Executive Summary

Minnesota Nutrient Reduction Strategy

The *Minnesota Nutrient Reduction Strategy* (*NRS*) will guide the state in reducing excess nutrients in waters so that in-state and downstream water quality goals are ultimately met.

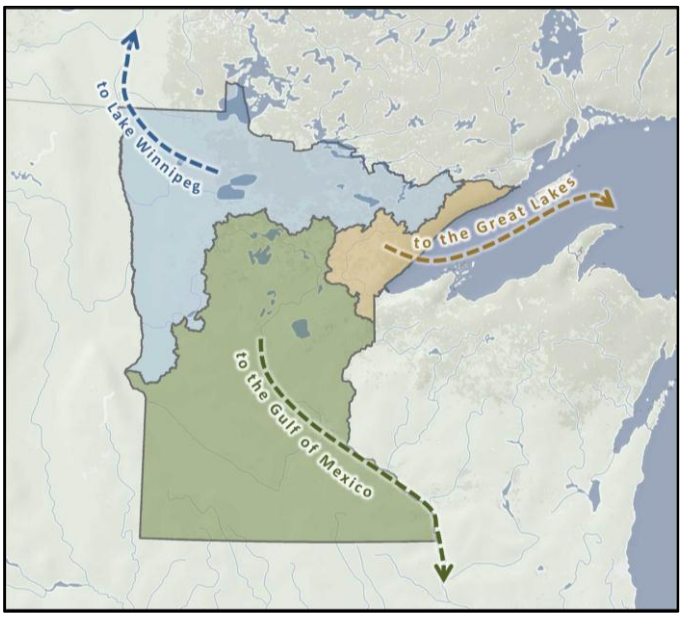

Figure 1. Major drainage basins in Minnesota.

Nutrient impacts are widespread. Excessive nutrients pose a significant problem for Minnesota's lakes, rivers, and groundwater, as well as downstream waters including the Great Lakes, Lake Winnipeg, the Mississippi River, and the Gulf of Mexico. Nutrients are important for human and aquatic life; however, when levels exceed normal conditions, problems can include excessive algae growth, low levels of oxygen, toxicity to aquatic life and unhealthy drinking water.

Substantial nutrient reductions are needed across much of Minnesota. For example, in 433 Minnesota lakes with impairments related to nutrients, an average of 45 percent phosphorus reduction is needed to meet water quality standards. Phosphorus levels in 48 river stretches exceeding the pending river eutrophication standards need an average 41 percent reduction. Many of these rivers flow toward the Mississippi River and into Lake Pepin, where similar levels of phosphorus reduction are needed to achieve a healthy lake. Nitrate, a dominant form of nitrogen in polluted waters, commonly exceeds the levels established to protect drinking water, especially in wells located below sandy soils and shallow soils above fractured bedrock. Nitrate levels are high enough to harm the food chain for fish in some rivers and streams fed by groundwater and drainage ditches.

This NRS is driven by the environmental needs of both waters within Minnesota and waters downstream of Minnesota, including Lake Winnipeg, the Gulf of Mexico and Lake Superior. In-state lake standards and pending river eutrophication standards, as well as planning goals for downstream

waters, have clearly defined the magnitude of needed reductions. The timing of NRS development also aligns with several other supportive efforts, some of these efforts are described below:

- The 2009 Minnesota *Clean Water, Land and Legacy Amendment* provides additional funding for water quality protection and restoration until 2034.
- Along with 11 other states represented on the Gulf of Mexico Hypoxia Task Force, Minnesota committed to develop a NRS to protect in-state waters and the Gulf of Mexico.
- The Minnesota Water Management Framework developed in 2014 lays out the state's approach for implementing watershed-based planning that will sustain a 10-year statewide cycle of locally-led water quality improvement plans.
- The Minnesota Department of Agriculture updated its *Nitrogen Fertilizer Management Plan* in 2014 for protecting groundwater from nitrate pollution.
- The legislature directed the Minnesota Pollution Control Agency (MPCA) to develop nitrate standards which will eventually increase protection of Minnesota aquatic life from the toxic effects of high nitrate.
- Manitoba, North Dakota and Minnesota are working together to update plans for protecting Lake Winnipeg from severe algae blooms.

The overall theme of the NRS is ***A Path to Progress in Achieving Healthy Waters***. The NRS guides activities that support nitrogen and phosphorus reductions within Minnesota water bodies. In addition, nutrient reductions will also benefit the Gulf of Mexico hypoxia problem and other waters downstream of Minnesota including Lake Winnipeg and Lake Superior. Fundamental elements of the NRS include:

- Defining progress with clear goals
- Building on current strategies and success
- Prioritizing problems and solutions
- Supporting local planning and implementation
- Improving tracking and accountability

Successful implementation of the NRS will require broad support, coordination, and collaboration among agencies, academia, local government, and private industry. An interagency coordination team, representing 11 agencies, helped develop the draft NRS. Public input was sought and used by the interagency coordination team to produce the final NRS.

Goals and Milestones

The NRS includes nutrient reduction goals and milestones at several levels. For individual water bodies in Minnesota, state water quality standards define the goals. For major basins, such as Lake Winnipeg and the Mississippi River/Gulf of Mexico, planning goals for reducing Minnesota's nutrient contributions were developed (Table 1). These major basin goals are intended to be measured where the basin waters leave the state (e. g., Mississippi River Basin where it leaves Minnesota at the Iowa border). Nutrient reduction targets have been previously developed for major drainage basins and provide a suitable framework for NRS load reduction goals. In addition, the NRS includes a groundwater/source water protection goal to address groundwater as a drinking water source.

