10	8.90	increase
Un-ionized Ammonia	---	---	---	0.0050	0.0020	decrease
Fecal Coliform Organisms	---	---	487	373	1,157	no trend

Zumbro River South Fork at CSAH-14, 3 Mi N of Rochester (ZSF-5.7)	1950s	1960s	1970s	1980s	1990s	overall trend
Biochemical Oxygen Demand (5-day)	---	---	5.0	2.8	2.1	decrease
Total Suspended Solids	---	---	30.5	25.6	36.8	no trend
Total Phosphorus	---	---	0.95	0.35	0.22	decrease
Nitrite/Nitrate	---	---	3.30	5.20	5.95	increase
Un-ionized Ammonia	---	---	---	0.0085	0.0020	decrease
Fecal Coliform Organisms	---	---	132	115	409	no trend

D: Lake Water Quality

The direct drainage (exclusive of the Minnesota, St. Croix and Upper Mississippi River basins) of the Lower Mississippi River drains three separate ecoregions. The Driftless Area (DA) includes the river itself as well as the surrounding bluff area and comprises 23 percent of the basin. It is relatively lake-poor because of a lack of glacial activity in this portion of the basin. The North Central Hardwoods (NCHF) is located on the northwest portion of the basin and accounts for nine percent of the basin in terms of area. The Cannon River is a major tributary that drains from this ecoregion, whose watershed contains several lakes. A majority of the basin's lakes are in this ecoregion. The Western Corn Belt Plains (WCBP) accounts for 68 percent of the basin and is drained by several major tributaries which flow eastward to the Lower Mississippi, including the Zumbro, Whitewater and Root Rivers.

For the Lower Mississippi River basin, 47 lakes (45,237 acres) were assessed. Of the 47 lakes, 91 percent, representing 43,701 acres (97 %), were monitored. The high percentage of monitored data reflects monitoring conducted by MPCA, as well as monitoring conducted by citizens in the Citizen Lake Monitoring Program (CLMP), Lake Assessment Program (LAP), or studies in conjunction with local water plans.

The majority of assessed lakes are located in the NCHF (29 lakes, 62 percent), followed by the WCBP (15 lakes, 24 percent). The DA ecoregion had two assessed lakes -- Lake Winona and Lake Pepin. Lake Pepin is the largest lake in the basin and perhaps the most studied. It is about 25,000 acres and represents 55 percent of the assessed lake acres in the basin. Based on the assessed lakes, the NCHF lakes have an average surface area of 529 (±75) acres and average maximum depth of 32 (±4) feet while the WCBP lakes have an average surface area of 323 (±118) acres and average maximum depth of 25 (±7) feet.

Lake water quality often is evaluated in relation to excessive concentrations of algae, which reduce the aesthetic appeal – or “swimmability” – of lakes. Although many factors influence the level of algae production in a lake, phosphorus very often is the limiting growth factor. Thus, the concentration of phosphorus is a key indicator of whether a lake supports swimming use fully, partially or not at all. Because “swimmability” is a partly subjective attribute, which varies by region, the MPCA has developed regionally specific criteria for determining the degree to which the goal of swimmable use is being attained by a specific lake. Since the Lower Mississippi River drains multiple ecoregions, swimmable use was determined based on the ecoregion-based phosphorus criteria and is summarized as follows. Only seven lakes (15 percent), accounting for 2,490 acres (6 percent), fully support swimmable use. In contrast, 36 lakes (77 percent), accounting for 40,082 acres (86 percent), are non-supporting. The remainder of the lakes (8 percent) partially-support swimmable use. An ecoregion-based analysis will place this in perspective.

Of the 29 assessed lakes in the NCHF, six lakes (21 percent) fully support swimmable use, while 20 lakes (67 percent) do not support swimmable uses. The remainder (12 percent) partially support swimmable use. In terms of trophic status, the majority are eutrophic or hypereutrophic (15 lakes, 52 percent). Cannon, Jefferson, and Sakatah are three of the larger lakes in this portion of the basin which do not support swimmable use based on this assessment. The only three assessed mesotrophic lakes in this basin are located in this ecoregion.

In the WCBP portion of the basin only one lake (Beaver Lake, Steele County) fully supports swimmable uses. The remainder do not support swimmable use (13 lakes) or partially-support swimmable use (1 lake). The majority of the lakes (87 percent) are hypereutrophic and the remainder are eutrophic. Among the assessed lakes in this ecoregion, those not supporting swimmable uses (although swimming does occur) are: Lake Byllesby on the Cannon River, Zumbro on the Zumbro River and several shallow lakes on the floodplain of the Vermillion River. All of these lakes are impacted by point and nonpoint sources. In each case point sources are a significant portion of the phosphorus loading to the lakes at low flow while nonpoint sources dominate at average to high flows.

Lower Mississippi River Basin Lake Assessment
Support of swimmable use for all assessed lakes and by ecoregion

	Fully Supporting	Support - Threatened	Partial - Support	Non - Supporting
All – lakes	7		4	36
All – acres	2,490		2,665	40,082
CHF ecoregion	6		3	20
WCBP ecoregion	1		1	13
DA ecoregion				2

Case Study: Lake Zumbro, near Rochester, Olmsted County

The Rochester Water Reclamation Plant (RWRP) was among the first major municipal wastewater treatment facilities (greater than 5 miles from a lake) to receive a 1.0 mg/l P limitation. The facility is on the South Fork of the Zumbro River. Although approximately 10 miles upstream of Lake Zumbro, the issue of whether phosphorus (P) control at the RWRP was needed to protect Lake Zumbro water quality was adjudicated in an administrative hearing in 1978 when the City was required to implement a 1.0 mg/l P effluent limitation. The lake experienced severe nuisance algal blooms and MPCA studies suggested that the RWRP contributed approximately 77 percent of the phosphorus loadings to the lake.

The city installed P removal equipment when construction for the upgraded Water Reclamation Plan was completed in June 1984. However, the facility began to exceed the 1.0 mg/l P limit in 1985. The City agreed to a Stipulation Agreement with the MPCA in 1987 which required that the City be in compliance with its permit by July 1, 1988. However, the City requested a review of the phosphorus effluent limitation in its NPDES permit in 1988 since its consultants had determined that the facility had little effect on the lake.

MPCA conducted a lake/watershed study that also included computer modeling. This study, and subsequent permit hearings, suggested that an effluent phosphorus limit was still needed to improve Lake Zumbro water quality. The City has upgraded its phosphorus removal system and has been in compliance since 1988. The MPCA studies conducted on the lake have suggested that, although the facility is approximately 10 miles upstream of the lake, the effluent limit has improved lake water quality. Total phosphorus (TP) trends exhibit a decline from the 300 to 600 µg/L range during the late 1970's to the 100 to 250 µg/L range during 1991 through 1998 (Figure 1). Based on the Kendall tau-b statistic this is a statistically significant decline in TP (Rk = -0.8, p= <0.001). The very high summer-mean TP in 1993 is likely a function of the extremely high precipitation and flood events of that summer. Similarly, chlorophyll-a trends show a decline from 70 - 113 µg/L in 1976 and 1985 to 16 - 37 µg/L in 1990 through 1998, with the exception of 1992 which had a mean of 75 (±20) µg/L based on 6 samples. While this decline in chlorophyll-a is not statistically significant based on the Kendall tau-b statistic it could be considered significant if we compare the "pre" chlorophyll-a concentrations (plus or minus standard error) with the "post" treatment concentrations (Table 2). Secchi transparency has increased only slightly over the entire period of record and no significant difference is evident based on Table 2 or Figure 3.

These data suggest significant progress has been made towards improving the water quality of Lake Zumbro. For example, the summer-mean TP concentration in 1998 is very near the WCBP ecoregion-based P criteria level of 90 µg/L. The ecoregion-based criteria level would likely be a good interim goal for Lake Zumbro until further work is done to define a more appropriate goal. Further goal-setting efforts should consider goals for specific segments of the reservoir as well, since the near-dam segment can be expected to differ substantially from the inflow segment of the reservoir. Flow regime might also be a consideration in this process since nutrient loading and the relative contributions from point and nonpoint sources will vary substantially with changes in flow.

The reductions in TP have yielded measurable reductions in chlorophyll-a and this hopefully has translated into a reduction in the frequency and severity of nuisance blooms (Figure 2). However further reductions in P loading to the lake will be required to achieve a TP concentration of 90 µg/L or lower. Some concerns remain that, of the 12 point source permittees in the Lake Zumbro watershed, only two (Rochester and Pine Island) have 1 milligram per liter effluent phosphorus limitations. Individually, none of the remaining facilities greatly impact Lake Zumbro, but collectively they contribute substantially to the phosphorus loadings to the lake. As their permits are renewed individually, significant impacts on Lake Zumbro cannot be demonstrated. However, it is likely that limits for these facilities, along with needed non-point loading reductions, can be best approached through basin planning and working collectively with municipalities and agricultural producers in the watershed to achieve the needed reductions in nutrient loading to the Zumbro River and hence Lake Zumbro.

Lake Zumbro summer-mean water quality prior to P control at Rochester ("pre") vs. "post" P control (excludes 1985 when treatment was first initiated but limit not met). Includes standard error of the mean.

	TP ppb	Chl-a ppb	Secchi m
Pre (1976-1981)	368 ± 37	81 ± 11	0.9 ± 0.1
Post (1988-1998)	146 ± 21	43 ± 9	1.0 ± 0.1

Figure 1. Lake Zumbro Summer-mean Total Phosphorus. Includes standard error of the mean.

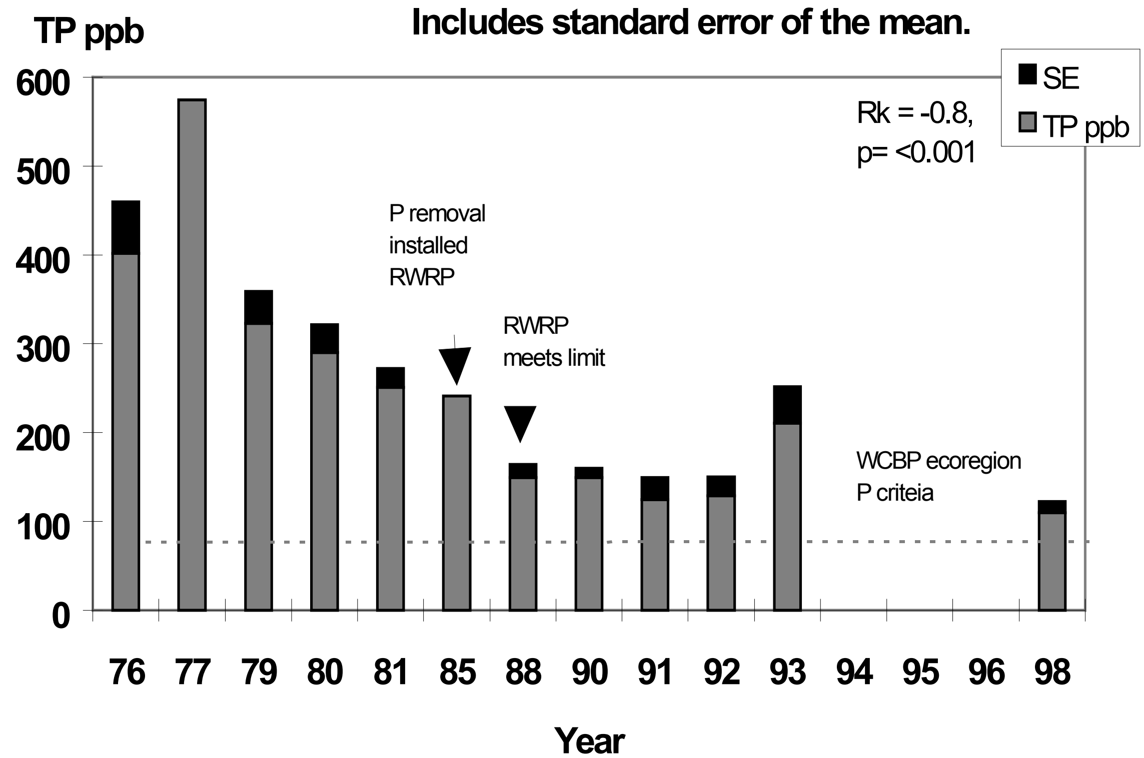


Figure 2. Lake Zumbro Summer-mean Chlorophyll-a.

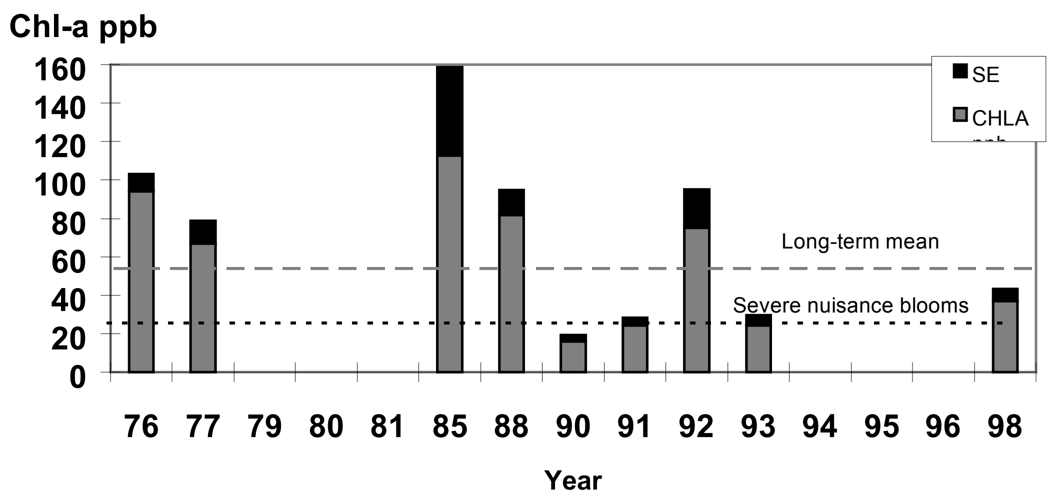
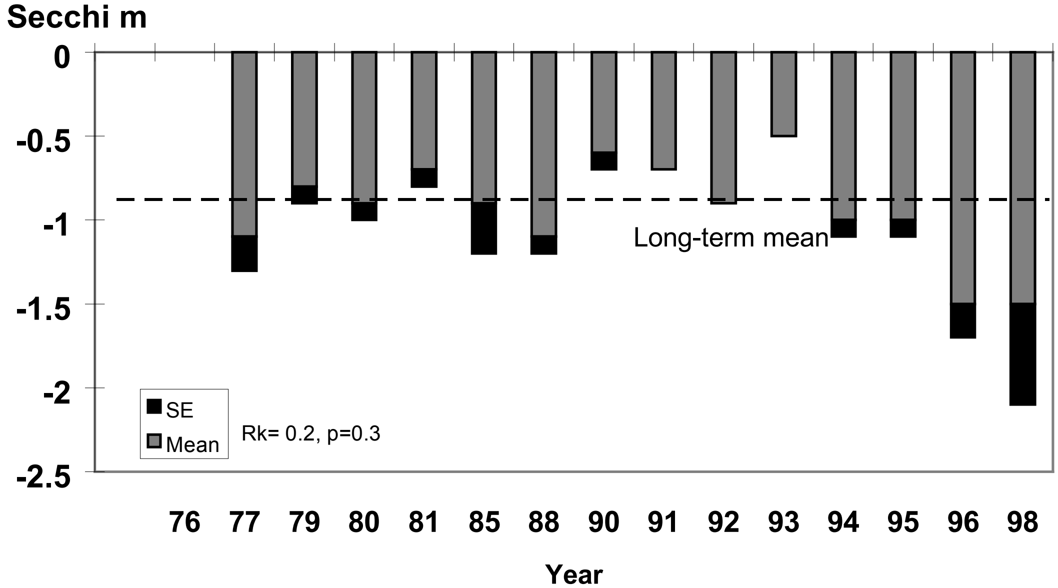


Figure 3. Lake Zumbro Summer-mean Secchi



Case Study: Lake Pepin

Lake Pepin is a natural lake on the Mississippi River. It has a surface area of about 40 square miles and a mean depth of 18 feet. Its watershed is about 48,634 square miles and includes the Upper Mississippi, St. Croix and Minnesota Rivers and drains about 55 percent of Minnesota and a portion of Wisconsin. This results in watershed to lake ratio of about 1,215:1. This large watershed area promotes short water residence times that range from 6 to 47 days, with an average of 9 days. Severe water quality problems were documented in Lake Pepin during the low flows of 1988. During that summer severe nuisance algal blooms and fish kills occurred. These events triggered many of the recent studies on Lake Pepin and its watershed.

Phosphorus and water loadings vary substantially from low to high flow, as do relative contributions to the phosphorus and water budgets for Lake Pepin. Figure 4 depicts the range in phosphorus loading from low, average, and high-flow years and the relative contributions from the four principal external sources: Upper Mississippi, St. Croix, Minnesota, and MCES - Metro Plant. In addition to these “external or watershed” sources internal recycling of phosphorus (particularly soluble reactive phosphorus) plays an important role in the nutrient budget of the lake. This “internal” loading is most pronounced during summers of low to average flow in Lake Pepin and phosphorus loading from previous years becomes a part of the “phosphorus budget.”

Figure 4 indicates that relative contributions to the external phosphorus loading to Lake Pepin vary substantially over a range from low to high flow. At low flow, point source loadings dominate while at average to high flow the Minnesota, Upper Mississippi, and St. Croix Rivers become increasingly important with the

Minnesota River being the greatest contributor. In general, nonpoint sources in these three basins would be the principal source of phosphorus under high flow conditions, while point sources would be significant contributors during low flow events.

Establishing a *water quality goal* was an important part of the overall study of Lake Pepin. Two major aspects of the goal setting process were (1) to define what constitutes “nuisance algal blooms” for Lake Pepin and (2) determine what factors or environmental conditions contribute to the nuisance conditions. A combination of user perception survey data (from Lake Pepin and the surrounding ecoregions), citizen interview, and water quality data were used to define nuisance conditions and determine when these conditions were likely to be encountered.

Total phosphorus and chlorophyll-a are typically used for identifying use-impairment related to eutrophication (e.g. Minnesota’s in-lake phosphorus criteria). Chlorophyll-a is the better parameter for making direct linkages to nuisance conditions, while phosphorus can be a more appropriate parameter from modeling and source-control standpoint. For Lake Pepin chlorophyll-a was considered the most appropriate parameter for goal setting since chlorophyll-a was relatively insensitive to phosphorus concentration at high flows (short residence time) and it was more directly linked to nuisance conditions. In Lake Pepin chlorophyll-a varies as a function of total phosphorus concentration, inorganic turbidity, mixing depth, and water residence time. A summer-mean chlorophyll-a concentration of 30 μg/L was selected as a goal for Lake Pepin -- this goal minimizes the frequency of “nuisance algal conditions (40 μg/L)” and “severe nuisance algal conditions (60 μg/L)” in Lake Pepin. Since water residence time partially controls the production of algae biomass and algal composition in Lake Pepin it was also important to associate the goal with a particular flow range. In this case the range corresponded to 4,578 cfs (120 day, 50-year low flow, less than two- percent reoccurrence frequency). This flow is comparable to the low flows of 1976 and 1988 when severe nuisance blooms were encountered. A flow value of 20,000 cfs was recommended as the upper limit for applying the goal. A summer-mean flow of 20,000 cfs provides a residence time of about 11 days which is within the 8-14 days required for full algal response to nutrients in lakes.

This goal has provided a basis for predicting the phosphorus reductions necessary, under different flow conditions, to achieve acceptable water quality conditions in Lake Pepin. As with goals in other projects this chlorophyll-a goal has provided a target that all participants in the process can focus on. In the course of these discussions and modeling it has become evident that there will be a need for reductions from all basins, including point and nonpoint sources, if improvements in the water quality of Lake Pepin are to be realized and the chlorophyll-a goal achieved over the prescribed range of flows.

Over the period of record (1976 - 1998) there has been a decline in TP over time in Lake Pepin (Figure 5) with a long-term summer-mean of 230 μg/L. Since the major low-flow event of 1988 TP concentrations have ranged between a low of 167 μg/L in 1997 to 234 μg/L in 1992. Chlorophyll-a concentrations have declined as well since 1988 with concentrations ranging from a low of 20 μg/L in 1993 and 1996 to a high of 36 μg/L in 1992 (Figure 6). Most of these summers were characterized by relatively high flows and hence short water residence time would contribute to the lower chlorophyll-a concentrations. Secchi transparency has been fairly stable at about 0.7 to 1.1 meters in recent years (Figure 7).

Reductions in point source loading to (or tributary to) Lake Pepin will occur over the next several years as more WWTF's will have P effluent limitations as a part of their permits and hence be treating to 1 mg/L or lower in most instances. The most prominent of upstream point sources is the 250 mgd MCES Metro Plant which is scheduled to have bio-P treatment on-line by 2003. These point source reductions coupled with continued nonpoint source reductions will yield improvements in the water quality of Lake Pepin as well as the Lower Mississippi River.

Figure 4. Estimated Summer TP Loading Rate to Lake Pepin. Flow-weighted means as compared to Lock and Dam 3 inflow.

