MINNESOTA

watermarks

gauging the flow of progress 2000 – 2010

ENVIRONMENTAL QUALITY BOARD

Minnesota Watermarks: Gauging the Flow of Progress 2000 – 2010 was produced by the EQB Water Resources Committee with assistance from the Water Management Unification Task Force, the basin teams and many others. It was prepared by committee director Marilyn Lundberg at Minnesota Planning. *Minnesota Watermarks* was approved by the Environmental Quality Board at its September 2000 meeting and fulfills the requirement in Minnesota Statutes 103B.151 for a 10-year Minnesota water plan.

The report is the culmination of an 18-month interagency process to set a new direction for water management in Minnesota. Organizations participating include: the Board of Water and Soil Resources; the Metropolitan Council; the Minnesota departments of Agriculture, Health and Natural Resources; the Minnesota Geological Survey; Minnesota Planning; the Minnesota Rivers Council; the Pollution Control Agency; the River Defense Network; the U.S. Department of Agriculture Natural Resources Conservation Service; the U.S. Geological Survey and the University of Minnesota Water Resources Center. The Office of Dispute Resolution provided facilitation. The seven newly formed Basin Teams involved numerous other organizations and citizens. The cost to design and print this report was $8,000.

Upon request, *Minnesota Watermarks* will be made available in an alternative format, such as Braille, large print or audio tape. For TTY, contact Minnesota Relay Service at 800-627-3529 and ask for Minnesota Planning.

Minnesota Planning is a state agency charged with developing a long-range plan for the state, stimulating public participation in Minnesota's future and coordinating activities with state agencies, the Legislature and other units of government.

The Environmental Quality Board, staffed by Minnesota Planning, draws together five citizens and the heads of 10 state agencies that play a vital role in Minnesota's environment and development. The board develops policy, creates long-range plans and reviews proposed projects that would significantly influence Minnesota's environment.

Additional copies of this report are available on the Internet (www.mnplan.state.mn.us) or by contacting Minnesota Planning.

September 2000

MINNESOTA PLANNING ENVIRONMENTAL QUALITY BOARD

Room 300
658 Cedar Street
St. Paul, MN 55155
www.mnplan.state.mn.us
651-296-3985

MINNESOTA

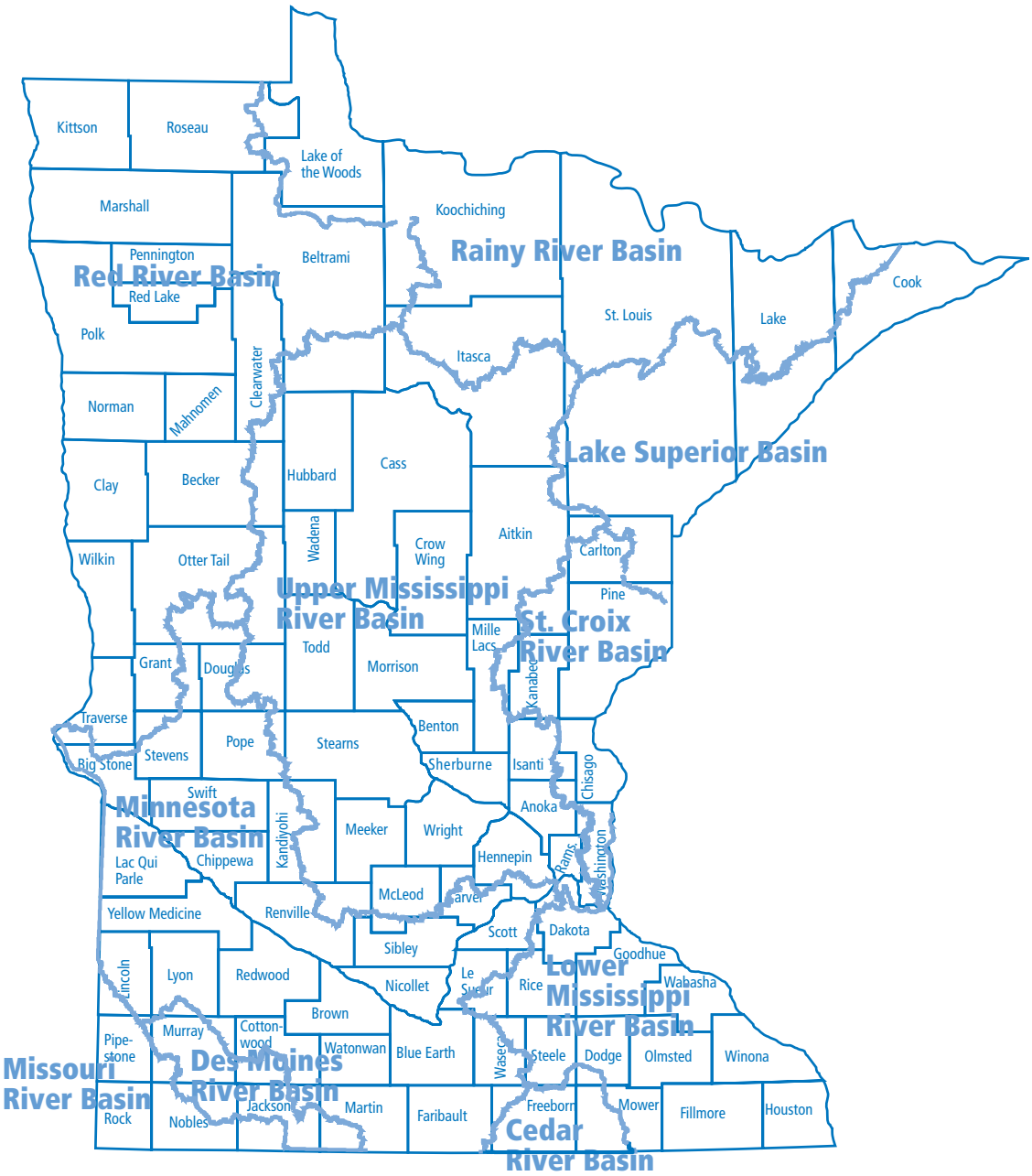
watermarks

gauging the flow of progress 2000 – 2010

WATER BASINS KEY FEATURE OF *MINNESOTA WATERMARKS*

The land in Minnesota drains into 10 major river basins. Water from these basins flows in three directions: the Red and Rainy flow north; the Lake Superior Basin flows east; the remaining basins flow south.

To develop the 10-year water plan, interagency basin teams led public information efforts and developed basin reports. For planning purposes several water basins were combined. The Minnesota, Des Moines and Missouri River Basins in the southwestern part of the state were grouped and the Lower Mississippi and Cedar River Basins in southeastern Minnesota were also grouped.



Summary

Coming out of Governor Jesse Ventura's Water Management Unification Initiative, *Minnesota Watermarks: Gauging the Flow of Progress 2000-2010* heralds the start of a 10-year process toward unifying water management in Minnesota. It contains four statewide goals, nine objectives and 10 indicators to help measure results. As part of this process, teams were established to determine specific goals and objectives for Minnesota's major water basins and to identify common concerns. The results of these team efforts are included in this report.

The statewide goals are to improve water quality, conserve the diverse characteristics of Minnesota's waters, restore and maintain healthy aquatic ecosystems, and provide diverse recreational opportunities. Most of the statewide indicators integrate a variety of water-related measurements.

Trends show status of water resources

Overall, Minnesota's water resources are in good shape. More than 65 percent of assessed streams and lakes meet water quality standards and criteria. Only 5,000 of the 92,000 stream miles and 2,500 of the 12,000 lakes are assessed, however. Significant reductions in serious water pollutants — biochemical oxygen demand, phosphorus, ammonia and fecal coliform bacteria — have been reported in state streams. But nitrogen pollution levels are increasing, and suspended solids remain a problem.

Monitoring shows pollutants such as nitrate are seeping into groundwater throughout the state, with high levels in many places. While groundwater quality trend information is lacking, work is underway to set up sampling networks that will be used to assess trends. Levels of Atrazine, a common pesticide, are declining in wells monitored over time in central Minnesota but remain about the same in the southeast.

Water levels in lakes, streams and aquifers vary considerably across the state and change with natural conditions and pressures of human activity. Water levels in streams and wells reflect periodic drought and flood conditions. Levels were generally high throughout the 1990s, with most stream flows above normal and catastrophic flooding occurring in some places. Water use for many purposes increases during drought conditions, which could occur at any time. Groundwater use is growing. Changes in use need to be monitored, because groundwater levels affect surface waters.

Water resources are a key factor in ecosystem health. While measuring levels of a specific toxic compound indirectly reflects problems, new measures that combine information to create an index identifying the number of species of fish or plants present, their pollution tolerance and their health will directly show how environmental conditions are altered. Such indices already exist or are being developed throughout the state. Threats to Minnesota's ecosystems from the introduction of exotic species are increasing. While prohibited exotic species have not been detected in 10 of Minnesota's 81 major watersheds, several species, such as purple loosestrife and Eurasian water milfoil, are spreading.

People have more opportunities to use lakes and streams as the number of public access sites and fishing piers has increased. The quality of water recreation depends on access as well as many other factors. Satisfaction of recreational experiences will be measured in the future by periodic surveys.

Seven basins identify specific goals and objectives

Minnesota Watermarks looks specifically at seven water basins: Lake Superior; Minnesota, Missouri and Des Moines Rivers; Rainy River; Red River; Upper Mississippi River; Lower Mississippi and Cedar Rivers; and St. Croix River. Based on the reports of each basin team, these sections describe the basin and the status of planning efforts, highlight basin goals and objectives, condition and pressure indicators, point out particular issues of concern and discuss next steps. Three basins also have targets for specific indicators.

Some basins have had notable population changes, while most have areas that are growing rapidly. Trout streams abound in some basins, deep clear lakes in others and important shallow lakes in still others. Some areas are susceptible to water erosion, others to wind and some to both. Land uses vary throughout the state, with some basins high in forest lands and others high in urban areas or cropland. Exotic species affecting one basin may not yet be a problem in another.

While the differences are notable, many conditions and problems cut across several basins:

- **Local planning and funding.** Strengthening local planning and ensuring adequate financial resources for local water management were key issues in most basins.
- **Land use.** Land use and its relationship to the condition and quality of lakes, streams and groundwater was of interest in every basin.
- **Prevention.** Most basin teams noted the high quality of water resources and the importance of keeping these resources in top condition.
- **Education and stewardship.** Water resources are greatly affected by the actions of individuals who sometimes unknowingly pollute.
- **Climate effects.** Recognizing that all aspects of the environment are interrelated, all of the basin teams noted that weather and climate change must be considered in planning for Minnesota's water resources.

■ **Coordination**. A continuing, cooperative effort is needed because several groups and units of government have an interest in water or are charged with managing them.

During the next decade, the state government will continue to work with federal and local governments, as well other groups, to unify efforts, focus on major water basins and measure results. The framework detailed in *Minnesota Watermarks* is a starting point for the efforts that will be needed to protect Minnesota's prized water resources.

Goal: Minnesotans will improve the quality of water resources.

OBJECTIVE A.
Protect and improve water quality in rivers, streams and other water courses.

Indicator 1. Percentage of stream miles assessed that meet water quality standards and criteria.

OBJECTIVE B.
Protect and improve lake water quality.

Indicator 2. Percentage of lake acres assessed that meet water quality standards and criteria.

OBJECTIVE C.
Protect and improve groundwater quality.

Indicator 3. Percentage of drinking water wells sampled that meet nitrate standards.

Goal: Minnesotans will conserve water supplies and maintain the diverse characteristics of water resources to give future generations a healthy environment and a strong economy.

OBJECTIVE D.
Maintain groundwater levels to sustain surface water bodies and provide water supplies for human development.

Indicator 4. Water levels in wells in relation to precipitation.

OBJECTIVE E.
Maintain the hydrologic characteristics of surface water bodies that support beneficial uses.

Indicator 5. Annual stream flow in relation to precipitation.

Indicator 6. Lake levels in relation to the 10-year average.

Goal: Minnesotans will restore and maintain healthy aquatic ecosystems that support diverse plants and wildlife.

OBJECTIVE F.
Ensure that aquatic environments have conditions suitable for the maintenance of healthy self-sustaining communities of plants and animals.

Indicator 7. Index of biotic integrity for lakes, rivers and wetlands.

OBJECTIVE G.
Limit geographic range of exotic species.

Indicator 8. Number of major watersheds with specific quantities of prohibited exotic species.

Goal: Minnesotans will have reasonable and diverse opportunities to enjoy the state's water resources.

OBJECTIVE H.
Provide access to water-based recreation sites.

Indicator 9. Number of public access sites on lakes, rivers and streams.

OBJECTIVE I.
Improve or maintain the quality of water recreation.

Indicator 10. Survey of degree of satisfaction with water-related outdoor experiences.

Introduction

"I am concerned about growth in the area and an increase in the use of water resources," said Daniel Kalmon at a public meeting on the St. Croix Basin. "It is good to be able to participate as a citizen and to comment on what is happening."

To paraphrase a famous state resource on radio: Minnesota — where the rivers are strong, the lakes are good-looking, and the fishing is above average.

When the average American hears the word *Minnesota*, chances are good that the first image that comes to his or her mind is water. Home to the headwaters of the nation's largest river and big, clear lakes teeming with fish, Minnesota is a water mecca. Minnesotans, as well as tens of thousands of visitors who account for the state's $9 billion tourism economy, count on clean, clear water for drinking, cooking, bathing and recreation.

Minnesota Watermarks: Gauging the Flow of Progress 2000-2010 outlines the state's plan to protect and conserve Minnesota's water. It heralds the start of a 10-year process to unify efforts and measure results. The legislatively mandated plan is a major component of Governor Jesse Ventura's Water Management Unification Initiative. The Governor's executive order establishing the initiative includes:

- Focusing on major water basins, such as the Mississippi, Minnesota and Red Rivers, to recognize the differences in water resources and management choices throughout the state
- Unifying water management through interagency teams in each basin that will work with local entities and the public
- Measuring results by developing and tracking indicators of progress toward a statewide framework of goals and objectives adapted to each basin

The Environmental Quality Board Water Resources Committee and a Water Unification Task Force provided leadership for the two-year process leading to this report. Seven interagency teams of state and federal staff were organized in Minnesota's major water basins to unify efforts and gather public input in their region. While the state has 10 major water basins, three on the southern border drain relatively small areas in Minnesota and were added to adjacent basins for planning purposes. The basins encompassed in this plan are: Lake Superior; Lower Mississippi and Cedar Rivers; Minnesota, Missouri and Des Moines Rivers; Rainy River; Red River; St. Croix; and Upper Mississippi River. Because four basins affect the Twin Cities region and the area contains large numbers of people and water-related groups, a Metro Committee was formed to gather input from this area.

To focus public discussions, the committee and task force in 1999 produced *Preparing for Water Plan 2000: A Public Review Draft,* which contained four goals, 10 objectives and 29 indicators to measure results. In September 1999, the committee, task force and teams first met to discuss the Governor's water initiative, the 10-year water plan and assignments. Working with governmental entities, water interests and the public through February 2000, this group gathered feedback on four questions:

- Did the goals and objectives address water needs? If not, what would?
- Did the 29 indicators measure progress? If not, what would?
- What indicators of human behaviors or pressures that pose a risk to water resources should be tracked?
- For each indicator, what should the target be for 2010?

Minnesota Watermarks is built on the task force and basin teams reports and contains two major sections. The first focuses on four statewide goals, nine objectives and 10 indicators designed to show trends. The indicators generally consolidate a number of individual measures that reflect the resource condition. For example, the water quality indicators show whether Minnesota water bodies are meeting standards, which consist of numerous specific components. The second section summarizes each of the seven basin reports, highlighting the similarities and unique character and priorities of each basin. The complete report of each basin team is available separately as an appendix and on the Minnesota Planning web site at www.mnplan.state.mn.us.

Another water policy report is due to the Minnesota Legislature in September 2002. Between now and then, the committee, task force and basin teams will continue to work together to decide key strategies and related responsibilities, track progress toward the goals and objectives, set 10-year targets and evaluate whether existing actions and programs are meeting needs. The basin teams recommended taking a wide variety of measurements and will need to continue to define the feasibility of these and set priorities for tracking.

An emerging issue in water quality is the presence of pharmaceutical compounds and endocrine-disrupting chemicals in water supplies. Excreted substances such as chemotherapy drugs, antibiotics, analgesics, cholesterol-lowering drugs, caffeine and other pharmaceutical compounds are showing up in treated municipal wastewater, septic tanks and other effluent sources. Most such compounds are not covered by drinking water standards, which leaves the possibility of trace amounts of these substances appearing in tap water.

Common goals and objectives designed to unify efforts

Common goals and objectives will help unify water planning and management across the state. The following four goals, nine objectives and 10 indicators reflect extensive feedback from basin teams and others. They serve as the foundation for state, federal and local plans and management efforts, and provide direction for basin and local plans.

When reviewing indicators for each objective, it is important to recognize that water resource conditions often change slowly. Many trends that the teams and other respondents indicated would be valuable to track cannot yet be measured adequately. For example, information about the complex groundwater flow and its interaction with surface water is inadequate to answer today's questions. Water use from some groundwater sources may not be sustainable for the long term, and little groundwater quality trend information exists. Toxic substances, including pharmaceuticals used by people and animals as well as compounds that disrupt the endocrine system, are among the pollutants found in water for which additional tracking is desirable. The statewide indicators often reflect data that exists or may be developed during the next decade, rather than the best information that explains water conditions. Monitoring that is done to assess the impacts of a particular activity may be used here to try to describe trends.

Goal: Minnesotans will improve the quality of water resources.

Since Minnesota's waters flow to three major North American drainage basins, the state has a key responsibility to protect water resources. Clean and clear water, however, is too easily taken for granted. Changing land uses, increased industrial activity and an ever-expanding population create the need for constant vigilance in protecting the state's waters. Pollutants are threatening lakes, streams and groundwater. While all water resources are interconnected, the following objectives give special consideration to streams, lakes and groundwater.

More than 190 Minnesota communities ranging in size from 50 to 200 people have no central wastewater treatment system.

OBJECTIVE A. Protect and improve water quality in rivers, streams and other water courses.

Water quality in rivers and other water courses, such as storm water and agricultural drainage systems, is threatened by a variety of sources. Nutrients, solids, bacteria and other common pollutants can harm the health of humans and animals and cause aesthetic problems, inhibiting the recreational use and enjoyment of streams, rivers and other water courses.

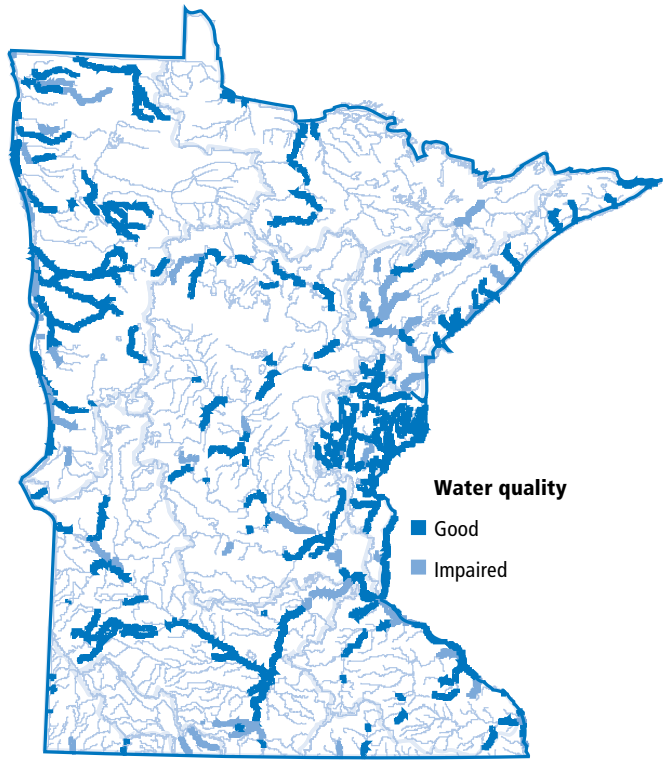
Indicator 1. Percentage of stream miles assessed that meet water quality standards and criteria.

Fit for swimming	68%
Fit for aquatic life	65%

In 1998 a majority of stream miles met standards but about a third did not.
Source: Pollution Control Agency

To protect the state's waters for a variety of uses, the Pollution Control Agency sets standards and criteria for streams. Stream criteria are based on a combination of aquatic life and swimming use-support standards. Assessments of aquatic life use-support are conducted to determine if the waters are of a quality that supports the aquatic life that would be found in the stream under the most natural conditions. Limits are established for specific pollutants that would impair certain uses, along with minimum acceptable levels of health for the aquatic communities in the waters. Specific pollutants or factors that contribute to pollution include biochemical oxygen demand, ammonia, nitrogen, phosphorus and suspended solids. Assessments of swimming use-support are conducted to determine if the waters are of a quality that supports primary body contact. Quality is determined

Two thirds of monitored streams sustain aquatic life



Source: Pollution Control Agency

based on in-stream monitoring of fecal coliform bacteria. The percentage of stream miles that meet these standards and criteria provides a direct measure of the condition of Minnesota's waters.

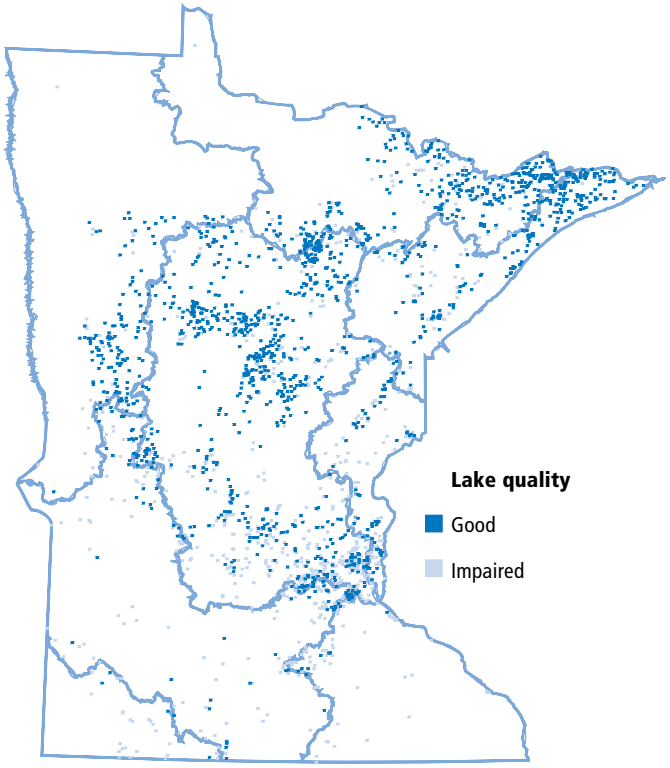
Of about 92,000 stream miles in the state, however, fewer than 5,000 are assessed. Therefore, percentages may not reflect the unassessed stream miles. Data for this indicator is collected by the Pollution Control Agency. Because monitoring methods and standards have evolved, trend information does not exist but should be available in the future.