Table 1. Major basin-wide nutrient reduction goals

Major basin	Phosphorus reduction goal	Nitrogen reduction goal
Lake Superior [a]	Maintain 1979 conditions	Qualitative – continued implementation of specific nutrient management programs
Lake Winnipeg [b]	10% reduction from 2003 conditions	13% reduction from 2003 conditions
Mississippi River [c]	45% reduction from average 1980–1996 conditions	45% reduction from average 1980–1996 conditions
Statewide Groundwater/ Source Water	Not applicable	Meet the degradation prevention goal of the Minnesota Groundwater Protection Act

a. Great Lakes Water Quality Agreement of 1978, amended by a protocol signed November 18, 1987.
b. 2003 Lake Winnipeg Action Plan. Goals to be updated after completion of the Red River/Lake Winnipeg strategy. Lake Winnipeg Goals are expected to change in the near future, resulting in additional load reduction needs.
c. 2008 Gulf Hypoxia Action Plan; Provisional goal; also includes drainage associated with Missouri, Des Moines, and Cedar rivers.

Milestones provide a realistic and meaningful benchmark of progress toward meeting major basin goals for nutrient reduction. They also establish a point in time to adapt strategies as necessary based on the rate of progress and changes in factors such as land uses, climate, regulatory environment, and technologies. A nitrogen reduction milestone was established for the Mississippi River because the final goals were determined to be impractical at this time. Additional research should enable feasible approaches for achieving the long-term nitrogen reduction needs. The nitrogen milestone for the Mississippi River is set at a 20 percent reduction by 2025. A provisional target date for reaching the 45 percent reduction goal for nitrogen in the Mississippi River is set at 2040, allowing time for the needed research and subsequent demonstration and promotion of new practices. Additional milestones can be added as new nutrient reduction goals are set for downstream waters or as new research and policies inform planning and decision-making. Figure 2 summarizes the timeline for achieving the Mississippi River phosphorus goal and nitrogen milestone.

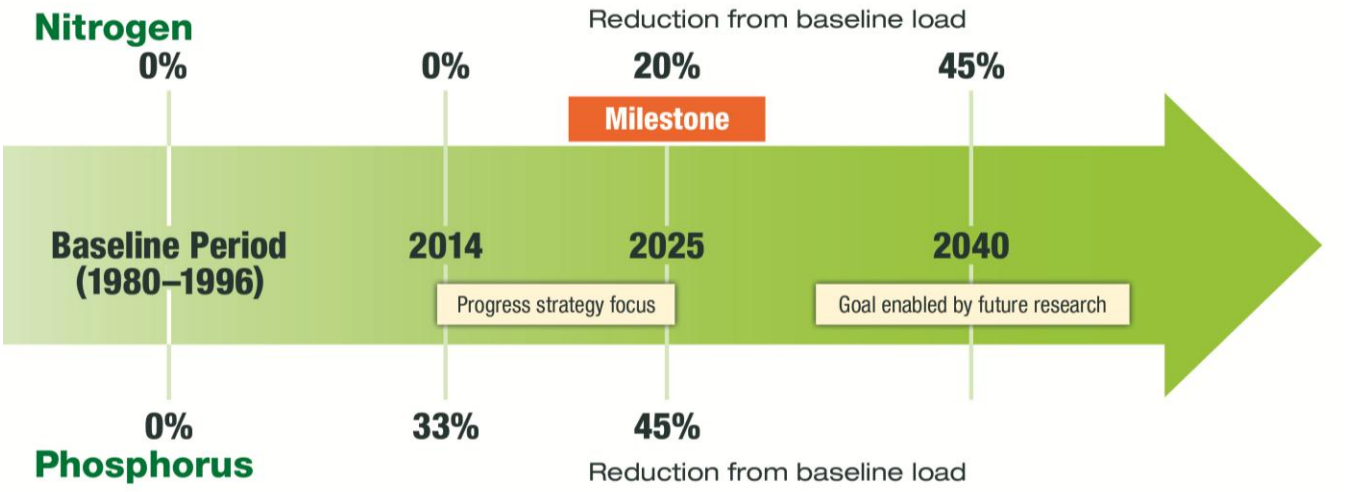

Figure 2. Timeline for achieving the Mississippi River milestone and goal.

Minnesota is implementing a watershed approach that assesses, restores and protects waters under the umbrella of the Minnesota Water Management Framework. This approach sets a 10-year cycle of water assessments, watershed restoration and protection strategy (*WRAPS*) development at the hydrologic unit code 8 (HUC8) watershed level, and local water planning (e. g., *One Watershed One Plan*). The NRS provides the information and collective objectives needed to address watershed nutrient goals downstream of the HUC8 watersheds. These downstream objectives can then be integrated with needs and prioritized actions within the HUC8 watershed. HUC8 watershed goals and milestones should be developed so that cumulative reductions from all watersheds will achieve the goals and milestones in waters downstream.