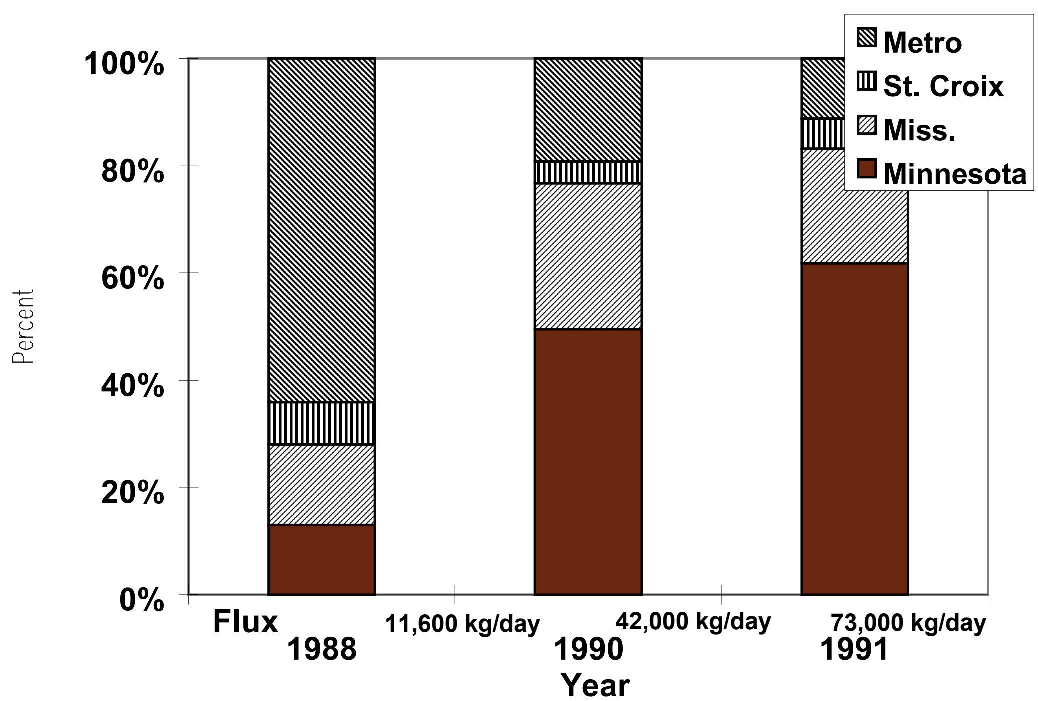


Figure 5. Lake Pepin Summer-Mean Total Phosphorus

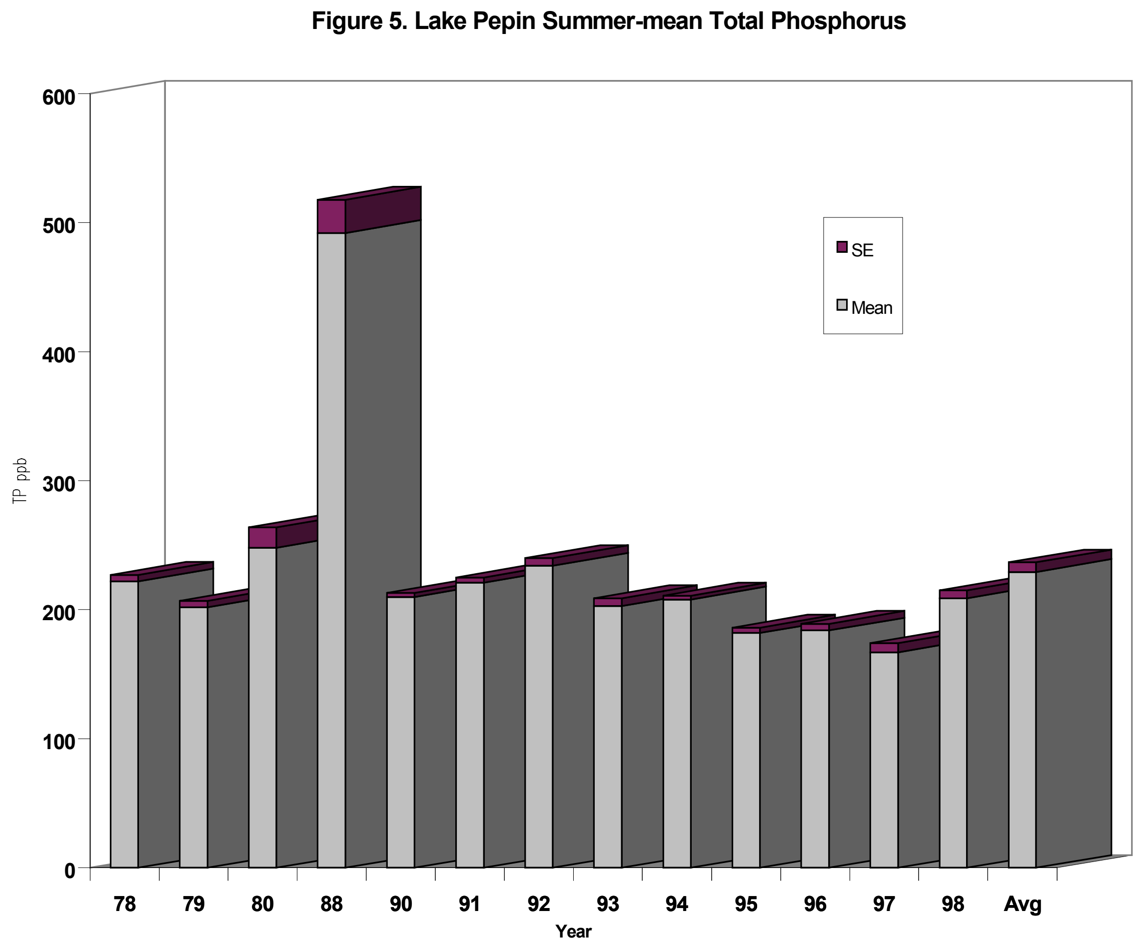


Figure 6. Lake Pepin Summer-Mean Chlorophyll-a

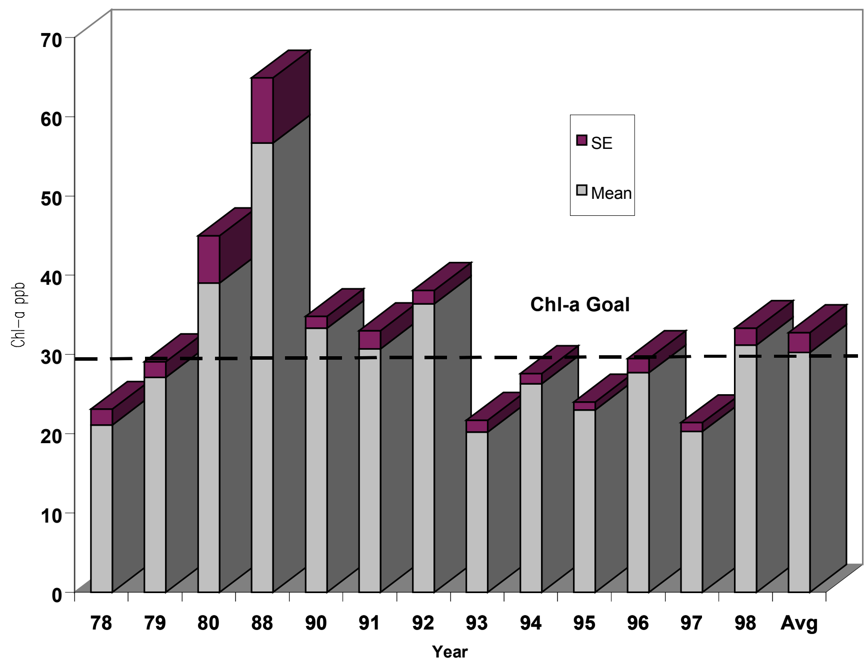
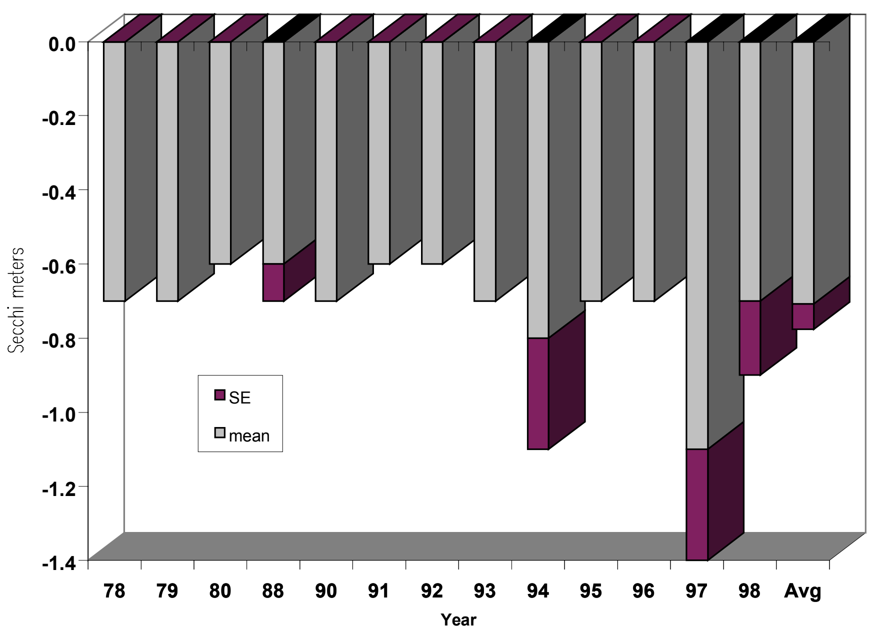


Figure 7. Lake Pepin Summer-Mean Secchi Transparency



D: Ground Water Quality

The MPCA's Ground Water Monitoring and Assessment Program provides the following summary of ground water quality results for the Lower Mississippi River Basins and Cedar River Basins, respectively:

Lower Mississippi River Basin
Eighty-eight samples were collected. Twenty-four were from the Prairie du Chien aquifer, 19 from the Jordan, 13 from the Galena, 12 from the St. Peter, 11 from the Franconia, 5 from glacial aquifers and the remainder from other aquifers.

1. Ground water quality is generally good but varies between aquifers. Concentrations of total dissolved solids were highest in the buried glacial aquifers and lowest in the sandstone aquifers (St Peter, Jordan, Franconia). Dissolved solid concentrations increased from east to west and were highest in aquifers overlain by Des Moines Lobe till and gray drift. This was true for all bedrock aquifers.
2. The distribution of dissolved solids is inversely correlated with values for Eh (a measure of the potential for oxidation-reduction). In the eastern part of the basin, aquifers are oxygenated and had Eh values greater than 275 mV. In the west, oxygen is absent and reducing conditions were encountered in most wells. These results were verified by the distribution of tritium. Tritium was present in nearly all samples collected from the eastern half of the basin and absent from nearly all wells sampled in the western half, reflecting recharge and younger water in the east. Since wells were sampled at different depths but distributions of chemicals were not related to depth, the data suggest there is considerable vertical movement or mixing of ground water.
3. Higher nitrate concentrations were observed in samples reflecting oxygenated conditions and in samples containing detectable tritium, but the correlation was not particularly strong. This is because several wells in the eastern part of the basin had no detectable nitrate despite being vulnerable to nitrate contamination. These wells were probably located in non-agricultural areas where nitrogen inputs are low.
4. Concentrations of trace inorganic chemicals were generally low, with a couple exceptions. Cadmium concentrations were elevated in the area underlain by old gray till, with four exceedances of the drinking water standard (4 ug/L). Lead concentrations exceeded 2 ug/L across the eastern part of the basin, where bedrock is close to the land surface. There was no effect of aquifer type on the distribution of lead, suggesting the source of lead may be anthropogenic.

Five hydrogeologic regimes can be distinguished in the basin. In the extreme western part of the basin, Des Moines Lobe till overlies bedrock aquifers. Buried sand and gravel aquifers are present within the till, but bedrock aquifers are the primary source of drinking water. Ground water moves slowly through the unconsolidated deposits and eventually reaches the bedrock aquifers. The long residence times lead to reducing conditions in ground water, low sensitivity to nitrate contamination, and high concentrations of dissolved solids. The area underlain by old gray drift provides a transition zone between east and west. The drift provides some protection for underlying bedrock aquifers. In the eastern part of the basin, bedrock aquifers are close to the land surface and are vulnerable to contamination, but water quality is good if the aquifers are not contaminated. Surficial sand and gravel aquifers are not common in the basin, but when present, are highly vulnerable to nitrate contamination. Aquifers that occur along and within river valleys appear to be highly vulnerable to nitrate contamination, but nitrate is often not present in ground water because the land is not used for agriculture.

<u>Cedar River Basin</u>

Since there are few wells completed in the upper part of the Upper Carbonate deposits, most of the data collected probably reflects water quality of lower, confined bedrock units. Seven samples were collected from the Cedar Valley aquifer, four from the Galena aquifer, and one each from the St. Peter and Prairie du Chien aquifers.

1. Concentrations of total dissolved solids increase from east to west. This maybe due to infiltration of recharge water through glacial deposits. Highly leached pre-Wisconsin deposits, found in the eastern part of the basin, contribute fewer dissolved ions than deposits of Wisconsin age, located in the west. These dissolved ions consist primarily of calcium, magnesium and bicarbonate. Another factor affecting water quality may be travel time – the time it takes for water to percolate through the glacial deposits and into bedrock aquifers. Although results for tritium indicate most water is pre-1953, concentrations of dissolved oxygen decrease from east to west. Oxygen is more likely to be present in younger, more recently recharged water.
2. Concentrations of arsenic exceed 3 ug/L in areas where stagnation moraines occur. These are in the western part of the basin. A similar pattern of high arsenic concentrations in areas of stagnation moraines occurs statewide.
3. Nitrate concentrations were below the reporting limit of 0.5 mg/L in all sample wells. Low concentrations of nitrate are most likely the result of samples being collected from older wells in well-protected aquifers, as evidenced by the absence of tritium in most samples.
4. There were no significant differences between the Galena and Cedar Valley aquifers in the concentration of any sampled chemical.

Four hydrogeologic regimes can be distinguished in the Cedar River Basin. Ground moraine associated with the Des Moines Lobe covers the central part of the basin. Till associated with the Des Moines Lobe contributes high concentrations of dissolved solids to underlying bedrock aquifers. Surficial sand and gravel deposits are not extensively used as a source of drinking water. Old gray drift occurs in the east and contributes fewer dissolved solids than Des Moines Lobe till. Stagnation moraines occur in the west and are locally associated with high concentrations of arsenic. Sand and gravel aquifers and bedrock aquifers underlying areas overlain by sand and gravel deposits are vulnerable to contamination from nonpoint sources.

It is recommended that samples be collected the upper portion of the Upper Carbonate bedrock units to determine if confining layers are present and what impact these confining layers have on water quality. A better understanding of the hydrogeologic system is required in this basin before specific recommendations can be made for long-term monitoring.

<u>Private well samples</u>

A summary of samples from privately managed drinking water supplies in southeastern Minnesota counties reveals substantial differences in the percentage of wells that exceed drinking water standards for total coliform bacteria and nitrate nitrogen. The summary was developed by Olmsted County Public Health Services, which provides well water testing services for several counties in southeastern Minnesota. This summary does not constitute a representative sample of well water quality identified by aquifer source. In addition, it is not possible to determine the degree to which poor well construction or poor wellhead area management contributed to high contaminant concentrations. Nevertheless, this is one of the few sources of data that indicate the level of contamination of some private drinking water in the region.

The percentage of drinking water samples that tested positive for coliform bacteria in 1999 ranged from one in six to almost half, as follows (lowest to highest percentage detection): Houston County (16%); Rice County (18%); Olmsted County (21%); Mower (23%); Winona (25%); Dodge (27%); Wabasha (31%); Goodhue (33%); Fillmore (45%).

The percentage of 1999 drinking water samples that exceeded the maximum contaminant level of 10 parts per million for nitrate-nitrogen was less than 10% for Rice, Dodge, Mower, Olmsted and Winona Counties; slightly above 10% for Goodhue and Wabasha Counties, and approximately 30% for Fillmore County (data for Houston County are not yet available). The percentage of private well samples containing 1-9.9 ppm nitrate nitrogen was considerably higher. The percentage of wells with greater than 1 ppm nitrate nitrogen ranged from about 18% in Rice County to 70% in Wabasha and Fillmore counties.

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IV: Land-Water Relationships

Watershed management is based on the principle that the water quality of any particular water body is a reflection of how land is used within the watershed that drains to that water body. The soils, hydrogeology and biological diversity of a watershed were shaped over millenia by the combined forces of climate, glaciation, erosional processes and a host of biological and chemical interactions. European settlement starting in the early 1800s changed the land-water relationships that had been formed over geologic time. This has resulted in increased surface water runoff and soil erosion with consequent stresses on stream, lake and wetland hydrology, structure and water quality. Close interaction between surface and ground water quality in much of southeastern Minnesota means that ground water quality may be threatened by land uses that degrade surface water quality, in addition to land uses that directly affect the transport of substances to an aquifer.

Because land-water relationships vary considerably over short distances, being affected by a multitude of site-specific variables, it is hazardous to generalize about such relationships within large land areas such as the Lower Mississippi River Basin. However, a review of watershed assessments and field studies within and adjacent to the basin helps to identify some broadly relevant land-water relationships that can help to guide land-use management decisions on a basin scale. The information that follows is meant to be suggestive, not definitive, of such relationships, and is no substitute for more thorough assessments at the basin, major watershed and minor watershed scales that are called for in the Watershed Management Strategy. These relationships will be presented in the context of a number of specific water quality pollutants.

A complementary approach to evaluating land-water relationships is the agro-ecoregion approach developed by Dr. Dave Mulla, Department of Soil, Water and Climate, University of Minnesota. Mulla has defined a number of agro-ecoregions in southeastern Minnesota. Agro-ecoregions are defined as zones having unique soil, landscape and climatic characteristics which confer unique limitations and potentials for crop and animal production. The 4,650,100 acre landscape of southeastern Minnesota has been subdivided into eight unique agro-ecoregions based on distinctions between soil types and geologic parent material, slope steepness, natural an artificial internal drainage, and erosion potential. Each agro-ecoregion is characterized by unique physiographic factors that influence the potential for production of nonpoint source pollution and the potential for adoption of farm management practices. To view an agro-ecoregion map of southeastern Minnesota, and for a detailed description of the eight subregions, visit the following University of Minnesota web site: http://www.soils.agri.umn.edu/research/seminn/doc/agecoregionnew.html

A: Sediment

Most of the data available on erosion and sedimentation rates have been developed for agricultural watersheds. In the steeply sloping land of the eastern basin, major assessments have been completed for the Bear Creek, Garvin Brook and the Whitewater River watersheds. In the more flat and gently rolling areas of the western basin, information from the Dobbins Creek watershed is combined with data from several minor watershed evaluations on the western edge of the Minnesota River Basin.

Report 1. 2000 Minnesota Corn-Soybean Residue Survey Results
Summary for the Lower Mississippi River Basin in Minnesota

Rank	County	Percent of Corn and Soybean Fields Meeting Residue Targets[1] in 2000		Residue Trend Analysis Percent of Corn and Soybean Fields Meeting Residue Targets[1,2]					
		CORN	SOYBEANS	1995	1996	1997	1998	1999	2000
1	Le Sueur	75%	78%	47	72	*	65	74	77
2	Waseca	59%	70%	42	26	63	33	38	64
3	Houston	57%	81%	*	*	*	*	*	64
4	Dakota	53%	57%	*	*	33	34	29	54
5	Winona	47%	79%	*	*	*	*	*	53
6	Freeborn	39%	69%	*	*	*	*	*	53
7	Fillmore	44%	52%	47	*	*	26	14	47
8	Steele	32%	55%	*	*	*	*	*	43
9	Dodge	36%	47%	*	*	*	39	36	41
10	Mower	24%	45%	*	*	*	*	10	34
11	Olmsted	30%	38%	65	*	*	26	*	33
12	Rice	23%	41%	*	*	*	6	18	32
13	Goodhue	17%	45%	*	*	*	*	*	28
14	Wabasha	22%	24%	*	*	*	*	*	23
	Averages	40%	56%	*	*	*	*	*	46
				Average of Counties Reporting					

1 Fields meeting residue targets include fields with >30% residue plus fields with >15% residue when following soybeans.

2 An asterisk indicates no data were collected.

The single most notable relationships are those relating land surface cover, slope and precipitation to soil erosion rates. This relationship is summarized in the Revised Universal Soil Loss Equation (RUSLE). A relationship between two of the variables, surface residue cover and soil erosion rates (keeping slope and precipitation constant) is shown in the graphic below. Also shown are the results of the 2000 crop residue transect survey for the counties of the Lower Mississippi River Basin (above).

INSERT GRAPH

The Bear Creek Watershed, located in Houston and Fillmore counties in Minnesota and Winneshiek and Allamakee Counties of Iowa is managed by Iowa Department of Natural Resources as a "put-and-take" trout fishery. Nearly all the land is classified as highly erodible, with slopes ranging from 5 to 14%. Average erosion rates are 10 to 17 tons per acre per year. It is estimated that approximately 17 percent of gross erosion from cropland is delivered to the stream, and that approximately 29 to 34 percent of gross erosion from forestland reaches the stream. Streambank erosion was very minimal, amounting to only four percent of soil erosion delivered to the stream. Erosion from crop and forestland results in heavy sedimentation over natural stream substrate, which has greatly reduced natural trout reproduction. The goal of the project is to reverse these losses through erosion-control measures.

The Whitewater River Watershed is located in Olmsted, Wabasha and Winona Counties. Sediment is a major problem in this watershed, which includes several designated trout streams. Concentrations of suspended sediment range from several milligrams per liter during base flow conditions to levels in the 5,000 to 7,000 milligram per liter range during high-flow periods. Erosion rates are high, but less than those found in the Bear Creek Watershed. About 19 percent of cropland acres are estimated to be eroding at greater than the replacement rate of soil loss, or 5 tons per acre. A sediment budget for the watershed shows that the vast majority of sediment, 68 percent, comes from sheet and rill erosion, three percent from ephemeral gully erosion, eight percent from classic gully erosion, and 21 percent from stream bank erosion.

The Wells Creek Watershed in Goodhue County shows that overall positive trends in land use that have reduced soil erosion, may also be improving the hydrology of southeastern Minnesota streams. Hydrologic data suggest that base flow discharge has increased significantly over the past 35 years. This is thought to be the result of increased infiltration of precipitation, the flip side of reduced surface runoff. Wells Creek base flow is fed by groundwater recharge from the aquifers along and underlying the main stem.

The Garvin Brook Watershed in Winona County was the subject of intensive study in the 1980s under the Rural Clean Water Program. Sediment and flow monitoring showed that suspended sediment greatly increases during runoff events, often resulting in more sediment being transported in one day than in several months or one year of baseflow condition transport. Immediately following storm events, Total Suspended Solids spiked up to 350 milligrams per liter in one instance, and up to 6,200 milligrams per liter a month later in response to a rainfall event that was only 24 percent greater. As storm intensity and duration increased, peak runoff, sediment and nutrient transport increased exponentially. Larson et al. (1997) have argued that rare "catastrophic" storms generate the majority of erosion, and that conservation tillage alone is not adequate to protect the soil against erosion during these events. Conservation structures such as terraces and sediment basins are needed, too.

Over the project period, TSS median concentrations declined from a beginning value of 85 milligrams per liter to values of 35 milligrams per liter and less. Median summer to fall turbidity continually decreased as well, from 27 to 4 nephelometric turbidity units (NTUs). The changes in TSS and turbidity cannot be explained by changes in flow, and may be attributable to increased adoption of soil conservation practices.

The Coon Creek Watershed south of La Crosse, Wisconsin, has been the subject of considerable study beginning with research by Aldo Leopold early in the century, and continuing with the unique historical sediment studies of Stanley Trimble, at the University of California-Los Angeles. Trimble's latest analysis showed that the amount of sediment discharged by Coon Creek into the Mississippi River has remained fairly constant over the twentieth century, even though erosion rates in the watershed have gone through dramatic changes. The reason for the fairly constant sediment yield, as measured at the watershed's point of discharge to the Mississippi, is deposition within the watershed. During the period of maximum soil erosion rates, approximately 1920 to 1940, the floodplains of the lower main valley received about 15 centimeters of vertical accretion of sediment a year. Rather than being discharged from the mouth of Coon Creek, suspended sediment settled in the alluvial floodplain. Following improvements in farmland management, the rate of sediment accretion in the lower valley fell to 0.53 centimeters a year, from 1975 to 1993. While overall rates of sediment storage decreased, the site of sediment storage also shifted from the lower valley to floodplains higher up in the watershed. Some of these floodplains were newly developed, the result of lateral streambank erosion that widened stream channels and created new, wide floodplains that later became vegetated and served as sediment traps. Trimble describes the process as morphological feedback. In earlier studies, Trimble had predicted that upper tributaries would be net sediment sources for decades to come. His studies show that erosion and deposition patterns within watersheds of the driftless region of southeastern Minnesota and southwestern Wisconsin are dynamic, and caution should be used in relating sediment yield to rates of soil erosion. Although Trimble's study does raise questions about the connection between upland soil erosion and sediment loads to the Mississippi, his study does not deal with or cast doubt upon the relationship between upland soil erosion and suspended sediment or turbidity in the tributary itself.

Dobbins Creek Watershed: Use of the Agricultural Nonpoint Source model on this watershed in Mower County showed that big storms have huge impacts on sediment delivery. A single 5-inch rain event, for example, resulted in the delivery of 11,700 tons of sediment to the watershed mouth at East Side Lake – 925 pounds for each acre in the 25,000-acre watershed. That's roughly equivalent to the amount of sediment that would be delivered to the watershed mouth over the course of an entire "normal" year with 30 inches of precipitation doled out in 77 individual rainfall events, most of them small.

An estimated 97 percent of the sediment budget of East Side Lake originated from storm flows and spring runoff in this predominantly agricultural watershed. Average sediment yield for the watershed was modeled at 875 pounds/acre, with one subwatershed contributing twice this amount and another subwatershed contributing just one-fourth of the average sediment yield.

The sediment load is sufficient to deposit a 0.8 inch-thick layer of sediment on the bed of East Side Lake every year, on average.

Modeling of an extreme solution showed that converting the entire 25,000-acre watershed to meadow would reduce sediment losses from a 5-inch rain event by 91 percent. A more moderate solution of gully removal *and* introducing conservation tillage on all cropland would result in a 33 percent reduction in sediment load for the 5-inch storm event. Interestingly, neither of these BMPs alone would have much impact. Modeling less extreme conditions in a normal 30-inch rainfall year predicted that gully removal and complete adoption of conservation tillage would result in a 60 percent reduction in sediment delivery.

Minnesota River Basin: Several minor watersheds on the eastern fringe of the Minnesota River Basin underwent a land-use assessment as part of the Minnesota River Assessment Project (MRAP) in 1990-91. The Level II assessment, conducted by the Natural Resources Conservation Service, evaluated sediment and nutrient runoff from 10 minor watersheds. Results from two watersheds – County Ditch #5 in southeastern Blue Earth County, and the Maple River in northeast Faribault County, will be used here to illustrate land-water relationships in the western Lower Mississippi River Basin with similar conditions: flat to gently rolling land, heavily drained for intensive row-crop agriculture.

Gross erosion rates in these two headwater watersheds averaged two to three tons per acre – below the rate of replacement (T) of approximately five tons per acre. Sediment yield at the mouths of the watersheds was 0.55 to 0.60 tons per acre, reflecting a sediment delivery ratio of approximately 20 percent in these small, headwater streams.

Various degrees of adoption of conservation tillage were modeled. This

Best Management Practice has been shown to reduce soil erosion by approximately two-thirds, compared to fall moldboard plowing. The first management option, applying conservation tillage to land eroding at T or greater, reduced predicted soil erosion by five to 15 percent, and sediment yield by nine to 25 percent. The second option, applying conservation tillage on all cropland acreage, resulted in predicted soil erosion reductions of 33 to 46 percent, and sediment yield reductions of 31 to 52 percent.

Two nutrient management options were evaluated along with sediment reduction. The first option called for 15 percent or greater residue on cropland combined with a spring preplant application of 120 pounds of anhydrous nitrogen and an incorporation at planting time of 30 pounds of nitrogen and 70 pounds of phosphate. This option resulted in predicted reductions of 43 to 48 percent less total phosphorus runoff, and 12 to 14 percent less nitrogen loss to surface water, as measured at the watershed outlet. These results show a strong trend of reduced nutrient losses with increased crop residue cover.

The second option applied conservation tillage (30 percent residue) to all fields and banded 30 pounds of nitrogen and 20 pounds of phosphate at planting with a side dress application of 120 pounds of anhydrous nitrogen at the first cultivation. This option resulted in a reduction in total phosphorus losses of 68 to 74 percent, and a reduction in nitrogen losses of 12 to 14 percent. The impact of the second option on nitrogen reductions was identical to the impact of the first option. One reason for the failure of the split nitrogen application to show an impact is that the majority of nitrogen leaves the field as surface runoff, according to the model.