Urban land use and human population density influence fish community composition and water quality in Twin Cities metropolitan area streams. The U.S. Geological Survey found that a high percentage of impervious surfaces in a watershed contributes to increased concentrations of chemicals and nutrients in the stream's water as the result of runoff. Such increases are correlated to decreased fish species diversity.

OBJECTIVE B. Protect and improve lake water quality.

Generally, the clearer the water of a lake, the more suitable it is for recreation. The more a lake is polluted by such nutrients as phosphorus or solids in the form of soil from erosion, the more algae will grow in the lake and the dirtier the water will be. High levels of algae or solids decrease transparency; some natural materials such as tannic acid from bogs and calcium carbonate precipitates may discolor water or reduce transparency as well. Shoreland development, urban and agricultural runoff, reduction in near-shore aquatic vegetation and increased recreational use put pressure on lakes.

Different conditions contribute to lake quality



Source: Pollution Control Agency

Indicator 2. Percentage of lake acres assessed that meet water quality standards and criteria.

Fit for swimming	65%

In 1998 the majority of lake acres had good water quality.

Source: Pollution Control Agency

This indicator focuses specifically on criteria to assess the ability of Minnesota lakes to support recreation and aesthetic enjoyment. Unlike streams, swimming criteria in lakes is based on trophic state, which is determined by measurements of Secchi transparency, chlorophyll-a and phosphorus.

Minnesota's ecoregions, based on soils, landform and other factors, provide a good basis for evaluating what the lake condition should be. For example, there are different expectations for lakes in the northern forests than in the western plains.

Data for this indicator is collected by the Pollution Control Agency. Of the 12,000 lakes of more than 10 acres, fewer than 2,500 are assessed. Therefore, percentages may not reflect the unassessed lakes. Trend information currently does not exist but should be available in the future.

OBJECTIVE C. Protect and improve groundwater quality.

Groundwater is the source of drinking water for more than 75 percent of Minnesotans and 98 percent of the state's nearly 1,000 community water systems. Ground and surface water are interconnected. Activities that discharge potential pollutants on the land or affect surface water also will affect groundwater quality. Identifying trends in groundwater quality is difficult due to the typically long response times of aquifers to changes in activities at the land surface. No single data set exists to track trends in groundwater quality.

Indicator 3. Percentage of drinking water wells sampled that meet nitrate standards.

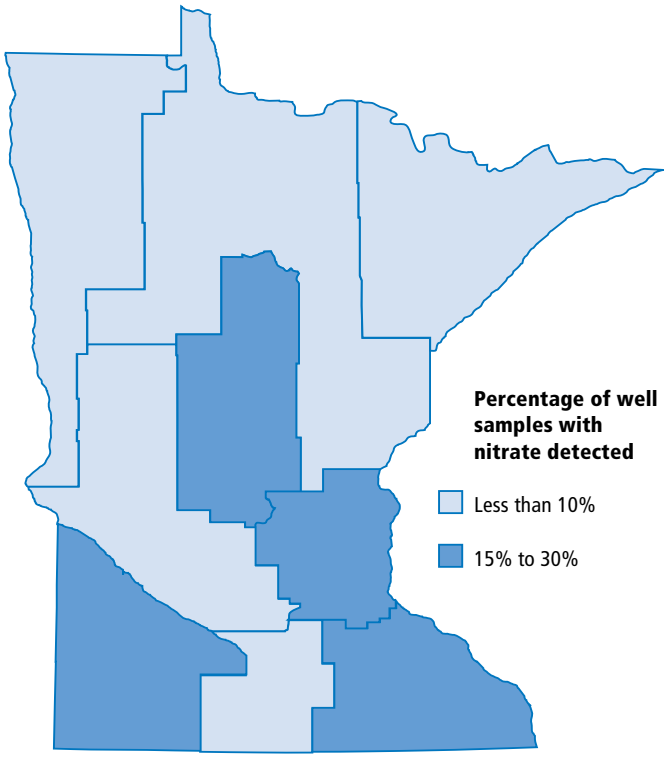
Wells not meeting nitrate standards	0.4%

Very few sampled wells had excessive nitrate levels between 1973 and 1999.

Source: Department of Health

Nitrate is the most common contaminant found in groundwater in Minnesota and is used nationally as an indicator of overall quality. Some nitrate in groundwater occurs naturally, but most comes from human activities. To prevent degradation of groundwater quality, it is necessary to understand how water moves in the subsurface. Nitrate is very soluble and moves easily with recharge water into aquifers that supply various uses; hence, it is a good indicator of where aquifers have been influenced by activities at the land surface. The state standard for nitrate is 10 parts per million.

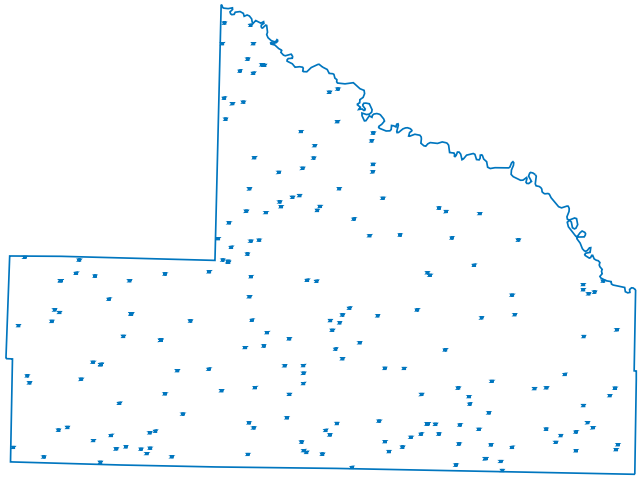
Nitrate contamination poses a greater problem in central and southern areas



Nitrate levels are detected if they exceed one part per million; wells were sampled over a five-year period, 1992 to 1996. Most experts consider nitrate above this level a sign of human influence on water quality. An interagency committee defined the map areas to reflect similar geology and threats to groundwater.

Source: Pollution Control Agency

Many private wells have high nitrate levels



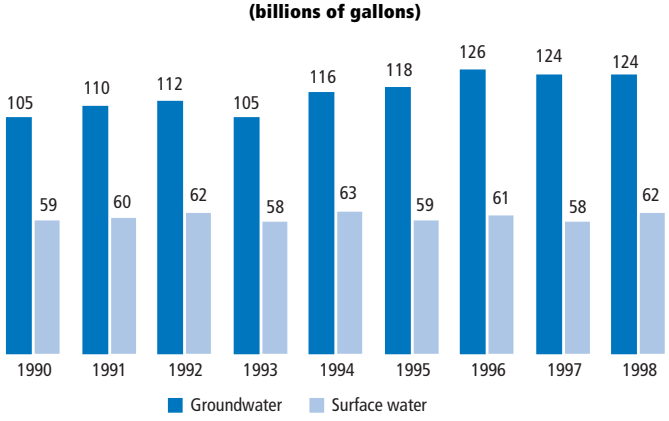
Brown County collected nitrate data from private wells and the map depicts those wells that exceed nitrate standards. The statewide data for public supplies or new wells from the Department of Health show only two wells over the standard.

Source: Department of Health

Only 0.4 percent of sampled wells had excessive nitrate levels between 1973 and 1999. The Department of Health collects this data from testing of new wells and public water supply wells. The data reflects average annual values during those years and indicates that public drinking water supplies are safe. However, public and new wells are purposely sited and finished in aquifers that are relatively clean to avoid contaminant problems. Nitrate data collected by counties and through nitrate clinics shows that the data from sampled wells does not reflect the extent of nitrate contamination in private drinking water supplies or in groundwater.

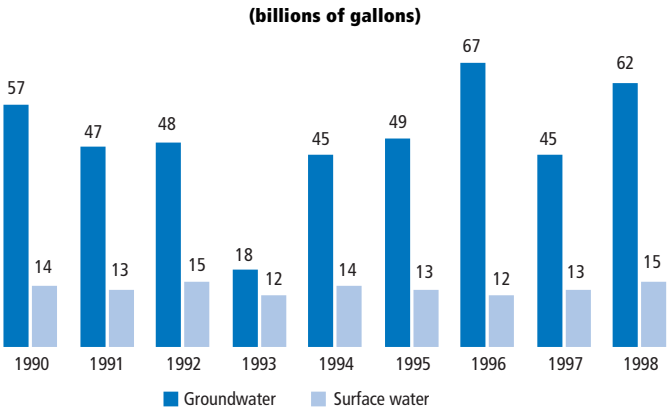
Collection of groundwater quality information to describe trends is underway. Contaminants first show up at the water table. Recognizing this situation, the Department of Agriculture and the Pollution Control Agency are designing monitoring wells to sample at the water table in sensitive areas. Trends will be assessed from the sampling at these sites after about five years.

Groundwater use for public supply increasing



Source: Department of Natural Resources

Irrigation use changes with weather



Note: Water use fluctuates with rainfall and temperature. The reduction in water use in 1993 reflects a cool wet summer.

Source: Department of Natural Resources

Goal: Minnesotans will conserve water supplies and maintain the diverse characteristics of water resources to give future generations a healthy environment and a strong economy.

Minnesotans tend to take water for granted in planning for development; they expect to find it available everywhere in a quantity and quality that meets their demands. The supply in some areas is inadequate, however, and elsewhere, contamination or the natural quality prevents the use of available water. Several issues need to be considered: competing users can strain local water supplies; individual demands for water either stay the same or rise when the supply of water falls during droughts; and high water levels that may happen infrequently need to be taken into account when planning construction so floods do not cause unnecessary and costly damage.

OBJECTIVE D. Maintain groundwater levels to sustain surface water bodies and provide water supplies for human development.

The demand for clean water is growing, and Minnesota is increasingly tapping into its groundwater. The use of groundwater for public water supplies exceeded that of surface water in about 1980 and continues to grow. Irrigation, drawing mainly on groundwater, also continues to increase, especially during dry years. Using too much water from a vulnerable supply could cause lakes, rivers or wells to dry up.

Indicator 4. Water levels in wells in relation to precipitation.

	Number above the median	Number in the median range	Number below the median
1990	0	4	13
1991	1	5	10
1992	6	9	4
1993	3	12	4
1994	11	7	2
1995	5	14	0
1996	11	8	1
1997	4	13	2
1998	7	10	4
1999	6	10	4

Water levels vary over the years in 21 selected wells.

Note: Water levels were compared to the long-term November median for each well. The total number of wells in some years does not equal 21 because records are missing or incomplete.

Source: Department of Natural Resources

Water levels are a good indicator of the overall condition of the water supply. Measurements of the water levels in wells integrate the effects of climate and other natural variations with the pressures of human activity. Changes in land surface may affect recharge negatively. Large natural variations in precipitation also occur naturally and may mask the influence of human activity on a regional or basin scale. Minnesotans' demand for water does not take into account the changing amounts of water available due to climatic variability. In fact, pumping and demand for water tend to increase when rainfall is short and water levels are declining.

Shallow groundwater levels usually vary in concert with precipitation. The Department of Natural Resources obtains measurements of the levels in selected water table wells across the state. November levels are used as baseline because they tend to reflect the sum of conditions that occurred during the preceding season. The median is computed from the November levels over time. In 1990, water levels were recovering from the drought years of 1987 through 1989, and more wells had levels below than above their long-term median for November. As the decade progressed, many wells showed water level increases into the median range or above.

The Department of Natural Resources Observation Well Network includes about 700 wells that are maintained expressly to measure water levels; they are located throughout developed parts of the state in 77 counties. Wells will be in every significant state aquifer and in some monitoring locations in every county when the network is completed.

Total water use is increasing in Minnesota. Use was 705 gallons per person per day in 1996 compared with 558 in 1986.

OBJECTIVE E. Maintain the hydrologic characteristics of surface water bodies that support beneficial uses.

Again, natural variation in supplies is inversely related to demand. When water use increases during drought, an already stressed river can become dry. Costs of flood damages increase if flood-prone lands are developed. Surface water is a valuable source of drinking water; 26 community water supplies draw from lakes or rivers, and nearly 1 million people rely on Mississippi River sources.

Indicator 5. Annual stream flow in relation to precipitation.

	Number above normal	Number in the normal range	Number below normal
1990	9	70	2
1991	42	33	6
1992	57	22	2
1993	61	20	0
1994	64	17	0
1995	63	18	0
1996	80	1	0
1997	76	5	0
1998	47	33	1

The majority of state stream flows were running above normal in the 1990s.

Sources: Department of Natural Resources and United States Geological Survey

Year-round and partial-record sites provide data to calculate flow statistics for the 81 major watersheds. Each watershed is then characterized as experiencing high, normal or low flows by comparing flow conditions for the specific water year to the

period of record for that station. The water year is from October 1 to September 30. Since the flow conditions are summarized for the entire water year, severe spring or summer flooding in the basin may not result in above-average flows for the whole year.

The abundance of precipitation in the 1990s resulted in above-normal flows for several watersheds and catastrophic floods for several basins. Annual stream flows in the last decade often exceeded normal ranges. The majority of watersheds had flows above the normal range, while a few dipped below normal in the northern part of the state. During the 1996 water year, only one of 81 watersheds exhibited flows that were normal or below normal. Five watersheds were in the normal range the following year, despite severe flooding in the Red and Minnesota River Basins.

One of the more confusing phrases used in meteorology and hydrology is "100-year storm." The phrase erroneously implies that an intense rainstorm dubbed as an "100-year" event brings rainfall totals unseen in the last 100 years and not to be experienced again for another century. The phrase actually means that the chance of the rainfall totals of that storm occurring at the same location during the same year is 1 percent. The occurrence of a "100-year storm" on one day does not mean that the same amount of precipitation could not fall the very next day.

Indicator 6. Lake levels in relation to the 10-year average.

	Above normal	Below normal
1990	1	23
1991	9	16
1992	9	16
1993	20	4
1994	17	8
1995	19	6
1996	16	9
1997	21	4
1998	13	12
1999	18	7

Lake levels rising during the 1990s.

Note: Totals for each year may not equal 25 because some lakes were at their 10-year average or data was missing for a particular year.

Source: Department of Natural Resources

The Department of Natural Resources, with the help of citizen volunteers, monitors the levels of more than 800 lakes. Lake levels are recorded weekly or after a significant rainfall and are then added to a historical database. Once sufficient data has been collected, a 10-year average level is determined. Each lake is then classified as having above- or below-average levels. Designated as indicators are 25 lakes across the state, with most major basins having at least one such lake.

During the water years 1990 to 1992, many lakes were below normal. Indicator lakes did not have such low levels again until the 1998 water year. Lake levels were above normal in most water years in the past decade. This resulted from a cumulative departure from normal precipitation that added up to significant excesses in precipitation over large parts of the state. At the same time, small areas of the state have had deficits in precipitation that also are reflected in lake levels. Land-locked lakes (those that have no outlet) particularly reflect the effects of high or low precipitation.

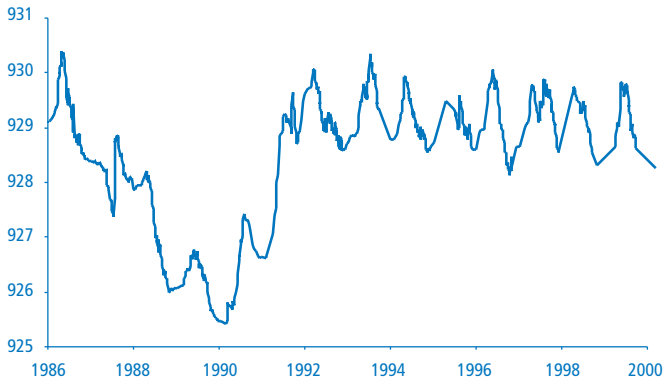
Goal: Minnesotans will restore and maintain healthy aquatic ecosystems that support diverse plants and wildlife.

Managed ecosystems in which plant and animal diversity closely resemble that of undisturbed systems tend to be more resilient, stable and healthier. Because the natural environment can be modified by human activities, the diversity of plants and animals is a commonly used measure of ecosystem health. Naturally diverse systems have a variety of species and habitats and a complex food web. As habitats or species are eliminated, relationships between species change, and the system becomes more susceptible to decline and collapse. Exotic plants and animals tend to displace native species and may reduce diversity and disrupt normal ecosystem processes.

OBJECTIVE F. Ensure that aquatic environments have conditions suitable for the maintenance of healthy self-sustaining communities of plants and animals.

While the loss of wetlands, forests and grasslands may be visible and apparent, the loss of plants and animals that depend on them may be less so. Changes to the ecosystem often are made incrementally, and adverse effects are not considered or even understood. Variability of some species at a statewide scale may mask deterioration of species in local areas because of loss of habitat or overuse. If pollution affects food sources, it also can affect reproduction, as was the case with the bald eagle's decline due to DDT, a pesticide commonly used before the 1970s but now banned.

Lake levels are constantly changing



Note: Hydrograph shows water levels of Lake Minnetonka in Hennepin County.

Source: Department of Natural Resources

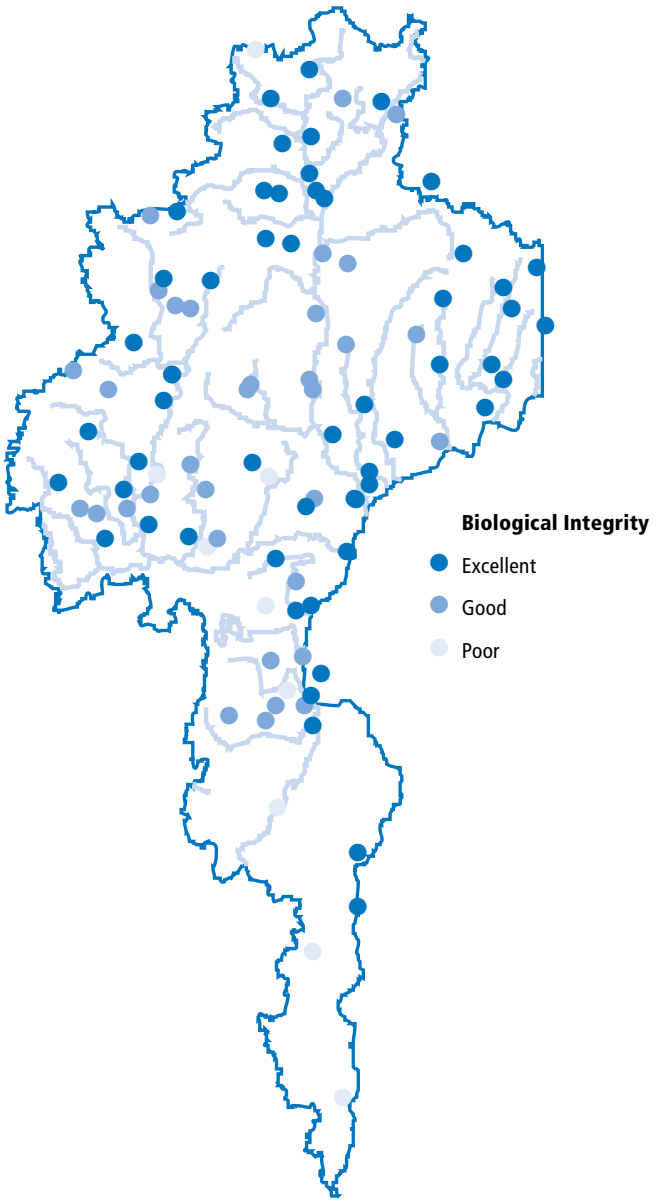
Indicator 7. Index of biotic integrity for lakes, rivers and wetlands.

Traditional, quantitative measures of water quality, such as levels of a specific toxic compound or dissolved oxygen, indirectly classify the health of a water body. Such performance-based measures examine the expected effects on aquatic life but do not describe how a water body is impaired overall. Indices of biotic integrity organize information on groups of organisms, such as fish or plants, to characterize the biological health of waters. The indices combine various types of information, such as the number of species present, their habitat requirements, their pollution tolerance and the health of individuals, to calculate a score for a site. A high score indicates that the site supports a community of organisms that would be expected at a high quality or minimally impacted site. A low score indicates that environmental conditions have been altered, usually by human activities, resulting in adverse changes in the biological community.

The indices can be used in warm- and cold-water rivers and streams and some wetlands, and may soon be available for lakes. These indices use data on fish, aquatic invertebrates or wetland plants. Indices of biotic integrity for fish have been developed for the Minnesota, Red, and St. Croix River Basins. Indices are being developed for the Upper Mississippi River and Lake Superior Basins, with ones for the Rainy River, Lower Mississippi River, Cedar River, Des Moines River and Missouri River Basins to follow. A macroinvertebrate index of biotic integrity has been completed for the St. Croix River Basin, and is underway in the Upper Mississippi River and Lake Superior Basins. Staff at the Natural Resources Research Institute have developed an index for North Shore streams. Such index methods could be applied to other ecosystems, such as forests and grasslands, to help gauge their health.

"Biological monitoring allows us to understand more of the processes occurring in our watersheds by determining what organisms are found in a stream and comparing it to what organisms are expected to be present. Biological integrity of streams is directly influenced by human activity (forestry, agriculture, urban development, recreation, grazing, etc.). Measuring biological integrity provides an insight to the human impacts upon stream systems and provides clues regarding where we need to protect streams or where we can start helping to restore their integrity." — James Karr, developer of the biotic index concept

Biotic integrity is good in most St. Croix streams



Source: Pollution Control Agency

OBJECTIVE G. Limit geographic range of exotic species.

Healthy ecosystems can be degraded by the introduction of exotic or non-native species. The result can be the loss of desired native species or a reduction in economic or recreational values.