Water Quality Standards

Nutrient related water quality standards and drinking water *standards* are an important part of the water quality policy framework in Minnesota and nationally. Both lake and pending river eutrophication standards in Minnesota include phosphorus, but they do not include nitrogen. Eutrophication standards were set for lakes in 2008, and finalization of the river eutrophication standards is expected by Fall 2014. Nitrate standards to protect aquatic life in Minnesota surface waters are anticipated in the next few years. Phosphorus loading is often directly related to total suspended solids in rivers, especially during moderate to high flow events. Minnesota has existing standards for turbidity and plans to replace the turbidity standards with total suspended solids standards.

An evaluation of monitoring data indicates that meeting in-state lake and pending river eutrophication standards will likely result in meeting the major basin goals for phosphorus reduction. For example, Lake Pepin, a riverine lake on the Mississippi River, requires a greater phosphorus load reduction from this point in time than reductions needed to meet the Gulf of Mexico hypoxia goal. However for nitrogen, current in-state standards will not drive enough change to sufficiently address Minnesota's share of nitrogen to the Gulf of Mexico and Lake Winnipeg. Future nitrate standards to protect aquatic life will also necessitate nitrate reductions in some waters of the state, but we will not know the effect of those standards on downstream loading until they are established.

Headwaters to the Mississippi River
Photo Credit: MPCA

Evaluating Progress Since the Baseline Period

In developing the NRS, an assessment of recent progress to reduce nutrients in waters was conducted using available government program data. Each of the major basins in Minnesota has a reduction goal that is established according to a designated baseline period when that goal was established. For the Mississippi River, the National Hypoxia Task Force established the load reduction goals based on average conditions that occurred from 1980 -1996. Estimates of recent progress based on best management practice (BMP) adoption were then validated with river monitoring results.

Several regional, state, or federal programs were identified as key nutrient-reducing programs in Minnesota. Program staff provided input on quantifying outputs or outcomes of program

implementation. Data from the Natural Resource Conservation Service Environmental Quality Incentives Program (EQIP), Reinvest in Minnesota Program (conservation easements), Minnesota's eLINK database which tracks state-funded nonpoint source BMPs, MPCA's Feedlot Program, and estimated phosphorus reduction from septic system improvements and the statewide lawn phosphorus fertilizer ban were compiled from 2000 to present. Reductions in wastewater nutrients were also quantified. Table 2 summarizes the load reductions that were quantified as part of this effort. While the assessment of progress from BMPs and changes since 2000 does not incorporate all BMPs and land management changes, river monitoring results generally support the magnitude of estimated recent progress.

Table 2. Summary of recent progress by sector as compared to overall load in each major basin.
The load reductions in this table represent estimated load reductions that will occur at the state border as a result of practices since 2000.

	Percent in load change by cropland BMPs		Percent in load change by certain misc. source BMPs		Percent in load change by wastewater		Recent progress (as % of total load delivered)	
Major basin	P	N	P	N	P	N	P	N
Mississippi River	-8%	-2%	-1%	NA	-24%	+2%	-33%	0%
Lake Winnipeg	-3.7%	0%	-0.3%	NA	-0.3%	0%	-4.3%	0%
Lake Superior	-0.7%	NA	-1.3%	NA	+2.8%	NA	+0.8%	NA

Note: P=phosphorus; N=nitrogen. A negative number indicates reduction; a positive number indicates an increase.

The greatest progress during recent years has occurred with phosphorus reductions in the Mississippi River, where the estimated phosphorus reduction is 33 percent since 2000. Mississippi River monitoring showed a similar reduction (31 percent) in Red Wing after accounting for changes in flow conditions. Estimated Mississippi River phosphorus and nitrogen reductions achieved during recent years is shown in Figure 3 and Figure 4, as compared with baseline loads and milestone and goal loads. The NRS addresses the gap between current conditions (which includes quantified recent progress) and goals and milestones.

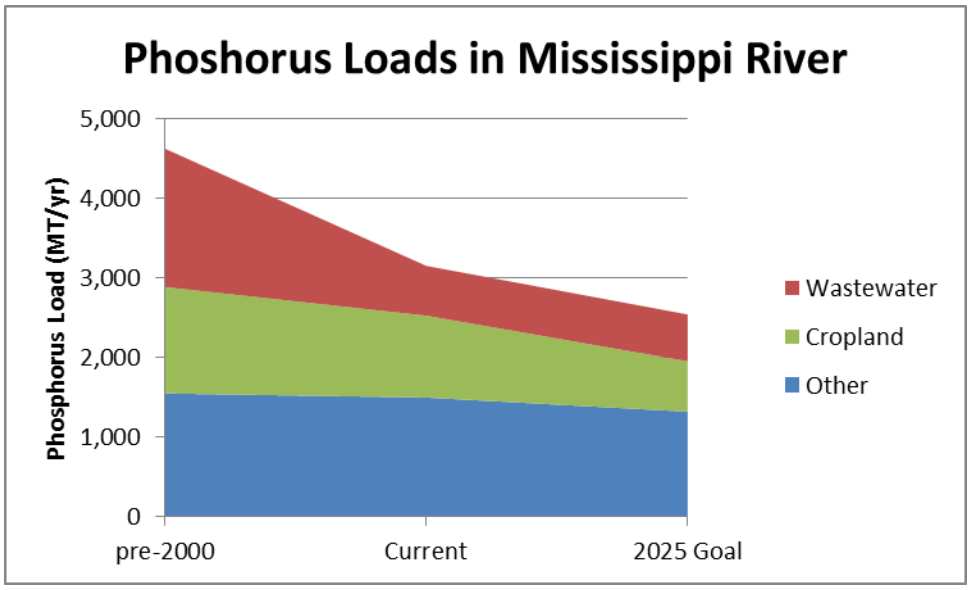

Figure 3. Minnesota's annual phosphorus loading in the Mississippi River at the state border during an average flow year in the past, current and NRS projected future. Other sources include atmospheric deposition, urban runoff, non-agricultural rural runoff, streambank erosion, barnyard runoff and septic systems.