B: Nutrients (Nitrogen and Phosphorus)

Nitrogen: Nitrogen concentrations in Lower Mississippi River Basin tributaries have been increasing for several decades, and detections of high concentrations in private wells are fairly common. There are many sources of nitrogen which contribute to these problems. According to statewide estimates, soil organic matter and nitrogen fertilizer are by far the leading sources of inorganic nitrogen, the form of greatest concern to groundwater contamination. These sources provide 42 percent and 36 percent of total inorganic nitrogen, respectively. While manure and legumes each contribute only 6 percent of inorganic nitrogen in the state, the failure of farmers to take credit for these sources when determining commercial fertilizer application rates leads to excessive fertilizer application and increased potential for nitrogen leaching and runoff. Southeastern Minnesota river counties, and counties adjacent to them, are estimated to have some of the highest levels of plant-available nitrogen contributions from manure in the state.

Farm nutrient management evaluations conducted by the Minnesota Department of Agriculture show that farmers often apply more nitrogen fertilizer than necessary in the Lower Mississippi River Basin. Usually this is because they don't give enough credit to nitrogen provided by applied manure and previous legume crops such as soybeans and alfalfa, as the University of Minnesota recommends. The result is increased potential for nitrate leaching and runoff. An evaluation of 22 farmers in the Whitewater River Watershed in 1998 indicates that farmers apply approximately 12 percent (16 pounds per acre) more nitrogen than necessary because of failure to give adequate credit to previous soybean crops and applied manure. This level of nitrogen over-use is relatively modest, likely the result of educational efforts undertaken through the Whitewater River Watershed Project. Despite fairly good nitrogen management, nitrogen levels in the Whitewater River remain high. This may be partly attributable to a shift in agriculture away from alfalfa and towards corn and soybeans. Alfalfa fields erode little and leach very little nitrogen. Plus, alfalfa is an effective scavenger of nitrogen deep in the soil profile, at the same time as it is able to fix nitrogen when soil supplies are insufficient to support growth. Soybean fields tend to be highly erosive, although soybeans also scavenge nitrogen in the shallow soil profile.

An earlier 1993 evaluation of dairy farmers in several southeastern Minnesota counties by the MDA showed a higher difference between actual and recommended applications. This was at the very time when new and lower University of Minnesota nitrogen crediting recommendations had been published, but were not yet widely publicized. Factoring in all appropriate credits from fertilizer, legumes and manure, farmers over-applied nitrogen by an average of 53 pounds per acre.

The Olmsted County Groundwater and Wellhead Protection Project found that shallow wells in geologically sensitive areas under agricultural production showed a relatively high percentage (27 to 44 percent) of wells exceeding 10 milligrams per liter nitrate nitrogen, while newly constructed or municipal wells showed a much lower percentage (1-4 percent).

Agronomic field trials in Olmsted County in 1987 illustrate the effect of management practices on nitrogen leaching. At an application rate of 150 pounds per acre of nitrogen applied to corn, $N0_3$–N concentrations in the soil water at 5 feet began to climb rapidly. A nitrogen rate of about 120 pounds per acre would have optimized yield and profitability to the farmer while minimizing nitrates in the groundwater. Fall application of anhydrous ammonia resulted in lower yields than the same rate applied in the spring before planting. Moreover, $N0_3$–N concentrations in the soil water were 50 to 70 percent higher with the fall applications.[9]

In the Garvin Brook Watershed study, 160 private wells were analyzed. More than 36 percent exceeded the nitrate drinking water standard and nearly 20 percent had bacterial contamination. Nitrate-nitrogen concentrations four to eight feet below fertilized land generally were between 20 and 50 milligrams per liter. Drainage from feedlots contributed to high ammonium concentrations in soil profiles but did not result in high nitrate levels in the soil profile. The greatest source of nitrogen, by far, was agricultural applications of fertilizer and manure to cropland. Over the course of the project, participating farmers

[9] University of Minnesota Extension Service, "Best Management Practices for Nitrogen Use in Southeastern Minnesota," AG-FO-6126-B, 1993

reduced nitrogen use by an estimated 21 percent, according to farmer surveys. The average rate of nitrogen applied to lawns was 70 pounds per acre. It was estimated that 4,000 pounds of nitrogen fertilizer were being applied each year in Lewiston, the watershed's largest town, compared to an estimated three to four million pounds of nitrogen annually applied to crop land and one million pounds of nitrogen from manure generated in the watershed. The total annual nitrogen released from septic tanks was estimated to be 0.2 percent of annual nitrogen from fertilizer and animal manure in the project area.

Phosphorus: Phosphorus often is the limiting growth factor that contributes to the production of excessive algae in surface water in southern Minnesota. This is particularly true of lakes and reservoirs, where hydraulic residence time is sufficient to permit the growth of blue-green algae, in particular. In addition to natural lakes that are so affected, reservoirs such as Lake Byllesby and Lake Zumbro are heavily affected by phosphorus-induced hypereutrophication. Backwater lakes of the Mississippi River also may be vulnerable, especially in low-flow years. Lake Pepin, a natural lake formed from an alluvial sediment dam at the mouth of Wisconsin's Chippewa River, is a well-known example of hyper-eutrophication that occurs at low river flows.

Major sources of phosphorus to surface water are from point and nonpoint sources. Point sources include municipal and industrial wastewater treatment facilities, and nonpoint sources include surface runoff from agricultural and urban land. Which source predominates depends on precipitation and flow conditions. At low flow, when precipitation and therefore surface runoff tend to be low, continuous daily discharges from point sources tend to provide the bulk of phosphorus. For example, monitoring data on Lake Zumbro from the early 1980s show that the Rochester Water Reclamation Plant was responsible for more than 70 percent of the total phosphorus budget of Lake Zumbro in low-flow years. (This is not likely to be true today, because effluent concentrations now are limited to one milligram per liter.) A more recent Lake Assessment Program study of Lake Byllesby showed that point sources were responsible for approximately half the total load of phosphorus to the lake in low-flow years, and about one-third of the total load in average years. Point source phosphorus is particularly important to control for two reasons. First, it is the predominant source of phosphorus during low river flows, when streams and reservoirs and lakes are most vulnerable to eutrophication. Second, point source phosphorus is highly soluble, therefore immediately available to stimulate the growth of algae.

Nonpoint sources tend to be the dominant source of phosphorus at high and average flows. Much nonpoint source phosphorus is attached to sediment and is transported to surface water as overland flow. The concentration of phosphorus in sediment varies from less than one pound per ton for sandy soil, to as much as three pounds or more per ton for finely granulated clays where phosphorus applications over the years have been high. As noted in the above discussion of sediment, practices that reduce soil erosion also help to reduce phosphorus runoff. Soil erosion control practices combined with proper adjustment of rate and placement can reduce phosphorus runoff from agricultural fields by two-thirds or more, compared to black-till conditions. Surface-applied manure is an obvious source of phosphorus runoff, but few studies have estimated the magnitude. MPCA modeling of two lake watersheds in southern Minnesota indicate that livestock feedlot runoff comprises less than 15 percent of all phosphorus runoff. Cropland runoff, which includes the effect of surface-applied manure, typically contributed 80 percent or more of all phosphorus runoff.

Most phosphorus is exported from cropland as sediment-attached runoff. High erosion rates generally are associated with high phosphorus runoff. For example, University of Minnesota data show that conventionally tilled corn experiences approximately four times as much phosphorus runoff as no-till corn. Phosphorus levels in the soil are an additional factor affecting the amount of phosphorus runoff. The higher the concentration of phosphorus in the soil, the more total phosphorus is exported with each ton of sediment runoff. The University of Minnesota recommends that no additional phosphorus be applied to fields where soil tests indicate that additional phosphorus is very unlikely to result in a crop yield response. This point is reached at 20 parts per million using the Bray test for soil phosphorus, or 16 parts per million using the Olsen test. [10]

C: Fecal Coliform Bacteria

Certain types of bacteria pose a potential health risk to those who come into contact with surface water. These bacteria come from a variety of sources, including agricultural runoff, inadequately treated domestic sewage, even wildlife. Some of these bacteria may cause disease. Other potential disease-causing agents from these sources include viruses, protozoa, and worms. But it's bacteria that cause the most problems. Of greatest concern are bacteria from human feces.

The limitations of available monitoring tools make it difficult to determine whether bacterial contamination in a water body is from human or animal sources. It is, however, possible to determine whether the bacteria originated in the intestinal tract of a mammal. These kinds of bacteria are called fecal coliforms. If fecal coliform bacteria levels exceed state water quality standards, it's an indication that fecal matter is entering the stream in quantities that pose a potential threat to public health.

There are many types of fecal coliform bacteria, and not all of them cause disease in humans. But where there are coliform bacteria there may be pathogens (disease-causing organisms) of concern. Thus, widespread violation of the fecal coliform standard in the Lower Mississippi River Basin indicates serious pollution and a possible health *concern*, but it doesn't necessarily mean there is an immediate health *threat* in any particular area.

Selected reaches of streams and rivers in the Lower Mississippi River Basin are routinely monitored for fecal coliform bacteria. At some sites where routine monitored has indicated exceedence of

[10] Rehm, George, and John Lamb, Michael Schmitt, Gyles Randall and Lowell Busman, "Agronomic and Environmental Management of Phosphorus," Minnesota Extension Service FPO-6797-B, 1997

the water quality standard, more intensive monitoring has been conducted to determine the degree and scope of the fecal bacteria problem at and upstream of the initial monitoring site. Altogether, these data strongly indicate the widespread presence of fecal coliform bacteria in the region's rivers and streams at levels that exceed water quality standards, often by a wide margin.

Widespread impairment of streams by fecal coliform bacteria is documented by several sources of information.

- The 1998 303(d) list for the Lower Mississippi and Cedar River Basins list 42 reach impairments. Twenty are for fecal coliform bacteria exceedences of the state standard. Exceedences are found in all parts of the basin and in all stream sizes, from second- and third-order streams (Robinson Creek and Salem Creek) to main stem tributaries. Most main stem tributaries exceed the standard at the mouth (exception is Zumbro, which is impaired at two sites upstream). The Mississippi River itself is listed as impaired for three reaches.
- Since the 303(d) list is based on a sampling regime less frequent than is required by the rules pertaining to the fecal coliform bacteria standard, intensive sampling of these sites was conducted in 1997 and 1998 by the MPCA[11] to determine with more confidence whether the standard was being exceeded. In all cases, more frequent sampling confirmed that the fecal coliform bacteria standard was being exceeded at the listed sites. The degree of standard exceedence in southeastern Minnesota was considerably greater than elsewhere in the state, particularly in the Whitewater River, Prairie Creek and the Root River.
- Sampling has been undertaken in connection with several impaired reaches in the past two years to initiate the TMDL process or as part of a Clean Water Partnership project, in the following streams: Vermillion River, Straight River, South Branch Root River, and Cedar River. In all cases, sampling was conducted at the frequency required by the rule at multiple sites upstream of the listed site of impairment to help identify sub-watersheds contributing disproportionately to the problem.
  - Straight River TMDL[12]: Seven sites were sampled in 1999-2000. About 72% of samples exceeded 200 organisms/100ml – all sub-watersheds exceeded the standard several times.
  - Vermillion River TMDL[13]: County staff and citizen volunteers monitored 5x/mo at 11 primary sites throughout the watershed, May through September, 1999. Five additional sites received some sampling. Out of the total of 16 sites, 13 exceeded the standard for fecal coliform bacteria.
- Cedar River TMDL[14]: Ten samples were collected at each of 13 sites

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[11] Minnesota Pollution Control Agency, "Fecal Coliform Bacteria in Rivers," January 1999.

[12] Chapman, K. Allen, "Fecal Coliform Pollution in the Straight River: An Information Assessment," Minnesota Center for Environmental Advocacy, Nov. 2000.

[13] Morrison, David, "Vermillion River Watershed Citizen Monitoring Fecal Coliform Bacteria Monitoring Project, May – September, 1999," unpublished presentation.

[14] Mower County Environmental Health Dept., "2000 TMDL Cedar River Study," unpublished manuscript.

from July 13 –August 23, 2000. Very few samples showed a concentration below the 200 organism/100 ml standard – each site averaged above the sample. Monitoring will be expanded in 2001 to further evaluate where the problem is coming from.

- South Branch Root River Watershed Project:[15] As part of Minnesota's process of ranking wastewater treatment facilities for funding, 1999-2000 fecal coliform data was analyzed under the methodology used to develop the 1998 303(d) list. The upper portion of the South Branch was determined to be impaired. Monitoring conducted Aug. 2, 1999, at 11 sites showed an exceedence of the 200 organism/100 ml at 10 of the 11 sites. On Aug. 30, 1999, three days after rainfall, samples were collected at both stream and spring sites. Samples from three of the springs were in the 2,300 to 3,400 org/100 ml range, verifying strong connectivity between surface and ground water flows in karst topography. Stream samples also were extremely high, with 5 reporting concentrations above 2,000 org/100 ml. The average for 5 fecal coliform samples taken in 1999 was well above the standard at three sites.
    - Olmsted County[16]: Volunteers and county staff sampled and tested surface water at 31 sites in Olmsted County approximately once a week from March to December 1999. Sites included the South Zumbro, Middle Zumbro, Root River and Whitewater River. Of the 121 bacteria samples taken, 89 (74%) failed to pass the swimming standard of 235 E. coli/100 ml ("Recommended Standards for Bathing Beaches" – a standard used as a guideline by ten states bordering the Great Lakes and Upper Mississippi River. This number also is cited in EPA's Ambient Water Quality Criteria for Bacteria-1986 as a single sample maximum allowable density for a designated beach area.) Only one site, at the discharge of a reservoir, consistently met the standard.

The relationship between land use and fecal coliform concentrations found in streams is complex, involving both pollutant transport and rate of survival in different types of aquatic environments. Intensive sampling at several of the sites listed above in southeastern Minnesota shows a strongly positive correlation between stream flow, precipitation and fecal coliform bacteria concentrations. In the Vermillion River watershed, storm-event samples often showed concentrations in the thousands of organisms per 100 milliliters, far above non-storm-event samples. A study of the Straight River watershed divided sources into continuous (failing individual sewage treatment systems, unsewered communities, industrial and institutional sources, wastewater treatment facilities) and weather-driven (feedlot runoff, manured fields, urban stormwater). The study hypothesized that when precipitation and stream

[15] Fillmore County, "Watershed News: South Branch of the Root River Watershed Project," Fall 1999, April 2000 and November 2000 issues.

[16] Wilson, Bob, "Summary of 1999 E. coli Sampling of Streams in Olmsted County," Presentation to Olmsted County Environmental Commission, April 19, 2000.

flows are high, the influence of continuous sources is overshadowed by weather-driven sources, which generate extremely high fecal coliform concentrations. However, during drought, low-flow conditions continuous sources can generate high concentrations of fecal coliform, the study indicated. Besides precipitation and flow, factors such as temperature, livestock management practices, wildlife activity, fecal deposit age and channel and bank storage also affect bacterial concentrations in runoff (Baxter-Potter and Gilliland, 1988).

Several studies have found a strong correlation between livestock grazing and fecal coliform levels in streams running through pastures. Several samples taken in the Grindstone River in the St. Croix River Basin, downstream of cattle observed to be in the stream, were found to contain a geometric mean of 11,000 organisms/100 ml, with individual samples ranging as high as 110,000/100ml. However, carefully managed grazing can be beneficial to stream water quality. A study of southeastern Minnesota streams by Sovell found that fecal coliform, as well as turbidity, were consistently higher at continuously grazed sites than at rotationally grazed sites where cattle exposure to the stream corridor was greatly reduced. This study and several others indicate that sediment-embededness, turbidity and fecal coliform concentrations are positively related. Fine sediment particles in the streambed can serve as a substrate harboring fecal coliform bacteria. "Extended survival of fecal bacteria in sediment can obscure the source and extent of fecal contamination in agricultural settings" (Howell *et al*., 1996).

Hydrogeologic features in southeastern Minnesota may favor the survival of fecal coliform bacteria. Cold groundwater, shaded streams and sinkholes may protect fecal coliform from light, heat, drying and predation (MPCA 1999). Sampling in the South Branch of the Root River watershed showed concentrations of up to 2,000 organisms/100 ml coming from springs, pointing to a strong connection between surface water and ground water. The presence of fecal coliform bacteria has been detected in private well water in southeastern Minnesota. However, many such detections have been traced to problems of well construction, wellhead management, or flooding, not from widespread contamination of the deeper aquifers used for drinking water. One study from Kentucky showed that rainfall on well-structured soil with a sod surface could generate fecal coliform contamination of the shallow groundwater through preferential flow (McMurry *et al*., 1998).

Finally, fecal coliform survival appears to be shortened through exposure to sunlight. This is purported to be the reason why, at several sampling sites downstream of reservoirs, fecal coliform concentrations were markedly lower than at monitoring sites upstream of the reservoirs. This has been demonstrated at Lake Byllesby on the Cannon River, and the Silver Creek Reservoir on the South Branch of the Zumbro River in Rochester.

An MPCA evaluation for the Minnesota River Basin suggests that improper Individual Sewage Treatment Systems (ISTS) may be responsible for approximately 74 fecal coliform bacteria organisms per 100 milliliter sample within larger rivers. [17] However, transport and survival of fecal coliform bacteria are not well understood, particularly as they are affected by the interaction of surface and groundwater flows in karst geology. Wastewater treatment facilities are required to disinfect their wastewater before it is discharged.

Data exist on the fecal coliform bacteria concentrations from businesses, homes and unsewered communities. However, watershed allocations of fecal coliform bacteria load have not yet been attempted in Minnesota. Bacterial contamination of surface and ground water by antibiotic-resistant micro-organisms has been expressed as a public concern in southeastern Minnesota; however, data on this issue do not appear to have been collected in the Lower Mississippi River Basin. Monitoring is needed to fill this data gap.

D: Pesticides:

The presence of commonly used pesticides has been detected in private well water in southeastern Minnesota. However, such detections have generally been traced to problems of well construction or wellhead management, not widespread aquifer contamination.

Minnesota Department of Agriculture pesticide sampling from 1992 to 1996 in southern Minnesota indicate commonly used corn herbicides are present in surface water following nearly all storm events and snow melts. Insecticides have not been detected. There is not a strong correlation between the quantity of pesticide applied and its occurrence in streams. Chemical characteristics appear to be more important in determining whether a compound appears in surface water. The herbicides acetochlor, alachlor, atrazine, cyanazine, dicamba, and metolachlor are detected at highest concentrations during storm events immediately following application on fields. Atrazine and one of its metabolites, de-ethyl atrazine, are detected year-round in streams throughout southern Minnesota. Monitoring results were similar for watersheds ranging in size from 25 to 16,200 square miles.

In the Garvin Brook Watershed study in the 1980s, monitoring showed that low levels of atrazine and cyanazine leached into the vadose zone of the soil following recharge events after pesticide application. Two private wells east of Lewiston had pesticide levels above drinking water standards. Mixing of pesticides close to wells was seen to be of particular concern, both at farms and commercial application centers.

E: Hydrologic Modification:

Modern land uses result in significant modifications of surface and ground water hydrology in southeastern Minnesota. Some of the most significant of these land uses are row-crop cultivation of farm land, the drainage of farm land, particularly in the western basin using a combination of surface drainage and subsurface tile drainage, the covering of urban land with impervious surfaces, and the mining of aggregate (sand and gravel) below the water table.

[17] David Morrison, "Contributions from Septic Systems and Undersewered Communities," presented at Bacteria in the Minnesota River , Mankato, Minnesota, Feb 16, 1999

Small urban watersheds are very sensitive to the percentage of the watershed surface that is impermeable. Numerous urban watershed studies show that when urban development proceeds to the point where this percentage passes 10 percent, degradation in channel stability, water quality and stream biodiversity begin. When the percentage of impervious surface exceeds 25 percent the degree of degradation becomes severe. More runoff reaches the stream faster, resulting in streambank erosion. Base flows are harder to maintain when water flows are directed over the surface rather than through the ground. Temperatures increase. The effects of impermeable surface are mainly felt in smaller urban watersheds, and are not very noticeable at the large watershed or basin scale. [18]

The percentage of precipitation that runs off the land surface is referred to as the runoff coefficient. Runoff coefficients within an urban area vary between 0.70 to 0.95 in downtown areas, to 0.25 to 0.40 for residential-suburban areas, to as low as 0.05 to 0.10 for flat lawns with sandy soil. [19] Runoff coefficients for farm land range from almost zero for set-aside land with permanent vegetative cover, to the range of 0.15 to 0.25 for typical land uses in south-central Minnesota[20] Practices that affect surface runoff from agricultural fields can greatly affect the hydrology of the watershed, hence the structure and stability of the streams. A modeling study of Prairie Creek, part of the Cannon River Watershed, shows that crop residue management can substantially reduce peak flows associated with rainfall events ranging from one inch to six inches. In the upper watershed, reductions in peak flow were approximately 50 percent, compared with more modest reductions of 13 percent downstream.

The effect of land drainage on stream structure and water quality is thought to be dramatic. However, quantitative estimates for southeastern Minnesota are not readily available. Qualitatively, extensive land drainage with surface ditches speeds up the delivery of runoff to receiving streams, resulting in higher peak flows and greater streambank erosion. Subsurface tiling will not result in the same speed of runoff delivery as that caused by surface ditches, except where surface tile intakes create a direct conduit for surface water escape. However, the combination of surface ditching and sub-surface tile drainage results in the drainage of marshy areas that previously were hydrologically isolated. This has reduced the surface water storage capacity of the landscape and increased the volume of runoff to the region's streams.

[18] Schueler, Thomas, and Richard Claytor, P.E., "Impervious Cover as a Urban Stream Indicator and a Watershed management Tool," Center for Watershed Protection, Silver Spring MD.
[19] American Society of Civil Engineers, "Design and Construction of Sanitary and Storm Sewers," Manuals and Reports of Engineering Practice, No. 37, 1970.
[20] Minnesota Pollution Control Agency, "Lake Washington Water Quality Improvement Project, Diagnostic Study Report,"Clean Water Project # 931-1-112-40

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V: Environmental Goals

One of the main purposes of basin planning is to organize the activities of natural resource management agencies around the attainment of environmental goals. Thus, defining these goals as precisely as possible is a critical aspect of basin planning. The environmental goals listed below were developed for Water Plan 2000, and are included in "Minnesota Watermarks: Gauging the Flow of Progress 2000 to 2010," published in October 2000 by the Environmental Quality Board. As stated in the Introduction, both the Lower Mississippi River Basin Team and BALMM contributed to the development of goals for the Lower Mississippi River Basin. These goals are for water quality, water quantity and ecosystem health.

A: Water Quality Goals

Groundwater Protection:

- NO_3-Nitrogen < 10 mg/L
- Total coliform bacteria, NO_3-N and 85 listed contaminants: reduce concentrations and detections in public and private wells to meet state drinking water standards.

Surface Water Quality:Rivers:

- Minimum of 10 inches (25 cm) of transparency[21]
- Reverse trend of increasing NO_3-N concentrations in streams
- Achieve fecal coliform bacteria standard in lakes and streams.[22]
- For Vermillion, Straight, Cannon and Zumbro rivers. Reduce mean phosphorus concentrations to levels needed to restore downstream reservoirs (approximately 90 parts per billion in-lake P concentration for lakes Cannon, Byllesby and Zumbro), and that are consistent with a restoration strategy for Lake Pepin (Cannon and Vermillion Rivers).
- *Mississippi River (including Lake Pepin)*: Reduce sediment load from tributaries.

Surface Water Quality: Lakes:

- Maintain/increase clarity as measured by Secchi disk
- Reduce P loads to reduce algae blooms and maintain O_2 levels

B: Water Quantity Goals

Keep stream and spring flows and groundwater levels within historic ranges.

C: Aquatic Ecosystem Goals

- Mussels: maintain diversity of native species
- Aquatic insects: establish baseline Index of Biotic Integrity
- Fish
  - Cold-water streams: introduce/maintain brook trout
  - Warm-water streams: maintain/incr. smallmouth bass
  - Mississippi River: maintain/increase walleye
- Reptiles/amphibians: maintain toad and frog populations; reduce deformities
- Birds: maintain/increase perching birds, shore birds, puddle ducks and diving ducks, and territories occupied by bald eagles.
- Mississippi River: slow sedimentation and aging of navigation pools, maximizing biodiversity, meeting reasonable transportation needs.

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[21] About equivalent to turbidity standard (< 25 NTUs) or Total Suspended Solids SS) < 90 mg/L

[22] < 200 org./100 ml monthly mean, or 2000 org/100 ml in 10 percent of samples

III: Geographic Management Strategies

Traditionally, natural resource management agencies at the local, state and federal levels have attempted to fulfill their missions of natural resource management and environmental protection through a series of specific programs aimed at curbing negative behaviors while offering incentives to stimulate positive changes. Such programs have helped considerably to reduce negative environmental impacts such as soil erosion and sedimentation, pollutant discharges from industry and municipalities, illegal dumping and careless disposal of hazardous waste. Although this *programmatic* strategy has resulted in important accomplishments, much remains to be done before the waters of the Lower Mississippi Basin are fit for a full range of uses including recreation, consumption and the support of aquatic life.