Indicator 8. Number of major watersheds with specific quantities of prohibited exotic species.

Number of exotic species	Number of watersheds
0	10
1	26
2	22
3	12
4	8
5	1
6	1
7	1

Most watersheds had at least one prohibited exotic species as of July 2000.

Source: Department of Natural Resources

The number of harmful aquatic exotic species in each of the state's 81 watersheds measures the extent of change and stress

imposed by exotic plants and animals. The table depicts this stress by summarizing the distribution of aquatic "prohibited" exotic species in Minnesota's watersheds. Species in the "prohibited" category have a high potential to harm natural ecosystems, native species or the use of the state's water resources. The use of prohibited exotic species is tightly regulated to limit their introduction into Minnesota and their spread within the state.

Presently, watersheds with zero or one prohibited exotic species are generally found along the southern, western and northern borders of the state. Watersheds that abut Lake Superior have the highest totals. Over the next 10 years, the change in the total quantity of these species in each watershed will provide a measure of the spread of harmful exotics, as well as the introduction of new species into the state.

Several of the prohibited exotic species are present in Minnesota's waters as of 2000:

- curly-leaf pondweed
- Eurasian water milfoil
- flowering rush
- grass carp
- purple loosestrife
- round goby
- ruffe
- sea lamprey
- white perch
- zebra mussel

Other prohibited species are not known to be in Minnesota waters as of 2000:

- African oxygen weed
- aquarium watermoss or giant salvinia
- Australian stonecrop
- bighead carp
- black carp
- European frog-bit
- hydrilla
- Indian swampweed
- nutria, any strain
- rudd
- silver carp
- water aloe or water soldiers
- water chestnut
- zander

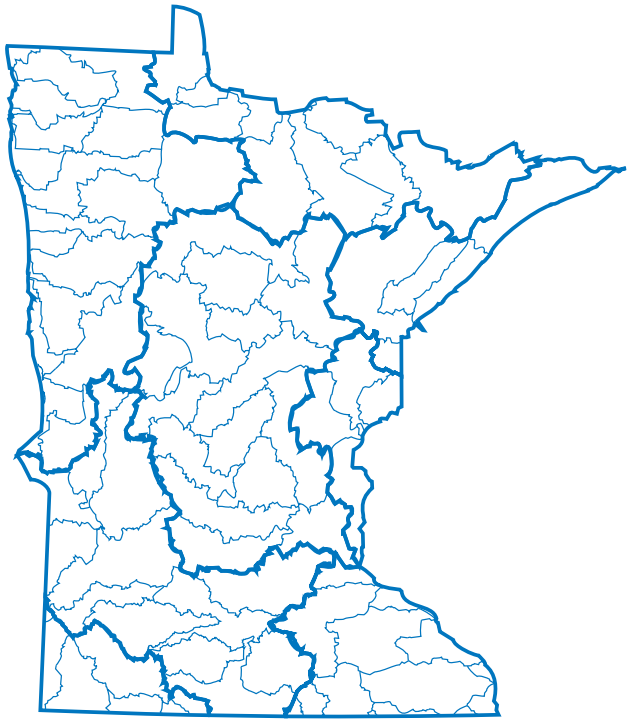
The Department of Natural Resources gathers and maintains information about the locations of aquatic prohibited exotic species and the total quantity in each watershed. For example, watersheds with no known infestations in any lake, river, or wetland have a total of zero; those with five different species present have a total of five. The number of infestations of a particular prohibited exotic species within a watershed does not matter in the scoring, only whether it is present or absent.

Goal: Minnesotans will have reasonable and diverse opportunities to enjoy the state's water resources.

Water is a central element in Minnesota's wealth of recreational opportunities. It is the primary feature in most parks and essential to numerous sports and hobbies. Minnesota has a long tradition and policy of public access to water resources that promotes use and enjoyment by all citizens for many types of activities, include fishing, boating, canoeing and camping. While access is important, there is a pressing need to balance recreational use and water protection. The number of registered boats in the state increased from 157,767 in 1959 to 780,680 in 1998, while the number of registered personal watercraft went from 55 in 1974 to 30,013 in 1998. Despite level sales of fishing licenses since 1991, fishing demands have continued to increase statewide. As pressure on water resources mount, state government needs to understand how satisfying water recreation is for both residents and tourists.

The Minnesota Department of Natural Resources and the University of Minnesota Sea Grant Program in 1994 surveyed boaters in Minnesota, Wisconsin and Ohio to evaluate and compare regional differences in exotic species education and awareness programs. Survey results indicated that "Minnesota boaters are more knowledgeable about exotic species issues and have already changed their behavior to a greater extent (to prevent the spread of exotics) than boaters in the other two states. This suggests that educational programs are effective."

Minnesota has 81 major watersheds



Source: Minnesota Planning

OBJECTIVE H. Provide access to water-based recreation sites.

With more than 12,000 lakes and 90,000 miles of streams and rivers, Minnesota offers a wealth of water-based recreational opportunities. The public has access to water resources for recreation through a variety of settings, including local, state and national parks, state and national forests, and other public holdings. The Department of Natural Resources collects trend information on public access.

Indicator 9. Number of public access sites on lakes, rivers and streams.

1990	3,000
1991	3,020
1992	3,040
1993	3,060
1994	3,080
1995	3,100
1996	3,120
1997	3,140
1998	3,160
1999	3,180

Public access to recreational waters is growing.

Source: Department of Natural Resources

Public access sites on lakes, rivers and streams have risen from 3,000 in 1990 to 3,180 in 1999. The number of sites is an indicator of how well the state is meeting its policy of providing access to water resources. These sites include boat and shore access, as well as fishing piers. Public access sites help meet outdoor recreation demands, improve the quality of life and attract tourists. In addition to being used for fishing and launching motor boats, public access sites provide opportunities for birdwatchers and canoeists, among others.

With one boat for every six people, Minnesota ranks number one among all 50 states in the number of recreational watercraft per capita.

OBJECTIVE I. Improve or maintain the quality of water recreation.

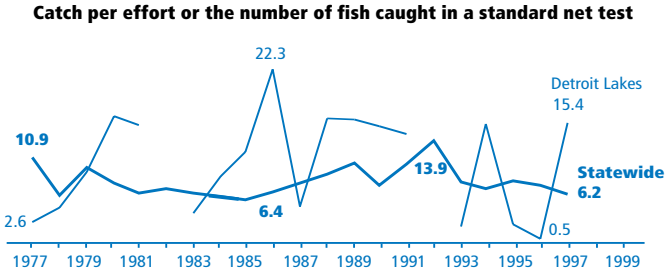
Enjoyment and safety decline on waters subject to heavy recreational use. In recent years, the Department of Natural Resources has surveyed boaters to measure their satisfaction and levels of use. It also conducts fishing surveys to determine the amount and rate of fish harvest. To prevent conflicts between various recreational uses, surface water use regulations now apply to about 300 separate water bodies. Fish harvest regulations address the management needs of about 100 lakes and 30 rivers.

About 600 Minnesota streams totaling nearly 2,000 miles are designated as trout waters.

Indicator 10. Survey of degree of satisfaction with water-related outdoor experiences.

From lakeshore homeowners to birdwatchers and swimmers, the users of Minnesota's water resources are as diverse as the waters themselves. Because the basin teams expressed a strong interest in knowing how satisfied recreational users of Minnesota waters are, Minnesota Planning, in cooperation with the Department of Natural Resources and other state agencies, is initiating a survey to monitor trends in a variety of outdoor water uses. Repeated surveys can provide a measure of the quality of recreational experiences and allow the state to track changes over time. No general water recreational trend information exists, and trend information for specific types of users is lacking.

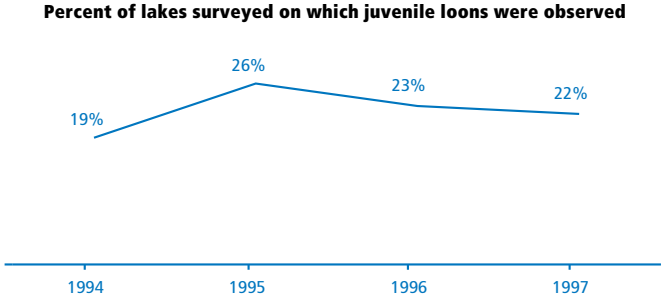
Long-term statewide walleyeye populations in unstocked lakes are relatively unchanged but sporadic in the Detroit Lakes area



Despite considerable annual variation, the walleye population appeared to grow until the early 1990s, but has since declined. Estimates for a single area, like Detroit Lakes, shows more variability due to the annual changes in local conditions such as fishing pressure, water temperatures and predator populations. No data was available for the walleye population in 1982 and 1992 in the Detroit Lakes area.

Source: Department of Natural Resources

The proportion of lakes where juvenile loons were observed remained relatively constant between 1994 and 1997



Loons are long-lived, and reproduction rates appear stable.

Source: Department of Natural Resources

The state conducts some surveys to examine specific concerns and ensure that management goals address current issues. Boaters' and anglers' opinions are tracked periodically by the Department of Natural Resources. Between 1985 and 1998, for example, the number of boats on lakes in the north-central lake region did not change significantly, yet more boaters perceived lakes to be crowded in 1998 than in 1985 (15 percent of respondents versus 5 percent, respectively). Overall, satisfaction with boating experiences is high, with only 10 percent of the boaters reporting that they are dissatisfied to any extent.

Anglers are surveyed to help determine the amount of fishing activity and level of harvest on individual lakes. From 1935 to 1994, surveys of users on 918 of the about 5,000 lakes managed for sport fishing were conducted. Most surveys have been conducted on lakes that have either lake trout or walleye. Relatively few lakes are the focus of more than one survey, although surveys are conducted continually on some larger, more important lakes, such as Mille Lacs. Recreational fishing pressure on Minnesota waters is highly variable. Survey results show that fishing pressure on walleye lakes has increased steadily since the 1950s. While the number and weight of walleyes caught have remained steady, the time needed to catch a fish has increased. For northern pike, the number and weight of fish caught and the time needed to catch a fish tend to decrease as fishing pressure increases.

The state of recreational boating in north-central Minnesota changed markedly between 1985 and 1998. A 1998 Department of Natural Resources survey of boating in that part of the state found that over the 13 years, the average horsepower of boat motors increased from 46 to 93. This change reflected the trend away from fishing boats, which were the predominant craft in use in 1985, to runabouts.

Basin conditions and planning approaches vary

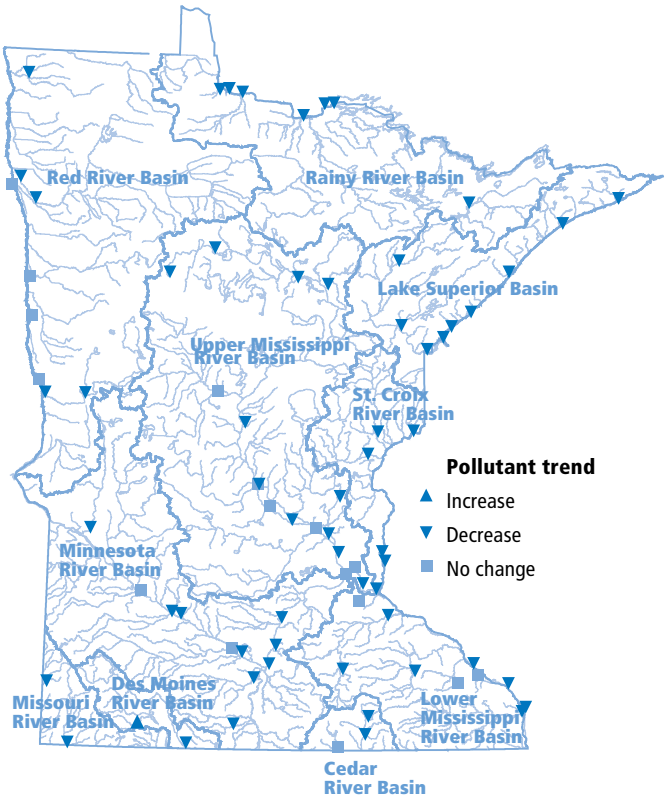
"It shall be Minnesota public policy to protect, preserve and enhance its many lakes as irreplaceable natural assets, held in trust for future generations, while encouraging responsible current use for widely diverse purposes." — Report of the 1992 Lake Management Forum

The overview presented in the first part of this report provides the general goals and objectives for the state as a whole. The reports of the basin teams contain specific goals, objectives and indicators tailored to the particular conditions found in each basin. These goals and objectives, along with those for the whole state, will be used to move toward creating strategies and actions that will address concerns about water resources in Minnesota. Basin teams will develop targets to further implement the indicators for each basin.

State agencies will use the goals, objectives, indicators and targets to the extent possible to guide program priorities and initiatives. Local governments play a major role in water management in Minnesota and have helped shape the state framework and the basin reports. Local governments will incorporate these planning elements into local water plans and use them to guide other planning efforts.

The reports of the seven basin teams reflect some similarities and commonalities, as well as a variety of conditions and priorities across the state. Basin planning efforts were already progressing in several basins when this initiative was started. In other basins, the process of water planning is just beginning. Regardless of the stage of planning, each basin team, starting with a similar core of state and federal agency representatives, undertook an effort unique to each basin to gather together representatives of local government, water interests and other groups or individuals to develop recommendations specific to

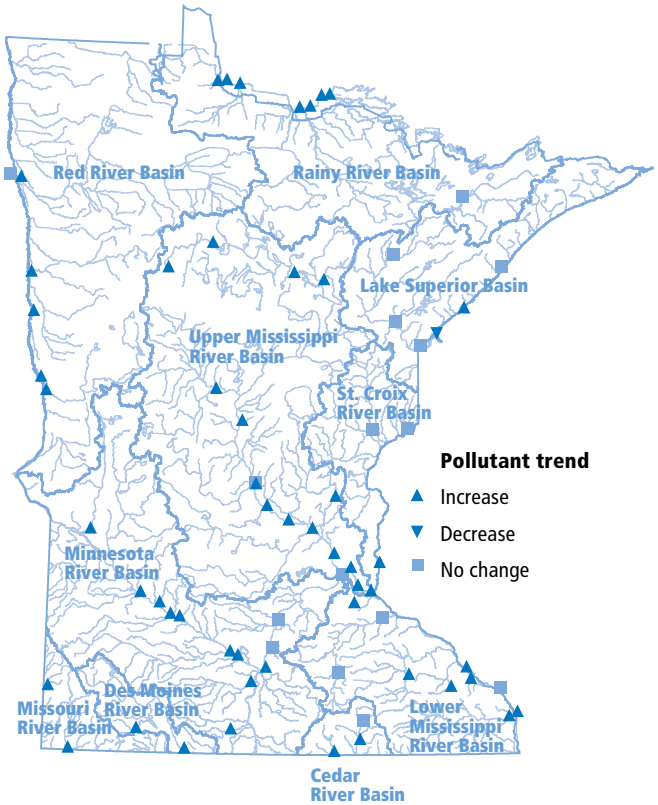
Total phosphorus pollutant levels have decreased at nearly eight out of 10 monitoring sites



Of the monitoring stations with valid data, 78 percent show a decrease in pollutant levels, 1 percent show an increase, and 21 percent show no particular trend in either direction. Common sources of phosphorous include fertilizer, animal waste, wastewater treatment facilities, and plant matter such as leaves.

Source: Pollution Control Agency

The health of Minnesota's waterbodies have been negatively affected by increases in the levels of nitrogen



Where valid data exists, 1 percent of monitoring stations show a decrease in pollutant levels, 75 percent show an increase, and 23 percent show no particular trend in either direction. Common sources of nitrogen are plant matter like grass, wastewater treatment plants and fertilizer. Nitrogen is measured as nitrite/nitrate.

Source: Pollution Control Agency

their basin for the state water plan. Some teams added members from other organizations, created an advisory group or adapted an existing board, and all held public meetings and met individually with various local governments.

Most basins share some border or drainage with neighboring states. In addition, the Red River, Rainy River and Lake Superior Basins include international waters. These three basins are also under the jurisdiction of the International Joint Commission, which was established by the United States and Canada in a 1909 treaty and has goals and objectives for these basins.

Based on feedback from the public and other sources, basin teams were asked to report on several points, beginning with suggested changes to the draft goals, objectives and indicators of the state plan. They were also to go beyond the listed indicators of water resource condition, such as water quality and water quantity, and include indicators of human behavior — or pressures — on the water resource, such as how much water is used and how land is used or managed. When examined with the condition indicators and in the context of a basin's geology, soils and climate, pressure indicators highlight human behaviors that may adversely affect water resources. Once identified, these behaviors can be addressed in planning.

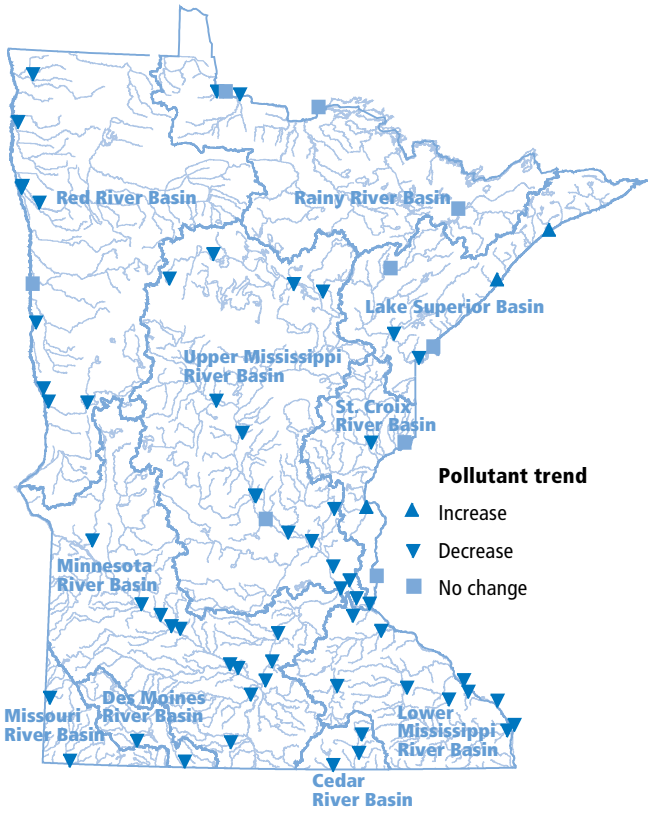
Basin teams were asked to develop 10-year targets for the indicators, but due to the status of planning within many basins, only three teams recommended targets. Teams were also to report on water-related issues of importance in their basin.

Several issues were raised by many basins, including:

■ **Local planning and funding.** Strengthening local planning and ensuring adequate financial resources for local water management were key issues in most basins. The basin teams' emphasis on funding issues illustrates the need to explore approaches and priorities tied to local resource governance capability. Some areas have a strong local tax capacity, but others do not. The committee for the Twin Cities region recommended expanding self-funded local entities, but others looked for more state and federal assistance.

■ **Land use.** Land use and its relationship to the condition and quality of lakes, streams and groundwater was of interest in every basin. Pressures from shoreland development, impervious

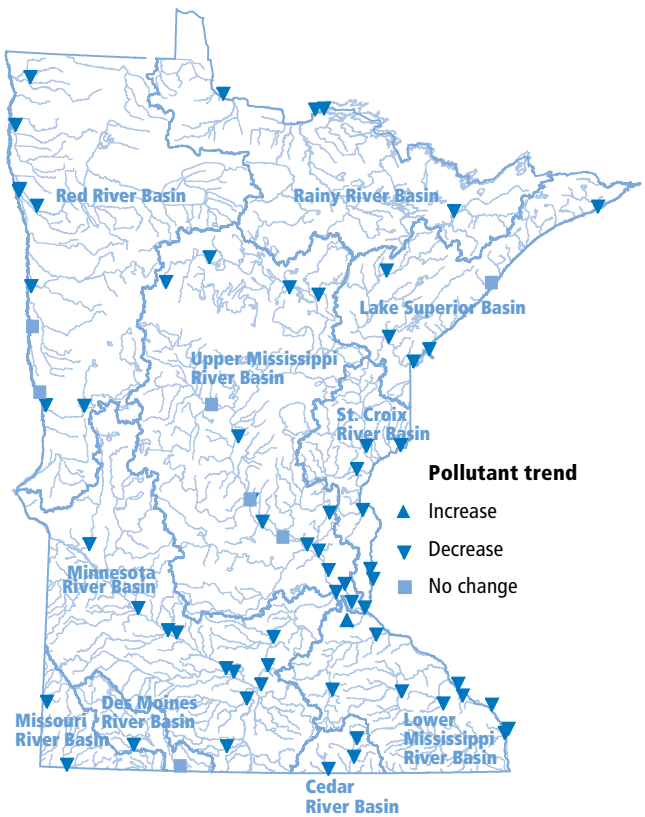
Ammonia levels have decreased at nearly all Minnesota monitoring stations



Of the monitoring sites having sufficient data, 83 percent show a decrease in pollutant levels, 4 percent show an increase, and 13 percent show no particular trend in either direction. Animal waste, fertilizer, remnants of organic matter and wastewater are some of the sources of ammonia.

Source: Pollution Control Agency

Biochemical oxygen demand levels have decreased at nearly all monitoring sites



Common sources of biochemical oxygen demand include animal waste, wastewater and other biodegradable materials. Where valid data exists, 89 percent of the monitoring sites show a decrease in pollutant levels, 1 percent show an increase, and 10 percent show no particular trend in either direction.

Source: Pollution Control Agency

surfaces, changes in vegetative cover, drainage and types of tillage were among the many specific indicators listed. The land use issues tied to flooding were emphasized as a concern in several basins. Soil erosion, excess nutrients in waters and property damage also were linked to flooding and land use.

■ **Prevention.** Most basin teams noted the high quality of water resources and the importance of keeping these resources in top condition. The diversity and integrity of the aquatic ecosystems need to be better understood and protected. Concerns about protecting trout streams, native fish species and the threatened and endangered mussel species were stressed by many.