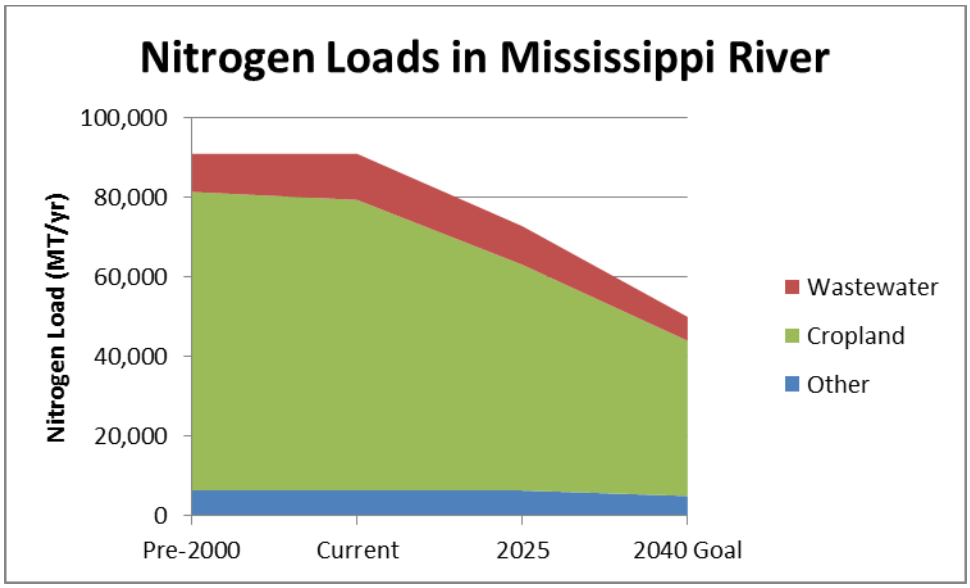

Figure 4. Minnesota's annual nitrogen loading in the Mississippi River at the state border during an average flow year in the past, current and NRS projected future. Other sources include atmospheric deposition, forest, urban runoff, and septic systems.

The full effects of these reductions have not yet been observed in river monitoring at the Minnesota/Iowa border. Lake Pepin and Mississippi River backwaters are likely recycling historically deposited phosphorus, thereby masking the full downstream effects of the load reductions. Evaluation of NRS progress will include a combination of monitoring and modeling at different points along the state's rivers, and will consider such effects as lag time and climate.

Metropolitan Wastewater Treatment Plant
Photo Credit: Metropolitan Council

Priority Management Areas

State level priority sources and major watersheds are based on the highest nutrient-loading to waters. Identifying priority areas within major watersheds occurs through local watershed planning such as "One Watershed, One Plan" and as part of WRAPS. It is important to recognize that while prioritization is an effective management tool for directing limited resources, nutrient reductions needed to meet the NRS goals cannot be achieved through implementation in a limited number of high-priority watersheds. BMP adoption is needed on millions of acres, and thus reductions are needed for priority sources in most watersheds.

Priority sources (Table 3) are determined on the basin scale, although it should be noted that different sources might be more or less important at the local scale. Priority sources could differ depending on the scale at which reductions are needed and could be adjusted through local and regional planning processes. The NRS does not consider sources that cannot be greatly reduced by local or regional implementation activities which include atmospheric deposition and loads from forested areas as reduction priorities.

Table 3. Priority sources for each major basin

Major basin	Priority phosphorus sources	Priority nitrogen sources
Mississippi River	Cropland runoff, wastewater point sources, and streambank erosion	Agricultural tile drainage and other pathways from cropland
Lake Superior	Nonagricultural rural runoff [a], wastewater point sources, and streambank erosion	Wastewater point sources
Lake Winnipeg	Cropland runoff and nonagricultural rural runoff	Cropland

a. Includes natural land cover types (forests, grasslands, and shrublands) and developed land uses that are outside the boundaries of incorporated urban areas.

Priority watersheds have the highest nutrient yields (loads normalized to area), and also include watersheds with high phosphorus levels in rivers. Figure 5 identifies major watershed priorities.