To go the next step in environmental improvement, it is necessary to do two things:

1. First, reach agreement on specific goals for water quality, water quantity and aquatic ecosystem health. Initial agreement has been achieved on the goals for water quality and quantity and aquatic ecosystem health, as indicated above.
2. Second, determine strategies for achieving these goals through modifications in land use and waste management. Often, remaining water quality, water quantity and ecosystem problems have multiple causes; accordingly, they can seldom be solved by the use of a single program. More often, multiple sources must be dealt with through multiple programs or approaches. These problems require integrated strategies whereby a combination of land uses are modified to achieve a common goal.

Three basic geographic approaches to the planning and implementation of integrated solutions are watershed management, aquifer protection, and flood plain management. Each of these is a specific geographic, or place-based approach to natural resource management. They can be used alone or in combination, depending on the specific problem, or combination of problem, that needs to be addressed. Each approach, and some of the key environmental management programs associated with them, will be described.

A: Watershed Management

<u>Lead author</u>: Norman Senjem, MPCA

A watershed is a land surface area from which water drains to a common point such as a river, lake, watershed or recharge area for a groundwater aquifer. Watershed management is a way of protecting or restoring water bodies such as these by modifying land uses within the upstream watershed. It often includes two major phases: a data collection and evaluation phase that culminates in the development of a watershed management plan; and the implementation of this plan by landowners and users. The purpose of the first phase is to better understand how different types of land use in the watershed affect water quality, both individually and collectively. The purpose of the second phase is to apply this understanding to the protection or restoration of the water body that is the main focus of the watershed project. A watershed team comprised of local citizens, businesses, organizations and stakeholders, together with local, state and federal government representatives, ideally is involved both in the development and implementation of the management plan.

The following three stream restoration strategies outline a watershed management process at three hydrologic scales. Taken together, this process meets the needs of the Total Maximum Daily Load (TMDL) Process [23]for impaired waters, in a manner that encourages local leadership and allows flexibility in how impairments are evaluated and addressed.

Stream Restoration Strategies

Strategy A1: Basin-Wide Scale: Coduct basin-wide water quality and land use evaluations with state and federal agencies working in partnership with local government, stakeholders and citizens through BALMM. Develop basin-wide environmental goals and broad land-use strategies to achieve them.

[23] The Federal Clean Water Act (CWA) requires that a Total Maximum Daily Load (TMDL) be developed for impaired water bodies reported by state Section 303(d) lists to the U.S. EPA. A TMDL is the amount of pollutant that a water body can receive and still meet water quality standards. It is equal to the sum of allowable loads from point and nonpoint sources, considers seasonal variation and includes a margin of safety. Further information on the TMDL process in Minnesota can be found on the MPCA web site at www.pca.state.mn.us/water/tmdl.html

Action 1: Estimate the geographic scope of regional impairments in the Lower Mississippi River Basin. Water quality monitoring indicates that impairments for turbidity, fecal coliform bacteria and nitrate-nitrogen are widespread. Phosphorus impairments may be confined to the northernmost streams that discharge into impaired lakes and reservoirs. These streams include the Vermillion and Cannon as well as the Zumbro River upstream of Lake Zumbro. Relationships between regional impairments and downstream problems such as Mississippi River impairments and Gulf of Mexico Hypoxia should also be noted.

Action 2: For each regional impairment define water quality objectives (often defined by rule) and associated outcome measures and indicators. These are defined earlier in the Scoping Document and in the Lower Mississippi River Basin portion of Watermarks. These indicators would include state indicators (ambient water quality concentrations) and pressure indicators (land runoff, BMPs, wastewater loads, etc.)

Action 3: Based on available information and best professional judgement, define broad-based land-use strategies to achieve environmental goals. The BALMM has developed seven land-use strategies for basin-wide application, which are described in the next section of the Basin Plan Scoping Document.

Action 4: Seek technical and funding support to implement land-use strategies across the basin. (The Conservation Reserve Enhancement Program in the Minnesota River basin is an example.)

Action 5: Implement at appropriate scales. This may be: a) basin-wide, as in the case of BMP development or education; b) major watershed-wide where organization and infrastructure is present to conduct broad strategies; or in a c) minor watershed, when this is the preferred scale at which counties, SWCDs and other local government agencies involved in land resource management feel they can be the most effective.

Action 6: Monitor at regular intervals to evaluate progress toward reaching objectives on a basin scale. This may include water quality monitoring at critical points, such as mouth-of-tributary; land-use surveys; and surveys that measure knowledge, attitudes and preferences of basin citizens.

Strategy A2: Major Watershed Scale: (Integrated with basin-scale strategy)
Action 1: Conduct water quality assessments to refine water quality objectives, outcome measures and indicators. Led by MPCA with partners, assisted by consultants.

Action 2: Refine strategies for achieving objectives, outcome measures and indicator targets. Use modeling where feasible to evaluate alternative reduction scenarios. Fully engage local and regional agencies and the public in developing and evaluating alternative scenarios and finally selecting a preferred reduction scenario.

Action 3: Geographically target the strategies to subwatersheds, including minor watersheds.

Action 4: Implement strategies in targeted subwatersheds and minor watersheds, according to the major watershed plan.

Action 5: Monitor at regular intervals to evaluate progress toward reaching objectives on a major watershed scale.

Strategy A3: Minor Watershed Scale: (Integrated with basin and major watershed strategies)
Action 1: Choose priority watersheds for implementation, consistent with basinwide strategies and major watershed assessments. There are two basic approaches to choosing minor watersheds for implementation priority:

- Evaluation of a minor watershed's restoration potential. This may be estimated by considering a combination of factors including degree of impairment, potential for improvement, and effort required to achieve a given degree of improvement. Moderately impaired streams whose watersheds have some variety of land use and ecological connectivity, including channel or riparian integrity, generally will have a higher degree of restoration potential than minor watersheds that are heavily impaired and whose landscapes are highly altered and lack diversity.
- Assessment of a watershed's degree of contribution to a downstream impairment. For example, watersheds that yield the highest relative quantities of sediment, nutrients or other pollutants within a major watershed may be chosen as priorities for restoration.

Whichever of these approaches is appropriate will depend at least partly on an evaluation of the relative merits of achieving downstream or "mouth of watershed" objectives for a large stream or river, compared to the value of restoring the quality of minor tributary impairments. Local and regional preferences should be consulted to help answer this question. However, whichever minor watershed approach or combination of approaches is chosen, the total scope of implementation should be sufficient to address downstream impairments.

Action 2: Develop an implementation strategy that addresses the regional impairment within the minor watershed. The following steps may be followed to implement the Total Maximum Daily Load (TMDL) process for phased TMDLs where additional information is needed.

Action 2a: Cooperate with local units of government, watershed organizations and stakeholders throughout the process. Encourage local leadership.
Action 2b: Gather relevant published data on suspected sources of impairment in the watershed draining to the impaired reach. This includes feedlot inventories, assessments of ISTS compliance, identified unsewered communities, and maps indicating areas particularly vulnerable to soil erosion, surface runoff and delivery of pollutants to the impaired water body.
Action 2c:Travel the watershed to better identify significant pollution sources.
Action 2d: Use this information to complete a TMDL Worksheet. Develop one or more Reduction Strategies that, according to estimates, will result in the attainment of water quality standards in the impaired reach. Ask local government, residents and stakeholders to choose a Reduction Strategy.
Action 2e: Submit the TMDL plan to EPA for approval. In cooperation with local units of government and stakeholders, address EPA comments to secure the plan's approval.
Action 2f: Implement the chosen reduction strategy. Identify sources of funding, provide technical support and program support as appropriate.
Action 2g: Evaluate progress on the reduction strategy. After the implementation period is completed, monitor water quality to determine whether the impaired reach now meets water quality standards.
Action 2h: If the first reduction strategy does not succeed in removing the impairment, conduct a more detailed analysis of the problem. On the basis of its findings, develop and implement a second reduction strategy.

Lake Protection and Restoration Strategies

Strategy A4: Lake Protection:
Give high priority to the protection of lakes that fully or partially support designated uses according to MPCA water quality assessments. Promote the adoption of BMPs and appropriate inspection and enforcement activities within the watersheds of these lakes.

The potential water quality of lakes depends on factors such as their shape, watershed size, residence time of water and the ecoregion within which they are located. The latter factor is particularly important in establishing benchmarks, or criteria, that can be used as goals to guide lake protection and restoration efforts. Ecoregion-based criteria have been developed for

each of the three ecoregions of the Lower Mississippi River Basin: North-Central Hardwood Forest, Western Corn Belt Plains, and Driftless Region. These eco-region based criteria serve as the primary basis for evaluating swimmable use support in lakes.
A total of 47 lakes in the basin have been assessed. Out of this total, six lakes (15 percent) were in full support of swimmable use; 5 lakes (12 percent) were in partial support; and the remaining 36 lakes (86 percent) were in non-support of swimmable use. These criteria also are the primary basis for listing lakes on the 303(d) list and it is anticipated that they also will be the criteria that eventually will be promulgated into water quality standards. According to the U.S. EPA's Clean Water Action Plan, states will be expected to adopt nutrient criteria for lakes and streams for water quality standards development by the end of 2003. The ecoregion-based phosphorus criteria should serve as the technical goals for individual lakes in the basin until lake and watershed studies (Lake Assessment Project studies at a minimum) provide a basis for setting a site-specific goal.

"Partial support" of swimmable use is a very desirable goal for many of the lakes in the Lower Mississippi River basin. Given that a very small percentage of the lakes fully or partially support swimmable use, lakes in these categories should be priorities for protection or rehabilitation-oriented projects. In many instances these lakes will be somewhat deeper than the norm for the basin or ecoregion, and have a higher likelihood of achieving lower phosphorus concentrations in contrast to shallower lakes.

Action 1**:** Periodically review lake monitoring data and identify lakes that fully or partially support swimmable use according to appropriate ecoregion criteria (or standards after they are promulgated).

Action 2: Inform local units of government, citizens and interested non-government organizations about lakes in their region that fully or partially support swimmable use.

Action 3: Encourage counties, watershed organizations to develop a lake management plan for lakes in the full or partial support categories.

Action 4: Encourage counties and watershed organizations to submit project proposals to help implement their lake management plan. Where water quality data are not sufficient, Clean Water Partnership may be the most appropriate program. If adequate diagnostic study has been conducted to establish relationships between water quality and the watershed characteristics, lake projects that promote the implementation of protective BMPS may be more appropriate.

Action 5: TMDL Strategy. Start first to address partially supporting lakes through the TMDL process. This process can lead to the identification of water quality goals and pollutant-reduction strategies that will prevent these lakes from getting worse and, eventually, improve them. Highly impaired lakes, by contrast, will require more extensive study.

Action 6: Overlay GIS feedlot coverages on maps depicting lakes, with their drainage areas and trophic status. Make it a priority to ensure that all feedlots in the watersheds of fully or partially supporting lakes are permitted and abiding by their land application guidelines. Target inspection and enforcement activities in these watersheds.

Action 7: Use GIS to identify where major urban areas are located in the watersheds of fully or partially supporting lakes. Target these areas for early adoption of Phase II stormwater rules.

Strategy A5: Restoration of Impaired Lakes:
The MPCA offers a series of lake-management programs which interested citizens groups can make use of as they try to better understand the nature of a lake's water quality problems, major sources of pollutants, and possible solutions that can be implemented. These programs will be briefly mentioned in the sequence in which citizens groups frequently make use of them.

Action 1: Citizens Lake Monitoring Program. Lake residents or citizens regularly collect data on Secchi disk transparency, together with occasional sampling for phosphorus and chlorophyll a. Trends are evaluated to estimate the lake's approximate trophic state.

Action 2: Lake Assessment Program. Lakes that warrant further investigation based on CLMP results can be studied in more detail under the Lake Assessment Program (LAP). In a one-year study, MPCA provides technical assistance to help a watershed group to collect relevant watershed and lake data, collect and analyze in-lake sampling for transparency, phosphorus, chlorophyll a, dissolved oxygen and other parameters, conduct limited tributary sampling, and write a report that describes the lake's problems and outlines possible future actions.

Action 3: Clean Water Partnership Program, Phase I: Local watershed organizations that are interested in seriously addressing a lake's problems may wish to apply for a Clean Water Partnership (CWP) grant from the MPCA. Phase I of CWP involves a detailed diagnostic study that goes considerably beyond the scope of a LAP study. It provides the basis for developing in-lake goals and a set of land use Best Management Practices recommendations to achieve them. Based on this watershed and lake assessment, an implementation plan is developed which becomes the basis for a Phase II Implementation grant application. The entire program can extend from 5 to 8 years.

Action 4: Implementation and continued monitoring. Lake management is on ongoing need that extends beyond the duration of any program. This involves continued attention to land use Best Management Practices implementation, dealing with new land-use issues as they arise, and monitoring to determine whether lake goals are being met or not.

Strategy A7: Determine Watershed Priorities for Protection or Restoration
The following criteria are suggested for 8-digit watershed prioritization:

a) Degree of watershed coordination capability present at the major (8-digit) and minor (11-digit) level;
b) Degree of watershed planning and assessment that have been conducted;
c) Degree of threat to drinking water sources;
d) Degree of land use development pressure;
e) Severity of downstream impacts on aquatic resources (for example, impacts on Mississippi River backwater areas)
f) Restoration Potential of water bodies within the watershed (stream segments, lakes, groundwater and wetlands)[24]

B. Aquifer Protection

Strategy Development Team: Bea Hoffmann, SE Minnesota Water Resources Board (lead author); Art Persons, MDH; Peter Zimmerman, MDH; Terry Lee, Olmsted County water planner; Joe Zachmann, MDA; Jim Lundy, MPCA, Norman Senjem, MPCA

Prevention of aquifer contamination is an important component of managing our drinking water resources. One approach to preventing pollution of our drinking water supplies is to recognize where ground water is especially vulnerable to pollution and to then take measures to protect these sensitive areas. The Minnesota Ground Water Protection Act of 1989 defines a sensitive ground water area as "a geographic area defined by natural features where there is a significant risk of ground water degradation from activities conducted at or near the land surface." For the purposes of this document, geographic areas that are in the vicinity of public and private drinking water sources are also considered vulnerable areas because of their public health importance.

Geologic criteria for assessing sensitive ground water areas are generally based on the properties of the geologic materials overlying the ground water. The sensitivity of the material is indicated by the "time of travel" for a water-borne contaminant to travel vertically from its source at or near the land surface to the aquifer. The most sensitive areas would have the shortest time of travel and have the least ability to retard the vertical movement of contaminants into the aquifer.

Wellhead Protection Areas

Objective: Achieve land uses compatible with management strategies identified in local and tribal wellhead protection plans.

Almost all the public water supply systems in the Lower Mississippi River Basin rely on ground water. Because of this, the protection of wells and the aquifers which supply them is an important public health issue. Minnesota's WHP program must address both state and federal

[24] Factors to consider in determining restoration potential include: 1) Degree of Impairment (identify impairments that are most likely to respond to appropriate and reasonable restoration measures; 2) Cost-Effectiveness of restoration measures; and 3) Natural Resource Endowments including undeveloped public land and biological diversity.

mandates. Concerns over the impacts that unwise land and water use have on the quality and quantity of ground water resources prompted the 1989 Minnesota legislature to pass the Minnesota Groundwater Protection Act. The Act granted MDH authority to develop a WHP program to protect public water supply wells from contamination.

Strategy B1: Support public water suppliers' efforts to develop wellhead protection (WHP) plans. For communities of 900 population or less, bring public water supplier into the WHP by 2003 and those of 900 population or more by 2006. The purpose of Wellhead Protection Planning is to prevent human-caused contaminants from entering public water supply wells. These efforts are needed to protect users from chronic health effects related to ingesting low levels of chemical contaminants.

Action 1: Educate the public water supply managers, public officials, and the general public about WHP principles and requirements.

Action 2: Encourage formation of WHP citizens committees.

Action 3: Provide technical assistance to public water suppliers to help them determine the five components necessary to determine their delineation areas.

> Action 3a: For communities under 3300, provide vulnerability assessments and delineations.
> Action 3b: Develop ground water flow models for SE Minnesota.
> Action 3c: Conduct pumping tests in representative aquifers to assist public water suppliers in determining their transmissivity values.
> Action 3d: Assist in verifying well locations on existing well logs for the purpose of determining ground water flow direction.
> Action 3e: Develop ground water flow modeling projects for SE Minnesota.

Action 4: Provide technical assistance to public water suppliers to help in determining an inventory of potential point source contaminants.

> Action 4a: Assist in obtaining a Geopositioning System (GPS) location for potential point source contaminants.
> Action 4b: Share existing contaminant source inventory databases with public water suppliers.
> Action 4c: Create parcel ownership and land use maps for WHP areas.

Action 5: Provide technical assistance to public water suppliers in determining appropriate management strategies for potential pollutant sources.

> Action 5a: Provide guidance documents for management of specific point source contaminants.
> Action 5b: Establish well sealing cost-share programs for WHP areas.
> Action 5c: Support programs to encourage ISTS upgrade in WHP areas.
> Action 5d: Provide technical assistance to communities considering land use regulations in WHP areas.

Action 5e: Facilitate local cooperation among jurisdictions falling within WHP areas.
Action 5f: Promote appropriate agricultural BMP's in WHP areas through education and cost-share incentives.
Action 5g: Provide education about management of sources within a WHP management area.
Action 5h: Implement WHP measures within inner WHP zones.

Strategy B2: Coordinate and support WHP plan implementation by state agencies with related missions such as the MPCA, MDA, and DNR.

Action 1: Develop protocol for inter-agency communication and coordination.

Action 2: Coordinate sharing of databases.

Strategy B3: Encourage integration of WHP protection into other plans including county water plans, watershed plans, and comprehensive land use plans.

Strategy B4: Assist public water suppliers in siting of new wells.

Action 1: Conduct site investigations.

Action 2: Assess risk of contamination by existing point and nonpoint source contaminants at proposed well location sites.
Strategy B5: Automate Wellhead Protection Data

Action 1: Integrate WHP data including updated County Well Index information into a basin-wide data center and internet-based site to improve transmittal of data.

Action 2: Develop a karst features database for the purpose of integrating into point source contaminant inventories.

Strategy B6: Support continued karst investigations to improve knowledge of ground water behavior in the basin.

Strategy B7: Implement new federal underground injection control regulations that impact certain types of on-site wastewater disposal systems in wellhead protection areas.

Supplementary materials:
Minnesota Rules Parts 4720.5100 to 4720.5590
Wellhead Protection Phasing List
State Agency Guidance Documents for Wellhead Protection Area Management

Private Drinking Water Wells

The primary source of drinking water in southeastern Minnesota is the individual underground well. In most cases, a well can provide a reliable, safe source of drinking water when it is properly located, constructed, and maintained. A combination of regulation and public education can help to ensure that proper guidelines are followed, and that the health risks associated with contaminated drinking water supplies are thereby reduced. The construction of new wells and the disclosure and sealing of existing wells are regulated by the Minnesota Department of Health statewide; however, counties or cities having a delegated well program regulate private well construction within their borders. The statutory authority for delegation of the duties of the Commissioner of Public Health is listed in MN Statutes 103I.111. The statutory requirements & authority for requiring wells to be sealed fall under MN Statutes 103I.301. Authority may also be claimed under MN Statutes 145A.04 Subd. 8.

Strategy B7: Well and Boring Construction

Action 1: Implement and conduct compliance monitoring and enforcement of State Statues and Rules pertaining to well and boring construction to assure public health and groundwater resources are protected through proper well and boring construction.

Strategy B8: Well and Boring Sealing

Action 1: Implement and conduct compliance monitoring and enforcement of State Statutes and Rules pertaining to well and boring sealing to assure public health and groundwater resources are protected through proper sealing of wells and borings.

Strategy B9: Well Disclosure Program

Action 1: Follow-up on all unused wells disclosed at property transfer to assure the well is sealed, put back into use, or is placed under a yearly renewable maintenance permit.

Strategy B10: Education

Action 1: Provide information and education to the public, legislators, the news media, special interest groups, civic organizations, and others to improve public understanding of the need for proper construction, maintenance, and ultimate sealing of wells and borings.

Action 2: Use existing educational tools such as the University of Minnesota Extension Service Farm-A-Syst and Home-A-Syst programs to evaluate and modify individual wellhead area practices.

Action 3: Provide technical assistance, education and training to professionals such as well and boring contractors, agency and local government staff, and other professionals through training programs, conferences, newsletters, publications and guidance memoranda.

Strategy B11: Special Well Construction Areas

Action 1: Develop special well construction areas in response to groundwater contamination problems by consultation with affected parties, consultants, and government agencies, and by developing technical publications, guidance criteria and maps in order to assure that potable wells are not constructed into the contaminated aquifer and that wells and borings constructed and sealed in the area do not adversely affect the contamination plume.

Action 2: Develop maps depicting where carbonate aquifers must not be used for a potable water supply, where past well construction practices necessitate special techniques for sealing or where hydrologic, water quality or well construction conditions require development of a special report or map.

Strategy B12: Research and Data Gathering

Action 1: Conduct research and gather data to further understand geology, hydrology, contaminant behavior and ground well/boring construction practices.

Strategy B13: Product Evaluation

Action 1: Evaluate new products and materials to be used in construction, maintenance, and ultimate sealing of wells and borings to assure the products and materials meet public health protection requirements of State Statutes and Rules.

Strategy B14: Well Water Testing

Action 1: Provide information to the public about the potential health risks associated with contaminated water supplies, especially those associated with vulnerable populations, and the need for regular testing of well water.

Action 2: Support programs that subsidize well water tests and purchase of bottled water when necessary, to income-eligible populations.

Action 3: Support programs that provide grants or low-interest loans to income-eligible homeowners for construction, repair, or sealing of private drinking water wells.

Action 4: Support policy changes that ensure that owners of rental properties not subjected to housing codes provide potable water supplies to their tenants.

Vulnerable Areas

The over-all objective is to manage land use to avoid adverse effects to highly sensitive aquifers. Such aquifers may be locally important resources for private drinking water wells not normally protected by land use plans in wellhead protection areas. Furthermore, pollutants in these aquifers may leak to deeper aquifers by means of fractures in confining units, or at the eroded subcropping edge of confining units.

Strategy B15: **Manage Recharge Areas Near Edge of Decorah Shale**
Ground water recharge areas that occur at the edge of the Decorah shale receive ground water from formations in the unconfined Upper Carbonate and are therefore especially susceptible to contamination. These areas should be managed as vegetative buffer areas (see Land Use Strategies, Perennial Vegetation).

Strategy B16: Map Development
Develop the following maps for each county or community as an aid to determining priority vulnerable areas within that jurisdiction:

- the eroded subcropping edge of confining units
- fractures in confining units that may recharge to aquifers beneath
- other solution features (e.g., sinkholes swarms, caves, zones of solution enlarged fractures, paleokarst zones, etc.) that may affect the movement of pollutants downward from water table aquifers to important resource aquifers

Strategy B17: Planning
Action 1: Integrate the possibility of contamination from vulnerable recharge

areas and surface contamination leakage through confining units into Wellhead Protection Plans, County Water Plans, Local Comprehensive Land Use Plans, and transportation plans.

Strategy B18: **Research Support**
Action 1: Research efforts to quantify the ability of soils to biologically filter ground water that is recharging highly sensitive or very highly sensitive aquifers and develop best management practices for land uses in these areas.

Strategy B19: Land-Use Ordinances
Action 1: Provide model land use ordinances, designed to protect vulnerable areas, to local governments.

Strategy B20: Protection and Preservation
Action 1**:** Permanently protect and preserve highly vulnerable areas through purchase of property easements or through programs that encourage property set-asides.

Strategy B21: Education Provide education and technical assistance in identifying and protecting sensitive aquifers to the following stakeholder groups:

- Water planners, land use planners, transportation planners
- Soil and Water Conservation District supervisors and staff
- Community water suppliers
- Elected and appointed officials
- Property owners
- Public

C: Floodplain Management

Strategy Team: Jim Cooper, DNR (Non-Structural Flood Damage Reduction); Judy Mader, MPCA; Norman Senjem, MPCA; Scot Johnson, DNR, John Sullivan, Wisconsin DNR (Mississippi River Dredging Management)

Objective: Reduce the potential for flood damage while enhancing the original functions of floodplains for water quality and ecological benefits.

Introduction: A river system includes much more than a main channel running at bankful or lower flows. An important part of a river corridor is the floodplain, a relatively flat area on both sides of a stream that is formed over centuries as the stream moves back and forth in a process of lateral migration. This process, and sediment deposition, continually reshape the floodplain, and often form a rich diversity of ecological niches. During floods, the floodplain serves vital functions ranging from sediment accumulation to providing areas suitable for fish spawning, to dissipating river energy and maintaining channel integrity. At other times of the year, the natural floodplain can be part of a biological corridor that supports a variety of wildlife. For a floodplain to continue to offer these services it must remain connected to the river, and as free as possible of fill, paved surface areas and other severe disturbances.