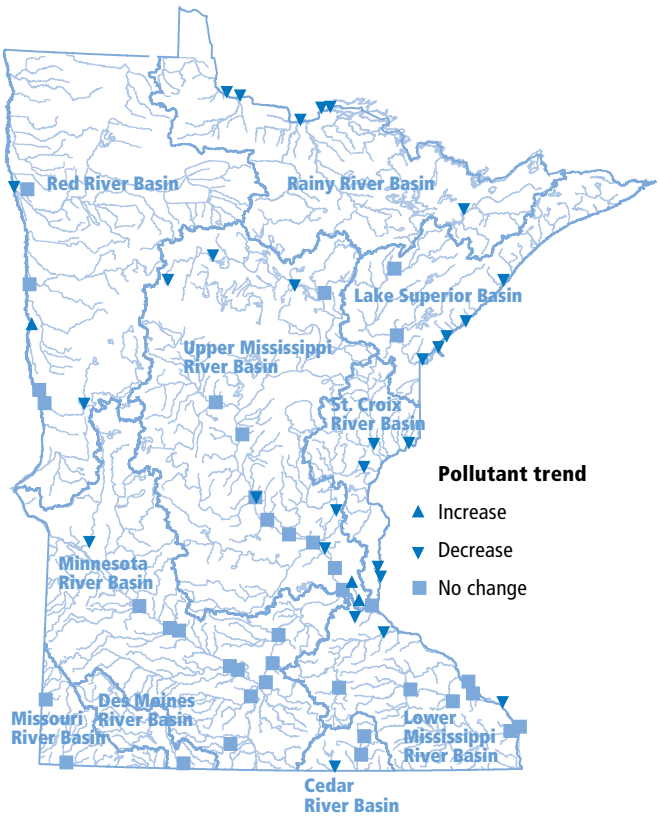
■ **Education and stewardship.** Water resources are greatly affected by the actions of individuals who sometimes unknowingly pollute. Problems with water resources are often the result of poor decisions about land use or water use. Education gives the public the information needed to "do the right thing." Getting volunteers to monitor lake or stream clarity, promote best management practices and inform their neighbors were cited by basin teams as a cornerstone of educational efforts. Forming lake associations or organizing preventive or restoration projects also can contribute to good stewardship.

■ **Climate effects.** Because all aspects of the environment are interrelated, all of the basin teams noted that weather and climate change must be considered in planning for Minnesota's water resources. While many aspects of climate change are unknown, drought and flooding, as well as effects from changes in temperature, occur periodically and need to be taken into account.

■ **Coordination**. Coordination is necessary because myriad local, state and federal government and even international entities have roles in water management. Governor Ventura's Water Management Unification Initiative is a first step in the new process. It needs to continue and be strengthened.

The following summaries of basin team reports review the status of planning in each basin; note statewide goals, objectives and indicators that are of particular importance in the basin; identify unique objectives and environmental and pressure indicators for the basin; and discuss the next steps for water planning in the basin.

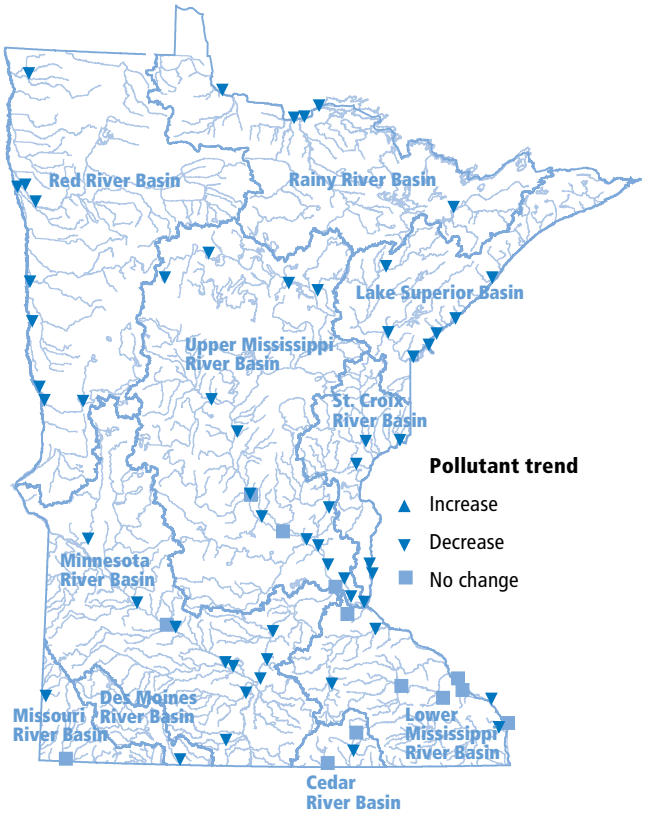
Over 90 percent of the levels of total suspended solids have either remained constant or decreased



Of the total monitoring sites that have valid data, 41 percent show a decrease in pollutant levels, 4 percent show an increase, and 54 percent show no particular trend in either direction. The most consistent decreases are in the Rainy and the St. Croix River Basins. Sources of total suspended solids include erosion from construction sites and agricultural fields as well as any uncovered soil and streambank erosion.

Source: Pollution Control Agency

Decreases in fecal coliform bacteria have been experienced throughout Minnesota



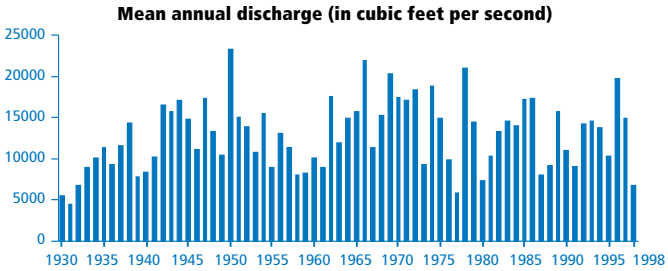
All of Minnesota's river basins have experienced decreases in the levels of fecal coliform bacteria. Of the monitoring sites that have valid data on fecal coliform, 82 percent show a decrease in pollutant levels, 0 percent show an increase, and 18 percent show no particular trend in either direction. Fecal coliform sources include human and animal waste.

Source: Pollution Control Agency

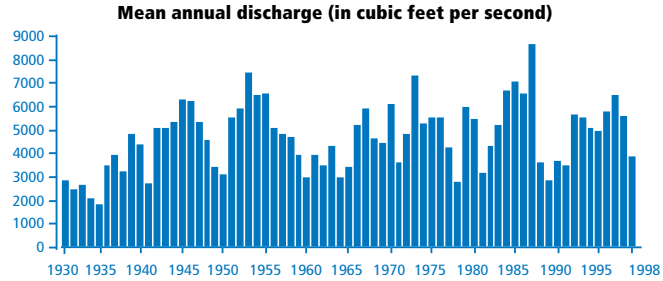
RIVER FLOWS FLUCTUATE GREATLY THROUGHOUT MINNESOTA DUE TO AMOUNT OF RAIN AND SNOW

In these seven stream-flow stations, water volumes are measured as they flow past a particular point. The drought of the 1930s is reflected by low flows. Since then, the overall flow trend has been relatively constant with expected annual fluctuations from changes in the climate. Differences from site to site are due to differences in the size of drainage areas, differences in characteristics such as land cover and development, and statewide climate variation.

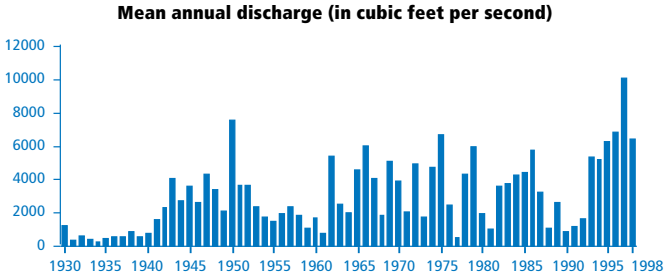
High and low flows in the Rainy River at Manitou Rapids differ from rivers further south in Minnesota. The drainage area is 19,400 square miles.



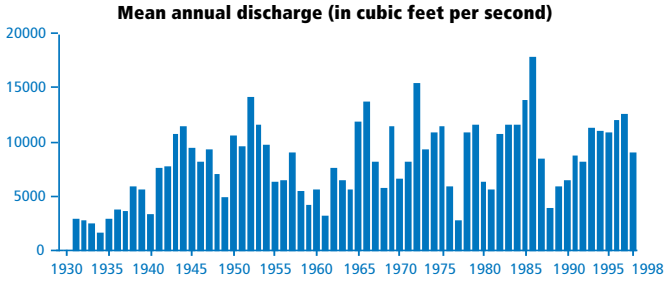
Repeated high and low flows are notable in the St. Croix River at St. Croix Falls. The drainage area is 6,240 square miles.



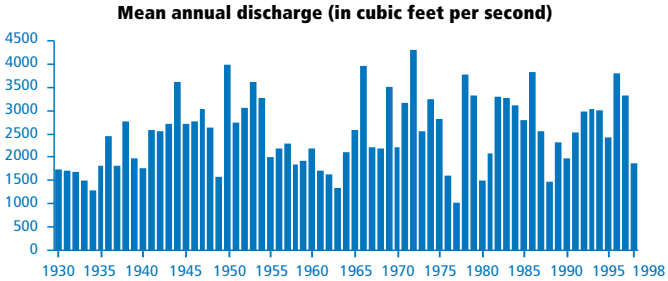
The record flood of 1997 is prominent in the Red River at East Grand Forks. The drainage area is 30,100 square miles.



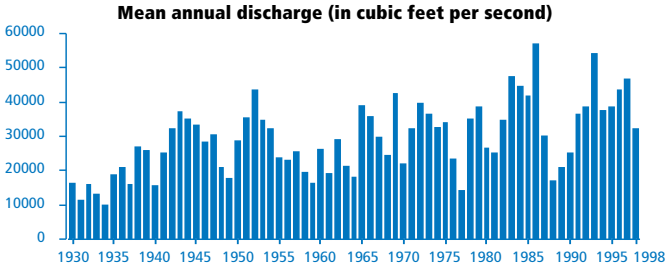
For the Mississippi River at Anoka — draining 19,1000 square miles — periodic low and high water levels are similar to the patterns in the St. Croix.



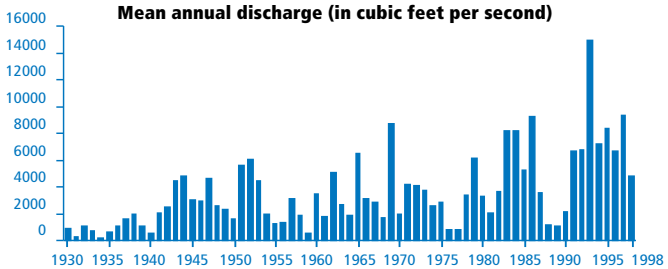
Flows in the St. Louis River at Scanlon, in the Lake Superior Basin — draining 3,430 square miles — have increased due to added precipitation.



Draining 59,200 square miles, the flows measured in the Mississippi River at Winona are increasing due to increases in rain and snow.



The flooding in 1993 from record rain and snow is apparent in the Minnesota River at Mankato. The drainage area is 14,900 square miles.



Sources: Department of Natural Resources and U.S. Geological Survey

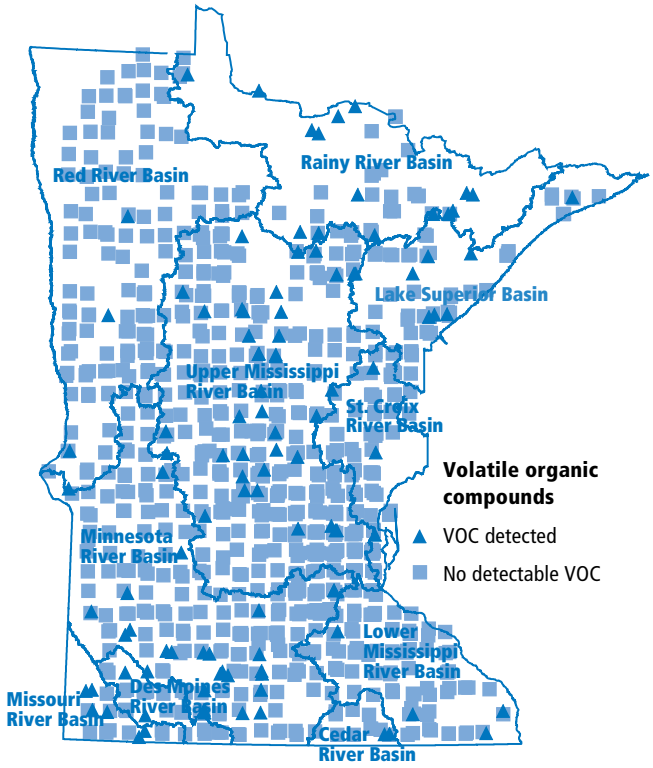
CONDITIONS FOR GROUNDWATER DIFFER THROUGHOUT THE STATE

When sand, gravel or shallow bedrock conditions occur at the land surface, water moves rapidly into groundwater. Pesticides, nitrate and other pollutants can more easily infiltrate into aquifers in these areas than in less porous areas where aquifers are more protected.

Many, but not all of the volatile organic compound detections are in areas where sand and gravel are at the land surface. Nearly one in eight wells sampled had VOC detected.

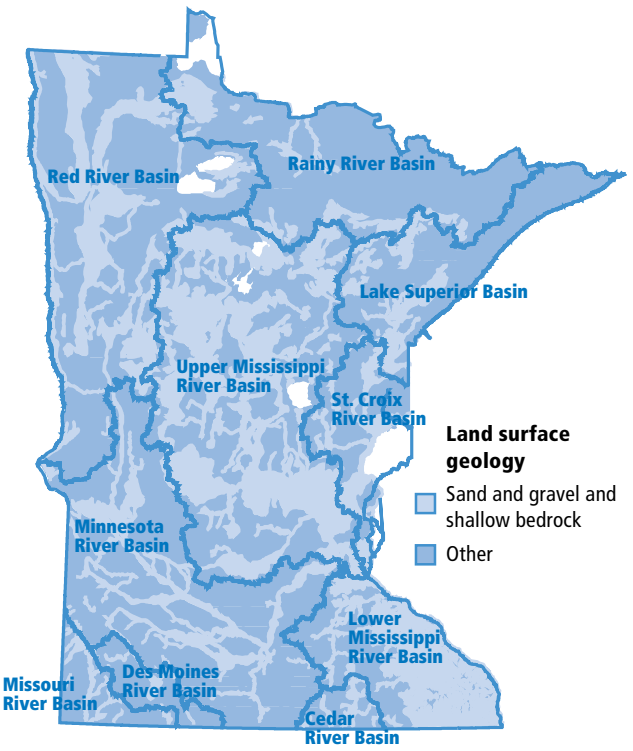
Since 1985, atrazine concentrations in the sand plain in the Upper Mississippi Basin have been declining, but remains steady in the Lower Mississippi Basin.

The majority of wells sampled betwen 1992 and 1996 had no detectable level of volatile organic compounds



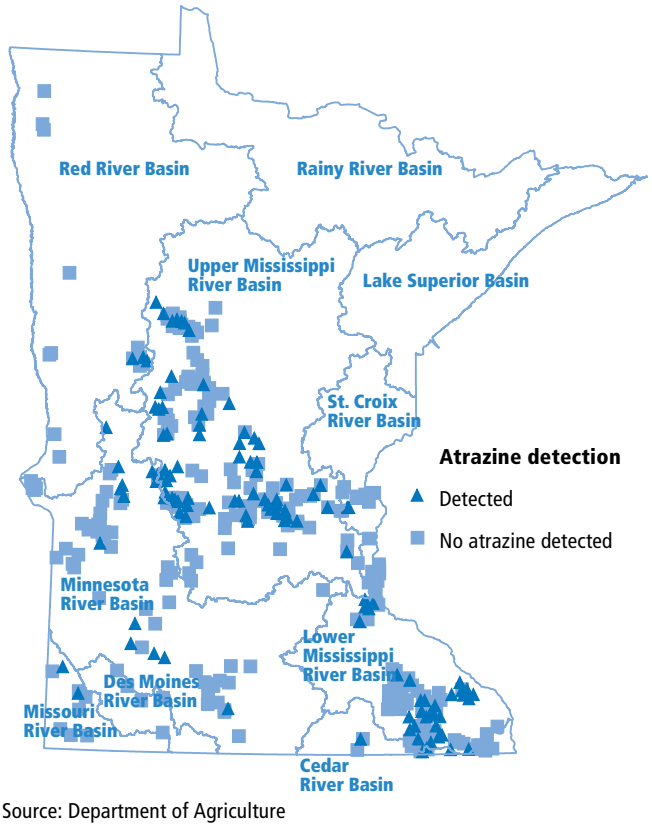
Source: Pollution Control Agency and Minnesota Geologic Survey

In many places land and groundwater are directly connected



Source: Minnesota Geologic Survey

Atrazine is the most commonly detected pesticide

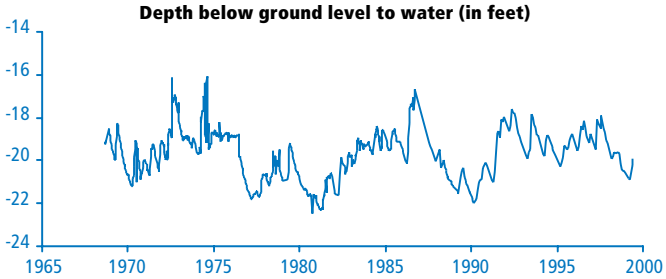


Source: Department of Agriculture

DROUGHT OR LARGE AMOUNTS OF RAIN OR SNOW CHANGE GROUNDWATER LEVELS

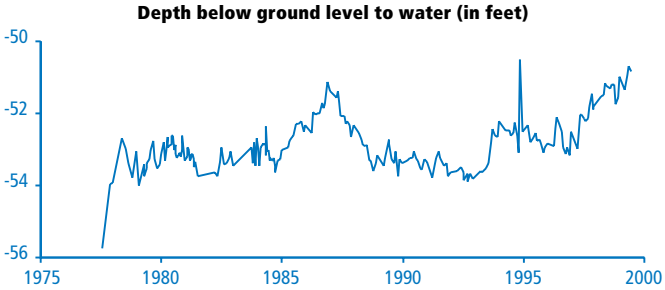
Fluctuations in water levels are primarily due to changing climate conditions; several reflect the droughts of the mid-1970s and mid-1980s. The well hydrographs illustrate the variation expected in the water table within the area it is located. These five wells were selected from among the state's 350 observation wells because they have been measured for a long time and are somewhat centrally located within each basin.

Water levels in the St. Croix River Basin well are related to changes in precipitation; the range is about 6 feet.



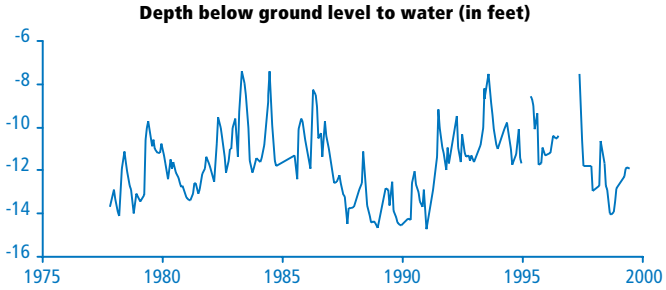
Note: The well measured in this graph is Obwell 58000, T45 R20 S26 DBB in Pine County.

The Red River Basin well varied about 6 feet since the late 1970s.



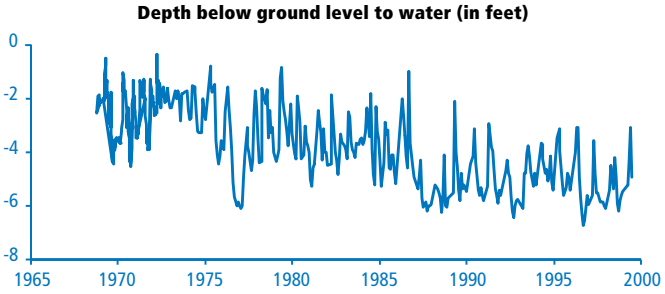
Note: The well measured in this graph is Obwell 3113,T138 R42 526 CDA in Becker County.

Rain and snowfall contribute to the 7- and 8-foot changes in water levels in the Minnesota River Basin well.



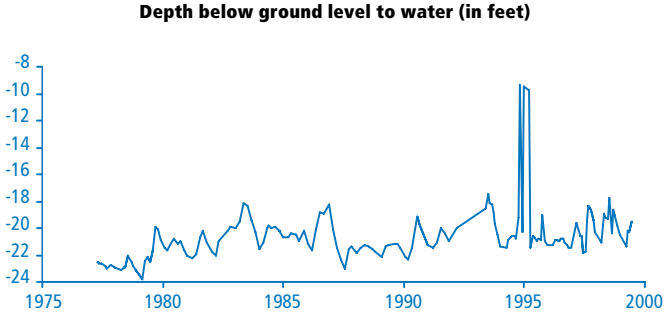
Note: The well measured in this graph is Obwell 64013, T112 R37 S21 CCC in Redwood County.

With slight water-level decline over the last 30 years, the well in the Upper Mississippi River Basin shows a seasonal variation due to nearby pumping for irrigation.



Note: The well measured in this graph is Obwell 49002, T39 R32 S1 BBB in Morrison County.

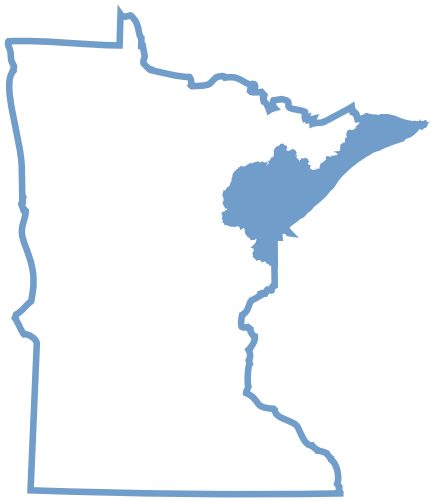
Climate and a nearby dam influence water levels in the Lower Mississippi River Basin well.



Note: The well measured in this graph is Obwell 19006, T112 R18 S8 ABA in Dakota County.

Source: Department of Natural Resources

Lake Superior Basin



The Lake Superior Basin drains over 6,150 square miles.