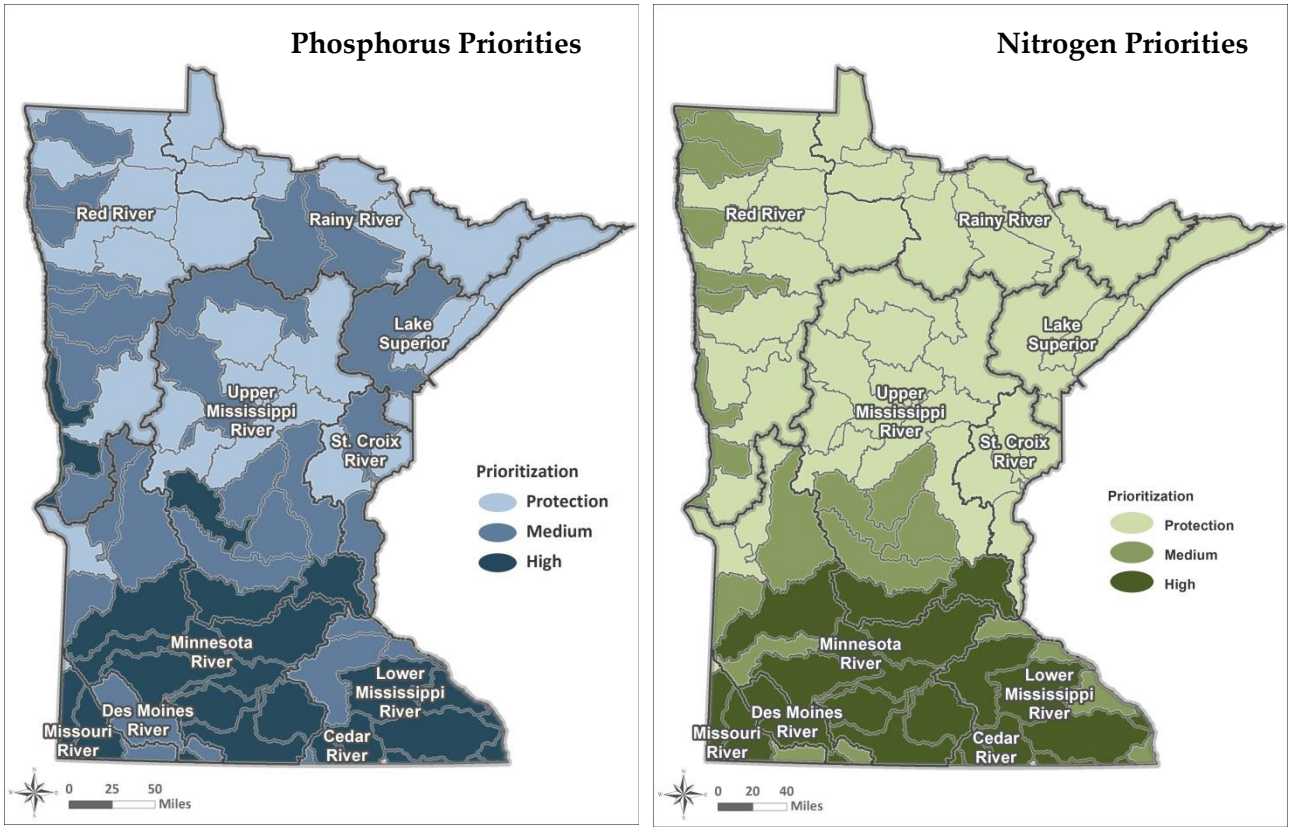

Figure 5. HUC8 watershed priorities.

Nutrient Reduction Strategies

No single solution exists for achieving the level of nutrient reductions needed to meet goals and milestones. It will take many actions and BMPs implemented over large areas of the state. To support the needed widespread change, the NRS includes two overarching strategies:

Develop a Statewide NRS Education/Outreach Campaign. Develop and implement a coordinated NRS outreach campaign that integrates with other efforts to promote statewide stewardship of water resources. This statewide campaign is responsible for raising general public awareness about the need to reduce nutrients in Minnesota waters and will support BMP specific education activities.

Integrate Basin Reduction Needs with Watershed Planning Goals and Efforts. As part of Minnesota's Water Management Framework, ensure that downstream nutrient reduction needs are addressed by cumulative local level efforts. Watershed restoration and protection strategies and accompanying comprehensive watershed management plans (e.g., One Watershed One Plan) should be developed to not only have the goal of protecting and restoring water resources within the watershed, but to also contribute to nutrient reductions needed for downstream waters both within Minnesota and those downstream of the state border. The *Minnesota Nutrient Planning Portal* was recently developed for accessing watershed nutrient-related information. It includes information on nitrogen and phosphorus conditions and trends in local waters, nutrient modeling, local water planning, and other nutrient information. Information from this portal can be used when developing local plans and strategies to reduce nutrient losses to local and downstream waters.

Wastewater Strategies

The current Phosphorus Rule and Strategy has, and will continue, to address phosphorus reductions in wastewater. The adoption of river eutrophication standards in 2014 is expected to result in additional wastewater phosphorus reductions in certain watersheds.

The history of phosphorus management at wastewater treatment facilities in Minnesota starting in 2000 is an example of a successful program to reduce a pollutant of concern. Several steps used in the successful Phosphorus Strategy (MPCA 2000) are also proposed for nitrogen:

- Influent and effluent nitrogen monitoring at wastewater treatment facilities
- Nitrogen management plans for wastewater treatment facilities
- Nitrogen effluent limits

- Add nitrogen removal capacity with facility upgrade
- Point source to nonpoint source trading

An approximate 20 percent reduction in wastewater nitrogen loads, along with reductions from other sources, will enable achievement of the nitrogen milestone for the Mississippi River. Until research and testing are complete, wastewater treatment facilities may be limited in their nitrogen removal achievements. This will be evaluated as more information is gathered throughout the life of the NRS and may result in modification of the nitrogen reduction milestones. As facilities complete these steps, assessment will help to identify changes needed to existing treatment processes and technologies. Major changes to treatment plants will require significant timeframes for design and construction.

Cropland Strategies

The NRS includes select cropland BMPs and treatment options to guide implementation; however, any combination of BMPs and treatment options that achieve the load reduction goals can be used. As new research occurs, additional BMPs and treatment options will likely become part of the NRS.