At the same time, human settlement of floodplains – towns, businesses, farms, and residences -- is a prominent feature of today's landscape that will endure for the foreseeable future. Flood damages to persons and property is a real concern that needs to be dealt with to minimize these damages. Balancing these objectives – minimizing flood damages while maximizing ecological services of the floodplain river corridor – is the goal of the following flood plain management strategies. Two such strategies have been prepared: one dealing with flood plain management for flood damage reduction; and another dealing with the management of dredging operations in the Mississippi River Valley. Additional strategies will be needed to more specifically address the functions of flood plains as part of the river corridor ecosystem.

Nonstructural Measures of Flood-Damage Reduction

Historically, flood relief has often been sought through construction of works for flood control such as dikes, dams, and enlarged channels. However, when it was found that average annual flood damages were increasing in spite of the billions of dollars spent across the nation in such works for flood control, a new philosophy was developed that was referred to simply as the non- structural alternative to flood control. This philosophy was intended to reduce flood damages through such things as development of flood warning systems, flood proofing, floodplain land use planning, and floodplain regulation with the structural measures being only a subset of comprehensive floodplain management.

In Minnesota, the non-structural alternative to flood control prompted the Minnesota Legislature to enact floodplain management statutes that emphasized non-structural alternatives. This statute exists today as Section 103F.105 in Minnesota Statutes that establishes policy which in part says: "It's the policy of this state to reduce flood damages through floodplain management, stressing non-structural measures such as floodplain zoning and flood proofing, flood warning practices, and other indemnification programs that reduce public liability and expenses for flood damages." This section of law goes on to say: "It is the policy of the state not to prohibit but to guide development of the floodplains." Floodplain management policy is stated in Section 103F.105 of the statutes.

Ecological Benefits. More recently awareness has developed over the ecological benefits of allowing the floodplain to function in a natural unobstructed but connected state utilizing floodplain storage to limit peak stages and discharges of major floods but allowing during normal runoff years those lands that have traditionally been used for agricultural production to continue to be used for such. In turn, those low-lying floodplain lands, wetlands, and ponding areas annually flooded would be allowed to continue to flood thereby sustaining waterfowl and fish spawning habitat and providing flood water storage. Sustaining a holistic functioning of these floodplains not only promotes healthy ecological biodiversity of both the floodplain and the adjoining river channel but also minimizes the extent of monetary damages when it floods.

Flooding experience of 2000 in southeast Minnesota. During late spring, early summer of the year 2000, record or near record flooding occurred in the Root River and Cedar River Basins of the Lower Mississippi River Basin planning area. In an attempt to identify the perceived effectiveness of implementation of the existing floodplain management policy, elected and non-elected government officials were contacted and asked: "In response to this year's late spring, early summer flooding what appeared to be lacking in terms of government/state government response to those that were affected by the flooding?" A summary of the responses and the list of those contacted is available from the Rochester office of DNR Waters. The responses received also were helpful in identifying priority strategies and actions that should be considered in the portion of the revised 2000 State Water Plan for southeast Minnesota relating to floodplain management.

Floodplain management strategies and actions.

Strategies and actions relating to state floodplain management policy and for management of floodplains for ecological benefits are grouped together. Strategies and actions relating to the Mississippi River Floodplain are listed as a subset. All the actions and strategies have been developed within the context of state floodplain management policy.

Strategy 1. Provide assistance to local units of government in preparation of flood plans that include flood preparedness, operation during flooding, and flood relief and recovery.

Action1. Prepare compendium of local, federal, and state programs that provide assistance to both local units of government and private interests in matters of flood preparedness, operation during times of flooding, flood recovery and relief and flood mitigation.

Action2. Include in compendium a summary of process that will be followed in disseminating flood relief information during and following flood events.

Action3. Develop a mechanism which promptly sets up public informational and consultation meetings following flooding on relief and recovery programs for local government and private interests.

Action4. Develop a mechanism which will, following flooding, accelerate identification and compilation of damage estimates which determine if the threshold for a federal disaster declaration will be met.

(The above action items evolved from response of the elected government and non-elected government officials that were queried following the year 2000 late spring, early summer flooding.)

Strategy 2. Remove flood prone structures from the floodplain.

Action 1. Inventory those communities and the number of high damage potential structures in those communities which have suffered repetitive flooding or have the potential to be substantially damaged because of flooding.

Action 2. Periodically advise local units of governments with flood-prone structures of the programs available to assist in removing such structures from the floodplain.

Action 3. Examine ways to speed up government acquisition process for the

purchase of flood prone properties of willing sellers.
(During the 2000 late spring, early summer flooding in southeast Minnesota, a number of buildings were flooded in Austin and Spring Valley, some of which suffered substantial damage while others have had a history of repeated flooding. The State Flood Damage Reduction program along with federal disaster assistance programs can provide local units of government substantial grants to communities for the purchase of such flood-damaged structures. Comment was received expressing a desire to have the acquisition process speeded up.)

Strategy 3. Acquire (through easement or purchase) the use of properties that are repeatedly flooded which are suitable as wildlife management areas and which would restore the natural floodplain storage areas.

Action 1. Inventory repeatedly flooded floodplain areas that would be suitable for wildlife management purposes, or which the restoration of the natural flood water storage would effectively reduce flood stages and peak flood discharges.

Action 2. Allocate funds to purchase flood-prone properties from willing sellers which would be suitable for wildlife management purposes or which would restore the natural floodplain storage characteristics thus reducing flood heights and peak discharges.
Action 3: Examine ways to speed up government acquisition process for purchase of flood-prone properties of willing sellers.

(As a result of flooding in 2000, some owners of land that have been flooded several times over the last ten years have expressed an interest in selling, but have expressed concern over the length of time it takes the government to make a purchase. Both state and federal wildlife management agencies have indicated an interest in purchasing some of these lands as wildlife management areas.)

Strategy 4. Promote the expansion of flood warning systems to allow for better emergency preparedness for flood prone areas.

Action 1: Utilize existing assistance programs to provide flood warning to those communities that don't have a warning system but have indicated an interest in having one such as Spring Valley.

Action 2: Examine the use of existing programs to replace the partial duration stream gage at the bridge on the Root River near Lanesboro that washed out during the 2000 late spring, early summer flooding to enhance downstream flood warning capabilities.
Action 3: Refit abandoned US Geological Survey stream gages for flood warning purposes and to collect stream flow data to allow more accurate risk determination and flood frequency analysis.

(Responses to the critique of the 2000 flooding specifically expressed an interest in developing a flood warning system for Spring Valley and that the Lanesboro bridge gage needed to be replaced. It's noted that the US Geological Survey will be discontinuing two permanent gaging stations in southeast Minnesota because cost share funding isn't available to keep them operating.)

Strategy 5. Seek means to develop up-to-date floodplain mapping for areas experiencing growth using state-of-the-art GIS technology.

Action 1: Inventory those floodplain areas that are not adequately mapped and are experiencing development pressures.

Action 2: Examine the use of existing programs to fund the development of up-to-date mapping using GIS technology for those floodplain areas experiencing development pressures.

(Comments received during the critique of the 2000 flood indicated a need for updated floodplain mapping for areas subject to development pressures.)

Strategy 6. Continue the administration of floodplain regulation and participation in the National Flood Insurance program at the local level.

Action 1.Provide education programs to local units of government and the public on floodplain and watershed hydraulics and hydrology, floodplain regulation techniques and the National Flood Insurance program.

Participation in the National Flood Insurance program requires that local units of government adopt and administer floodplain land use controls such as zoning and subdivision regulations and building codes. Minnesota Law requires that floodplain zoning regulations adopted by local units of government meet minimum state standards set by the Department of Natural Resources.
State floodplain zoning standards are compatible with the minimum floodplain regulations required for participation in the National Flood Insurance Program. All the counties and 57 cities located in the Lower Mississippi River Basin planning area participate in the National Flood Insurance program and therefore administer floodplain regulations that meet both flood insurance standards and minimum state floodplain standards. In the southeast Minnesota Counties (Houston, Fillmore and Mower) named in the federal disaster declaration because of the 2000 flooding, as of July 31, 2001, 395 flood insurance policies were in force; 156 policies are in force in Houston County; 75 policies are in force in Fillmore County of which 16 are in Spring Valley; and 164 policies are in force in Mower County of which 141 are in Austin.

Strategy 7. Examine cost effective options to reduce agricultural flood damages.

Action 1: Promote urban and rural land use practices on a watershed basis through implementation of all elements of Watermarks and the Lower Mississippi River Basin Plan Scoping Document, which will reduce runoff, reduce flood stages, and reduce the extent of floodwater inundation.

Action 2: Look for opportunities to restore or create wetlands.

Action 3: Seek funding for programs that provide cost share to local units of government for removal of debris from stream channels that cause a significant obstruction to flow and excessive stream bank erosion.

Action 4: Continue to use existing work force programs such as Sentence-to-Serve crews and Minnesota Conservation Corps crews to assist in removal of debris from streams and rivers.

(In the critique of government response to flooding in 2000, several commented that they expect floods to get larger and more frequent. Others commented there was a need to install more land treatment measures in the uplands of the watershed. Several indicated that Sentence- to-Serve Crews should continue to be used to help remove debris from stream and river channels.)

Mississippi River Dredging Management

The Mississippi River floodplain on the eastern border of Minnesota "is part of the largest riverine ecosystem in North America and third largest of seventy-nine such river systems in the world…. This floodplain ecosystem complex … is critical habitat for both aquatic and terrestrial species of flora and fauna... The ecological significance of this floodplain, as a commercial and recreational fishery and migratory waterfowl nesting area, flyway and hunting area, was formally acknowledged by the U.S. Congress as early as 1924. That year, at the urging of the Izaak Walton League, more than 200,000 acres of floodplain was designated by Congress as the Upper Mississippi National Wildlife and fish Refuge.[25]

A wide range of federal and state government agencies and non-government organizations are involved in managing the Mississippi River for commercial and ecological benefits: the Environmental Management Program; Long-Term Resource Monitoring Program; and ongoing evaluations of commercial navigation and its impact on water quality and the floodplain ecosystem. The following strategy addresses the management of dredging that is conducted to maintain a nine-foot navigation channel by the U.S. Army Corps of Engineers. The strategy has four main components. It addresses 1) preventive measures that can reduce the need for dredging; 2) siting decisions that affect the use of floodplain land for dredge spoil storage; 3) the management of dredging activities, particularly dredge placement sites, to reduce water quality and ecosystem impacts; and 4) beneficial re-use of dredge spoils.

Dredging is often conducted to maintain navigation access to or within a waterbody. Material that is then dredged from a waterbody must be disposed of -- Minnesota Statutes and Rules strongly discourage in-water disposal of pollutants (dredged material is defined as "other waste" in MN Stat. Chap. 115.03). Therefore, most dredged material disposal takes place on upland. Since permittees generally seek to reduce the financial cost of the dredging activity, dredged material is often placed in the nearest , and lowest cost, disposal site – the flood plain. The UMRCC Strategy from "A River That Works and a Working River"[26]that deals with dredging issues is "Manage channel maintenance and dredge material disposal to support natural resource management system objectives."

Regardless of the size of the disposal site, placement of dredged material within the flood plain:

[25] A River That Works and A Working River, January 2000, Upper Mississippi River Conservation Committee, Rock Island, IL,

[26] Ibid, pp. 25-26

a) smothers the flora and fauna at the site;
b) temporarily disrupts use of the area by wildlife;
c) hinders the conveyance of high or flood flows, thereby preventing the dissipation of flow energy; and
d) prevents the deposition of suspended sediment, which holds nutrients to “feed” flood plain vegetation, carried by the high or flood flows.

Strategy 8: Reduce turbidity in side-channels and backwaters of the Mississippi and minimize the need for navigation channel dredging by a) reducing the discharge of sediment from major tributaries, and b) channel management activities.

Action 1: Determine the potential for reducing sediment sources and increasing sediment sinks within tributary watersheds. Incorporate sediment source/sink analysis into major watershed assessments conducted for Total Maximum Daily Load studies and other purposes.

Action 2: Implement sediment reduction strategies in tributary watersheds (Strategies 1,2,3,4, and 6).

Action 2a: Attempt to increase the storage of sediment within tributary watersheds in upstream or alluvial floodplain locations. Evaluate the potential for reconnecting the mainstem with alluvial floodplains in major tributaries.

Action 2b: Judiciously use channel maintenance activities including monitoring, buoy positioning, sediment trapping and current control structures to reduce the need for dredging, while allowing the river to function in as natural a manner as possible.

Strategy 9: Reduce the number of permanent dredged material disposal facilities located in flood plains.

Action 1: Work with applicants and permittees to**:**
a) identify viable permanent disposal sites outside of the flood plain; and
b) beneficially re-use and remove dredged material that is stockpiled in the flood plain within a reasonable time frame.

Action 2: Educate applicants and permittees regarding:
a) the impacts of dredged material placement on the capacity of a flood plain to convey river flow during high water events; and
b) the impact of flood flows on the integrity of a dredged material disposal facility located in the flood plain; and
c) the impact of eroded material (both native soils and sediment from dredged material disposal sites) on the “health” of the waterbody.

Strategy 10: **Manage dredging activities to minimize adverse effects on water quality and the floodplain ecosystem.**

Action 1: Where practical, avoid dredging and transfer of dredged material during sensitive time periods such as fish spawning. Develop guidelines for seasonal constraints on river dredging operations. Cite guidelines in 401 certificates.

Action 2: Develop framework for determining effluent limits for Total Suspended Solids for dredge placement sites.

Action 3: Develop a monitoring protocol for dredge placement sites that includes both effluent and ambient water quality.

Action 4: Placement site management.

- Action 4a: Formalize Best Management Practices (BMPs) that are specific to dredging and disposal activities.
- Action 4b: Include, by reference, the BMP Document developed in the point above in the Dredging Exemption from State Disposal System permitting (MN Rule 7050.0212) for TSS.
- Action 4c: Through 401 Certification require that dredged material be handled in a manner that protects water quality.

Action 5: Increase inspection and enforcement of dredge disposal site activities by coordinating activities between the MPCA and DNR.

Action 6: Coordinate closely with the resource agencies in adjoining states on shared-water issues to avoid contradictory actions.

Strategy 11: **Encourage Beneficial Uses of Dredge Spoils**.
This will reduce the need to devote floodplain land areas to the permanent storage of dredge spoils, and reduce the need for aggregate mining to meet increased demands.

VII: Land-Use Strategies

A: Land-Use Strategy 1: Perennial Vegetation

Strategy Development Team: Howard Moechnig, NRCS/BWSR (Pasture Land Conservation Management), Mary Kells, BWSR, Tom Steger, Goodhue County NRCS, Tex Hawkins, USFWS (riparian buffers)

Objective: Increase – or, at a minimum, maintain -- acreage of land in hay and pasture, woods and meadow.

Environmental functions of perennial vegetation

Maintaining land with permanent vegetative cover is critically important to achieving water quality, water quantity and ecological goals and objectives in the Lower Mississippi River Basin. Land with permanent cover helps to reduce surface runoff and intercept pollutants such as pesticides, nutrients and sediment to protect surface and ground water quality. By increasing infiltration, perennial vegetation helps to replenish groundwater aquifers and retard the flow of water to streams to stabilize the hydrologic cycle and reduce stream bank erosion. Increased infiltration also helps to lower the temperature of streams by routing runoff through groundwater rather than over the surface. In addition, permanent vegetative cover is essential to support wildlife populations.

The degree of environmental benefits provided by perennial vegetative cover depends on the location and management of such land relative to other land uses in a watershed. To protect surface water quality, permanent vegetative cover can be strategically located on shoreland down-slope from intensive land uses, to increase infiltration and provide a sink for pollutants. Periodic harvesting may be needed to prevent the sink from eventually exporting pollutants, thereby becoming a pollutant source. To protect groundwater quality, permanent vegetative buffers may be established at critical geologic positions such as the periphery of sinkholes. Another example is groundwater recharge areas such as those that occur at the edge of the Decorah shale and receive ground water from formations in the unconfined Upper Carbonate aquifers that are contaminated with nitrate nitrogen and other pollutants (See Geographic Management Strategies/ Aquifer Protection/Vulnerable Areas, above).

Current land-use status

Perennial vegetation includes a variety of land uses within the Lower Mississippi Basin. Some of the land in perennial vegetation is under commercial use. This includes hay, pasture and public and private harvested forestland. Non-commercial land in perennial vegetative cover includes forest, meadows, wetland complexes or temporarily retired farmland. As of 1997, approximately one-quarter of the land in the Lower Mississippi River basin was in permanent vegetation, according to the NRI. Of these land uses, forest land accounted for the highest percentage of land in the basin (13%), followed by pastureland (8%), Conservation Reserve Program land (4%), and non-cultivated cropland (2%). Not included in this measure of perennial vegetation is a very significant item: hay grown in rotation with a cultivated crop, often in contour strips that provide excellent erosion control.

Land-use trends
Although forested acreage has held roughly constant over the past two decades, local resource managers from county and SWCD offices have noted a disturbing trend over the past several years with regard to permanent vegetation. With more and more mixed crop and livestock farmers leaving farming, land that used to be devoted to hay and pasture now is being used for row-crop production. Even if well managed for erosion control, row-crop land provides inferior runoff controls and habitat benefits compared to the permanent vegetative cover it replaces. Recent NRI data confirm that this trend has been taking place for quite a few years. From 1982 to 1997, acreage in noncultivated cropland and pastureland has declined from 627,700 acres to 447,900 acres, a decline of 28 percent. Acreage in intervening years has varied, reaching 514,000 acres in 1992. Thus, the objective of restoring land use to the 1982 levels for pasture and noncultivated cropland is not as distant as it might at first appear. Pastureland has consistently declined from 1982 through 1997, while noncultivated cropland acreage has varied considerably.

A: Perennial vegetation for harvesting, grazing and other commercial uses.

Objective: Restore area in pasture and noncultivated cropland to 1982 levels (630,000 acres) from current estimates of 448,000 acres.

Approximately eight percent of the land area of the Lower Mississippi River basin consists of pastureland, according to National Resources Inventory (NRI) data for 1997. This is down from 10 percent in 1982. In the intervening period land in pasture decreased by 22 percent, or more than 100,000 acres. Much of the pastureland is not suitable for cropland. Many acres of pasture are on very steep soils, where runoff is rapid and intermittent and perennial streams occupy the swales. Delivery of pollutants from these sites to streams is efficient. In terms of numbers of grazing livestock, six of the top ten counties in Minnesota are located in this basin.

Strategy A1: Maintain and, if possible, increase the production of beef and dairy in the basin by promoting the economic and environmental sustainability of cattle production.

Action 1: Support actions to improve the profitability of beef cattle production. Maintain or increase the use of well-managed cattle grazing on steep slopes and in riparian areas (see “Strategy A3: Pasture Land Conservation Management).

Action 2: Explore ways of working with the Minnesota Department of Agriculture’s “Dairy Initiative” to enhance the economic viability of dairy production in southeastern Minnesota.

Strategy A2: **Hay and Grassland Management Education.**

Action 1: Promote the productive management of hay and pastureland, including soil testing and application of potassium fertilizer where needed (30%

of soil samples indicate potash deficiencies).

Strategy A3: Pasture Land Conservation Management

Proper conservation treatment of eroding pasture lands includes rotational grazing for forage management, as well as management of sensitive areas within the pastures, such as stream corridors, springs, shallow soils, very steep soils, and areas containing woodlands with commercial potential. Installation of facilitating practices, such as fencing and watering systems, is critical to success of the rotational grazing systems. Proper treatment of pasturelands in this basin will increase infiltration of rainfall, reduce soil erosion, reduce nutrient movement to streams, and help to reduce peak flows in streams, as well as improve the stability and health of sensitive areas.

Within the last two years there has been an increased interest by producers to establish rotational grazing systems (Prescribed Grazing Systems). A Section 319 grant to BWSR, titled Grazing Lands Improvement Project, is being implemented. Through this project there will be at least six workshops developed and given to service providers and producers in the topic areas of forage plant identification, planning prescribed grazing systems, and pasture monitoring. In addition, a workshop will be developed to provide information regarding sensitive area management within pastures. The Environmental Quality Incentives Program (EQIP) provides financial incentives and technical support to producers who want to implement prescribed grazing systems. Interest in this program is very high, with demand exceeding technical and financial resources. Approximately 60 prescribed grazing plans have been developed in this basin through this program.

Action 3A1**:** Provide Technical Resources to Producers and Service Providers

Most service providers and producers lack knowledge of the intricacies of planning and monitoring a good prescribed grazing system. This problem will be addressed somewhat by the section 319 grant mentioned above, but this is only a good start. These workshops, to be effective, must be limited to 20 students at one time. This educational process needs to be continued beyond the life of the 319 project. The following tasks will be accomplished within the next two years:

Task 1: Prepare course materials and present the following courses:

- Pasture Forage Plant Identification
- Planning Prescribed Grazing Systems
- Monitoring Prescribed Grazing Systems
- Fencing Systems for Prescribed Grazing Systems (This will require some type of grant for equipment)
- Livestock Watering Systems (This will require some type of grant for equipment)
- Managing Sensitive Areas Within Prescribed Grazing Systems

Task 2: Develop a grazing systems planning guidebook. This is already nearing completion through EQIP grants.

Action 3A2: Study Impacts of Livestock in Riparian Corridors

There is evidence that properly managed grazing in riparian areas can have a positive effect on the streams in southeast Minnesota. It is also understood that if grazing in these areas is not properly managed the results will be a negative impact on the environment. This is a controversial subject and it is contrary to the information published to promote the federal buffers initiative. Because of the sensitive nature of the streams in this basin, this issue needs to be fully discussed and researched soon, to prevent damage to the riparian corridors through well-intentioned actions.

Task 1: Study existing research on the topic of grazing stream corridors, the effects of forested buffers, and on the effects of grassed buffers on stream riparian areas in the driftless regions of Minnesota, Wisconsin, and Iowa.

Task 2: Prepare a document that outlines procedures for evaluating stream corridors to make determinations of the best possible treatment of riparian zones.

Task 3: Prepare a workshop to train service providers how to evaluate riparian areas.

Action 3A3: Provide Incentives to Producers to Apply Facilitating Practices

The only existing cost share program that provides assistance to livestock producers for practices that facilitate rotational grazing systems (fencing, watering systems, heavy use area protection, etc.) is the federal Environmental Quality Incentives Program (EQIP). Other options include modification of the State Cost Share Program, inclusion in legislative initiatives such as HR4013, and programmatic changes such as that sought by the Grazing Lands Conservation Initiative (GLCI).

The GLCI is promoting the inclusion of a line item in the budget for NRCS for the specific purpose of management of grazing lands in the U.S. The budget could be for personnel, cost share dollars, and/or research.

Action 3A4: Program Delivery

Currently there is a staffing shortage in all agencies for the specific purpose of promoting proper grazing lands treatment. With the documented interest by producers, one staff person (most applicably in NRCS) working full time in southeast Minnesota would be able to provide one-on-one technical assistance, prepare technical materials, and provide information through workshops and field days. Development of technical materials would be another important aspect of this position.

Producers who rely upon rotational grazing systems have the option to belong to any of the grazing clubs in the area (approximately 4 clubs exist). In addition serious graziers are already effectively networking with each other on a regular basis in this area of the state. Some of the most knowledgeable graziers in Minnesota are located within this area.

One goal of the current NRCS grazing lands conservationist in Minnesota is to develop a series of courses/workshops that would constitute a grazing school if combined. The option exists to offer a “grazing school” or to offer any one of the courses/workshops, depending upon the requirements of a group of producers or service providers. The following is a listing of courses already developed or to be developed:

- Pasture Forage Plant Identification
- Planning Prescribed Grazing Systems
- Fencing Systems for Prescribed Grazing Systems
- Livestock Watering Systems in the Lower Mississippi River Basin
- Monitoring Pastures in Prescribed Grazing Systems
- Managing Sensitive Areas Within Prescribed Grazing Systems

Strategy A4: Forest Land Management (Adapted from the Whitewater River Watershed Project Plan)

Objective: Make forests a sustainable, renewable resource in the watershed through proper forest planning and management.

Strategy A4-1: Promote appropriate timber harvesting techniques.
Action 1: Promote the use of forester-assisted private timber harvest (currently used on an estimated10-20 percent of private forestland).
Action 2: Create a rating system of basin loggers and disseminate the results to woodland owners. Ratings would be based on BMPs used in timber harvesting already done in the area.
Action 3: Encourage the use of cost share on private timber sales to obtain adequate regeneration, especially of oak.
Action 4: Education wood lot owners on proper timber harvesting techniques.

Strategy A4-2: Develop Forest Stewardship Plans
Encourage forest landowners to develop a forest stewardship plan. These plans should recognize the full range of utility and limitations to forest resources and should match biological diversity with soil type, climate and regeneration rates. Plans also should include disease and pest control measures and means of controlling undesirable species.

Strategy A4-3: Expand Forested Areas.
Work for expansion of forested areas within the basin, in order to utilize the forest's supreme ability to prevent water runoff and erosion.
Action 1: Suggest that woodlands be started where land voluntarily taken out of production has problems with sheet and rill erosion. Examples would be land enrolled in RIM and CRP.
Action 2: Suggest tree plantings for windbreaks, shelterbelts as buffer areas between floodplains and agricultural land, gully heads as well as around springs, sinkholes and headwater areas.
Action 3: Cost share for establishment of forests and for methods of protection from predators of trees.