PERCENT OF CROPLAND ERODING ABOVE TOLERANCE LEVELS

	1982	1987	1992
Wind	0	0	0
Water	0	0	0

LAND USE CHANGES

	1992 Acres in thousands	Percent change 1982-1992
Cropland	130	-2.48%
Grassland	80	-28.52
Forest	2,055	-0.29
Urban	117	13.76
Wetland	1,382	.05

Source: U.S. Department of Agriculture Natural Resources Conservation Service

POPULATION

1990	1998	Percent change
205,297	208,740	1.68%

Source: Minnesota Planning

The Minnesota Lake Superior Basin is the headwaters for the Great Lakes. The basin is 84 percent forested, which has allowed it to retain relatively good water quality in its lakes and streams. The forests contribute to the scenic beauty of the area, provide good hunting and fishing, attract tourists and residents, and support the forest industry, which is a major component of the basin's economy.

In addition to Lake Superior, the basin has 151 designated trout streams and many lakes. The state has designated 53 lakes as Outstanding Resources Value Waters, affording them special protection. It also contains part of the Boundary Waters Canoe Area Wilderness, seven designated scientific and natural areas, and 16 state parks.

These are all set in an area with poorly buffered, thin soils that are sensitive to acid rain. Some soils are sandy loams but change to highly erodible red clay on the steep slopes surrounding Lake Superior. The trout streams are primarily fed by surface runoff. The forest canopy keeps surface water flows cool enough to maintain trout and other cold-water species. Heavy development pressures, increasing timber harvest demands and gravel mining operations are straining this resource by fragmenting the forest canopy and changing watershed hydrology.

The Lake Superior Basin includes the more populated portions of Carlton, Cook, Lake and St. Louis counties. Between 1990 and 1998, the basin's population rose 1.7 percent. The population of Duluth, which accounts for about 41 percent of the basin's total population, remained virtually unchanged during that period. Cook County grew 16.4 percent, Carlton County gained 7.6 percent, and Lake County increased by 2.7 percent.

Status of basin planning

The basin team had help from the Lake Superior Basin Programmatic Work Group, a relatively new group that represents various governmental entities, in completing the basin report. Other planning efforts include the Remedial Action Plan for the St. Louis River, the Lakewide Management Plan for Lake Superior and the State of the Lakes Ecosystem Conferences.

Statewide goals, objectives and indicators of particular importance

Water quality is good in the Lake Superior Basin, but nutrients such as phosphorus, which at excessive levels will stimulate blooms of algae, are of special concern, as are mercury, PCBs, dioxin and other pollutants. The indices of biotic integrity for fish developed for the basin will be important because they will monitor the health of fish, including the presence of tumors.

The team is interested in tracking lake levels and stream fluctuations to investigate the impacts of human activities and land use, such as withdrawals for irrigation, lawn watering, municipal water use or exports of water. Recreational opportunities draw many tourists to this region. Surveying all types of water users would help assess the satisfaction of motorized and non-motorized boaters, property owners and other users.

Unique objectives and environmental indicators

Trout streams and lakes are a vital part of the basin, so measuring their health will be essential. Water temperature determines oxygen solubility and is an indicator of watershed characteristics, such as forest canopy cover and changes in percentage of impervious surfaces. The existence of cold-water species in a body of water after November 28, 1975, constitutes an "existing use" that must be protected by the states under the federal Clean Water Act Antidegradation Policy, Section 131.12(a)(1). Comparing the

current status of cold-water fish such as brook and rainbow trout in streams and lake trout and splake in lakes with what existed since 1975 would show if management efforts are protecting the integrity of the basin's streams and lakes, and thereby protecting existing uses.

Pollutants such as mercury, PCBs and dioxin are major water quality concerns. Not only do these threaten recreational use, but they also dramatically affect the fish and wildlife that rely on the waters. Accumulated levels of toxic substances in fish is of particular concern.

The habitat of wild rice has been on the decline in the area. Measurement of remaining and reestablished stands of wild rice could be a useful indicator of lake and watershed health, as well as of a historically self-sustaining aquatic plant community.

Some of the exotic species in the Lake Superior Basin are unique in the state; most of these have been carried into the area by international and regional shipping traffic. The exotic species of concern in the basin include purple loosestrife, ruffe, round gobey, spiney water fleas, zebra mussels and rusty crayfish.

Because tourism is vital for the economy of the basin, the number of resorts and swimming beaches is important. Tracking increases year after year is simple and inexpensive. Additional trends in recreational opportunities may be established through the use of Department of Natural Resources public resource information maps, which identify public lands available for recreational use.

Public Recreation Information Maps bring together the most up-to-date information on federal, state and county lands and their recreational facilities. They make it easier to find unique spots for outdoor enjoyment. Each map displays parks, forests, scientific and natural areas, waterfowl production areas and wildlife management areas. In addition, each map shows facilities such as state trails, fishing piers, campgrounds, historic sites and more.

Unique objectives and pressure indicators

To better control pollutants, efforts must be made to enforce existing laws and protections. Both wastewater and septic systems have guidelines that must be followed to ensure compliance.

Septic system compliance is crucial to maintaining good water quality in Minnesota lakes. Compliance trends are a good indicator of the how well private citizens are doing at limiting the pollution of water. Wastewater permit violations are relatively common, and tracking the number will hold businesses and public utilities accountable.

Many types of land uses pose a threat to water resources. Shorelands are especially sensitive. Tracking the percent changes in the shoreland impact zone (area half-way to the allowed building line) would provide a general barometer of river and lake health. Changes in forest canopy, for instance, can have a ripple effect on water temperature, erosion and sediment loads. Farming this zone can lead to nutrient and pesticides reaching the water. Developments add impervious surfaces and fertilized lawns. Shorelines cleared of trees reduce leaves and downed trees in the water that add to fish habitat. Lake vegetation cleared for swimming beaches and boat access reduces fish habitat. More positive changes could be assessed by tracking the number of revegetation and riparian area management plans.

Acid rain forms when sulfur and nitrogen oxides from air pollution mix with moisture in the atmosphere. The acids fall to earth in rain, fog or dust where they can make lakes too acidic for fish and other aquatic life to survive. At least 2,200 Minnesota lakes are vulnerable to acid rain.

Other issues of significance in the basin

Citizens are a key part of the political process and need to be involved in finding and implementing solutions to problems that affect Minnesota's waters. For this reason, the basin team recommends a goal of having Minnesotans participate in the stewardship of the waters of the state.

A special objective would have citizens actively involved in monitoring and managing basin water resources and watersheds. Citizens currently voluntarily conduct monitoring — including water levels, clarity in lakes and rainfall — for several state agencies. Without this data collection effort, the agencies, given their limited funding and staff, would not be able to provide the information now available.

Counting the number of lake and river associations or citizens doing water monitoring would show success in this area. The number of people participating in environmental education and monitoring programs would also reflect citizen involvement.

Next steps

The Lake Superior Basin Team and Programmatic Work Groups are working on a plan to be completed December 2001. The vision is that the state water plan will complement the basin plan, and together, they will be a useful tool for protecting and improving Minnesota's water resources.

Basin team

Pollution Control Agency; Minnesota departments of Natural Resources, Agriculture and Health; Board of Water and Soil Resources; U.S. Department of Agriculture Natural Resources Conservation Service; and American Indian tribal, county and local governments involved with natural resource and land use issues.

SELECTED UNIQUE ENVIRONMENTAL CONDITION INDICATORS IN THE LAKE SUPERIOR BASIN

Goal: Minnesotans will improve the quality of water resources.

OBJECTIVES	INDICATORS
Protect and improve water quality in rivers, streams and other water courses.	~ Biochemical oxygen demand ~ Stream water temperature ~ Expanded fish advisories ~ Indices of fish tumors ~ Cold-water fish species that have existed or did exist after 1975
Protect and improve lake water quality.	~ Cold-water fish species that have existed or did exist after 1975 ~ Indices of fish tumors ~ Expanded fish advisories
Protect and improve groundwater quality.	~ Chloride

Goal: Minnesotans will conserve water supplies and maintain the diverse characteristics of water resources to give future generations a healthy and a strong economy.

OBJECTIVES	INDICATORS
Maintain the hydrologic characteristics of surface water bodies that support beneficial uses.	~ Changes in wetland acres, type and function

Goal: Minnesotans will restore and maintain healthy ecosystems that support diverse plants and wildlife.

OBJECTIVES	INDICATORS
Ensure that aquatic environments have conditions suitable for the maintenance of healthy self-sustaining communities of plants and animals.	~ Remaining and reestablished wild rice stands

Goal: Minnesotans will have diverse opportunities to enjoy the state's water resources.

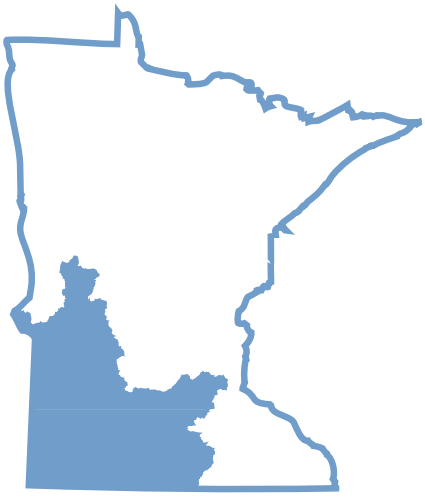
OBJECTIVES	INDICATORS
Provide access to water recreation sites.	~ Number of public swimming beaches ~ Number of resorts operating on basin waters ~ Expansion of recreation sites, as indicated on public recreation information maps
Improve or maintain the quality of water recreation.	~ Property owners' satisfaction with their lake experience

SELECTED UNIQUE PRESSURE INDICATORS IN THE LAKE SUPERIOR BASIN

Goal: Minnesotans will improve the quality of water resources.

OBJECTIVES	INDICATORS
Protect and improve the quality in rivers, streams and other water courses.	~ Percentage of land conversion in the shoreland impact zone
Protect and improve lake water quality.	~ Percentage of land conversion in the shoreland impact zone ~ Septic system compliance trends ~ Number of wastewater permit violations

Minnesota, Missouri and Des Moines River Basins



The Minnesota, Missouri and Des Moines River Basins drain over 18,259 square miles.

PERCENT OF CROPLAND ERODING ABOVE TOLERANCE LEVELS

	1982	1987	1992
Wind	36.7	42.7	40.5
Water	13.9	13.2	10.8

LAND USE CHANGES

	1992 Acres in thousands	Percent change 1982-1992
Cropland	8,555	-4.47%
Grassland	1,272	36.72
Forest	276	-2.71
Urban	608	8.50
Wetland	1,783	-0.70

Source: U.S. Department of Agriculture Natural Resources Conservation Service

POPULATION

1990	1998	Percent change
846,918	925,185	9.24%

Source: Minnesota Planning

The Minnesota River flows 335 miles from the South Dakota border into the Mississippi River in St. Paul. The hydrology in the river's basin today differs greatly from what it was before settlement in the middle 1800s, when the basin stored much more water in wetlands and swamps and its vegetation was largely prairie. Since then, much of the area has been drained for agricultural purposes. Land use in the basin is largely agriculture, with urban and industrial uses growing in importance, especially in and around the expanding Twin Cities metropolitan area.

The Minnesota River is affected by nutrients such as phosphorus and nitrogen, sediment, low dissolved oxygen and bacteria. In addition to causing local impacts, some pollutants have cumulative effects that are felt farther downstream: phosphorus affects the lower Minnesota River, causing low dissolved oxygen levels; sediment has been linked to the accelerated filling in of Lake Pepin; and nitrogen is a factor in the zone of hypoxia in the Gulf of Mexico, an area below the delta of the Mississippi in which the water near the bottom lacks adequate dissolved oxygen. The decreased amounts of water storage in the basin affect stream flows and contribute to extreme high and low flow.

The Missouri and Des Moines River Basins drain all or part of nine counties in the southwest corner of Minnesota. While it drains 10 states and a bit of Canada, the Missouri River Basin drains only a small part of Minnesota — 3,317 square miles. The Des Moines River Basin lies mostly in Iowa, but its headwaters are in southern Minnesota. Both the Des Moines and Missouri Rivers drain to the Mississippi River.

The population of these combined basins, which include the southwestern portion of the Twin Cities metropolitan area along with the cities of Mankato, Alexandria, New Ulm, Marshall and Worthington, rose 9.2 percent from 1990 to 1998. Scott County increased by 34.7 percent, making it the second fastest-growing county in the state. Basin counties outside the metropolitan area that gained population include Douglas (9.8 percent) and Nicollet (7.3 percent); those that lost population include Lac qui Parle (-4.3 percent), Faribault (-3 percent) and Big Stone (-6.5 percent).

Lakes in these three basins are predominantly shallow and vary in quality. Lakes in the northern part tend to be deeper and have better water quality than those in the south. Phosphorus is usually the primary pollutant of concern in lakes because excess levels lead to nuisance algae blooms. One of the main pollutants in groundwater is nitrogen in shallow surficial aquifers. Water quantity is a problem in the southwest. Concerns about water quality and quantity have led to the expansion of rural water distribution systems with centralized public drinking water supplies in the western part of the basin.

Status of basin planning

Attention has centered on the Minnesota River for many years and increased in 1989, when more than 30 federal, state and local agencies began the Minnesota River Assessment Project. This resulted in Governor Arne H. Carlson setting a 10-year goal for the Minnesota River to be fishable and swimmable. The state established a Minnesota River Citizens' Advisory Committee to review the project's results. In 1994, the committee made the following recommendations to improve water quality: restore floodplains and riparian areas; restore wetlands; manage drainage ditches and storm sewers as tributaries; improve land management practices; monitor water quality throughout the Minnesota River Basin; establish a Minnesota River Commission to oversee the cleanup effort; establish local joint powers agreements; improve technical assistance to local governments; engage the general public in water issues; and enforce existing laws.

A good deal of planning is occurring at all levels in the Minnesota River Basin. Counties identify local goals for water resource use and protection in their comprehensive local water plans. Larger in scope are watershed plans. Both types of plans can influence local land use decisions. Other plans include the Department of Natural Resource's *Minnesota River Watershed Comprehensive Recreational Guidance Document*, which provides guidance for developing recreational opportunities within the watershed, and the Pollution Control Agency's *Minnesota River Basin Plan*. Components of these plans have been used in developing the basin's report.

The Missouri and Des Moines River Basins lack the extensive state and federal plans and assessments that the Minnesota River Basin has. Plans for these basins are primarily developed by local governments.

Statewide goals, objectives, and indicators of particular importance

The statewide goals, objectives and indicators fit the three basins well. For a number of waters, meeting water quality standards will be an improvement. In some surface waters, dissolved oxygen, turbidity and bacteria often exceed the standard. Nitrogen poses a problem both locally and downstream. Exotic species of particular concern are Eurasian water milfoil, zebra mussels and curly-leaf pond weed. Water conservation, healthy ecosystems and recreation are also important to the basins.

Unique objectives and environmental indicators

Over the past decade, local, state and federal assessments have identified a number of problems in the Minnesota River Basin. Consequently, targets either have been or will be established. Some of these targets are included in the table.

Both the Des Moines and Missouri River Basins have unique priorities as well. Protecting the Topeka shiner, an endangered fish species found in Minnesota, is a priority in the Missouri River Basin. Because of shallow lake depths and lake fertility issues, aeration systems for fish management are necessary in the Des Moines River Basin. An indicator measuring the number of aeration systems on lakes is suggested to monitor lake health.

Unique objectives and pressure indicators

The team suggests land use indicators for each objective because land uses directly affect water resources. Local planning drives land use change; thus, plans can be used to indicate progress on environmental issues. A county's comprehensive plan can form the basis for more specific natural resource plans. The team would like to track many types of plans that would provide local information and strategies for water management, including lake management, source water protection and water conservation plans. The latter would involve developing strategic use plans with large water users.

It is important to determine the areas — whether watershed, county or smaller — that would benefit from having an up-to-date resource plan so that the appropriate water quality issues are addressed. Such plans form a foundation on which measurable improvement can occur. Tracking plans by farmers on application of nutrients, manure and pesticides would show efforts to reduce associated problems. Although it may be challenging to measure success in improving water quality, these plans signify progress in addressing human impacts on water resources.

Water recreation is an asset in the three basins. It is important to promote the area as a viable recreational resource within the state and the upper Midwest. In addition, resource protection should be addressed in future development proposals. Striking a balance between development and recreational resource protection can sustain resources for generations to come. Counting the number of communities using conservation connections and "smart growth" principles, as well as public and private cooperative ventures for managing water resources and recreation, would reflect trends toward a sustainable use of resources and opportunities for access to natural spaces.

While it is not unique for a basin to have groundwater quantity and quality problems, these are especially significant in the Missouri and Des Moines River Basins. Where aquifers are sensitive to contamination, it is important to monitor for pollutants. The risk of contamination is greater for the shallow aquifer systems.

Other issues of significance in the basin

While financial resources have been dedicated to identify problems and improve the water quality of the Minnesota River, adequate funding is and will continue to be important to carrying out this task. Watershed projects in the Missouri and Des Moines River Basins also depend on adequate funds to solve their priority water quality problems. The team recommends that state and federal funds be provided in sufficient amounts to ensure success in improving high-priority water resources.

Land use change occurs on the local level. Thus, it is important to involve local governments, watershed projects and other interests in planning and implementation processes. The number of cooperative ventures among public agencies and private-sector interest groups is worthy of tracking.

Next steps

The team will work toward determining how each indicator will be measured and develop strategies to meet targets. Developing the next part of this plan will require working in cooperation with county water planners, soil and water conservation districts, watershed projects and the Minnesota River Basin Joint Powers Board.

Basin team members

Pollution Control Agency; Minnesota departments of Natural Resources, Health and Agriculture; Board of Water and Soil Resources; and U.S. Department of Agriculture Natural Resources Conservation Service. The team solicited input from soil and water conservation districts, county water planners, watershed projects, the Minnesota River Basin Joint Powers Board and the general public.

SELECTED UNIQUE ENVIRONMENTAL CONDITION INDICATORS IN THE MINNESOTA, MISSOURI AND DES MOINES RIVER BASINS

Goal: Minnesotans will improve the quality of water resources.

OBJECTIVES	INDICATORS AND TARGETS
Protect and improve water quality in rivers, streams and other water courses.	~ Stream transparency readings *Specific to the Minnesota River Basin:* ~ Annual phosphorus loading in the Minnesota River at Jordan: reduce to 200 tons (60 percent) at low flow, 700 tons (40 percent) at medium flow and 1,200 tons (40 percent) at high flow ~ Nitrogen concentrations: reverse increasing trend ~ Sediment loading: reduce watersheds by 30 percent from historic levels (average annual loads 1980 to 1989, by 2010) ~ Carbonaceous biochemical oxygen demand: reduce by 40 percent under low flow conditions to maintain dissolved oxygen levels at 5 milligrams per liter in the lower Minnesota River
Protect and improve lake water quality.	~ Fish, invertebrate and macrophyte populations in lakes *Specific to the Missouri and Des Moines River Basins:* ~ Dissolved oxygen levels
Protect and improve groundwater quality.	~ Chloride in groundwater ~ Volatile organic compounds in groundwater ~ Total atrazine *Specific to the Missouri and Des Moines River Basins:* ~ Water quality changes in shallow aquifers

Goal: Minnesotans will conserve water supplies and maintain the diverse characteristics of water resources to give future generations a healthy environment and a strong economy.

OBJECTIVES	INDICATORS AND TARGETS
Maintain groundwater levels to sustain surface water bodies such as lakes, wetlands, fens and rivers and provide water supplies for human development.	~ Number of aquifers with sustainable-yield problems ~ Number of calcareous fens identified and protected
Maintain the hydrologic characteristics of surface water bodies that support beneficial uses.	~ Number of new subdivisions or building permits for shoreland area

Goal: Minnesotans will restore and maintain healthy aquatic ecosystems that support diverse plants and wildlife.

OBJECTIVES	INDICATORS AND TARGETS
Ensure aquatic environments have conditions suitable for the maintenance of healthy self-sustaining communities of plants and animals.	~ Number of territories occupied by bald eagles ~ Frog and toad populations ~ Mussel community index ~ Number of species on threatened or endangered species lists *Specific to the Des Moines River Basin:* ~ Blue-winged teal and mallard populations ~ Nesting colonial birds and other aquatic species

Goal: Minnesotans will have reasonable and diverse opportunities to enjoy the state's water resources.

OBJECTIVES	INDICATORS AND TARGETS
Provide access to water recreation sites.	~ Miles of stream corridor easements ~ Percentage of public water accesses meeting the requirements of the Americans with Disabilities Act
Improve or maintain the quality of water recreation.	~ Number of lakeshore and river parks ~ Miles of corridor linking new and expanding recreational facilities and areas to existing recreational opportunities *Specific to the Missouri and Des Moines River Basins:* ~ Hunter satisfaction surveys

SELECTED UNIQUE PRESSURE INDICATORS IN THE MINNESOTA, MISSOURI AND DES MOINES RIVER BASINS

Goal: Minnesotans will improve the quality of water resources.

OBJECTIVES	INDICATORS AND TARGETS
Protect and improve water quality in rivers, streams and other water courses.	~ Number of acres of restored floodplains, including re-establishment of vegetative buffer ~ Number of acres of restored and preserved wetlands ~ Implementation of erosion control practices (percent of cropland meeting 30 percent residue guidelines from tillage transect survey) ~ Number of nutrient and pesticide management plans ~ Enrollment of acreage in wetland and riparian conservation programs
Protect and improve lake water quality.	~ Number of upgraded individual sewage treatment systems

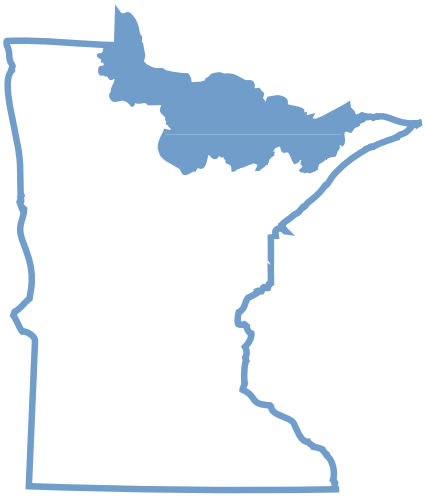
Goal: Minnesotans will conserve water supplies and maintain the diverse characteristics of water resources to give future generations a healthy environment and a strong economy.