Agricultural BMPs recommended for the NRS are grouped into the following four categories:

1. Increase fertilizer use efficiencies, emphasizing:
    a. Nutrient management through reduction of nitrogen losses on corn following soybeans
    b. Switch from fall to spring fertilizer applications (or use nitrification inhibitors)
    c. Application of phosphorus in accordance with precision fertilizer and manure application techniques, including applications based on soil test results and University of Minnesota recommendations
2. Increase and target living cover, emphasizing:
    a. Cover crops on fallow and short season crops such as sweet corn, corn silage, peas, small grains, and potatoes
    b. Perennials in riparian zones and on marginal cropland
    c. Research and development of marketable cover crops to be grown on corn and soybean fields
    d. Research and development of perennial energy crop(s)
3. Field erosion control, emphasizing:
    a. Tillage practices that leave more than 30 percent crop residue cover or alternative erosion control practices that provide equivalent protection

   b. Grassed waterways and structural practices for runoff control

4. Tile drainage water quality treatment and storage, emphasizing:
   a. Constructed and restored wetlands
   b. Controlled drainage when expanding or retrofitting drainage systems
   c. Water control structures
   d. Research and development of bioreactors, two-stage ditches, saturated buffers and other ways to store and treat drainage waters

Example BMP scenarios to achieve the nutrient reduction goals and milestones in each major basin were developed. In general, the conceptual strategy for nitrogen includes increasing fertilizer and manure use efficiency through nutrient management, treating tile drainage waters, and implementing living cover BMPs. NRS phosphorus reductions from cropland are based largely on precision use of fertilizer and manure, reducing soil erosion, and adding riparian buffers and other living cover on the landscape.

Residue Management
Photo Credit: NRCS

Increased adoption of agricultural BMPs is critical to implementing the NRS and achieving goals and milestones. The NRS provides many recommendations on how to increase BMP adoption and recognizes that new ideas and strategies are also needed to achieve the high level of BMP adoption. Key cropland strategies include:

- Advance the use of vegetative cover through riparian buffers and adoption of cover crops on short season crops, while working to advance cover crop and perennial crop options for Minnesota's climate and markets for perennials.
- Work with farmers to improve soil health, which will include more crop residue and soil erosion control, especially for protection of soil during the increasing frequency of high intensity rains.
- Work with co-op agronomists, certified crop advisers, and agricultural producers on an educational campaign to achieve greater nutrient efficiencies. Provide greater confidence in reducing rates by offering crop nutrient insurance for reduced fertilizer rates and other self-demonstration projects.
- Increase education and outreach on water quality issues and BMPs needed to reach nutrient reduction goals. Encourage participation and provide education through the Agricultural Water Quality Certification Program. Develop recognition programs for excellent nutrient management such as Watershed Heroes.
- Develop strong public-private partnerships to support increased delivery of voluntary BMPs and optimize opportunities to improve the rate of BMP adoption in targeted areas. Increase demonstrations, promotion and incentives for implementing tile drainage management, wetland construction and other practices to reduce nutrients from tile drainage waters.
- Provide the necessary research and demonstration that will lead to increased adoption of cropland BMPs.

Miscellaneous Source Strategies

Phosphorus reductions from miscellaneous sources such as streambank erosion, subsurface sewage treatment systems, stormwater, and feedlots are needed to meet the overall goals and milestones in the Mississippi River and Lake Winnipeg major basins. Strategies already being used will further the progress toward reducing these nutrient loads. Existing programs have strategies that allow for systematic reductions in loads from subsurface sewage treatment systems, stormwater, and feedlots.

A large-scale strategy is also under development to address sediment reduction. The strategy will help address sediment-related nutrient load reductions. In addition, implementation of Total Maximum Daily Loads (TMDLs), particularly for turbidity-impaired streams, will likely address sediment-bound phosphorus sources that are a result of bank and channel erosion.

Protection Strategies

Protection strategies are needed in watersheds facing development pressures and changes in agricultural and land use practices, as well as in areas with vulnerable groundwater drinking water supplies. The Minnesota Water Management Framework requires protection strategies as part of WRAPS development, and therefore should address the potential for increased nutrient loads at a watershed scale. In addition, protection strategies should consider mitigation measures to address increases in Red River Basin tile drainage.

Specific to groundwater protection, the MDA is completing its Nitrogen Fertilizer Management Plan during 2014. The strategies outlined in that plan serve as the NRS's strategies for groundwater protection and include implementation of BMPs which protect groundwater resources, wellhead protection planning and implementation, a broad education and BMP promotion component, and a phased mitigation strategy to reduce groundwater nitrate concentrations to drinkable conditions in high nitrate zones.

Quantified Overview of Nutrient Reduction Strategy

The following figures for the Mississippi River Major Basin summarize the overall strategies to achieve the phosphorus goal and nitrogen milestone. Similar figures have also been developed for the Red River Basin (see Chapter 5). Each of the figures includes suggested reductions by source for each of the key BMP categories. The figures are organized to provide the baseline load by sector (agricultural, wastewater, and miscellaneous), quantified progress since baseline, and the breakdown of BMPs and implementation activities that are needed to meet the goals and milestone.