Strategy A4-4: Improve current timber stands
Action1: Try to improve current timber stand quality from a present state of 73 percent poor, to medium-stocked conditions.
Action 2: Strive to remove cattle from woods where possible

B: Noncommercial Perennial Vegetation

Strategy B1: Protect Existing Natural Vegetation bordering major streams, tributaries, lakes, wetlands or sensitive groundwater recharge areas.

Action 1: Determine priorities for maintaining existing perennial vegetation -- on the basis of the need to protect priority water bodies, improve wildlife conservation potential, etc.

Action 2: Consult landowners concerning their interest in permanent easement programs such as Reinvest in Minnesota. Pursue funding through appropriate agencies and non-government organizations. Support a full-time position within the basin to contact landowners to encourage enrolment in these programs.

Action 3: Consider the development of county land use ordinances that would protect existing areas with natural vegetation. See model ordinance for natural area protection developed by the State Planning Agency. Combine with the purchase and transfer of development rights.

Action 4: Consider the feasibility of property tax reductions or exemptions for permanent conservation easements and shoreland buffers.

Strategy B2: Riparian Buffers
Objective: Increase stream miles of riparian buffers at least 50 feet wide bordering protected waters.

Introduction: Riparian buffer implementation will target protected waters in the basin. In addition, the strategies will allow for counties to accelerate buffer implementation to protect all water resources in the county. It is understood that riparian buffers are to be considered just one of the BMP's necessary to reduce sedimentation and nutrient loading to the water resources. Upland watershed management is encouraged and should include a combination of BMP's in order to reduce soil erosion to tolerable limits, sustain soil productivity, slow runoff, and reduce the need to use riparian buffers as the catch all for sediments and nutrients.

Many counties statewide are implementing buffer initiatives. Information is available on these projects to any counties that are interested.

After reviewing buffer references and discussing implementation with county field office personnel, the team agreed that local buffer initiatives need supplemental establishment of permanent vegetative cover in targeted areas of the basin.

Haying, grazing, buffer width, manageable fields and other issues are generally recognized but are not referenced to program specifics.

The strategy is designed to provide some general guidelines in the form of goals and actions that can be used to implement related water plan activities. References were reviewed to ensure that county priorities were taken into consideration.

Strategy B2a--Information/Education:
Create an awareness among the public of the water quality and other resource benefits of vegetative riparian buffers in rural and urban settings.

Action 1: Develop rural and urban landowner handbooks for county residents that include riparian buffer opportunities/programs.

Action 2: Develop an information media campaign incorporating local and regional media outlets.

Action 3: Work with partners to update fact sheets outlining various types of buffers and their benefits.

Action 4: Encourage non-governmental organizations' participation in the promotion of buffer implementation.

Strategy B2b: Inventory/Mapping: Encourage counties to map and identify areas where perennial vegetation and riparian buffers exist or are needed.

Action 1:Work with counties to obtain appropriate GIS data layers necessary to accomplish buffer needs assessment.

Action 2: Work with universities and research/management agencies to collate and analyze data sets while providing training opportunities for student interns and technicians.

Strategy B2c: Land Treatment/Implementation:

Action 1*:* Seek out funding sources for accelerating one-on-one technical assistance to landowners through local units of governments and nongovernmental organizations.
Action 2: Work with partners to formulate rules/policies to allow hay or grazing under an approved management plan.
Action 3: Pursue avenues of conservation tax credit for landowners who utilize buffers on their land.

Action 4: Extend funding opportunities for enrollment of riparian buffers in programs that afford permanent protection.

Action 5: Seek out sources of additional funding or assistance for counties to provide supplemental incentives for riparian areas not eligible for existing programs. This could address protecting headlands, squaring off fields, crediting existing buffers and being able to enroll whole riparian fields when remaining cropland fragments are unmanageable.

Action 6:Use shoreland zoning regulations as an incentive to accelerate voluntary implementation of riparian buffers.

Strategy B2d: Research/Demonstration/Monitoring:
Action 1: Maintain contact and coordinate with the USGS-led Agroecosystem Team on riparian buffer research. This research proposes to evaluate riparian buffer management in an integrated, watershed scale study that blends three key components: the aquatic system, the terrestrial system, and, equally important, the landowner and the constraints that affect his/her adoption of BMP's.
Action 2: Encourage citizen/partner involvement in water monitoring activities.

Strategy B2e: Develop an evaluation program that updates acreage of permanent vegetative cover and riparian buffers on an annual basis.

Action 1: Review implementation annually utilizing student interns and/or county partners.

Action 2: Complete annual progress report to BALMM with status of implementation of vegetative buffers.

B: Land-Use Strategy 2: Wetland Preservation and Restoration

Lead Author: John Voz, Mower SWCD

Introduction: It is estimated that approximately half of the acreage of pre-settlement wetlands in the Lower Mississippi River Basin (880,000 acres according to CURA estimate) has been drained and developed for economic uses such as farming and urban development. The remaining wetland acres perform valuable functions that need protection – hence the statewide goal of "no net losses of wetlands," which this strategy embraces.

As wetlands have disappeared from the landscape, the quality of adjacent waters has suffered. The ability of wetlands to filter or catch pollutants has provided a strong argument for their protection from being drained or filled. But viewing wetlands strictly as storm water retention areas or watershed kidneys is myopic. The wetland biological communities provide intrinsic values and functions, which are as important as the wetland's function and value within the watershed or ecosystem context. These include:

> Water quality improvement. Wetlands help to remove or retain nutrients, organics and sediment carried by runoff. Many chemicals are tied to sediment and trapped in wetlands. Biological processes convert pollutants into less harmful substances. For example, wetlands can help to denitrify runoff, converting nitrate-nitrogen to nitrogen gas.

> Biological Diversity: Wetland complexes, including surrounding upland acreage, afford suitable habitat for terrestrial and aquatic organisms and birds, in addition to plant species that thrive in wet soils. Wetlands thus form an important part of a landscape mosaic that supports a diversity of life forms.

> Hydrologic stability. Wetlands provide for storage of precipitation and snowmelt on the landscape. Storage helps to retard surface runoff to streams, thereby reducing peak flows and resulting flooding, stream scouring and stream bank erosion. Wetlands also can enhance groundwater recharge.

When a wetland's watershed is altered to accommodate agriculture or urbanization (housing, industry, and retail), its hydrology will be affected. Water level changes in the wetland often also become more frequent and prolonged. This is often referred to as "bounce", which has been documented to:

- Shift plant communities from diverse native species to monocultures of species tolerant of unpredictable hydrologic conditions;
- Contribute to destabilized shoreline conditions favorable to weedy plant species;
- Increase suspended solids and turbidity;
- Alter water chemistry conditions;
- Impact wildlife, including mammals, birds, reptiles and amphibian populations, and
- Simplify the wetland invertebrate community.

Altering the hydrology can also divert surface or groundwater from the wetland. Sometimes referred to as *dewatering,* projects in a wetland's watershed that reroute or redirect water from wetlands pose a serious threat to wetland resources as well.

Not all wetlands are equal in terms of their biodiversity, wildlife habitat and aesthetic values. Likewise, not all wetlands are equal in terms of the water quality benefits they provide. In order to make wise resource management decisions for the individual wetland, and for the surrounding water and land resources, those charged with managing the resources must have the appropriate tools to help gather information that will lead them to the best management decisions for the community. The overall goal of this wetland strategy is to protect the quantity and quality of the wetland resource in the Lower Mississippi River Basin.

Strategy 2A: Improve Wetland Restoration Efforts Basinwide
Encourage high-quality wetland restorations, creations and recover lost wetland integrity.

Action 1: Update the National Wetland Inventory for the Lower Mississippi River Basin. Include updates, digitize maps for Geographic Information Systems, and evaluate status and trends. Suggested priority areas include:

- Rochester and surrounding urban corridor
- The urban fringe and developing areas of Dakota County
- Agriculture areas with inadequate mapping
- Forested areas

Action 2: Develop a comprehensive inventory of cropped, drained and restorable wetland sites. Develop a regional database for the Lower Mississippi River Basin which identifies hydric soils that are cropped. Use database to identify possible wetland restoration sites.

Action 3: Conduct gap analysis at appropriate scale to identify critical discontinuities in wildlife habitat and ecological benefit. Provide this information to local governments.

Action 4: Evaluate restoration efforts and priorities at the watershed scale. Identify and target the restoration of wetlands which, if restored, would provide a high degree of benefit to hydrology, water quality and biological diversity.

Action 5: Based on the above information, and landowner interest, assess the annual need for wetland protection and restoration in the Lower Mississippi River Basin. Evaluate the funding needed to support this degree of protection and restoration. Determine the adequacy of existing funding sources relative to this estimated need.

Action 6: Promote wetland banking within minor watersheds with high development. Explore the possibility of agricultural wetland banking sites strictly to offset agricultural wetland impacts. Explore ways of addressing the problems of cash flow and perceived financial risk that may discourage private landowners from developing wetlands for sale to a regional bank.

Action 7: Streamline and improve programs for permanent conservation easements, such as Reinvest in Minnesota, Wetland Restoration Program, etc.

Action 8: Engage non-government organizations in wetland protection and restoration projects. Consider cities as sources of funding for wetland restoration.

Action 9: Support the development of Wetland Functional Assessments[27] to facilitate better decision-making and protection of wetland functions and values.

- Evaluate and revise the Minnesota Routine Assessment Method for the Lower Mississippi River Basin.
- Train local governmental units to conduct functional assessments as part of local water planning.

Strategy 2B: Support local wetland management and protection efforts.

Action 1: Support the piloting of comprehensive wetland decision making in agricultural regions.

Action 2: Work toward eliminating multi-agency wetland regulation and creating "one stop shopping" at the local level.

Action 3: Review how fines are assessed by county Farm Service Agency offices for Swambuster violations. Consider issuing a range of penalties rather than the current "all or nothing" approach.

Action 4: Support increased local enforcement of the Wetland Conservation Act and local wetland protection ordinances.

Action 5: Draft model language for local plans (e.g., comprehensive zoning) that protects the biological integrity of wetlands, including fringe/buffer areas.

Strategy 2D: Wetland Education and Outreach

Action 1: Provide training workshops on wetland ecology, hydrology, soils, botany, classification, functional assessment and condition assessment

Action 2: Provide wetland "essentials" training for realtors, contractors, developers and other development professionals.

Action 3: Promote local and regional field tours of wetlands for local officials.

Action 4: Find effective ways to communicate wetland benefits, flooding and stormwater processes, alternative runoff management, cumulative impacts of land use decisions and smart growth.

Action 5: Promote interactive wetland educational programs like "WOW" and "Project WET" to provide K-12 students a

[27] Wetland functional assessments evaluate the suitability and quality of the many functions ascribed to a given wetland. The hydrogeomorphic method (HGM) evaluates several attributes, many of them physical factors, for the wetland being assessed and compares them to expectations of similar wetlands in the same geographic and hydrologic class. Regional Guidebooks must first be developed before HGM assessments can be implemented. A guidebook for depressional wetlands in the Prairie Pothole region is under development and could be applied in Minnesota. A second functional assessment method developed for use in Minnesota is the Minnesota Routine Assessment Method (MRAM), developed by the Minnesota Interagency Wetland Group. It is intended as an evaluation tool to document and organize field observations made by trained wetland professionals. MRAM can be applied to essentially any wetland type in the state, since the method does not integrate the various functions into a single value or result the functional evaluation is made for each function on a relative scale. Results are intended to illustrate the consequences of proposed land use actions on individual functions.

personal experience with wetlands. Promote wetland-related activities or studies for school science fairs.

Action 6: Get citizens involved in hands-on monitoring of their communities' wetlands through a program modeled after the Wetlands Health Evaluation Program in Dakota County.

Strategy 2E: Address Wetland Research Needs

Action 1: Research the role of wetlands within systems such as hydrologic systems or ecosystems

Action 2: Improve methods to determine wetland water budgets and groundwater recharge contribution of individual wetland basins or complexes and map important regional recharge zones.

Action 3: Research and develop improved guidance for buffer widths and quality criteria in urban and rural landscapes.

Action 4: Explore the use of created wetlands as treatment systems for excess nutrients, sediment and other pollutants.

Action 5: Research the water quality impacts of different wetland grazing regimes.

Action 6: Research the need for and ecological/ hydrological benefits of eliminating non-functional judicial drainage ditch systems.

Action 7: Evaluate how the property tax system influences local government and landowner decisions about natural resource management, with particular focus on wetlands.

Action 8: Promote and expand the use of remote sensing methods for underground tile lines to develop regional inventories.

C: Land-Use Strategy 3 Row-Crop Land Conservation

Strategy Development Team: Bev Nordby, Mower SWCD, John Moncrief, U of M Extension; Tim Wagar, U of M Extension; Gyles Randall, U of M South-Central Agricultural Experiment Station, Lowell Busman, U of M Extension, Norman Senjem, MPCA

Row-crop production has been the predominant land use in the Lower Mississippi River Basin for many decades. Cultivated cropland currently accounts for approximately 60 percent of total land use (National Resources Inventory, 1997). The steep slopes and erosive soils of the Lower Mississippi Basin, combined with intensive cultivation, create a high potential for soil erosion. High erosion rates can result in reduced soil productivity as well as water quality impairments.
Soil erosion from cropland has been identified as a major source of water quality concerns, such as high turbidity and suspended solids and habitat alteration, in several watershed studies (Whitewater, Garvin Brook, Lake German-Jefferson, etc). Each major tributary to the Mississippi River, and several reaches of the Mississippi River itself, exceed the state standard for turbidity, which usually is a consequence of high rates of soil erosion. These impairments will be addressed through watershed management efforts, including the Total Maximum Daily Load process.

A four-part strategy is recommended to address the problem of soil erosion and sediment pollution[28]:

Strategy 3A: Promote alternative land uses.
On highly erodible land adjacent to streams and lakes, promote alternatives to corn and soybean production to reduce the potential for soil erosion. Alternatives include corn/hay strip cropping on the contour, conservation easements or pasture for highly erodible land, and other ways of increasing the amount of land with perennial vegetation. "Land-use Strategy 1: Maintain/increase Perennial Vegetation" includes details on how this may be accomplished.

Strategy 3B: **Promote the adoption of conservation tillage**.
Conservation tillage has been demonstrated to result in greatly reduced rates of soil erosion and is a key recommended practice for reducing the transport of sediment and associated pollutants to rivers and lakes in agricultural regions of Minnesota. Under many circumstances, conservation tillage can be adopted by farmers without reducing yield or profit. However, University of Minnesota research indicates that over the long run, using conservation tillage to benefit water quality and minimize agronomic risk requires attention to location-specific factors such as soil type, climate, rotation and nutrient management practices.

The objective of this strategy is to develop and publicize guidelines for conservation tillage in the Lower Mississippi River Basin. These guidelines will describe for each major type of tillage system the following

[28] These strategies should be implemented in concert with a broader program of environmental education that clearly identifies the problems being addressed, e.g., loss of soil productivity and degradation of water quality in specific ways.

factors: expected erosion rates, expected agronomic performance, managerial “critical success factors”, effect of soil and climatic factors, and other considerations that will help farmers determine how best to control erosion while maintaining profitability using residue management. Guidelines will be based primarily on land grant university-supervised field research from Minnesota, Wisconsin and Iowa, and will be developed for several key crop rotations: corn-soybeans; corn-corn; and corn-alfalfa. A second objective is to publicize these conservation tillage guidelines through the printing and dissemination of Extension bulletins, workshops, conferences, field days and other appropriate methods.

This strategy, broadly applied, creates a basic level of protection against soil erosion. On moderately sloping fields, crop residue management alone may be enough to keep erosion rates below T. A rotation average of 30% crop residue can reduce soil erosion by up to 65%. However, on steeper slopes, additional practices usually are needed to reduce the potential for erosion, particularly the high rates of erosion that result from extreme weather events. Thus, the widespread adoption of conservation tillage in the Lower Mississippi River Basin is proposed as a basic erosion control strategy that will have to be supplemented with other practices on very erosive fields. The following actions are proposed to support the strategy:
Action 1: Develop conservation tillage guidelines for the Lower Mississippi River Basin

The University of Minnesota, working through the Minnesota Alliance for Conservation and Resource Management, has obtained a Section 319 grant from the MPCA to develop conservation tillage guidelines specific to sub-regions of the basin: the karst/driftless region, and the “loess cap” region to the west. Tim Wagar, John Moncrief, Gyles Randall, Lowell Busman and Norman Senjem are working on this project. The following tasks will be accomplished over the next two years:

- Develop tillage guidelines
- Publish tillage guidelines
- Put guidelines on University’s web page
- Publicize guidelines at basin workshops

Action 2: Track Adoption through annual crop residue transect surveys.

Several counties have measured crop residue adoption through the transect survey in 1998 and 1999 (Dodge, Fillmore, Olmsted, Dakota, Mower, Rice). In 2000, this survey was conducted in all counties. Resulting data can be used to educate the public and to help focus educational and technical assistance where it is most needed.
Action 2a: Annually publish a summary of crop residue cover for the 14 counties in the basin and for each of the major watersheds.
Action 2b: Annually write and distribute a news release announcing the results of the transect survey. Distribute to daily and weekly newspapers and Agri-News.
Action 2c: Use the results of the transect survey to target low-adoption/high-erosion areas for education and demonstration projects.
Action 2d: Explore the use of satellite imagery to produce reliable estimates

of crop residue cover as an alternative to crop residue transect surveys.

Action 3: Develop Educational Campaign to Promote the Adoption of Conservation Tillage

Many state and local agencies have some involvement in researching and promoting conservation tillage: University Extension, NRCS, BWSR, SWCDs as well as county water planners. There is a need to develop a consistent message, and to identify key audiences (key geographic areas; key influencers such as canning company field reps, farm equipment dealers, etc.)

Action 3a: Identify key areas (low adoption/high erosion) for an educational campaign.
Action 3b: Attempt to determine reasons for non-adoption of conservation tillage from farmers, implement dealers, crop consultants, and local resource managers.
Action 3c: Develop educational support materials that address key reasons cited for non-adoption.
Action 3d: Implement educational campaign.
Action 3e: Consider adapting a "No Fall Tillage of Soybean Stubble" campaign patterned after a program used in Winneshiek County, Iowa.

Strategy 3C: Implement practices to achieve soil loss of T or less

Conservation tillage alone is not sufficient to achieve the goal of T on all cropland. Especially on highly erodible land, additional practices such as grassed waterways, buffers, detention ponds, strip cropping in a corn/alfalfa rotation are needed to bring erosion rates to T or less. Sometimes, the best option may be to devote highly erodible land to uses other than row crop farming. The following strategy identifies a concerted approach that local government (SWCDs, counties, Extension) can take to address land with different degrees of erosion potential.

Action 1 – for land eroding at less than 2T: According to 1997 NRI data, more than ninety percent of the land in the basin falls under this category. Although erosion rates are modest, local problems of turbidity can and do result from unchecked erosion.

- Strategy A (above), "Promote the adoption of conservation tillage," is the primary action recommended for land with low to moderate erosion. This practice alone often can bring erosion to T on land eroding at up to 2T. It is a good basic practice that can be widely promoted throughout the basin.

Action 2 (Land eroding at 2T to 4T): According to 1997 NRI data, 154,700 acres of cultivated cropland in the Lower Mississippi River Basin are eroding at a rate of 2T - 4T. This land comprises only 5.5% of the cultivated cropland in the basin, but accounts for 19% of the total soil loss from water erosion from in the region from cultivated cropland.

- Each SWCD in the basin should identify land eroding at 2T-4T. Work with landowners individually and in neighborhood meetings to evaluate a full range of conservation options to keep erosion at or below T. Inform landowners of the basin effort to achieve T by 2010. Aggressively promote practices, such as grassed waterways and buffer strips in addition to conservation tillage on row-crop land.

Action 3 (Land eroding at 4T or more): According to 1997 NRI data, 61,200 acres of cultivated cropland in the Lower Mississippi River Basin are eroding at a rate of 4T or greater. This land comprises only 2.2% of the cultivated cropland in the basin, but accounts for 16% or the total water erosion in the region from cultivated cropland:

- Each SWCD in basin should identify land eroding at 4T or greater. Work directly with landowners to evaluate full range of conservation options to keep erosion at or below T. Inform landowners of the basin effort to achieve T by 2010. Explore ways to substitute hay and pasture for row-crops. Explore permanent easement programs especially in locations with high potential ecological benefits. Target programs such as RIM and CRP. Watch for opportunities that may come from new initiatives to reduce sediment to the Upper Mississippi River.

Action 4: Southeastern Minnesota Structural Repair.
On very steep land, sediment control structures often are needed to prevent recurring ephemeral (gully) erosion. It is estimated that some 2,700 sediment control structures were built between 1970 and 1990 on private lands in the rugged blufflands of southeastern Minnesota. These practices were designed with a life expectancy of up to 35 years. Those completed before 1970 are now approaching their sediment storage capacity or are in need of repair. The Environmental Quality Incentives Program (EQIP) which replaced ACP in 1997 as USDA's conservation cost-share program does not provide for such repaid work.

Action 4a: Structure Inventory – SWCDs should estimate the total number of structures and estimate the sediment-reduction potential from repairing them, and the cost of repairing them to meet technical standards.
Action 4b: Demonstration Program: SWCDs to demonstrate the benefits of structural repair with 4 to 8 examples per county. Seek funding to implement in interested counties.
Action 4c: Funding Sources: Seek funding to restore the soil conservation infrastructure of bluffland counties. Consider opportunities such as sediment-reduction and flood-control watershed projects as well as region-wide funding through Upper Mississippi River Basin initiatives.

Strategy 3D: **Improve Conservation Incentives**

Farmers' choices of resource management practices are affected by economic incentives that arise both from the marketplace and public policies for agriculture. There is a need, firstly, to identify disincentives to the use of best management practices that are embedded in current laws and rules. Secondly, there is a need to determine whether existing conservation programs effectively appeal to the full range of agricultural producers and landowners – from large corporate farms to hobby "farmettes." Thirdly, there is a need to test new forms of incentives besides traditional cost-sharing. Finally, there is a need to provide incentives that produce long-lasting changes in conservation practices, instead of short-lived changes that end as soon as external funding sources cease.

Action 1: Support changes in the Federal Farm Program that would focus on conservation rather than crops

The federal farm program, due for revision in 2002, has a potentially strong influence on farmer's soil management choices. For example, by tying income-support payments to a farmer's production history of corn and soybeans, the farm program creates incentives to continue or increase production of these crops, which tend to cause much higher rates of erosion than is caused by some alternative crops, such as hay. In addition, USDA program rules sometimes discourage rather than encourage conservation practices. As an example, a farmer wishing to replace a filled-in waterway with a wider, improved structure may not be eligible for the Conservation Reserve Program continuous signup incentives because the grassed waterway has no cropping history.

> Action 1a: Support changes that would weaken or remove the bias favoring corn and soybean production over alternative crops in the Federal Farm Bill.
>
> Action 1b: Support the Conservation Security Program being proposed by Senators Tom Harkin (D-IA) and others, which would provide payments to farmers based on conservation, not production.

Action 2: Conservation Compliance: Conduct spot checks on an adequate percentage of farm conservation plans in each county to determine compliance with the federal farm program.

Action 3: Explore the concept of Tax Incentives to bring cropland erosion rates under T.

Research the concept of rewarding landowners with a tax incentive. The SWCD/NRCS office will assist the landowner in developing a conservation plan that would bring their land under the soil loss tolerance level "T". A real estate tax incentive would be available for those with plans and following them.

> Action 3a: Learn from those who have tried property tax incentive programs in Minnesota and Wisconsin. Invite Wisconsin resource managers from St. Croix or Dunn County to explain the Pollution Reduction Incentive Program.
>
> Action 3b: Explore the potential for pilot-testing a property tax incentive program.

Action 4: Develop a strategy to work with large farmers on implementing conservation practices

Economics of scale and pressures to reduce costs are resulting in farms getting larger with farmers and corporations cropping thousands of acres. Although large farmers appear to be adopting beneficial farm management practices such as conservation tillage, structural conservation practices do not appear to be a high priority in many large operations. This may indicate that incentive programs that are effective with traditional-sized farms may not be effective with larger operations.

Action 4a Attempt to develop more effective incentives for motivating large farm operators to adopt conservation practices.

Strategy 3E: **Encourage local governments to revise, upgrade or develop agricultural erosion and sediment control ordinances.**

Winona, Olmsted, Fillmore and Mower Counties all have agricultural erosion ordinances. Encourage other local governments to develop ordinances, while helping counties to update the existing ordinances.

Action 1: Develop a fact sheet describing agricultural erosion and sediment control ordinances – their key provisions, and how they are being used.
Action 2: Conduct workshops and presentations to discuss how ordinances can be used together with incentives and education to foster improved soil conservation practices.
Action 3: Offer interested counties assistance in drafting erosion and sediment-control ordinances using BWSR's model ordinance and the experience of other counties.

Strategy 3F: **Develop a strategy to work with canning companies and farmers on erosion control**.

Canning crops are planted on 90,720 acres in the Lower Mississippi basin. Typically these acres experience extremely high erosion rates because they lack residue cover and have a short growing season.