OBJECTIVES	INDICATORS AND TARGETS
Maintain groundwater levels to sustain surface water bodies such as lakes, wetlands, fens and rivers and provide water supplies for human development.	~ Per capita use of water
Maintain the hydrologic characteristics of surface water bodies that support beneficial uses.	~ Number of flood-damaged structures removed ~ Number of upland land use practices that reduce or retain overland runoff flows ~ Number and costs of drainage projects (ditch and tile improvements; feet of tile purchased) and systems managed to reduce peak flows ~ Acres of land converted to filter strips and buffers

Goal: Minnesotans will restore and maintain healthy aquatic ecosystems that support diverse plants and wildlife.

OBJECTIVES	INDICATORS AND TARGETS
Ensure aquatic environments have conditions suitable for the maintenance of healthy self-sustaining communities of plants and animals.	~ Number of acres of sustainable agriculture
Limit geographic range of exotic species.	~ Acres of preservation of existing natural habitats and restoration of degraded habitats ~ Acreage of pastures and right-of-ways managed for removal of exotic species
Improve or maintain the quality of water recreation.	~ Number of multiuse areas providing nonconflicting recreation opportunities and enhanced habitat

Rainy River Basin



The Rainy River Basin drains over 11,238 square miles.

PERCENT OF CROPLAND ERODING ABOVE TOLERANCE LEVELS

	1982	1987	1992
Wind	59.9	77.5	68.5
Water	0	0	0

LAND USE CHANGES

	1992 Acres in thousands	Percent change 1982-1992
Cropland	243	-15.6%
Grassland	105	132.52
Forest	3,579	.47
Urban	74	3.36
Wetland	3,326	-0.34

Source: U.S. Department of Agriculture Natural Resources Conservation Service

POPULATION

1990	1998	Percent change
54,538	55,640	2.02%

Source: Minnesota Planning

The Rainy River Basin sits on Minnesota's border with Canada and is home to some of the state's finest forest and water resources. Voyageurs National Park and the Boundary Waters Canoe Area Wilderness are located within the Rainy River Basin, as are several of Minnesota's most famous walleye fisheries and many top-notch trout streams. A majority of the land is forested. Prominent uses of natural resources in the area are forestry, mining and various forms of recreation.

Population in the basin grew 2 percent between 1990 and 1998 — an increase that is somewhat understated due to unusual circumstances in Koochiching County. Officially, Koochiching lost nearly 3 percent of its population during the period. However, the 1990 population was somewhat inflated by the presence of a large construction crew building a Boise-Cascade paper mill. Lake of the Woods County is the most rapidly growing portion of the basin, increasing by nearly 12 percent during the period.

Status of basin planning

Originally composed of representatives from state and federal agencies responsible for managing natural resources in the basin, the Basin Team was expanded to include local resource managers from throughout the basin. Serving on the team were staff members of soil and water conservation districts, county environmental services and zoning departments, water planners, the U.S. Forest Service, Voyageurs National Park and the Red Lake and Bois Forte bands of Chippewa Indians. The International Joint Commission also participates in planning and regulating resources in the area.

Citizen involvement in the planning process is crucial. The team wanted to work from the local level up to develop a plan that would satisfy the residents of the basin as well as resource managers. The team's primary objective is to ensure that goals, objectives and indicators in the state plan are broad enough to be relevant to the Rainy River Basin. There was not enough time in the state planning effort to develop basinwide goals, objectives and indicators, so these, along with strategies and projects, will be included in the basin plan.

Statewide goals, objectives and indicators of particular importance

Because lakes are a valuable resource in the Rainy River Basin, fecal coliform content and trophic state should be monitored. Levels of nitrogen and fecal coliform in groundwater are a concern in the basin. Groundwater quantity and water table depletion do not appear to be issues because of the basin's relatively small population. Recreational uses of the basin's water resources are particularly important. Comprehensive surveys measuring the satisfaction of all types of users, including those who want to quietly enjoy water resources, would be useful in determining priorities.

Unique objectives and environmental indicators

The susceptibility of lakes to acid precipitation and mercury deposition is of significant concern in the Rainy River Basin. In other parts of the world, lakebeds are in limestone, which neutralizes the acid in rain, but in northern Minnesota, the lakebeds are in granite, which does not weaken the acid. Because trout streams are important to the basin, stream temperatures would be a valuable measure for assessing stream health. Stream quality changes must be addressed before populations of fish and aquatic life are lost. A similar measure of value might be water quality downstream of rice paddies. Wetland quality and function are important in the basin as well. Wetland functions are now better understood and should be addressed.

As in the rest of the state, exotic species are a concern in the Rainy River Basin. Infestations of exotics have not been dramatic, as in other regions, but preventing further spread is crucial. Among the exotics of specific concern in one or more counties in the basin are purple loosestrife, Eurasian water milfoil, rainbow smelt, rusty crayfish and zebra mussels.

Wild rice is grown in the northern one-third of the state on an estimated 18,500 acres in the counties of Aitkin, Beltrami, Cass, Clearwater, Crow Wing, Itasca, Koochiching, Lake of the Woods, Polk, and Pennington. In 1999, cultivated wild rice production was 6.2 million processed pounds, up from 3.9 million pounds in 1989.

Unique objectives and pressure indicators

Onsite sewage treatment is a major water resource concern in the Rainy River Basin, particularly on the bedrock lakes toward the eastern part of the basin, where soils and slopes frequently are limiting factors. The need to develop and apply new technologies for onsite sewage treatment is significant.

Industrial and urban source pollution is a problem here as in other parts of the state. The water quality of the Rainy River is monitored and has improved dramatically in recent years. However, paper mills in Minnesota and Canada discharge more waste water into the Rainy River than all other sources combined. The list of pollutants measured by the state should include toxic pollutants.

Other issues of significance in the basin

The state is encouraged to give local water planning substantial support in the future. Locally based, state-supported water planning has been successful in the counties of the Rainy River Basin. The collaboration of local groups, state agencies and others working to improve and protect water resources has created a strong base of local support. These efforts should translate into increased water quality for downstream areas in the basin.

Providing public education and information is crucial for successful water management. A public information and education tool kit should be developed to encourage local involvement.

The key to success in the Rainy River Basin is the involvement of citizens and other local interests. This involvement is necessary if local water planning efforts are to succeed. The state plan should be the beginning of a partnership across all jurisdictions. State planning efforts would be more manageable for local governments if they were better integrated with ongoing planning processes. To foster the integration of local planning, the team recommends reorganizing schedules to incorporate county water plan updates and reduce conflict with year-end reports for local government.

Measurements of progress in meeting the state objectives need to reflect the landform type in addition to the basin or watershed. The basin would profit from a geographic land use component incorporated into future plans to better identify where water quality issues are broadly divergent. This could be done by regional landform or ecoregion. For example, water conditions differ in a forested area compared to a peat bog or a plains area. Identifying where there are natural variations in the conditions of waters is an important element in evaluating land use.

In addition, climate variations need to be considered when compiling results. Some water quality parameters can vary significantly from year to year, depending on climatic conditions. Annual rainfall, for example, generally increases from the west to the east, affecting water quality. Other factors, such as the effect of natural water color on water clarity, need to be considered carefully when comparing different water bodies or especially different major watersheds. Another important lake water quality parameter that can make setting targets difficult is the likelihood of an individual lake to thermally stratify, or develop thermal "layers." Indicators in any future plans should incorporate a weather or climate factor.

The Rainy River Basin is an international basin. Many international goals and objectives are already in place. The International Joint Commission's Rainy River Alert Levels are internationally adopted, ambient water quality standards based on standards of the United States, Canada, the state of Minnesota and the province of Ontario. The commission's standards should be adopted as the Minnesota water quality standards for the Rainy River. Clearer overall direction for greater international cooperation is needed for border waters. Local stakeholders need more opportunity for involvement with the International Joint Commission's Rainy River and Lake of the Woods boards. There is a significant need for increased communication across the U.S.-Canadian border among residents, stakeholders, elected officials and local, state or provincial and federal agencies.

Next steps

Basin goals, objectives and indicators, along with strategies and projects, will be developed as part of the Rainy River Basin plan in 2001.

Basin team members

Pollution Control Agency; Minnesota departments of Natural Resources, Health and Agriculture; Board of Water and Soil Resources; U.S. Department of Agriculture Natural Resources Conservation Service; Chippewa National Forest, Superior National Forest; Voyageurs National Park; U.S. Geological Survey; Arrowhead Regional Development Commission; Bois Forte Band of Chippewa Indians; Red Lake Band of Chippewa Indians; Rainy River First Nations; basin soil and water conservation districts, local water planners, county planning departments and various town board officers.

SELECTED UNIQUE ENVIRONMENTAL CONDITION INDICATORS IN THE RAINY RIVER BASIN

Goal: Minnesotans will improve the quality of water resources.

OBJECTIVES	INDICATORS
Protect and improve water quality in rivers, streams and other water courses.	~ Stream water temperature ~ Water quality downstream of rice paddies ~ Alkalinity/acid neutralizing capacity ~ Mercury content in fish tissue
Protect and improve lake water quality.	~ Carlson's Trophic State Index ~ Alkalinity/acid neutralizing capacity ~ Mercury content in fish tissue

Goal: Minnesotans will conserve water supplies and maintain the diverse characteristics of water resources to give future generations a healthy environment and a strong economy.

OBJECTIVES	INDICATORS
Maintain the hydrologic characteristics of surface water bodies that support beneficial uses.	~ Changes in wetland acres, type and function

Goal: Minnesotans will have diverse opportunities to enjoy the state's water resources.

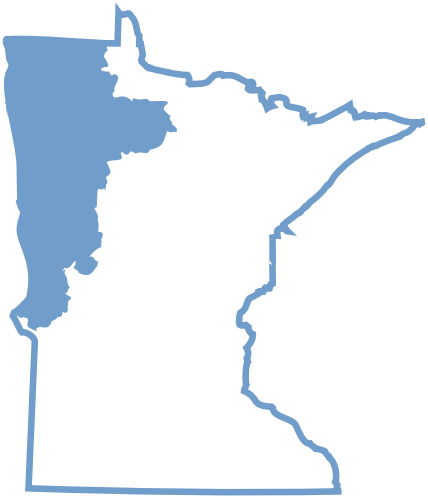
OBJECTIVES	INDICATORS
Improve or maintain the quality of water recreation.	~ Passive or quiet water resource user survey

SELECTED UNIQUE PRESSURE INDICATORS IN THE RAINY RIVER BASIN

Goal: Minnesotans will improve the quality of water resources.

OBJECTIVES	INDICATORS
Protect and improve water quality in rivers, streams and other water courses.	~ Sewage-born pathogens and nutrients
Protect and improve lake water quality.	~ Sewage-born pathogens and nutrients

Red River Basin



The Red River Basin drains over 17,743 square miles.

PERCENT OF CROPLAND ERODING ABOVE TOLERANCE LEVELS

	1982	1987	1992
Wind	79.4	81.1	83.9
Water	2.8	2.6	2.6

LAND USE

	1992 Acres in thousands	Percent change 1982-1992
Cropland	5,495	-10.90%
Grassland	1,463	81.92
Forest	2,084	-1.87
Urban	355	4.51
Wetland	2,716	0.34

Source: U.S. Department of Agriculture Natural Resources Conservation Service

POPULATION

1990	1998	Percent change
237,396	244,102	2.87%

Source: Minnesota Planning

The broad, flat valley of the Red River of the North basin has been called a "tabletop." Continental glaciers shaped a landscape of lake plains at the center of the basin and gently rolling uplands, lakes and wetlands along the basin margins. The fertile soils and landscape are conducive to agriculture. Productive cropland covers 66 percent of the land area, with pasture, forests, open water and wetlands comprising most of the rest.

From its origin at the confluence of the Bois de Sioux and Ottertail Rivers at Breckenridge, Minnesota, the Red River of the North meanders northward for 394 miles to the Canadian border, a path that is nearly double the straight-line distance. The Red River of the North normally receives more than 75 percent of its annual flow from its Minnesota tributaries as a result of regional climate patterns, soils and topography. Most runoff occurs in spring and early summer from rains falling on melting snow or saturated soils. Lakes, prairie potholes and wetlands are abundant in most areas outside of the Red River Valley lake plain. Dams, drainage ditches and wetlands alter the residence time of water, thereby affecting the amount of sediment, biota and dissolved constituents the water carries.

The population in the Red River Basin rose 2.9 percent between 1990 and 1998. The basin includes the metropolitan areas of Fargo-Moorhead and East Grand Forks, resort areas around Bemidji, Detroit Lakes and Fergus Falls, and river valley farming areas. The farming areas along the Red River continue to lose population. Counties such as Kittson (-5.4 percent), Marshall (-4.8 percent), Norman (-4.3 percent) and Red Lake (-2.7 percent) in the northern portion of the basin and Traverse (-4.8 percent) and Wilkin (-2.7 percent) in the southern portion have had long-term population loss. Clay County, which contains Moorhead, gained 5.5 percent. Resort counties also gained, including Becker (6.1 percent), Ottertail (7.3 percent) and Beltrami (10.2 percent). The floods of 1997 did not result in population loss except in the immediate East Grand Forks area.

Status of basin planning

Cooperative planning is quite advanced in the basin. Two recent studies — the U.S. Geological Survey's National Water Quality Assessment (1992-95) and the U.S. Army Corps of Engineers' Generic Environmental Impact Statement on Proposed Impoundments (1996) — provide information for planning efforts. A number of joint efforts are underway. In 1998, the Red River Basin Board, composed of representatives from Minnesota, North and South Dakota, and Canada, was organized to develop a water management plan for the basin. In the same year, federal, state, regional and local entities reached a Flood Damage Reduction Agreement that offers a model for reconciling water supply goals with watershed protection. The Minnesota Red River Basin Water Quality Plan, facilitated by the Pollution Control Agency, was developed by residents, water interests and federal, state and local government resource managers in 1999.

The Red River Basin Team coordinated with each of these efforts in conducting its planning and developing the basin's report. It drew on the work and participation of organizations and planning groups at the local, state and regional levels, and then sought the advice of four local committees established for water quality planning. Future efforts will include the updating of nine watershed district and 21 local county water plans and planning for protection of public source water supplies.

Statewide goals, objectives and indicators of particular importance

The quality of the water in streams, rivers and ditches in the basin is vitally important because the Red River is a source of drinking water. This quality is affected by the

area's geology, topography and land use, all of which increase the potential for nutrient and sediment loading. For this reason, tracking individual measures that comprise state standards and criteria for streams — especially the levels of phosphorus, nitrogen, ammonia, biochemical oxygen demand, total suspended solids and fecal coliform bacteria — is valuable.

Both groundwater quality and quantity are of concern in the basin. Several closed basin lakes have risen to record levels in the recent wet cycle, resulting in reduced water quality and damaged property. The hydrologic characteristics of streams and rivers in the basin have particular influence because the Red River flows north and the presence of ice in the north exacerbates flooding in the southern headwaters, yet in late summer and early fall, many tributaries have little or no flow. In addition, extensive drainage and the removal of wetlands, have affected the flow of surface water. Basin residents are interested in reducing the extremes when it is economically and ecologically responsible to do so.

Residents also are concerned about the biological integrity of aquatic species diversity in streams and rivers. An index of biotic integrity has been established for fish and is being extended to other aquatic species.

Enhancing water recreation activities matters to many in the basin, in part because it emphasizes the ecological value of the basin's waters. Lakes, which are concentrated mostly in the central and southeastern regions of the basin, are a major tourist attraction, and their water quality is critically important.

Unique objectives and environmental indicators

A new objective to reduce flood damages was recommended by the basin team. Flooding plagues the basin, and planning for controlling flood damage is continuing. The Flood Damage Reduction Agreement defines a process by which local watershed districts can reconcile water supply goals with ecological principles of watershed protection. Team members believe that the agreement is a model that could be used by other parts of the state.

Because of the area's unique geology, the need to increase knowledge of groundwater resources is significant. Arsenic occurs naturally in geologic formations in the region, which is a concern for drinking water supplies. Identifying and routinely measuring levels of particular compounds in groundwater is considered a good way to recognize emerging issues. The team proposed considering completed county geologic atlases, updated county local water management plans and protected recharge areas as strategies for improving understanding of groundwater.

Unique objectives and pressure indicators

Because land use activities directly affect water resources, planning participants suggested land use measures for most objectives. Crowding around shoreland is a growing problem, and zoning variances and wetland filling put pressure on lakes and streams. Poor feedlot and animal waste management contributes to excess nutrients, and measuring the number of feedlot and waste management plans gives an indication of protection efforts. Other land use indicators include measuring the acres or feet of buffer and filter strips and counting the number of sediment basins.

Converting marginal land from agriculture to permanent vegetation reduces problems from runoff and provides for wildlife habitat. Using conservation tillage transects or some other measure of conservation tillage could identify efforts to reduce sediment loading.

Other issues of significance in the basin

Adequate funding is the most important tool for implementing any water management plan. Basin residents and stakeholders are very realistic about the need to adequately fund their plans and recognize the importance of federal and state cost-sharing opportunities. To achieve the goals of the state plan, water resources protection, preservation and restoration have to be done at the local level.

Another high priority is to continue the well-developed basin management and intergovernmental cooperation that characterizes planning in the Red River basin. The plans and projects of the International Joint Commission and the Red River Basin Board, along with the basin plan and the Flood Damage Reduction Agreement, help shape local plans. There is a strong willingness to coordinate planning efforts to minimize effort and maximize results.

Recognizing that state and basin goals and objectives cannot be achieved without citizen involvement, planning participants suggest an educational goal of creating awareness so that citizens practice wise land and water stewardship. Participation in volunteer monitoring programs and lake associations could be a measure of citizen involvement. Planning participants also expressed interest in tracking the time it takes the state to act on violations in standards.

Next steps

The team that developed the Minnesota Red River Basin Water Quality Plan is working to develop an appropriate basin organization to lead plan implementation. Goals will be achieved through specific projects, and fund-raising strategies will be developed to support these projects. Basin-wide water quality monitoring will be expanded and a strategy coordinated to protect the Red River as a supplier of drinking water. Designing and implementing a nonpoint-source pollution reduction information and education campaign are also proposed. To ensure success, the team will continue to work toward integrating planning efforts, including the Flood Damage Reduction Agreement, to achieve water-related goals and objectives.

Basin team members

Board of Water and Soil Resources; Pollution Control Agency; Minnesota departments of Natural Resources, Agriculture and Health; and U.S. Department of Agriculture Natural Resources Conservation Service, with assistance from basin residents.

SELECTED UNIQUE ENVIRONMENTAL CONDITION INDICATORS IN THE RED RIVER BASIN

Goal: Minnesotans will improve the quality of water resources.

OBJECTIVES	INDICATORS
Protect and improve water quality in rivers, streams and other water courses.	~ Chemical oxygen demand, sulfates, sodium and protozoan, including cryptosporidium ~ Index of biological integrity ~ Stream water clarity
Protect and improve lake water quality.	~ Carlson's Trophic State Index
Protect and improve groundwater quality.	~ Number of compounds showing up in groundwater

Goal: Minnesotans will conserve water supplies and maintain the diverse characteristics of water resources to give future generations a healthy environment and a strong economy.

OBJECTIVES	INDICATORS
Maintain the hydrologic characteristics of surface water bodies that support beneficial uses.	~ Stream miles that have monitoring for stream suitability
Manage drainage and retention systems to balance water flow for flood damage reduction, economic purposes and natural resource enhancement	~ Trends in climatic cycles in relation to hydrologic characteristics of surface water

SELECTED UNIQUE PRESSURE INDICATORS IN THE RED RIVER BASIN

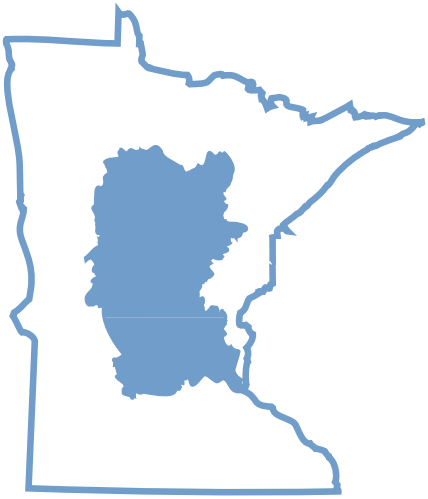
Goal: Minnesotans will improve the quality of water resources.

OBJECTIVES	INDICATORS
Protect and improve water quality in rivers, streams and other water courses.	~ Number of zoning variances granted in shoreland areas ~ A measure of conservation tillage
Protect and improve lake water quality.	~ Number of zoning variances granted in shoreland areas ~ Amount of conservation tillage ~ Number of wetlands filled and square footage of filling in shoreland areas ~ Number of feedlot waste and nutrient management plans implemented
Protect and improve groundwater quality.	~ A measure of best management practices in wellhead protection areas ~ Number of applications received for sealing unused, unsealed and abandoned wells ~ Number of acres protected or enhanced in aquifer recharge areas

Goal: Minnesotans will conserve water supplies and maintain the diverse characteristics of water resources to give future generations a healthy environment and a strong economy.

OBJECTIVES	INDICATORS
Manage drainage and retention systems to balance water flow for flood damage reduction, economic purposes and natural resource enhancements.	~ Number of acres of intensively farmed agricultural land receiving 10-year flood protection ~ Monetary value of infrastructure receiving 100-year flood protection ~ Reduction in flood damages ~ Acres of intensively farmed marginal agricultural land in long-term protection

Upper Mississippi River Basin



The Upper Mississippi River Basin drains over 20,089 square miles.

PERCENT OF CROPLAND ERODING ABOVE TOLERANCE LEVELS

	1982	1987	1992
Wind	30.8	37.1	37.8
Water	13.3	12.5	12.3

LAND USE CHANGES

	1992 Acres in thousands	Percent change 1982-1992
Cropland	3,580	-6.71%
Grassland	1,284	6.11
Forest	4,175	-2.23
Urban	861	14.14
Wetland	3,938	-.16

Source: U.S. Department of Agriculture Natural Resources Conservation Service

POPULATION

1990	1998	Percent change
2,330,502	2,545,189	9.21%

Source: Minnesota Planning

The Upper Mississippi River Basin is large and complex, draining all or portions of 30 counties and three ecoregions. The numerous lakes and streams found in the basin are generally thought to have good clarity. The northern portion is characterized by forests and wetlands with a significant number of seasonal homes. Agriculture is also a major land use in portions of the basin.