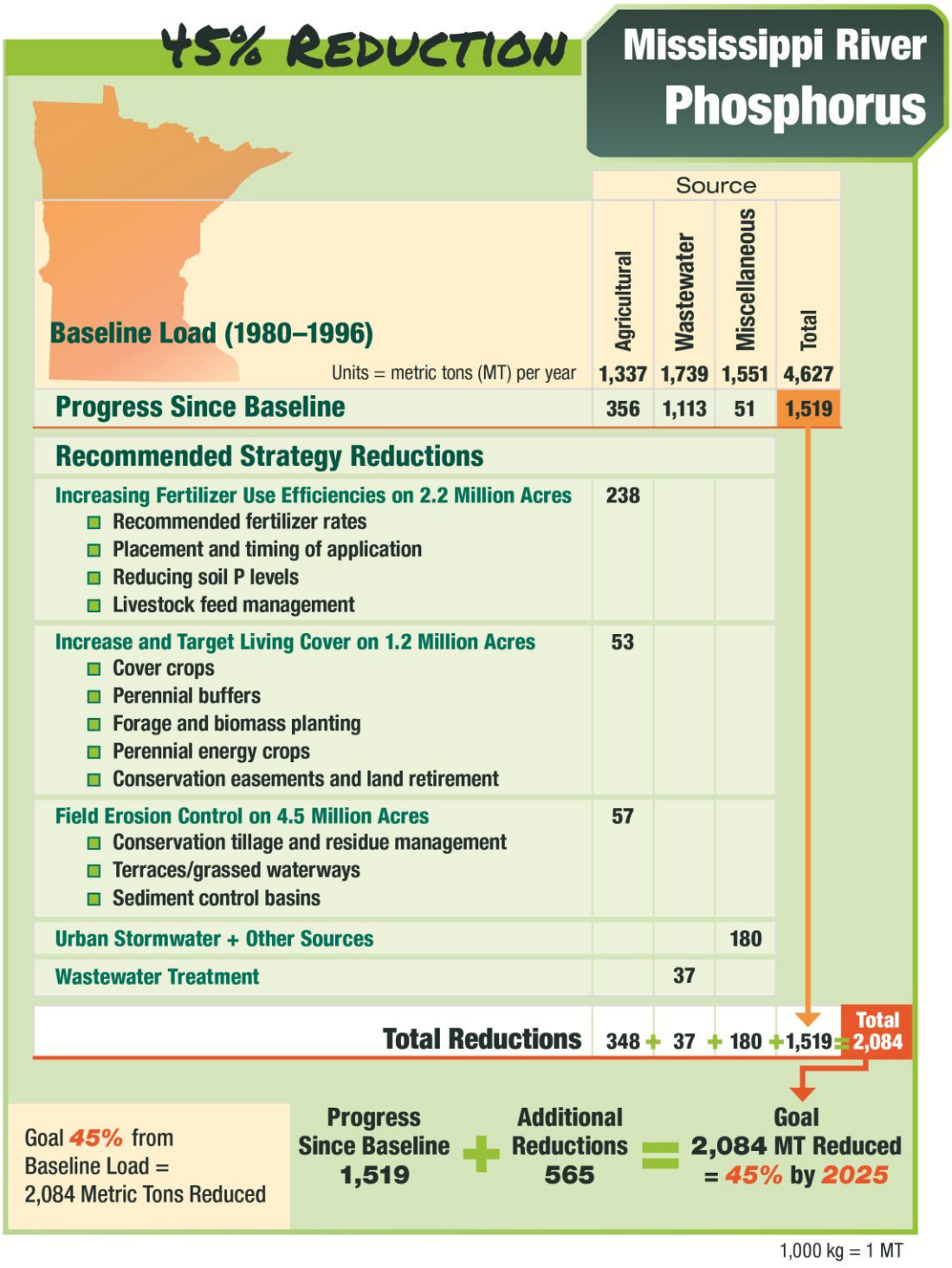

Figure 5. Phosphorus goal reductions for Mississippi River Major Basin.