Action 1: Develop a pilot project to promote temporary cover, increased residue and incorporating a crop rotation that would result in decreased soil erosion rates from canning crop acreage.

Strategy 3G: **Increase the percentage of protected surface tile intakes.**

In some of the western portions of the basin subsurface tile drainage systems make use of surface tile intakes to reduce ponding in depressional areas and accelerate the removal of excess water from the land. Surface tile intakes, if unprotected by risers, rock filters, grass buffers or other methods, can deliver substantial quantities of sediment, nutrients and pesticides to surface water through the tile drainage system.

Action 1: Research the effectiveness of alternative ways of protecting surface tile intakes.
Action 2: Meet with drainage contractors to discuss alternatives to surface tile intakes, such as denser pattern tiling in depressional areas.
Action 3: Promote the protection or elimination of surface tile intakes.

Land-Use Strategy 4: Reduce Impacts from Urban and Residential Land

Strategy Development Team: Dave Morrison, MPCA (Stormwater); Bill Buckley, Mower County (ISTS); Norman Senjem, MPCA (Wastewater Treatment Facilities)

Urban and residential land in southeast Minnesota generates specific kinds of pollution pressures. These pressures are related to surface water runoff from streets as well as industrial and commercial properties, and wastewater discharges from individual residences and communities. The pattern of development (concentrated or dispersed, for example) can affect the impact of new housing, streets and businesses on both hydrology and water quality.

Strategy 4A: **Offset and Reduce Stormwater Runoff**
It is important to minimize runoff volumes for new impervious surfaces and provide for stormwater pollutant treatment from residential, commercial, industrial, and transportation developments. Improperly managed urban stormwater can alter stream characters and geometry, accelerate eutrophication in lakes, bounce or destroy the habitat of wetlands, and change or contaminate ground water resources. The most common urban pollutants include sediment and salts; phosphorus, nitrogen and organic substances; oils and debris; fecal coliform bacteria and pathogens; and heavy metals (Cd, Cr, Pb, Zn, Cu, Hg).

Action 1: Encourage municipalities and local units of government to consider ordinance requirements for Better Site Design (BSD).

Better Site Design promotes more green space and less imperviousness along with natural areas preservation. BSD coupled with appropriate Best Management Practices (BMPs) such as swales and wet detention ponds provide for the least impact to wetlands, lakes and streams. BSDs minimize runoff generation up front instead of trying to retrofit BMP's. Traditional development plans should be revisited at the earliest possible phase in the approval process, particularly with regard to minimizing road lengths, widths, and *cul de sac* designs, decreasing large lot sizes and peak parking lot sizing designs.

Action 2: Encourage all communities to adopt the principles of the EPA Phase II Construction Stormwater requirements.

While only certain communities are required to obtain the Municipal Separate Storm Sewer System (MS4, NPDES) permits, the principal requirements should guide all communities in their development decisions. The six Minimum Control Measures (MCMs) are:

1. Illicit discharge detection and elimination to eliminate oils, toxins and other pollutants from entering stormwater systems.
2. Municipal operations pollution prevention efforts to reduce the impacts of poor operations practices and designs (street sweeping, salt use and storage, debris removal, etc.)
3. Construction site requirements to reduce sediment discharges. One acre or larger sites should

have a plan, a permit, and BMPs.
4. Post construction stormwater BMPs to reduce the amount of pollutants and the physical impact of new development. The BMPs are both structural (ponds, wetlands, devices) and administrative (fertilizer and pesticide control, advanced site design, economic incentives, etc.)
5. Public education and outreach to build community support and improve compliance.
6. Public involvement and participation to broaden support, reduce obstacles, gain expertise and build connections (storm drain stenciling, citizen watch groups, public meetings, etc.)

Action 3: Protect cool water streams.

Communities should require protection of the temperature status of cold- water streams. Practices that promote infiltration and maintain or increase the base flow of streams should be encouraged. Pre-treatment for pollutants may also be required for protection of ground water quality.

Action 4: Encourage all communities to set minimum stormwater standards by policy or ordinance. Some examples might be:

- No new direct discharges without treatment for sediment or other pollutants.
- Maximize ground water recharge. Runoff peaks and volumes controlled to not exceed stream geomorphology limits.
- Special protection for critical areas.

Action 5: Ensure that there are plans for BMP maintenance. Support local, county, and state efforts to enforce the existing ordinances or rules.

Action 6: Support the development of stormwater alternative management or BSD demonstration projects.

Action 7: Protect all wetlands from the detrimental impacts of stormwater by applying Wetland Conservation Act (WCA) requirements for wetland banking credits for stormwater ponds. While avoiding the use of existing or restored wetlands for stormwater treatment is not always feasible, this would limit damage to wetland types within the Lower Mississippi River basin.

Strategy 4B: **Increase percentage of population with properly functioning individual sewage treatment systems.**

In many counties, it is estimated that more than half of individual, on-site sewage treatment systems do not meet state standards. From these residences, and from unsewered communities, untreated human sewage is contaminating surface and groundwater with bacteria, nutrients, and other pollutants.
A number of options should be investigated as actions for meeting the goal of reducing the number of failing sewage treatment systems. One or all of the above actions could be utilized. Some, such as financial incentives, can be used in combination with others. Low-interest loans or partial grants (cost share) can be used with enforcement strategies, upgrades at the point of sale or upgrades with building permits, etc. Any one of these actions would take many years to accomplish

the goal, but together the time would be shortened considerably. Enforcement action may seem to accomplish the objective in the shortest period of time, but the political and financial objections may make it difficult to accomplish. Combining enforcement with upgrades at point of sale and building permits, in combination with loans or grants, would be preferred if state or local funding were available. This strategy would also require a minimal number of county staff, since the required compliance inspections could be performed by inspectors in the private sector and the number of systems going in would be spread over several years and would be less likely to over-burden the local inspection staff.

Action 1: Education. Educate the public in the areas of:

1. Public health as it can be affected by inadequately treated wastewater and by discharges of raw sewage.
2. State and county Individual Sewage Treatment System (ISTS) rules and regulations and the importance of proper siting, construction and maintenance.
3. Water quality and the impacts of improperly treated wastewater discharges on nutrient loads and fecal coliform bacteria concentrations.

Action 2: Local Ordinances. Amend local ordinances to include inspection and correction of failing ISTS at property transfer, building permit issuance, etc.

Action 3: Enforcement Programs
The following enforcement activities are recommended:

Action 3a: Implement pro-active enforcement actions where properties are evaluated for proper wastewater treatment. County staff or contract personnel would conduct evaluations and compliance inspections of properties served by ISTS.

Action 3b: Conduct inspections, targeting imminent health threats (IHT) or discharges for enforcement and correction.

Action 3c: Send letters of violation (notice of violation-NOV) giving required deadline for correction

Action 3d: Enforce Minnesota Rules ch. 7080 and county ordinance upon receipt of complaint of failing system or IHT.

Action 4: Financial Assistance

Action 4a: Make state and local funds available for systems installation at a reduced interest rate with no financial qualification. County can assist by collecting payments with property tax over 5-10 per period.

Action 4b: Consider establishing county or multi-county revolving loan fund for the Lower Mississippi Basin.

Strategy 4C: **Increase the percentage of population with phosphorus removal from wastewater treatment facilities upstream of affected waters** (including Lakes Zumbro, Byllesby, and Pepin)

The vast majority of towns and cities in the basin treat their wastewater for a wide range of pollutants as required in the National Pollutant Discharge Elimination System program, administered by the MPCA and the Environmental Protection Agency. However, in several watersheds there is a need to enhance wastewater treatment to remove phosphorus in order to protect downstream lakes. The cities of Rochester and Pine Island have been providing phosphorus treatment to 1 part per million for years, because of their impact on algae growth in Lake Zumbro. Phosphorus discharges from other towns has a less direct, cumulative impact on algae growth in impaired downstream lakes including Zumbro, Byllesby and Pepin. In accordance with the MPCA's phosphorus strategy, these cities' permits will be reviewed to determine the need for phosphorus removal at their next permit reissuance.

Action 1: Create Point Source Phosphorus Inventories
Develop inventories of point source phosphorus from wastewater treatment facilities in the following watersheds: Vermillion River; Cannon River; and Zumbro River. Where a publicly owned treatment facility (POTW) provides treatment for industries, include industrial phosphorus concentrations and loads in the inventory along with POTW concentrations and loads. Include the point source inventories as part of a whole watershed point-nonpoint source phosphorus budget.

Action 2: TMDL Process
Use phosphorus inventory data to develop waste load allocations in the Total Maximum Daily Load (TMDL) process if and when affected water bodies are put on the Section 303(d) list of impaired waters for which TMDLs are required.

Action 3: Conduct Phosphorus Management Planning
Work with the Minnesota Technical Assistance Program (MnTAP), POTWs and significant industrial contributors to identify economical ways of reducing industrial phosphorus contributions to POTWs. Develop a plan for reducing such contributions that can be included in the next NPDES permit as a Phosphorus Management Plan, as called for in MPCA's phosphorus strategy for point sources.

Action 4: Review Need for Phosphorus Treatment
At permit reissuance, conduct a review to determine the need for phosphorus controls at the POTW.

Action 5: Watershed Management Context
Conduct the above activities in the context of a comprehensive watershed assessment and management process that includes point and nonpoint sources of phosphorus and other pollutants. Include all sources and stakeholders in discussions to determine an appropriate mix of actions that will result in achieving water quality objectives in a manner consistent with economic and social needs and constraints of the community.

Strategy 4D:**Manage Urban and Residential Growth to Protect Water Resources**.
Water is a crucial resource in every community, from drinking water to maintenance of wastewater systems to providing for recreation opportunities and economic growth. The Communities in the Lower Mississippi River/Cedar River Basin are growing rapidly and therefore face the constant need to manage growth while protecting its surface water and ground water resources.

Action 1: Use Minnesota Planning's model for sustainable development as a guide to help coordinate the exchange of information among businesses, local government, and special interest groups within the basin. To accomplish this, co-sponsor a series of seminars and otherwise distribute information on the following topics:

a. How to get citizens involved in land-use decisions
b. Defining urban growth boundaries
c. Defining agriculture and natural resource protection districts
d. Defining a conservation subdivision district
e. Infrastructure planning
f. Regulatory tools and case studies:
    - Transfer and purchase of development rights
    - Orderly annexation agreements
    - Land-use law
    - Financial incentives, grants, and government programs
    - Legislation
    - Ordinance

Land-Use Strategy 5: Nutrient & Pesticide Management

Strategy Development Team: Joe Zachmann, MDA (lead author); Jeff King, Dodge County NRCS; Tim Wagar, U of M Extension; Derek Fisher, BWSR/Extension Conservation Agronomist; Tony Hill, Olmsted County; Norman Senjem, MPCA

The goal of crop nutrient management and the development of nutrient management plans is to increase the efficiency of all nutrient sources used by crops while managing production risks and environmental impact. Managing nutrients to increase crop use efficiency results in maximizing producer returns on economic investment while protecting and conserving natural resources, including surface and ground waters. Proper management of pesticides (herbicides, insecticides and fungicides) should produce the same results. At a different but still significant scale, proper management of nutrients and pesticides on lawns, turf and parkland is also necessary to achieve environmental protection goals within a watershed.

The following strategies are designed to encourage demonstrated principles in nutrient and pesticide management within the Lower Mississippi River Basin in Minnesota. They are primarily intended to help protect public and private drinking water supplies from nitrate nitrogen and pesticide contamination and to support surface water quality objectives such as phosphorus reduction to address lake and river eutrophication. In addition to contributing to local and regional objectives, the strategies should contribute to reducing the nutrient loadings from the Upper Mississippi River that have been related to the problem of hypoxia in the Gulf of Mexico.

The strategies are consistent with a variety of Best Management Practices and the Nitrogen Fertilizer Management Plan (NFMP) developed in response to the 1989 Comprehensive Groundwater Protection Act. The NFMP includes voluntary and possible regulatory components in order to prevent, evaluate and mitigate nonpoint source occurrences of nitrogen fertilizer in waters of the state. Best Management Practices for various nutrients and pesticides have been developed and are being adopted and evaluated in various geographic settings.

The strategies also include anticipated voluntary and regulatory guidelines established by revisions to and implementation of the state's feedlot rules. Certain types of feedlots and feedlot management systems are considered primary sources of phosphorus contamination to surface waters, as well as sources of nitrogen and fecal coliform contamination. Feedlot rules address manure management and field application practices so that such practices minimize associated nutrient environmental impacts. Separate objectives on feedlots and related phosphorus and land use issues appear elsewhere in this basin plan.

Strategy 5A: Improve efficiency and reduce environmental impacts of nutrients applied to agricultural crops.

Strategy 5A1: Reduce and eventually eliminate fall application of commercial nitrogen fertilizer in the karst region of southeastern Minnesota as recommended in Best Management Practices for Nitrogen Use in Southeastern Minnesota AG-FO-6126-B (1993).

Action 1: Commercial sector (Co-ops, dealers, crop advisors/managers) – Determine level of non-conformance, reasons for non-conformance, identify solutions, decide on implementation timeline.

Action 2: Farmers – Educate farmers on economics of proper timing (spring vs. fall) of nitrogen application as well as environmental consequences and the Groundwater Protection Act.

- News releases, fact sheets.
- Establish network of on-farm demonstrations exhibiting economic and environmental benefits of spring application
- Letters from MDA and/or extension agents.
- Extension workshops.

Action 3: Explore the feasibility of offering BMP insurance products designed to eliminate producer risk in adopting BMPs.

> Action 3a: Establish an exploratory committee to determine how best to develop such products and establish a pilot project within the basin.

Strategy 5A2: Work with producers to capture the maximum possible nutrient contributions from field-applied manure through proper testing, timing and incorporation as recommended in Best Management Practices for Nitrogen Use in Southeastern Minnesota AG-FO-6126-B (1993) and Manure Management in Minnesota AG-FO-3553-C (1990), and in keeping with relevant requirements in proposed revisions to MPCA feedlot rules.

Action 1: Encourage producer and dealer utilization of the Minnesota Department of Agriculture Manure Testing Laboratory Certification Program (a required element of nutrient management plans developed with NRCS EQIP funds and required under permits issued under the state feedlot rule revisions).

Action 2: Promote use of manure testing results by producers, private and commercial applicators, commercial fertilizer dealers, crop consultants, etc., to properly credit manure contribution to field nitrogen and phosphorus budgets.

Action 3: Work with U of M Extension to educate producers and dealers on proper manure application timing and placement relative to season and tillage methods. With respect to application methods, explore the following:

> Action 3a: Assess and develop equipment options/recommendations for even distribution of applied manure (including recommendations from U of M Ag Engineering faculty and from industry).
> Action 3b: Educate producers/applicators on the results of the assessment.
> Action 3c: Explore incentives for producers/applicators to upgrade to recommended options.

Action 4: Address producer "disposal" of excess manure on owned land by exploring exchanges or trades with neighboring farms.

Action 5: Explore opportunities/options for manure utilization cropland set-aside program focusing on the exclusive use of manure for crop nutrients.

- Designated areas would have an established cover crop.
- Up to two years of manure could be applied on the set-aside followed by rotation.
- Variances of existing rules would be required to allow, with minimal soil disturbance, the injection or incorporation of manure into cover crops.

Strategy 5A3: Work with producers to properly credit previous-year legume contributions to field nitrogen budgets.

Action 1: Work with U of M Extension to develop targeted educational programs on proper crediting of previous-year legume crediting.

Action 1a: Educate producers to curb application of manure to acres coming out of alfalfa production.

Strategy 5A4: General education: Promote application of commercial fertilizer (N and P) at University of Minnesota recommended rates.

Action 1: Work with the commercial sector (soil test labs) and the MDA soil test laboratory certification program to:

Action 1a: Conduct blind soil tests. Send soil from same sample to several labs. Compare recommendations to U of M recommendations.

- Discuss reasons for differences, etc.
- Report results to the Minnesota Department of Agriculture.
- Explore perceived "loopholes" in reporting/dissemination of U of M fertilizer recommendations directly to producers under MDA laboratory certification programs (e.g., fertilizer dealers often collect and submit for analyses soil samples, with results and U of M recommendations reported to the dealer rather than the producer).

Action 2: Work with the commercial sector (co-operatives, dealerships) to develop mutual understanding of voluntary vs. regulatory mandate of the 1989 Comprehensive Ground Water Protection Act and encourage support of University of Minnesota recommended fertilizer rates and BMPs.

- Potash and Phosphate Institute (PPI).
- Minnesota Crop Production Retailers.

Action 3: Work with farmers and producers to demonstrate that adoption of BMPs and recommended fertilizer rates is environmentally effective and profitable.

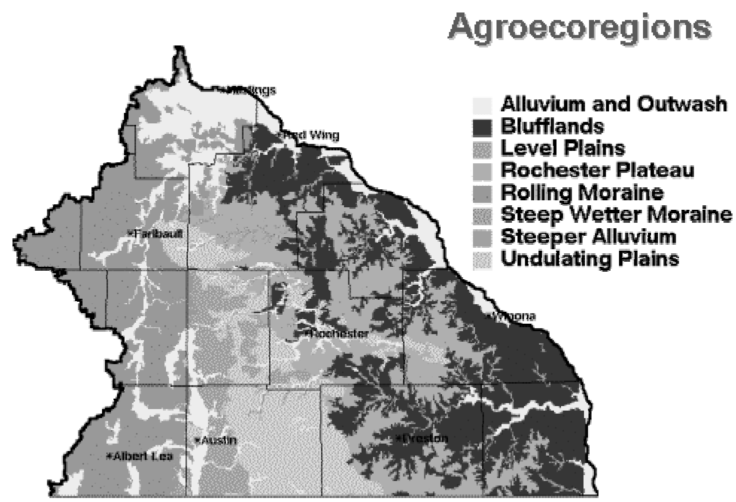
- Education at field days (Waseca; Red Top Farms Demonstration Plots, St. Peter; other).

Action 4: Work with the University of Minnesota & the Minnesota Department of Agriculture to develop appropriate grant proposals and on-farm crop nutrient management demonstration protocols.

Action 4a: Conduct field-scale demonstration plots as recently proposed in U of M Rapid Response Fund and Legislative Commission on Minnesota Resources proposals.
Action 4b: Education – Extension, especially as regards manure management.
Action 4c: Seek grant-supported or volunteer on-farm demonstration plots on a variety of farms using BMP and fertilizer protocols established by the University of Minnesota, Minnesota Department of Agriculture, Natural Resource Conservation Service, Soil & Water Conservation Districts, etc.

Action 5: Support and promote the writing of nutrient management plans as called for in state and federal feedlot program rules.

Action 5a: Determine appropriate roles for NRCS, SWCDs, Extension and Private Consultants and Farmers in developing and implementing nutrient management plans required by state and federal programs.
Action 5b: Promote Nutrient Management Plan development using software recommended by entities such as NRCS, MES, MDA, etc. such that plans are consistent and adaptive to the principal agroecoregions within the basin. [Each agroecoregion contains unique physiographic factors that influence the potential for production of non-point source pollution and the potential for adoption of farm management practices]. The graphic below illustrates the diversity of agroecoregions within the basin.



Action 5c: Consider the use of program incentives and requirements to encourage farmers to develop, implement and update nutrient management plans.
Action 5d: Encourage and assist individuals from the private sector to become authorized third-party vendors for nutrient management plan development and implementation.
Action 5e: Consider developing quality assurance protocol for review of Nutrient Management Plans to effectively develop educational efforts and program focus.

Strategy 5B: Community/watershed projects

Action 1: Identify high-priority areas where high nutrient levels in surface or ground waters are a concern (wellhead protection area, lakes, etc.) that may be attributable to agricultural or urban nutrient use.

Action 2: Coordinate with the MDA to conduct Farm Nutrient Management Assessment Process projects as part of community efforts to better understand nutrient management in the Basin.

Action 3: Coordinate with the U of M Extension Service Master Gardener Program to develop educational and outreach projects that address proper timing and rates of lawn and turf fertilization.

Action 4: Review Olmsted County Hydrologic Unit Area project as a model for working with crop producers in a priority area to promote adoption of Best Management Practices.

Strategy 5C: Reduce surface runoff and leaching of fertilizers, nutrients and pesticides from urban lawns, golf courses, parks, and other vegetative surfaces.

Action 1: Promote the sale and use of phosphorus-free lawn fertilizers.

Action 2: Encourage periodic soil testing before lawn fertilizers are applied.

Action 3: Develop and distribute educational material on regional lawn care BMPs, including promotion of recommended timing and application rates for lawn fertilizers and pesticides.

Action 4: Develop educational material on the proper disposal options and cleanup methods for pet waste.

Action 5: Increase the use of native and low-maintenance landscapes in urban areas through demonstrations and educational material. Promote recommended management practices and guidelines for natural landscaping and reduced-chemical turf, lawn and garden care.

Action 6: Assist urban communities in developing and implementing comprehensive stormwater management plans. (see urban stormwater Strategy 7A)

Action 7: Encourage urban communities to implement stormwater management “housekeeping BMPs” (see urban stormwater Strategy 7A) and to consider developing ordinances regarding use of pesticides near waterways, and signage requirements for lawns treated with pesticides and fertilizers.

Action 8: Conduct stormwater management and erosion control workshops for local staff, builders, developers and the general public. (see to urban stormwater Strategy 7A)

Action 9: Increase the use of Integrated Pest Management (IPM) through the development and distribution of educational materials, demonstrations and workshops for homeowners and lawn care managers.

Action 10: Promote use of pesticide BMPs and evaluate adoption. The MDA, U of M and NRCS have created pesticide BMPs addressing handling, use, timing, selection, spills, mixing, loading and the management of waste.

Local units of government can work with NRCS and SWCD staff to develop and provide cost-sharing for Integrated Pest Management Plans, and Weed and Pest Management Plans for crop producers within the basin.

Action 11: Promote the use of computer software to assist in making pesticide use decisions. The NRCS has developed the "Windows Pesticide Screening Tool" (WinPST), which the Minnesota-based non-profit Institute for Agriculture and Trade Policy has incorporated into a "Pesticide Decision Tool" (PDT). Together, WinPST and PDT provide a user-friendly method of evaluating pesticide use, fate and transport along with environmental and human health impacts.

Action 12: Consider surveying agricultural chemical facilities and applicators working within or providing services to the basin to determine information needs. Based on the results of the survey, target educational efforts. Local units of government can team up with MDA staff to assist agricultural chemical facilities and applicators operating within or supplying services to the basin in obtaining the appropriate information for proper licensing and certification.

Action 13: Actively assist local units of government and the MDA in establishing waste pesticide collection programs for facilities, applicators and households within the basin.

Action 14: Coordinate with the MDA, MPCA, NRCS, SWCD and BWSR to maximize county understanding and use of grant and loan programs for BMPs, education and outreach, infrastructure improvements to farmsteads to reduce nonpoint source pollution, conservation reserve and easement programs, and other incentives available to improve water resources within the basin through land use management, improvements or changes.

Land-Use Strategy 6: Animal Feedlot Management

Strategy Development Team: Norman Senjem, MPCA (lead author); Dave Wall, MPCA; Ron Leaf, MPCA; Jerry Hildebrandt, MPCA; Chuck Peterson, MPCA; Jeff King, Dodge County NRCS; Joe Zachmann, MDA; Tim Wagar, U of M Extension; Derek Fisher, BWSR/Extension Conservation Agronomist

Livestock agriculture is vital to the economic and environmental health of the Lower Mississippi River Basin. Besides adding diversity to farm income, cattle production in particular also adds diversity to the landscape in the form of hay and pasture acreage used as a feed source. This adds to the amount of land in permanent vegetative cover, thereby increasing infiltration and reducing runoff and soil erosion. Thus, maintaining a healthy beef and dairy sector is a prerequisite to achieving a priority environmental goal in the basin. Land-use Strategy 1 (Maintain/increase Acreage of Permanent Vegetation) deals explicitly with this issue.

At the same time, livestock manure is a major potential source of pollution from nitrogen, phosphorus, fecal coliform bacteria and oxygen-demanding substances. Feedlots and manure application need to be carefully managed to minimize adverse effects. All feedlots have been required to obtain a permit from the MPCA or county when there is a change of ownership, expansion, construction activities, or a pollution problem. Often this is done with the involvement of county feedlot officers. Most counties in the Lower Mississippi River Basin are active partners with the MPCA in administering this program. Recent revisions to the feedlot rules (Minnesota Rules chapter 7020) provide new opportunities for the MPCA and counties to ensure that all feedlot operators (above 50 animal units) become registered or permitted.

The following recommendations are designed to

- Accelerate bringing feedlots into compliance with state and local requirements, particularly those that are known to be causing pollution, and that are located in high-priority areas;
- Provide greater assurance that feedlots which are already permitted are being managed according to the terms of their permits and all applicable feedlot rules;
- Provide greater assurance that feedlots that do not need permits under the new rules (most feedlots less than 300 animal units and many feedlots between 300 and 1000 animal units) are being managed in accordance with the feedlot rules;

Strategy 6A: Comprehensive Feedlot Registration/Permitting
The revised state feedlot rule distinguishes between producers in different size categories. Those in the largest size category (greater than 1,000 animal units) are required to obtain an operating permit. Construction permits are required for new or expanding feedlots with 300 to 1000 animal units; and interim permits are required for feedlots of less than 1,000 animal units that pose a pollution

hazard. In addition to these permitting provisions, the new rules call for all feedlots of 50 animal units or more (10 or more in shoreland areas) to become registered, and to re-register every four years. All producers – even those that do not have a permit -- are subject to compliance with technical standards in the feedlot rule that deal with feedlot runoff water quality, location restrictions, liquid and solid manure storage and land application of manure.