The basin is a diverse area including the cities of Minneapolis and St. Paul, most of the rest of the Twin Cities metropolitan area, the St. Cloud metropolitan area and much of the central lakes resort area of the state. It includes more than half of the state's population and many of the rapidly growing areas as well as some areas declining in population. For example, Sherburne County tops the state in growth with a 42 percent increase between 1990 and 1998 and the basin has five of the fastest growing cities. But St. Paul and Minneapolis, accounting for a fourth of the basin population, decreased in size. Some portions of the basin have experienced population growth in excess of 110 percent in the past 25 years. Between 1990 and 1998, the basin as a whole has gained 9.2 percent in population.

Status of basin planning

The conditions of the water resources in the Upper Mississippi River Basin are generally good in the north and somewhat impaired in the south. For this reason, water programs and activities of local governments tend to be aimed at protection in the north and restoration in the south. A water quality plan for the basin will be completed by the Pollution Control Agency in 2001. Other state efforts include establishing total maximum daily loads for rivers and lakes with a response plan and source water assessments in select areas. At the local level, three of the basin's six watershed districts outside of the Twin Cities metropolitan area are revising their plans, and 21 counties will update their comprehensive local water plans between 2000 and 2005.

Statewide goals, objectives and indicators of particular importance

Given the basin's large and diverse landscape, it is important that the indicators reflect local water quality characteristics. Dissolved oxygen, pH and phosphorous levels, as well as macroinvertebrate communities, are important indicators of water quality of streams, rivers and lakes. Measuring chlorophyll-a, trophic state indexes and total ortho-phosphorous will give a good indication of lake water quality in the basin.

Biological indicators are especially useful, including populations of native mussels and Blanding's turtles. As a general rule, however, the team believes that indicators are best developed at the local level and endorsed by local governments.

Unique objectives and environmental indicators

Development poses a threat to the water resources throughout the area. It is important to monitor indicators measuring the cumulative impact of development on key lakes as they are converted from an undeveloped to a developed state. Changes in upland and aquatic vegetation, as well as the percentage of shoreland altered, are examples of key environmental indicators.

The basin team recommends using surveys of recreational users and land owners, among others, as an indicator of water quality and recreation satisfaction.

Unique objectives and pressure indicators

Because population growth poses the biggest threat to water resources, tracking demographic and socioeconomic trends will help document these influences that may not show up in water data for some time, perhaps years. Indicators that show long-term, cumulative impacts are especially helpful, including those that reveal how environmental or natural resource impacts affect tax burdens and revenues. Shifts in land property values and uses also can be indicators. The number of nonconforming on-site sewage treatment systems affects both ground and surface water and should be monitored.

Since the devastating floods of 1997, the state has assisted local communities by cost-sharing the removal of about 2,500 structures from the 100-year flood plain.

Other issues of significance in the basin

The basin team received many comments about programs and issues relating to general water management. Suggestions include having the state develop a universal methodology for recording land use information, increasing the analysis of data collected and improving mechanisms for transferring information to local units of government. Optimum flows need to be established on rivers for fish habitat and waste assimilation as well as for local needs. To prevent decline, some undeveloped lakes, as well as the use of groundwater, should be monitored for cumulative impacts from development. Tracking the number of land acquisitions by conservancy groups would be one measure of preservation efforts. In addition, counting the number of communities delineating wellhead protection areas and developing source water protection plans would show protection efforts.

While water levels in all lakes fluctuate, some landlocked lakes experience large long-term fluctuations because outflow may only occur at very high levels. For example, since 1991, Sarah Lake in Polk county and Long Lost Lake in Clearwater County increased over 11 and 9 feet respectively.

Next steps

The Pollution Control Agency will complete a water quality plan for the basin by May 2001.

Basin team members

Board of Water and Soil Resources; Pollution Control Agency; Minnesota departments of Natural Resources, Health and Agriculture; Metropolitan Council; U.S. Department of Agriculture Natural Resources Conservation Service and U.S. Army Corps of Engineers. Private organizations, citizens and other interests provided assistance.

SELECTED UNIQUE ENVIRONMENTAL CONDITION INDICATORS IN THE UPPER MISSISSIPPI RIVER BASIN

Goal: Minnesotans will improve the quality of water resources.

OBJECTIVES	INDICATORS
Protect and improve water quality in rivers, streams and other watercourses.	~ Cumulative number of acres converted to land development ~ Changes in land use and vegetation ~ Number of pesticides detected in surface waters ~ Percent of shoreland protected by riparian buffer strips
Protect and improve lake water quality.	~ Cumulative number of acres converted to land development ~ Changes in land use and vegetation ~ Number of pesticides detected in surface waters ~ Percentage of shoreland protected by riparian buffer strips
Protect and improve groundwater quality.	~ Amount of total organic carbon

Goal: Minnesotans will restore and maintain healthy aquatic ecosystems that support diverse plants and wildlife.

OBJECTIVES	INDICATORS
Ensure aquatic environments have conditions suitable for the maintenance of healthy self-sustaining communities of plants and animals.	~ Change in sensitive or native vegetation populations ~ Change in natural mussel populations ~ Changes in aquatic vegetation ~ Changes in Blanding's turtle populations

Goal: Minnesotans will have reasonable and diverse opportunities to enjoy the state's water resources.

OBJECTIVES	INDICATORS
Provide access to water recreation sites.	~ Number of public riparian zones or beaches

SELECTED UNIQUE PRESSURE INDICATORS IN THE UPPER MISSISSIPPI RIVER BASIN

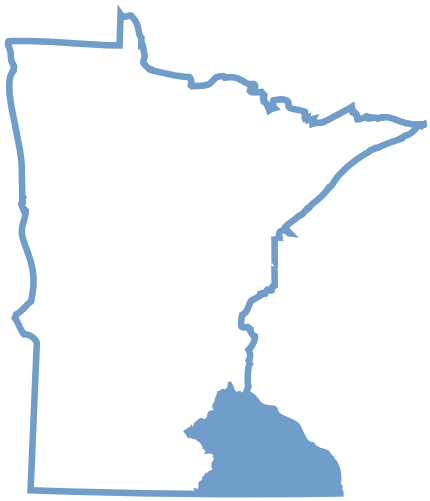
Goal: Minnesotans will improve the quality of water resources.

OBJECTIVES	INDICATORS
Protect and improve water quality in rivers, streams and other watercourses.	~ Percent of nonconforming on-site septic systems ~ Loss of upland resources and upland impacts ~ Track the cumulative impacts of development. ~ Track the decline of small land holdings.
Protect and improve lake water quality.	~ Percent of nonconforming on-site septic systems ~ Percent of shoreland altered ~ Percent change in shoreland impervious area ~ Loss of upland resources and upland impacts ~ Track the cumulative impacts of development. ~ Track the decline of small land holdings.
Protect and improve groundwater quality.	~ Acres of irrigated lands over sand plain aquifers ~ Number of Class V injection wells and underground injection ~ Number of feedlots and animal units per square mile ~ Number of abandoned wells

Goal: Minnesotans will conserve water supplies and maintain the diverse characteristics of water resources to give future generations a healthy environment and strong economy.

OBJECTIVES	INDICATORS
Maintain the hydrologic characteristics of surface water bodies that support beneficial uses.	~ Acres of irrigated lands over sand plain aquifers ~ Acres of impervious surfaces within designated watersheds

Lower Mississippi and Cedar River Basins



The Lower Mississippi River Basin drains over 7,345 square miles.

PERCENT OF CROPLAND ERODING ABOVE TOLERANCE LEVELS

	1982	1987	1992
Wind	6.2	6	6
Water	27.7	29	25.3

LAND USE CHANGES

	1992 Acres in thousands	Percent change 1982-1992
Cropland	2,814	-7.9%
Grassland	630	41.06
Forest	605	1.99
Urban	293	15.47
Wetland	243	-1.86

Source: U.S. Department of Agriculture Natural Resources Conservation Service

POPULATION

1990	1998	Percent change
539,787	603,997	11.89%

Source: Minnesota Planning

The Lower Mississippi River Basin, which includes the Cedar River Basin for planning purposes, is located in southeastern Minnesota. Cropland is the dominant land use. The basin includes rural as well as urbanized areas such as Dakota County and Rochester in Minnesota and La Crosse in Wisconsin.

Beautiful bluffs, springs, caves and numerous trout streams abound in the eastern basin, where steep topography and erosive soils increase the potential for soil erosion and resulting sedimentation of streams. The erosion potential is generally higher in this basin than elsewhere in the state. Sinkholes and disappearing streams highlight the direct relationship between surface and groundwater and the sensitivity of groundwater to pollution from land uses. In the western basin, Mississippi tributaries emerge as small streams out of a prairie landscape once rich in wetlands but now extensively drained to support productive agriculture. 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 basin's population grew 11.9 percent between 1990 and 1998. Most of the growth has been in Dakota (23.3 percent), Rice (10 percent), Dodge (10 percent) and Olmsted (11.8 percent) counties. The portion of the basin along the Iowa border experienced little population change.

Status of basin planning

Shortly before the basin team was selected for this effort, an ad hoc basin planning group had been formed to work on a basin plan. This group has become the Basin Alliance for the Lower Mississippi in Minnesota and is developing land use strategies for a basin plan scoping document. Since 1987, nine counties in the basin have participated in a joint powers board, the Southeastern Minnesota Water Resources Board. To its initial members, the basin team added two representatives — the executive directors of the nine-county Southeastern Minnesota Water Resources Board and the Cannon River Watershed Partnership.

Three objectives with specific indicators were added to those identified for the state plan. Numeric 10-year targets were identified where possible using water quality standards and other well-known benchmarks, such as the tolerable level of soil loss. Qualitative measures, such as "reverse a trend" or "increase levels," were specified where standards were missing.

Statewide goals, objectives and indicators of particular importance

Water quality targets were identified for phosphorus, nitrogen, fecal coliform bacteria and turbidity in streams and Secchi transparency in lakes. Nitrogen is a major concern both locally and in the Gulf of Mexico, where recurring hypoxia has been linked to high nutrient concentrations from the Upper Mississippi River Basin. Targets were set to reverse the increasing concentrations in streams and reduce concentrations in wells to meet drinking water standards. Since fecal coliform bacteria concentrations greatly exceed the standard in several streams in the basin, the team set a target of achieving the standard for all monitored tributaries within the decade. Purple loosestrife and eurasian watermilfoil, which are proliferating, are important exotic species to track.

In addition, the basin set distinct targets for types of streams and the Mississippi River. For example, targets for transparency vary: warm water streams would maintain at least 10 inches of transparency; cold-water streams would attain greater depth of

transparency to reduce the number of days turbidity exceeds the state standard; and the sediment load to the Mississippi River from tributaries would be reduced.

Unique objectives and environmental indicators

An array of birds, fish and other species is considered useful for tracking ecosystem health in this region. Indicators were selected to reflect species pertinent to the region and include different fish indicators for cold and warm water streams and the Mississippi River.

Understanding the satisfaction of boaters, anglers, birdwatchers and swimmers will help shape opportunities for recreational use. In addition, determining the number and water quality of swimming beaches will be useful.

The U.S. Geological Survey analyzed historical pesticide information and found that land use and pesticide use affect detections of pesticides in streams. In the Mississippi River basin, pesticides were found in or downstream of agricultural and urban areas. Atrazine, cyanazine, metolachlor and alachlor were the four herbicides most frequently found. Agricultural pesticide use was greatest in the Minnesota River Basin. Most concentrations were below levels considered harmful to human and aquatic health.

Unique objectives and pressure indicators

The new objective "manage land to support water quality and ecosystems" is measured by 10 indicators with targets. The indicators also provide measures for other objectives, and listing them together reflects their interrelationship. Land management is a major focus of local and tribal governments as well as state and federal laws and programs, and they have the authority to act to reduce detrimental effects. Targets were established to reduce soil erosion and improve farm and urban nutrient management, as well as to increase perennial vegetation and wetlands.

Another objective singles out the Mississippi River as a major water body with special needs. The lock-and-dam system maintaining the nine-foot channel greatly increased the rate of sediment deposition, including fine sediments in backwater areas. Frequent resuspension of these sediments creates a degree of turbidity that limits light penetration and impedes the growth of submersed aquatic vegetation, which greatly limits biodiversity in these potentially rich ecosystems. Reducing sediment loads from the tributaries would reduce the burden on the river systems.

Additional targets aim to reduce the frequency of severe algae blooms in several major lakes of the basin, including Pepin, Byllesby and Zumbro. This will require reducing phosphorus concentrations upstream in the Vermillion, Cannon and Zumbro Rivers, which is how progress toward protecting and improving lake quality will be measured.

The extent of water conservation efforts will be measured by tracking domestic, commercial, industrial and agricultural water consumption.

Other issues of significance in the basin

Engaging local organizations and citizens in water resource restoration activities was selected by the basin team as an objective that emphasizes the importance of the local and public involvement in water resources. The number of citizen monitoring projects and the number of watershed projects show citizen interest in water management. Comprehensive strategies for reducing key pollutants and creating good habitat conditions are planned for Vermillion, Cannon, Zumbro, Whitewater and Root River watersheds. Since land use may directly affect groundwater quality, a priority is to ensure that uses are compatible in areas affecting wells. Evaluating whether land uses are consistent with the wellhead plans developed by local communities provides a measure of efforts to protect drinking water supplies.

Next steps

The basin team will work to determine how each indicator and target could be measured and by whom. Work also will commence on evaluating programs and developing strategies to achieve the objectives.

Basin team members

Pollution Control Agency; Minnesota departments of Natural Resources, Health and Agriculture; Board of Water and Soil Resources; U.S. Department of Agriculture Natural Resources Conservation Service; and Metropolitan Council. The initial team was expanded to include the executive directors of the Southeastern Minnesota Water Resources Board and the Cannon River Watershed Partnership. An ad hoc basin planning group, established during the summer of 1999, provided considerable input on land use objectives. In addition to representatives of state agencies, other members of this ad hoc group included representatives of soil and water conservation districts, counties, the University of Minnesota Extension Service, the Minnesota-Wisconsin Boundary Area Commission, Whitewater River Watershed Project and South Zumbro Watershed Partnership. The Prairie Island Indian Community also participated in the water plan discussions.

Soil tests have shown that most lawns in the Twin Cities have very high levels of phosphorus. If phosphorus fertilizer is applied to these lawns, much of it runs off—to be carried to lakes, streams and wetlands. Yet in 1996 only about one quarter of the fertilizer sold in Minnesota contained less than 1 percent phosphate and over 21 percent contained over 10 percent, according to an analysis by University of Minnesota researchers reported in September 1999 CURA Reporter.

SELECTED UNIQUE ENVIRONMENTAL CONDITION INDICATORS IN THE LOWER MISSISSIPPI RIVER BASIN

Goal: Minnesotans will improve the quality of water resources.

OBJECTIVES	INDICATORS AND TARGETS
Protect and improve water quality in rivers, streams and other water courses.	~ Nitrogen concentrations in streams: reverse increasing trend ~ Stream transparency: minimum of 10 inches (25 centimeters) attained for warm water ~ Phosphorous loads: reduce to decrease algae blooms and maintain oxygen levels in lakes

Goal: Minnesotans will restore and maintain healthy ecosystems that support diverse plants and wildlife.

OBJECTIVES	INDICATORS AND TARGETS
Ensure that aquatic environments have conditions suitable for the maintenance of healthy, self-sustaining communities of plants and animals.	~ Diversity of native mussel species ~ Fish populations: introduce and maintain brook trout in cold water streams; maintain and increase smallmouth bass in warm water streams; and maintain and increase walleye population in the Mississippi River ~ Bird populations: maintain and increase populations of perching birds, shore birds, puddle ducks and diving ducks
Reduce sedimentation and slow the aging of navigation pools, maximizing biodiversity in backwaters while meeting reasonable transportation needs.	~ Sediment loads from tributaries to the Mississippi River: reduce

SELECTED UNIQUE PRESSURE INDICATORS IN THE LOWER MISSISSIPPI RIVER BASIN

Goal: Minnesotans will improve the quality of water resources.

OBJECTIVES	INDICATORS AND TARGETS
Manage land to support water quality and ecosystem health.	~ Area in pasture and uncultivated cropland: restore to 1982 levels (630,000 acres) from current estimates (448,000 acres) ~ Miles of stream riparian buffers: increase to least 50 feet on protected waters with native vegetation. ~ Miles of river where the flood plain is connected to the main channel during higher flow periods: maintain and increase ~ Buildings, fillings and impervious surface areas in and affecting flood plains: minimize ~ Soil loss of less than tolerance: achieve throughout basin by 2010 ~ Percentage of buffered surface tile intakes and drainage ditches: increase ~ Fall application of nitrogen fertilizer in the karst region: reduce and eventually eliminate ~ Use of phosphate-free fertilizer on lawns, golf courses and other urban areas: increase ~ Integrated pest management: increase ~ Percentage of population with properly functioning septic systems: increase ~ Phosphorus from wastewater treatment facilities upstream of the Zumbro, Byllesby and Pepin lakes: remove ~ Amount of acres where land is managed to protect and enhance wetland functions: increase ~ Feedlots, manure storage and management and other practices: ensure all feedlots are in compliance with feedlot rules by 2009

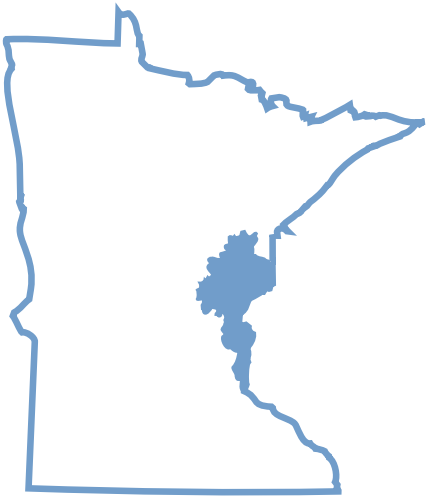
Goal: Minnesotans will conserve water supplies and maintain the diverse characteristics of water resources to give future generations a healthy environment and a strong economy.

OBJECTIVES	INDICATORS AND TARGETS
Maintain groundwater levels to sustain surface water bodies such as lakes, wetlands, fens and rivers and provide water supplies for human development.	~ Domestic, commercial, industrial and agricultural consumption of water

Goal: Minnesotans will have diverse opportunities to enjoy the state's water resources.

OBJECTIVES	INDICATORS AND TARGETS
Improve or maintain the quality of water recreation.	~ Swimmer and birdwatcher satisfaction surveys ~ Fecal coliform bacteria monitoring at beaches

St. Croix River Basin



The St. Croix River Basin drains over 3,529 square miles.

PERCENT OF CROPLAND ERODING ABOVE TOLERANCE LEVELS

	1982	1987	1992
Wind	10.6	16.9	18.1
Water	18.2	19.3	20.5

LAND USE CHANGES

	1992 Acres in thousands	Percent change 1982-1992
Cropland	485	-8.62%
Grassland	311	5.81
Forest	1,042	-1.38
Urban	110	15.26
Wetland	712	-0.11

Source: U.S. Department of Agriculture Natural Resources Conservation Service

POPULATION

1990	1998	Percent change
160,664	198,917	23.8%

Source: Minnesota Planning

The scenic features and good water quality in the St. Croix River Basin are widely recognized. Because of its many unique attributes, the St. Croix River is a federally designated Wild and Scenic River. It has also been designated as an Outstanding Resource Value Water by the U.S. Environmental Protection Agency, Wisconsin and Minnesota. Many watersheds within the basin, such as the Kettle River and a number of designated trout streams, also have state special-use designations.

The St. Croix River Basin is 7,760 square miles in size, of which 62 percent is located in Wisconsin and 38 percent in Minnesota. The river has 16 major tributaries, each draining at least 100 square miles of land. The St. Croix River Basin covers land in seven Wisconsin and seven Minnesota counties, encompassing an estimated population of about 350,000 people. A large portion of the basin is forested. Roughly the southern third of the basin is in the Twin Cities metropolitan area, which contains most of the basin's population and is pressured by rapid growth. Overall, the basin's population increased 23.8 percent between 1990 and 1998, with the bulk of the growth in Washington (32.3 percent) and Chisago (31.8 percent) counties. Other counties in the basin that had rapid increases were Pine and Kanabec, with 12.6 percent and 11.1 percent, respectively.

Status of basin planning

An interagency and interstate basin team has been working together since 1993 to coordinate Minnesota, Wisconsin and federal efforts in the St. Croix River Basin. This team was merged with the team for the Minnesota Water Plan because several people served on both. Wisconsin is also embarking on planning for the St. Croix River Basin, but this effort has a later time frame. The Lower St. Croix Wild and Scenic Cooperative Management Plan, which is in a final review stage, emphasizes cooperative basin planning and stewardship. Monitoring in the St. Croix River Basin is more advanced than in most basins; the basin has a monitoring plan implemented by both states, though additional funding will be needed to continue the effort. Recognizing the desire for trend information, the team recommended 68 indicators and selected targets for some. As a result of Wisconsin representatives participation in developing the basin's report, the state goals were broadened to include all basin residents.

Statewide goals, objectives and indicators of particular importance

A high priority is ensuring the basin's good water quality is not degraded; thus, tracking specific components that would lead to a designation of impaired water or a violation of a standard is very important. The team recommends monitoring trends in phosphorus, nitrogen, ammonia, turbidity and dissolved oxygen in streams and rivers. Tracking chlorophyll-a and Secchi transparency is recommended for lakes as well as streams. Fecal coliform bacteria is considered a good measure for water contact, and water temperature is helpful in gauging the health of trout streams.

The basin is the premier mussel watershed of the region, containing a high number of endangered and unique species. Exotics are a major concern, especially zebra mussels, purple loosestrife and rusty crayfish. Carp also should be tracked, because some lakes may not be infested. European buckthorn is adversely affecting native vegetation in the upland areas. Assessing the community structure and biotic integrity of fish, plants, algae and invertebrates is beneficial for understanding the environmental conditions.

Unique objectives and environmental indicators

Maintaining the quality and diversity of lakes, rivers and wetlands in the St. Croix River Basin are priorities and relate to a new objective to protect scenic and ecological values; this objective is delineated more fully in the discussion of pressure indicators. Trout streams abound in the basin, offering exceptional, nearby recreational opportunities for metropolitan residents. The team suggests tracking changes in the health of streams, lakes and wetlands by monitoring such things as indicators of biotic integrity (when developed), unionid mussel populations, populations and habitats of loons and bald eagles, and average percent of "embeddedness" of coarse substrates (the degree to which larger particles such as pebbles and gravel are surrounded or covered by fine sediment such as sand or silt).