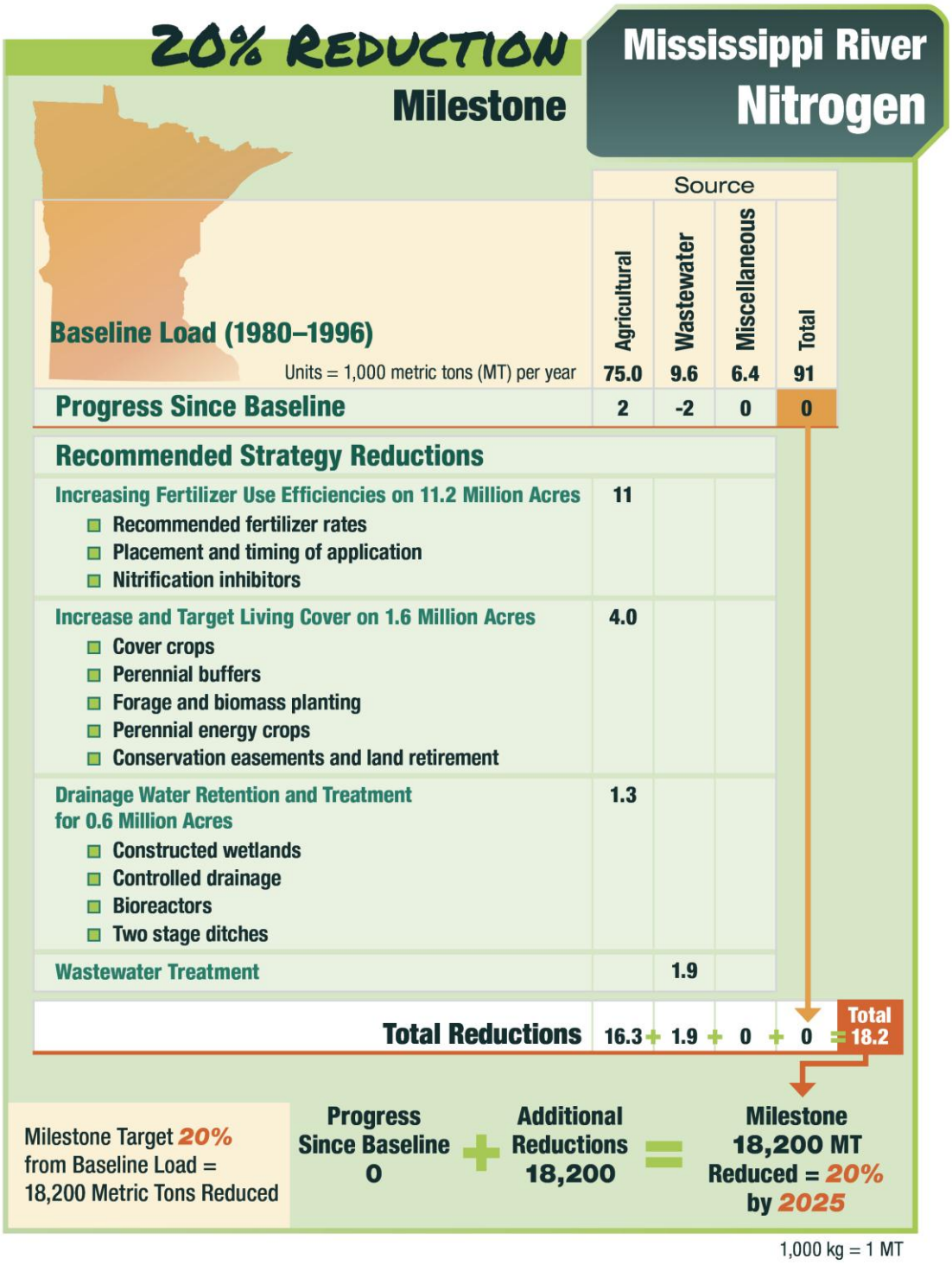

Figure 6. Nitrogen milestone reductions for Mississippi River Major Basin.

Adaptive Management and Tracking Progress

Progress towards goals and milestones will be tracked over time to determine if strategies are successful and where additional work is needed. To understand the level of nutrient reduction progress being achieved and ensure that on-the-ground implementation is on pace with the NRS goals and milestones, it is important to evaluate both changes in the adoption of BMPs (our actions) and water quality monitoring information (environmental outcomes). The basic components of the NRS's adaptive management plan are as follows:

- Identify data and information needed to track progress toward NRS goals and milestones.
- Create a system or approach for collecting data and information needed to track progress toward NRS goals and milestones.
- Evaluate trends as well as relationships between actions and outcomes.
- Adjust the NRS as necessary.

Implementation tracking will be done through both land management and water quality data. Program implementation data provides early indicator information about nitrogen and phosphorus reductions that, over time, should translate to in-stream nutrient reductions. An integrated and streamlined approach to track BMP implementation should be a priority. The NRS contains a suite of program measures that can be used to measure progress including various implementation activities. It is important to note that the selected program measures reflect government programs and do not capture industry-led conservation activities. As a result, while the selected program measures are strong indicators of program implementation trends, they are conservative indicators of statewide BMP adoption. BMP implementation that is occurring outside of government assistance is likely the largest gap in measuring success of the NRS. Comprehensively determining outcomes will require measuring conservation practices and farming activities that are not funded and tracked through government programs.

Future water quality evaluations will rely upon the Watershed Pollutant Load Monitoring Network and statewide water quality modeling. Many other local, regional, statewide, and national monitoring programs will inform water quality evaluations. No single water quality metric, monitoring site, or period of monitoring will provide the needed information to evaluate environmental outcomes. When monitoring data from multiple sites is used, along with periodic modeling and evaluation of anticipated lag times, then progress toward NRS goals and milestones can be more accurately assessed.

Water quality outcome measures will include the following:

- Trend in actual load
- Trend in flow weighted mean concentration
- Extent of river and lake eutrophication impairments
- Statistical comparisons of baseline loads and concentrations at low, medium, and high flow periods with comparable flow periods during recent years
- Extent of groundwater nitrate above drinking water standards in high-nitrate areas, including those watersheds where nitrate coming from groundwater impairs surface waters

The NRS centers on a series of goals and milestones and targeted actions identified to achieve those goals and milestones over time, with periodic reevaluation and reassessment. Tracking and reporting will occur at 2-year, 5-year, and 10-year intervals. There is currently no integrated reporting, data management and report generating system that will allow for automated tracking of NRS output and outcome information to assess progress over time. The approach for tracking progress requires the development of a system to ensure the efficiency and reliability of progress tracking. Developing a tracking system of this nature will be a multi-agency undertaking that must take into consideration the existing data management approaches used by numerous programs within several agencies.

The NRS provides for accountability, incorporates adaptive management, and ensures that Minnesota stays on the ***Path to Progress in Achieving Healthy Waters***.

Lake Superior
Photo Credit: MPCA