Action 1: Encourage all counties in the lower Mississippi River Basin to become delegated to administer the state feedlot permitting program.

Action 2: Ensure that all producers are registered or permitted, as required. This will develop a base level of information to determine the level of need for corrective actions and manure management planning. Ensure that registration information is periodically updated.

Strategy 6B: Promote Open Lot Agreement (Extended Compliance Option)

The new rules feature a new choice for producers with fewer than 300 animal units: the extended compliance option. Producers who register by no later than Jan. 1, 2002, and later become certified for the Open Lot Agreement, will be given until 2010 to come into full compliance with feedlot runoff requirements in Minnesota Rules ch. 7050.

Producers will have until October 2005 to implement cost-effective measures designed to reduce feedlot runoff by 50 percent or more, until October 2010 to come into full compliance with feedlot runoff requirements. This option thus offers a gradual, flexible approach for small and medium-sized producers for whom cost of compliance is of critical importance. Producers in this size range who fail to become certified for extended compliance, and whose feedlots pose a pollution hazard, will be required to obtain an interim permit and come into full compliance by Jan. 1, 2002.

Action 1: Write and distribute a fact sheet that describes the extended compliance option in the revised feedlot rules. Include examples of low-cost methods of achieving runoff reductions of 50 percent or more. Describe what is meant by a 50 percent reduction compared to full compliance with feedlot runoff requirements.

Action 2: Local units of government take the lead in notifying all eligible producers in their county about the extended compliance option, possibly with the assistance of trained retired farmers or agriculturists.

Action 3: Write a news release describing the extended compliance option that can be localized by counties to distribute before producers are individually notified.

Action 4: Local units of government (with assistance from trained retired farmers or agriculturists) conduct follow-up visits in high-priority areas to encourage producers to enroll in extended compliance option.

- Priority 1 Areas: Feedlots located on a stream or lake, or within a wellhead protection zone or sensitive groundwater recharge area.
- Priority 2 Areas: Feedlots within 1000 feet of a stream or lake.

Action 5: Assist producers who enroll in the extended compliance option to identify and implement low-cost measures that can reduce runoff by 50 percent or more. Determine whether federal and state funding sources may be used for such measures. Identify and try to resolve any conflicts in funding guidelines.

Strategy 6C: **Determine priority feedlots for inspection, assistance and enforcement.**

Focusing inspection, assistance and enforcement on priority feedlots will help to ensure that the worst problems are addressed first, and that increased feedlot-related efforts will lead to water quality improvements.

Action 1:Identify key watersheds, wellhead protection zones and groundwater recharge areas to concentrate efforts and monitoring for effectiveness. Identify these as priority areas for feedlot inventory development, permitting, inspection, technical and financial assistance, and enforcement activities.

- BALMM should publish an annually updated list of priority areas.

Action 2: Prioritize feedlots for inspection, assistance and enforcement activities. Include a provision in county delegation agreements to sort feedlots into three priority areas based on feedlot registration information.

Priority Area 1: Feedlots located on a stream or lake, or within a wellhead protection zone or sensitive groundwater recharge area.
Priority Area 2: Feedlots within 1000 feet of a stream or lake.
Priority Area 3: Feedlots more than 1,000 feet from a stream or lake.

Action 3: Large Feedlots (300 to 1000 animal units): Prioritize inspection, assistance and enforcement activities according to feedlot size, pollution hazard and priority area.

Action 4: Identify and coordinate funding sources for fixing feedlot pollution hazards in priority areas through watershed management or wellhead protection projects.

Action 5: In highest priority areas, consider using the self-audit process to identify and correct problems with feedlots, as well as with septic systems and other potential environmental hazards.

- Work with county feedlot officers to develop list of priority areas;
- Provide a specified time period (say two years) for producers to address problems identified in the self-audit.
- Help local government to secure funding to correct problems identified in the permitting/self-audit process.
- Coordinate nutrient management planning with the self-audit process, working with local NRCS, SWCD and Extension.
- After the specified time period, use inspection and enforcement activities to bring non-cooperating producers into compliance with Minnesota Rules 7020.
- Track progress on reduction of pollutants including phosphorus.

Strategy 6D: Manure Management Plans (see also Nutrient Management Strategy #5a)

Ensure that those feedlot operators with more than 300 animal units are either certified or have a completed manure management plan by 2005, in accordance with all rules and state laws. Also, make sure that all feedlots with more than 100 animal units are keeping manure application records and encourage all farmers in sensitive areas to develop and use manure management plans.

Action 1: Clearly inform producers of state and local requirements and expectations related to manure management planning, record keeping and other practices associated with manure application.

Action 2: Promote the benefits of using manure management planning and record keeping

Action 3: Prioritize manure application record checks/audits in sensitive areas, including those areas along streams, in wellhead protection areas, etc.

Action 4: Further details on manure management are included in the nutrient management strategy (#6a) of the basin plan.

Strategy 6E: **Research and Demonstration**

Action 1: Explore the possibility of establishing on-farm demonstrations of anaerobic digestion, composting and other heat-generating processes that destroy pathogens in manure. Also, consider demonstrating liquid/solid separation with an aerobic digestion system.

Action 2: Conduct research to better understand the transport of fecal coliform bacteria from livestock manure to ground water and surface water in the karst region under a range of land application and incorporation methods.

Action 3: Develop a method of estimating nutrient runoff from feedlots using the Feedlot Evaluation Model on a representative sample of feedlots in a watershed and extrapolating results to all feedlots in the watershed.

Action 4: Support the development of revised state feedlot rules that would allow feedlot compliance to be determined on the basis of a whole-farm or a watershed assessment rather than only on the basis of individual feedlots and manure application. This would allow consideration to be given to environmental benefits associated with well-managed hay and pasture production that support livestock operations.

Action 5: Financial Needs Analysis:

- Action 5a: Evaluate the aggregate private cost of complying with key provisions of the new feedlot rule, including achieving 50 percent or greater runoff reduction under the extended compliance option, and addressing pollution hazards on feedlots from 300 to 1,000 animal units. Include the need for technical assistance in the cost estimate.
- Action 5b: Evaluate the adequacy of existing funding sources and levels relative to this aggregate need; and
- Action 5c: Explore how to better coordinate federal and state funding sources available to feedlot operators.

Land-Use Strategy 7: Aggregate Mining

Strategy Development Team: Bea Hoffmann, SE Minnesota Water Resources Board; Jeff Green, DNR; Norman Senjem, MPCA; Wendy Turri, MPCA

The purpose of this strategy is to help ensure that aggregate mining activities are conducted in a manner that minimizes potential impacts on ground water and surface water quality and air quality while maintaining local supplies at reasonable cost.

The continuing economic expansion of the past several years has greatly increased the demand for aggregate and gravel for use in new transportation and construction projects in Minnesota. The demand for sand and gravel has increased by 50 percent since the mid-1980s, and rapidly increasing demand in the Twin Cities Metro area may trigger more mining activity in southeastern Minnesota. Firms that operate mines want to maintain local availability at reasonable cost without undue impacts (noise, dust, traffic, water drawdowns, etc.) on local citizens. Quarrying above the water table poses risks mainly through fractures to groundwater combined with hazardous wastes and leaks and spills. Quarrying below the water table poses additional risks from surface water runoff, connections to groundwater conduits, well interference, spring impacts, flooding of quarries and sinkhole development.

Current state and local permitting processes are designed to prevent or minimize water pollution. Better coordination among state and local agencies is needed to ensure that this outcome is achieved on a regular basis. Mining operations are permitted for air and water pollutant discharges as well as water withdrawals. Mines with no water discharge are regulated by general permits, and those that require de-watering are regulated by individual permits from the MPCA. Hazardous waste permits are required if a shop is located at the mine. The DNR permits mines for water withdrawals. There is a need for counties, the PCA and DNR to share information to ensure that all working quarries are properly permitted. Reclamation is primarily a county responsibility. Several counties have expressed interest in developing and sharing guidelines for reclamation.

Strategy 7A: Develop inventories of limestone quarries and aggregate sites

Action 1: County inventories: list all known mines, noting those that are actively being quarried. Obtain lists of MN DOT aggregate sources to help track sites.
Action 2**:** Locate quarries on GIS maps and share this information among local and state agencies.

Action 3: Encourage the DNR to accelerate the pace of mapping of county aggregate sources.

Strategy 7B: Improve coordination between local conditional use permitting, MPCA water quality permitting, and DNR water appropriation permitting activities.

Action 1: Educate zoning administrators, commissioners, township officers and government staff about potential water quality problems created by aggregate mining operations, requirements for conducting Environmental Assessment Worksheets on proposed mining operations, and state agency permitting requirements.

Action 2: Establish a work group to coordinate permitting processes at the local and state levels.

> Action 2a: Develop mechanism for incorporating into local conditional use permits for aggregate mining explicit requirements for water quality permits from the MPCA (National Pollutant Discharge Elimination System permit for process water discharge; storm water permit; and hazardous waste permit).
> Action 2b: Develop mechanism to improve coordination between MPCA and DNR permitting of aggregate mines.
> Action 2c: Develop a mechanism for local units of government to notify MPCA and DNR of all active mining operations to ensure they have needed permits.

Strategy 7C: Ensure that proposed new aggregate mining operations obtain appropriate environmental review

Action 1: Educate local elected officials and appropriate staff about requirements for conducting an Environmental Assessment Worksheet in relation to proposed aggregate mining operations.
Action 2: Ensure that water quality concerns are adequately addressed in the EAWs.

Strategy 7D: Devote more attention to inspection and enforcement of permitted aggregate mining facilities.

Action 1: Educate local elected officials and appropriate staff about requirements for operating aggregate mines and encourage them to report to MPCA and DNR apparent violations of permit conditions and the use of closed mines for illegal dumping.
Action 2: Encourage local units of government to give notice every 5 years for permit updates.
Action 3: Provide information to counties on process to apply a per ton quarry tax that could fund inspection and enforcement of permit conditions and other costs to the county associated with quarry operations.

Strategy 7E: Develop guidelines for Best Management Practices for quarries, including definitions and BMP's for dry and wet quarries, active and inactive quarries, and proper closure requirements. Provide a checklist for counties to use when issuing conditional use permits.

Strategy 7F: Develop a demonstration site in the basin showing proper closure of a quarry or aggregate site.

Strategy 7G: Conduct investigations to determine if the MN DOT requirement for use of higher quality aggregate may direct quarrying to areas where operations disturb the vegetative buffer at the St. Peter/Decorah edge and to determine any other long-term environmental impacts of this requirement.

VIII: Monitoring and Evaluation

Lead Authors: Bill Thompson and Greg Johnson, MPCA

Purpose: Evaluate changes in water quality in the Lower Mississippi River Basin by establishing long term monitoring networks for physical, chemical, and biological variables and using trend analyses to determine the effectiveness of watershed management efforts.

Background:

The primary purpose of the basin plan is to improve and protect the water quality of the Lower Mississippi River Basin and its associated lakes, streams, wetlands and ground water. Water quality is defined here in a more comprehensive fashion. This definition includes physical, chemical, and biological aspects together. For example, physical water quality variables include water flow and sediment dynamics. Water resource integrity includes flow, chemistry, biology, energy, and habitat components. With this in mind, it is important to provide for adequate evaluation and assessment of water quality data to document changes over time. Over the past 60 years, water monitoring has been done by different groups and individuals for different reasons. Monitoring by the MPCA has historically focused on ambient monitoring of physical and chemical constituents in water. Other agencies such as MDNR or USGS have conducted water monitoring (fish and flow, for example) to meet their program objectives. However, we now know that additional information needs to be developed in conjuction with the historical-ongoing data sets, to better evaluate whether change in water quality is occurring as the basin plan and associated implementation efforts are completed. There are six major areas of need that will be addressed by this strategy, with the focus primarily on the surface water quality of streams and rivers. Additional strategies to utilize groundwater information, and provide linkages to both surface water and drinking water issues, need to be developed.

1. **Pollutant Loads**. First, there is a need to measure and document the loads of various pollutants at selected sites where continuous stage (water discharge or flow) is measured. The foundation for this work will involve the establishment (or continuation) of long-term physical and chemical monitoring sites at strategic locations throughout the Lower Mississippi River Basin.

2. **Biological Monitoring**. The second area of need is the development of a comprehensive biological monitoring component in the basin. Much work has been done in recent years in the development of tools for measuring and characterizing the health of our water resources by assessing the actual biotic communities present in streams and rivers. To date, most of this work has been done on the stream segment scale, with some work at the watershed scale.

3. **Correlate land use and water quality**. Monitoring and assessment of both land and water variables need to be conducted at multiple scales (basin, major watershed,

minor watershed, stream segment). Volunteer stream monitoring conducted in conjuction with land use monitoring such as crop residue transect surveys should be conducted at the minor watershed scale to enable the data to be correlated in space and time.

4. **Physical condition monitoring**. Since water quality is the integration of chemical, biological, and physical variables, it is critical to assess the physical condition of streams. This involves classifying stream reaches according to key channel dimension measurements and size of drainage area. This can help us to better understand stream stability, which relates to important issues such as streambank erosion rates. A stream classification system can help to define variables such as stream width, stream depth, and discharge - all related to drainage area. Sediment dynamics are also critical to understanding stream physical conditions. Incorporating stream physical data with other stream data sets will be an important step for comprehensive stream system evaluation in the future.

5. **Best-Attainable Stream Conditions**. While making progress on the first four items above, it will also be necessary to identify “best-attainable” stream conditions in the basin. This has also been called “reference” or “least-impacted” stream conditions. To accomplish this, data on land use/management will need to be assessed along with water quality data by stream reach. All sites and conditions will need to be scaled by drainage area, and categorized by stream type and classifications.

6. **Ground Water Monitoring**: Interactions between ground water and surface water quality merit investigation particularly in karst topography. Fate and transport of fecal coliform bacteria and nitrate nitrogen are of particular interest. In the Cedar River Basin, samples should be collected from the upper portion of the Upper Carbonate bedrock units to determine if confining layers are present, and what impact these confining layers have on water quality. A better understanding of the hydrogeologic system is required in this basin before specific recommendations can be made for long-term monitoring. In the Lower Mississippi River Basin proper, continued mapping of drift thickness and hydrogeologic sensitivity to contamination provides information useful for wellhead protection and aquifer management. A long-term monitoring network for nitrate and possibly pesticides should be established in vulnerable aquifers. Because ground water quality is affected by individual hydrologic events, monitoring must incorporate temporal variations.

The long-term physical and chemical monitoring network will best be accomplished through formation of a <u>multi-agency monitoring task force</u>. The task force could operate under the auspices of the Water Resources Center at Winona State University. This task force would provide data inputs from various monitoring sites for use in basin evaluation. It would also provide some oversight and coordination of the monitoring programs for maximum benefit to the system. Monitoring sites will include mainstem Mississippi River sites and major watershed river sites near their confluence with the Mississippi River. Several state and federal agencies and local groups are currently conducting monitoring within the Mississippi River Basin. These groups would be invited to participate in the task force.

Table of Agencies/Groups Involved in Water Monitoring - LMB

Agency / Group	Monitoring Sites/Activities
Metropolitan Council Environmental Services (MCES)	Vermillion and Cannon Rivers
Minnesota Department of Agriculture (MDA)	Middle Branch/Whitewater Cascade Creek
The U.S. Geological Survey Army Corps of Engineers	Long-Term Resource Monitoring Program sites at the mouths of major tributaries and at several locations on the main stem Mississippi.
The Minnesota Department of Natural Resources (Fisheries)	Fishery surveys and fish population assessments
MDNR's Water Division	Stream flow monitoring and physical stream assessments for selected rivers.
Wisconsin DNR	Mississippi River – fishery, mussels, wildlife and water quality information
Watershed Projects	Shorter-term monitoring of land and water
Local monitoring	County, school, citizen and smaller-scale efforts

To be successful, we must combine and utilize monitoring efforts conducted at different scales and organized by different groups. Funding limitations require that greater coordination occur among all groups involved.

Since pollution's ultimate effect or end-point is a biological response, it is important to understand some of the new tools for biological stream monitoring. One of these tools is a multi-metric macroinvertebrate index specific to the Lower Mississippi River Basin. This is being developed now by staff at WSU, and will complement MDNR's ongoing fishery surveys.

Much of this trend work will focus on the mainstem and major tributaries of the Mississippi River; however, sites will also be located on the smaller tributaries in the basin. MPCA staff will also be conducting biological monitoring of streams in the Lower Mississippi Basin within the next 5 years.

Citizen stream monitoring is another new tool for assessment and improvement of stream resources. A volunteer stream monitoring program was initiated by the MPCA in 1998. The Citizen Stream-Monitoring Program (CSMP) was developed following discussions with the volunteer monitoring community in the state. It uses a collaborative approach to stream monitoring by partnering with citizen volunteers who live on or near a stream and who monitor its water quality on a regular basis. There are currently about 50 CSMP volunteers enrolled to monitor streams and rivers in the Mississippi River Basin. Benefits of volunteer monitoring include a cost-effective way to augment existing water quality databases (sometimes for locations where there is no other data available), increased awareness of water-quality issues, and an enhanced sense of stewardship.

Overall Tasks:

1. Develop and implement a basin monitoring strategy.
2. Map all existing monitoring sites in the basin using Geographic Information System. Define the scale of all monitoring efforts by understanding drainage area and stream size parameters.
3. Develop a “data dictionary” for the basin modeled after the Whitewater Watershed Project’s data dictionary.
4. Use existing databases to assess water quality trends wherever possible. Support positive trends and seek to reverse or reduce adverse trends.
5. Monitor the addition or removal of Mississippi River Basin waters from the 303(d) list of impaired water bodies. [Significant additions of waters to the list would be a possible indication that inadequate or ineffective programs exist for those listings.]

<u>Physical and Chemical Monitoring</u>:

1. Develop a monitoring plan that will provide for the establishment of a long-term physical, chemical, and hydrological monitoring network that will provide statistically valid estimates of flow-weighted mean concentrations and mass loads of pollutants for use in assessing long-term water quality trends.
2. Create a multi-agency task force operating through the Water Resources Center at Winona State University, to coordinate the development and implementation of the long-term physical, chemical, biological and hydrological monitoring network.
3. Estimate costs and pursue the funding necessary to implement the monitoring plan. Try to redirect departmental program funds to support long-term monitoring. Funds would likely be needed for monitoring site equipment, staff, water sample analyses, and contract support services.
4. Implement the monitoring plan as funding and various agencies’ capabilities allow.
5. Adjust current efforts, if needed, to meet the needs of temporal or spatial trend analysis.

Biological Monitoring:

1. Develop a macroinvertebrate multimetric index for the Mississippi River basin. This would be similar in process to the warm-water and coldwater IBIs (index of biotic integrity) for fish.
2. Develop a monitoring plan that will provide for the establishment of a long-term biological monitoring network for use in assessing water quality trends.
3. Implement the biological monitoring plan as funding and capabilities allow.
4. Incorporate monitoring of additional sites for use in problem investigation and/or effectiveness monitoring. Efforts will be made to partner with watershed or stream restoration projects currently underway.
5. Develop a habitat index for the basin and relate results of habitat assessment to overall biological integrity.

Citizen Stream-Monitoring Program:

1. Promote and expand the CSMP to enhance volunteer stream monitoring at the basin, major watershed, and minor watershed scale.
2. Support other volunteer monitoring efforts in the basin by providing technical support.
3. Assist schools and other orgainzations to monitor a selected stream for multiple years. Provide methods and suggestions to these critical groups.
4. Develop news articles, TV news stories, etc., with selected citizen volunteers.
5. Hold a CSMP meeting every two years at various sites in the basin.

Combined Objectives:

1. Generate and publish regular reports documenting annual monitoring results and long-term trends as a means of establishing a baseline for assessing trends and, then, following through with the evaluations as time goes by.
   a) Collect, pedigree, and consolidate data from relevant sources:
      i) Lower Mississippi River Basin Long-Term Monitoring Network
         (a) Metropolitan Council Environmental Services
         (b) Minnesota Department of Agriculture
         (c) U.S. Geological Survey/ U.S. Army Corps of Engineers "Long-Term Resource Monitoring Program"
         (d) U.S. Fish & Wildlife Service
         (e) Minnesota Department of Natural Resources
         (f) Wisconsin Department of Natural Resources
         (g) Minnesota Pollution Control Agency
      ii) Current Clean Water Partnership projects
      iii) County monitoring projects
      iv) MPCA Biological Monitoring Program
      v) Citizen Stream Monitoring Program
      vi) MPCA Milestone Monitoring Program
      vii) Stream Channel Assessments
      viii) TMDL monitoring and assessment.

ix) USDA's National Resource Inventory (NRI)
x) Crop Residue Survey Data (by county, major watershed)
xi) Ground water data from public water suppliers, monitoring networks, and regional labs

b) Summarize findings in regular reports and present them to the Basin Alliance for the Lower Mississippi in Minnesota; Southeast Minnesota Water Resources Board; Whitewater Watershed Project; South Branch Root River Watershed Project; Wells Creek Watershed; Cannon River Watershed Joint Powers Board; Vermillion River Watershed Management Organization, similar watershed projects and Comprehensive Local Water Planning and SWCD committees.

Milestones:

1. Complete and begin implementing the Mississippi River Basin monitoring strategy by 2002.
2. Complete and begin implementing the long-term physical, chemical, and hydrological monitoring plan for the basin.
   a) Create a multi-agency task force – July 2001.
   b) Select monitoring sites for long-term physical, chemical, and hydrological monitoring network – July 2001;
   c) Formulate an analytical methodology – August 2001.
   d) Estimate costs and secure funding.
      i) Equipment, and/or contract, analytical and staff costs – August 2001.
      ii) Secure funding for costs – February 2001.
   e) Purchase and install additional equipment, as needed – Fall 2002 or Spring 2003.
   f) Operate monitoring sites – continuing for existing sites, begin new sites – Spring 2003.

3. Complete and begin implementing the long-term biological monitoring plan for the basin by the year 2005.
   a) Develop a macroinvertebrate biological index for the Lower Mississippi River Basin.
   b) Develop a fish based biological index for cold- and warm-water streams.
   c) Select and monitor sites that will be used in this plan.
   d) Summarize and interpret data, and communicate results to provide local, state, and federal resource managers the information needed in determining whether or not biological designated uses of rivers and streams are being met.
   e) Increase the number of CSMP volunteers in the Mississippi River Basin to 100 by December 2001
   f) Write the first report on the "State of the Lower Mississippi River Basin" report by Spring 2003.

IX: Future Directions

The completion of this Lower Mississippi River Basin Plan Scoping Document marks the first milestone in the basin planning process undertaken by BALMM starting in the autumn of 1999. This document identifies environmental goals and strategies for achieving them. Yet to be determined is the order in which the strategies should be implemented, the roles that local, state and federal agencies and non-government organizations should play in implementing them, and how best to coordinate their activities across the basin. This will involve widening the circle of discussion to include those who stand to be affected, for better or worse, by the implementation of the strategies. This list of "stakeholders" who have a "stake" in the subject in question will be different for each strategy, and will range from private land-owners and businesses to cities, sportsman and environmentalist organizations, and government entities which have not yet participated in the development of strategies. As the circle of discussion widens, it can be expected that strategies will be adjusted to take into account new information and concerns.

At the state planning level, discussions led by the Environmental Quality Board relative to the governor's Water Unification Initiative will proceed with the involvement of basin teams across the state. It is not yet clear what direction these discussions will take, but some refinement in environmental objectives and indicators may be expected along with the development of strategies for achieving them. Ideas or policies that result from this Initiative will be considered for inclusion in a final Lower Mississippi River Basin Plan, currently scheduled to be published in the summer of 2003.

At the same time, basin planning will proceed at a finer level of detail with the preparation of a Lower Mississippi River Basin Information Document by the MPCA. This document will organize data on water quality, pollutant sources and related topics by major watershed. This will set the stage for major watershed assessments, where relationships between water quality and land uses are further clarified. Information organized by major watershed should help to support work in subwatersheds, too.

The importance of these documents should not be over-emphasized, however. In the end, the working relationships and communication established through planning are often just as important, or even more important, than planning documents. Implementation of strategies through coordinated efforts need not be delayed until a final basin plan is prepared. Indeed, implementation of several began even before the draft plan was completed. In the spirit of "adaptive management," in which goals and strategies are adjusted and refined to reflect new knowledge gained through implementation, the Scoping Document and Basin Plan can be viewed as describing stages in a continuing process of implementation and planning that no document should attempt to finalize.

BALMM Members

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Support and production of this brochure provided by

Minnesota Pollution Control Agency

Reprinted April 2002

Printed on recycled paper with minimum 20% post-consumer waste.