Fishing is important in the basin, and tracking health advisories for water and fish consumption could show trends in pollutants and their spread. Urban and industrial sources of contamination could be tracked by monitoring mercury, PCBs, copper and heavy metals in sediment. In addition, the popular basin area needs diverse types of public access, since it contains a wide variety of unique waters that must be treated and accessed in different ways. Besides the intense boat use of the lower St. Croix River and recreational lakes, the basin is used by shore anglers, hikers, bird watchers, canoeists and shorelandowners.

Unique objectives and pressure indicators

A new objective was added to protect the scenic and ecological values of basin lakes and streams, particularly the Wild and Scenic St. Croix River and streams of special interest such as designated trout streams. This addition seeks to recognize that what is done to the shoreline of waters profoundly affects a quality water resource. Basin residents rank development pressures and land use changes as major concerns. Several other land use indicators are stressed, such as tracking impervious surfaces and the percent of floodplains lost by filling or diking. When floodplains are altered, floodwater storage is lost.

Urban and industrial wastes affect the quality of the land, and sediment contamination from mercury, PCBs, copper and other heavy metals also must be addressed. Counting the number of suspected abandoned wells and the number of class 5 injection wells could help find potential contamination sources of groundwater.

The basin team is studying the effects of dams. Both Wisconsin and Minnesota have been promoting the removal of dams, where feasible. While only the St. Croix Falls' dam and several in Wisconsin deviate from run-of-the-river operation, the basin team set a target for 100 percent of the dams operating run-of-the-river by 2010. Because the patterns of stream flow continually change, base flow of streams should be monitored to develop adequate trend data. The volume of groundwater appropriated is important, and increases in domestic, agricultural or industrial use can signal problems.

While recreation is important, it is also a major threat to water resources. The 211-mile-long St. Croix riverway is heavily used by watercraft of all sizes. The upper portion experiences largely nonmotorized use, while the lower portion is used primarily by larger motorized watercraft. Thus, while access is important for the public, it also may lead to overuse and affect the satisfaction of those not using motor boats for recreation. Heavy use creates noise problems along some stretches of the riverway, and increasing noise levels could signal changes in use or behavior. Stream bank erosion due to large wakes produced by boaters is also a concern, and studies have been conducted to identify those areas within the riverway where special restrictions on wakes may be necessary.

Other issues of significance in the basin

The basin team has proposed a goal that basin residents and their respective governments will have an accountable, locally responsive and coordinated management of water-related initiatives. It developed a new objective to improve coordination among levels of government so public resources are better used to address watershed problems and to reduce the number of conflicts between Minnesota's and Wisconsin's standards and rules. Indicators include the amount of resources allocated by each state and agency. In addition, the team recommends creating a coordinator's office for the basin.

Because of land use concerns, the basin is working to develop future best management practices for controlling rain-induced pollution that would apply to specific land uses to address soil loss, phosphorus runoff and biosolids management.

Improved educational efforts and data sharing also are needed. Another objective encourages education and stewardship with indicators to track educational funding and data management. Since much of the existing water data is disorganized, the team aims to reduce the number of watershed-related data sites, along with the time and cost needed to obtain watershed-related information. Since local governments regulate land use changes, their tracking of land use effects on water quality with the aid of geographic information system technology can be an important local indicator.

Next steps

The basin team must consider how to measure trends for the new indicators, as well as who will be charged with monitoring the indicators. The basin will need to evaluate suggested strategies and approaches to move toward the suggested goals and objectives.

Basin team members

Pollution Control Agency; Minnesota departments of Natural Resources, Agriculture and Health; Board of Water and Soil Resources; U.S. Department of the Interior National Park Service; Minnesota Wisconsin Boundary Area Commission; Metropolitan Council: University of Minnesota; University of Wisconsin; U.S. Geological Survey; U.S. Environmental Protection Agency; U.S. Department of Agriculture Natural Resources Conservation Service; and the St. Croix Band of Chippewa.

SELECTED UNIQUE ENVIRONMENTAL CONDITION INDICATORS IN THE ST. CROIX RIVER BASIN

Goal: St. Croix River Basin residents will improve the quality of water resources.

OBJECTIVES	INDICATORS AND TARGETS
Protect and improve water quality in lakes, wetlands, rivers and streams and establish priorities for their protection.	~ Total and ortho-phosphorus: set a standard for discharges so that they do not exceed 1 milligram per liter and there is no net increase of phosphorous ~ Water temperature ~ Health advisories for water use and fish consumption
Protect the scenic and ecological values of lakes and streams, particularly the Wild and Scenic St. Croix River and other lakes and streams of special interest, such as designated trout streams.	~ Percent of stable shoreline: increase ~ Percent of shoreland with buffers ~ Percent loss of native aquatic plan habitat

Goal: St. Croix River Basin residents will restore and maintain healthy ecosystems that support diverse plants and wildlife.

OBJECTIVES	INDICATORS AND TARGETS
Ensure aquatic environments have conditions suitable for the maintenance of healthy, self-sustaining communities of plants and animals.	~ Population of unionid mussels ~ Average percent of "embeddedness" of coarse substrates

Goal: St. Croix River Basin residents will have diverse opportunities to enjoy the state's water resources.

OBJECTIVES	INDICATORS AND TARGETS
Provide access to water recreation sites.	~ Numbers of sites for boat launching and parking spaces
Improve or maintain the quality of water recreation.	~ Riparian homeowner satisfaction surveys ~ Riparian parks and trail user satisfaction surveys

SELECTED UNIQUE PRESSURE INDICATORS IN THE ST. CROIX RIVER BASIN

Goal: St. Croix River Basin residents will improve the quality of water resources.

OBJECTIVES	INDICATORS AND TARGETS
Protect and improve water quality in lakes, wetlands, rivers and streams and establish priorities for their protection.	~ Sediment contamination tied to likely urban and industrial sources ~ Watershed land use changes
Protect the scenic and ecological values of lakes and streams, particularly the Wild and Scenic St. Croix River and other lakes and streams of special interest, such as designated trout streams.	~ Delta depositional areas associated with external sources such as storm sewers ~ Percent of shoreland developed ~ Changes in monetary value of shoreland properties ~ Increased noise levels on and along waters of special interest
Protect and improve groundwater quality.	~ Number of suspected abandoned wells ~ Number of class 5 injection wells

Goal: St. Croix River Basin residents will conserve water supplies and maintain the diverse characteristics of water resources.

OBJECTIVES	INDICATORS AND TARGETS
Maintain the hydrologic characteristics of surface water bodies that support beneficial uses.	~ Percent impervious surfaces ~ Volume of groundwater appropriated
Maintain flow of rivers and streams within historical range of variation.	~ Number of dam operations that deviate from run-of-the-river operation: all dams operated run-of-the-river by 2010 ~ Number of dams removed ~ Percent of floodplains lost
Maintain the quality and diversity of the St. Croix River Basin's lakes, streams and wetlands while acknowledging regional variation.	~ Net increase in wetland acres ~ Changes in wetland types and quality ~ Changes in stream types

Goal: St. Croix River Basin residents will have diverse opportunities to enjoy the state's water resources.

OBJECTIVES	INDICATORS AND TARGETS
Provide appropriate access to water recreation sites.	~ Boat number and type surveys and counts

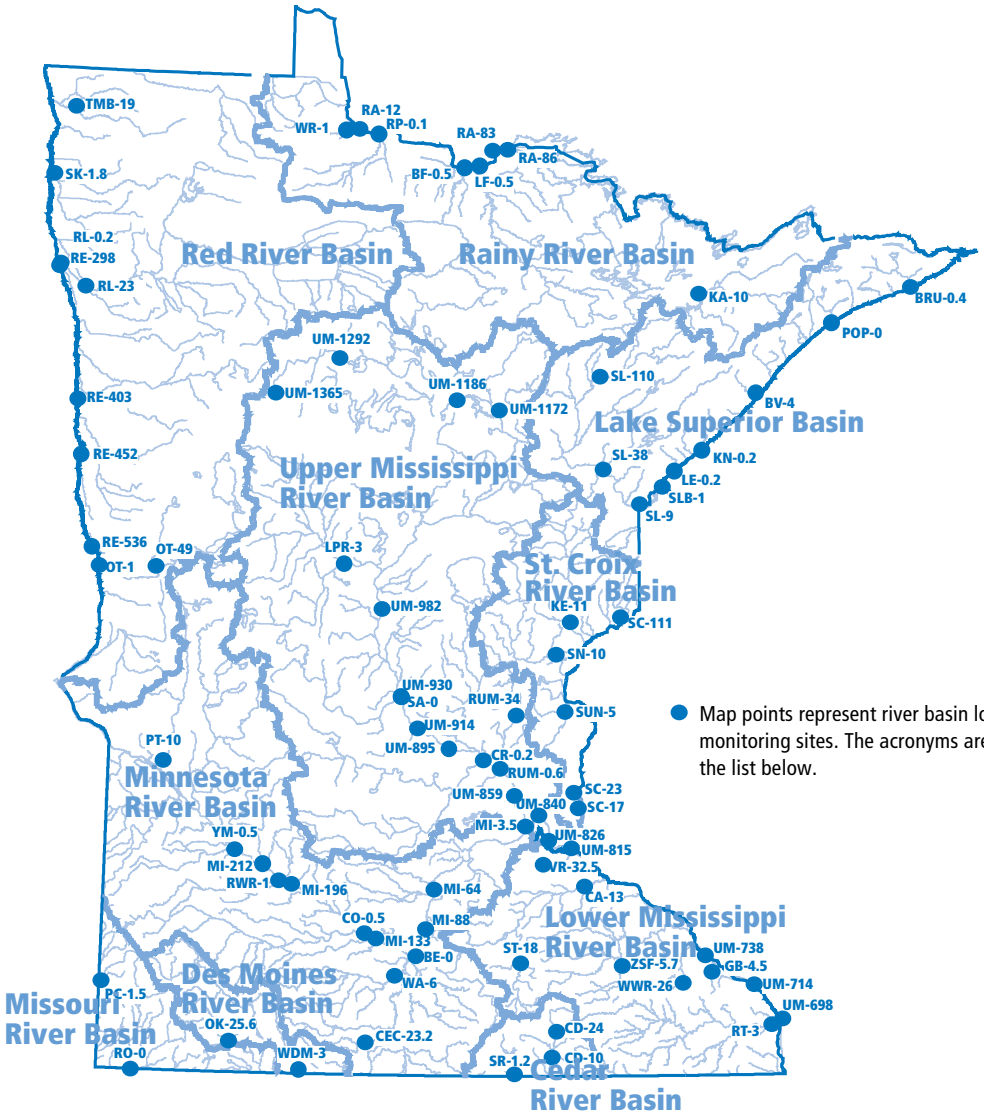
Going Forward

The goals and objectives detailed in this report provide a framework for managing water resources for the next 10 years. Over the next two years, the Water Resources Committee and Task Force will work with the basin teams to develop key strategies and evaluate current activities to move toward achieving the goals and objectives. The statewide indicators will be used to track progress. Decisions will be made about the priority as well as the feasibility of tracking the condition indicators and pressures recommended by basin teams. Emphasis also will continue on setting targets both for the statewide indicators and for indicators specific to some basins.

The basin teams involved local governments in helping to shape the statewide and basin reports, and the role of local government in water management was stressed by all the basin teams. A pilot program of the Board of Government Innovation and Cooperation offers local government new approaches for managing natural resources. Created by the 2000 Minnesota Legislature, the program provides local government with the ability to consolidate or create types of local government structures to strengthen natural resource management. Creative use of this program could address some local funding and governance problems.

This water planning effort initiated a new process for managing one of Minnesota's most vital resources. Continuing efforts will be tracked in a follow-up report in September 2002.

RIVER BASIN LONG-TERM WATER QUALITY MONITORING SITES



Map points represent river basin long-term monitoring sites. The acronyms are explained in the list below.

BE = Blue Earth River
BF = Big Fork River
BRU = Brule River
BV = Beaver River
CA = Cannon River
CD = Cedar River
CEC = Center Creek
CH = Chippewa River
CO = Cottonwood River
CR = Crow River
GB = Garvin Brook
KA = Kawishiwi River
KE = Kettle River
KN = Knife River
LE = Lester River
LF = Little Fork River
LPR = Long Prairie River
MI = Minnesota River
OK = Okabena Creek
OT = Ottertail River
PC = Pipestone Creek
POP = Poplar River
PT = Pomme deTerre River
RA = Rainy River
RE = Red River
RL = Red Lake River
RO = Rock River
RP = Rapid River
RT = Root River
RUN = Rum River
RWR = Redwood River
SA = Sauk River
SC = St. Croix River
SK = Snake River
SL = St. Louis River
SLB = St. Louis Bay
SN = Snake River
SR = Shell Rock River
ST = Straight River
SUN = Sunrise River
TMB = Two River (Middle Branch)
UM = Upper Mississippi River
VR = Vermillion River
WA = Watonwan River
WDM = Des Moines River (West Fork)
WR = Winter Road River
WWR = Whitewater River
YM = Yellow Medicine River
ZSF = Zumbro River (South Fork)

Source: Pollution Control Agency

Glossary

Aquatic invertebrates Animals without a backbone or spinal column that are found in lakes, streams, ponds, marshes and puddles. They help maintain the health of the water ecosystem by eating bacteria and dead, decaying plants and animals.

Aquifer A water-bearing porous rock or soil layer that yields water to wells.

Best management practice Voluntary practices used to prevent or minimize sources of nonpoint source pollution.

Biochemical oxygen demand Measures the amount of oxygen demanded by decomposition and respiration as organic matter contained in a given sample or body of water is consumed.

Ecoregion Areas of relative homogeneity defined for Minnesota based on land use, soils, landform and potential natural vegetation.

Ecosystem A community of plants and animals and the physical and chemical environment in which it exists.

Exotic species Nonnative species that adversely affect native species.

Erosion The wearing away of land surface by water or wind. It occurs naturally from weather or runoff but often is intensified by human activities.

Fecal coliform bacteria This bacteria is present in the intestines of humans and other animals. If found in water resources, it indicates sewage contamination has occurred and suggests the presence of disease-causing bacteria and viruses.

Hydrology The study of water that considers water flow, changes of state and interaction with the earth's surface and sub-surface.

Impervious surface Ground cover such as asphalt, concrete, hard-packed soil or rock that does not allow for the infiltration of water. Such surfaces increase the volume and speed of runoff after a rainfall.

Karst or karst terrain Topography of fractured or channeled limestone, dolomite or gypsum formed by the dissolution of these rocks by rain and underground water. Karst topography, largely found in southeast Minnesota, is characterized by closed depressions, sinkholes and underground drainage.

Nitrogen Nitrogen gas, nitrate, nitrite and ammonia are forms of nitrogen related through a complex cycle. Nitrate is the most common form of nitrogen in oxygenated water.

Nonpoint source pollution Pollution that arises from diffuse sources such as runoff from cultivated fields or urban areas.

Nutrients Elements or compounds essential to growth. Phosphorus and nitrogen are the two most common nutrients in runoff that threaten water resources. Sources include fertilizer and human and animal waste.

Pesticide A chemical substance used to kill or repel pests. Pesticides include herbicides to kill weeds, insecticides to kill insects and fungicides to kill fungi.

Phosphorus A chemical element that is necessary for algal growth. Sources include fertilizer, animal and human waste and plant matter.

River basin The surrounding land area that drains into a river or river system.

Secchi transparency A measure of water clarity that also could provide an indirect measure of the amount of algae in the water.

Suspended solids Particles of such things as dirt, plants and animals that hang in water and decrease the amount of light available for aquatic life, making it difficult for fish and other aquatic animals to breathe and feed. Erosion is a major cause of solids.

Volatile organic compounds Chemicals contained in a variety of commercial, industrial and household products that can evaporate rapidly from water into air at normal temperatures.

Watershed The surrounding land area that drains into a lake, river or river system. Minnesota has 81 major watersheds.

Water table The upper surface of the saturated zone. Below the water table all spaces in soil or rock are filled with water.

Wetlands Low-lying lands that frequently have standing water on them, such as swamps, marshes and meadows.

Zone of hypoxia An area along the Louisiana-Texas coast in which water near the bottom of the Gulf of Mexico contains less than 2 parts per million of dissolved oxygen. Hypoxia can cause stress or death in bottom-dwelling organisms that cannot move out of the zone.

Contributors

EQB Water Resources Committee

Paul Toren (chair)
Carolyn Engebretson (vice-chair)
Marilyn Lundberg (director), Minnesota Planning
Pat Bloomgren, Department of Health
Patrick Brezonik, University of Minnesota Water Resources Center
Greg Buzicky, Department of Agriculture
Ron Harnack, Board of Water and Soil Resources
Kent Lokkesmoe, Department of Natural Resources
Gary Oberts, Metropolitan Council
Tim Scherkenbach, Pollution Control Agency
David Southwick, Minnesota Geological Survey

Water Management Unification Task Force

Marilyn Lundberg, EQB Water Resources Committee Director; Paul Toren, EQB Water Resources Committee Chair; Barbara Blackstone (facilitator), Office of Dispute Resolution; Jim Birkholz, Greg Larson and Doug Thomas, Board of Water and Soil Resources; David Brostrom, River Defense Network; Molly MacGregor, Minnesota Rivers Council; Tim Koehler, U.S. Department of Agriculture Natural Resources Conservation Service; Bruce Olsen and Art Persons, Department of Health; Bob Patton, Minnesota Department of Agriculture; Paul Schmiechen and Glenn Skuta, Pollution Control Agency; Jack Skrypek, Sarah Tufford, Clarence Turner, Keith Wendt and David Wright, Department of Natural Resources; David Southwick and Bob Tipping, Minnesota Geological Survey; Judy Sventek, Metropolitan Council

Original basin team members

Lake Superior Basin: Brian Fredrickson (chair), Pollution Control Agency; Joel Peterson (vice-chair), Pollution Control Agency; Mark Nelson (vice-chair), Board of Water and Soil Resources; B. Kevin Daw (primary) and Kelly Voigt (alternate), U.S. Department of Agriculture Natural Resources Conservation Services; Mark Dittrich or Mark Zabel, Minnesota Department of Agriculture; Beth Kluthe, Department of Health; Mark Nelson, Board of Water and Soil Resources; Roger Nelson, Pollution Control Agency; Dan Retka, Department of Natural Resources

Lower Mississippi and Cedar River Basins: Mark Dittrich (co-chair), Minnesota Department of Agriculture; Norm Senjem (co-chair), Pollution Control Agency; John Nicholson (primary) and Mark Kunz (alternate), U.S. Department of Agriculture Natural Resources Conservation Service; Art Persons, Department of Health; Dave Peterson, Board of Water and Soil Resources; Walt Popp, Department of Natural Resources; Judy Sventek, Metropolitan Council; Mark Zabel, Minnesota Department of Agriculture

Minnesota, Des Moines and Missouri River Basins: Terry Bovee (co-chair), Department of Health; Larry Gunderson (co-chair), Pollution Control Agency; Mike Appel (primary) and Ann English (alternate), U.S. Department of Agriculture Natural Resources Conservation Service; Mark Dittrich or Mark Zabel, Department of Agriculture; Jack Frost, Metropolitan Council; Mark Hanson, Pollution Control Agency; Cheryl Heide, Department of Natural Resources; Chris Hughes, Board of Water and Soil Resources; Dave Leuthe, Department of Natural Resources

Rainy River Basin: Nolan Baratano (chair), Pollution Control Agency; Howard Christman, Department of Natural Resources; B. Kevin Daw (primary) and Kelly Voigt (alternate), U.S. Department of Agriculture Natural Resources Conservation Service; Mark Dittrich or Mark Zabel, Department of Agriculture; Beth Kluthe, Department of Health; Mark Nelson, Board of Water and Soil Resources

Red River Basin: Brian Dwight (co-chair), Board of Water and Soil Resources; Lisa Scheirer (co-chair), Pollution Control Agency; Mark Dittrich or Mark Zabel, Department of Agriculture; Mike Howe and Beth Kluthe, Department of Health; Glen Kajewski (primary) and Jim Ayres (alternate), U.S. Department of Agriculture Natural Resources Conservation Service; Paul Swenson, Department of Natural Resources

St. Croix River Basin: Keith Grow (co-chair), Board of Water and Soil Resources; Dale Homuth (co-chair), Department of Natural Resources; Tori Boers, Metropolitan Council; Mark Dittrich or Mark Zabel, Department of Agriculture; Mike Howe, Department of Health; Rita O'Connell, Pollution Control Agency; Harvey Sundmacker (primary) and B. Kevin Daw (alternate), U.S. Department of Agriculture Natural Resources Conservation Service

Upper Mississippi River Basin: Jim Hodgson (co-chair), Pollution Control Agency; Dan Steward (co-chair), Board of Water and Soil Resources; Jim Ayres (primary) and Harvey Sundmacker (alternate), U.S. Department of Agriculture Natural Resources Conservation Service; C. B. Bylander, Department of Natural Resources; Mark Dittrich or Mark Zabel, Department of Agriculture; Beth Kluthe, Department of Health; Judy Sventek, Metropolitan Council

Metro Committee: Steve Woods (co-chair), Board of Water and Soil Resources; Jack Frost (co-chair), Metropolitan Council; Judy Sventek (alternate co-chair), Metropolitan Council; Wayne Barstad, Department of Natural Resources; Tori Boers, Metropolitan Council; Art Persons, Department of Health; Glenn Skuta, Pollution Control Agency; Harvey Sundmacker (primary) and Ed Musielewicz (alternate), U.S. Department of Agriculture Natural Resources Conservation Service

Other contributors: Numerous others provided assistance with this report, including Renee Anderson, Susanne Maeder, Marilynn Taylor and Michael Tietz, Minnesota Planning; Carrie Bartz and Dave Christopherson, Pollution Control Agency; Marybeth Block, Board of Water and Soil Resources; John Hines, Department of Agriculture; Sheila Grow, Department of Health; Tim Kelly, Nick Proulx and Jay Rendall, Department of Natural Resources