MINNESOTA

2025 Minnesota Nutrient Reduction Strategy

Executive Summary

Background

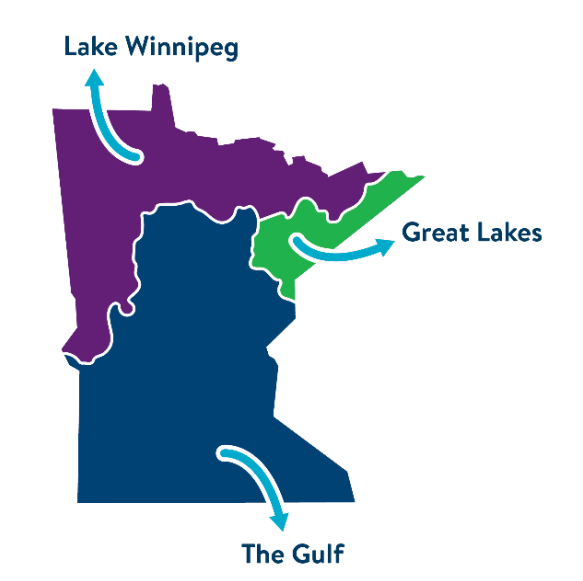
Since 2014, the Minnesota Nutrient Reduction Strategy (NRS) has guided the state in reducing excess nitrogen and phosphorus (collectively known as nutrients) in Minnesota's waters, ensuring that in-state and downstream water quality goals are met. Nutrients are important for human and aquatic life; however, when levels become elevated, excessive algae growth, low oxygen levels, toxicity to aquatic life, and unhealthy drinking water can result. A loss of nutrients is also often an economic loss.

The NRS was developed from the work of state, federal, and regional partner agencies and the University of Minnesota (UMN), along with broader input, and describes:

- Nutrient conditions in Minnesota waters
- Sources of excess nutrients
- Goals and milestones for addressing in-state and downstream water nutrient levels
- Science-based solutions to reduce nutrient loss
- The magnitude of changes needed on the land
- Specific strategies for increasing nutrient reduction efforts
- Ways of tracking progress

Reducing nutrients in Minnesota waters also benefits downstream waters, including the Gulf, Lake Winnipeg, and Lake Superior (Figure ES-1). The NRS establishes nutrient reduction planning goals that vary for these three major basins, with the target to reach all goals by 2040 (Figure ES-2).

Figure ES-1-1. Waters in Minnesota drain to the Gulf, Lake Winnipeg, and Lake Superior.



Following 10 years of implementation, the Minnesota NRS implemented planned updates to assess progress in reducing nutrients and better guide the state in meeting its nutrient reduction goals.

The successful implementation of the NRS continues to require broad support, coordination, and collaboration among agencies, academia, local government, and the private sector. State-level support provided to people and organizations at the local level leads to the implementation of more nutrient-reducing practices in both rural and urban areas. Those practices work to improve local waters, with cascading benefits to the waters downstream of Minnesota (Figure ES-3).

Figure ES-1-2. Timeline for achieving nutrient reduction goals for the Mississippi River.

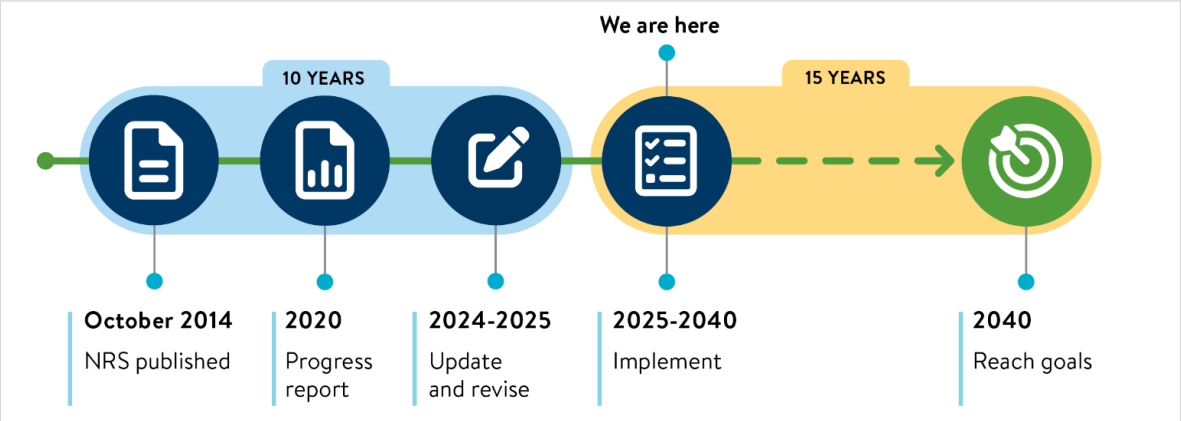


Figure ES-1-3. Overview of how NRS strategies and practices lead to water quality improvements.

Goals and progress overview

Statewide, high phosphorus concentrations cause eutrophication impairments in 686 Minnesota lakes and 50 river reaches. To meet water quality standards, phosphorus in these lakes and rivers should be reduced by an average of 42% from recent conditions. Protecting sensitive lakes from phosphorus inputs remains a high priority for Minnesota.

In-state phosphorus concentrations in lakes, rivers, and streams are generally showing signs of improvement, although 54% of 260 lakes assessed for trends had no trend detected. Of the 119 lakes with detectable phosphorus trends, 86 lakes (73%) showed decreases in phosphorus, while 32 lakes (27%) were increasing between 2007 and 2024.

River phosphorus concentrations have generally decreased or remained stable throughout Minnesota at most of the 61 MPCA river monitoring sites (2008–2022) and at all 15 of the seven-county Twin Cities Metro Area sites (2000–2021). Mississippi River phosphorus concentrations have decreased by over 40% since the 1980s, mostly attributed to reductions from wastewater (see Chapter 4).

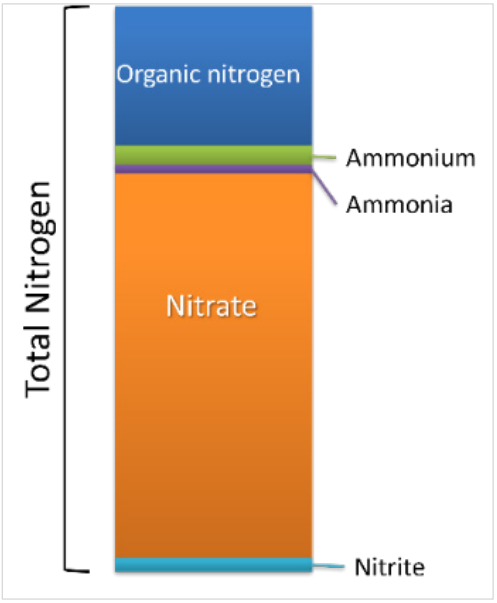
Nitrate is the most dominant form of total nitrogen (TN) in waters that are impacted by human activity (Figure ES-4). High nitrate concentrations can cause drinking water standard exceedances in groundwater and wells. In southern Minnesota, some stream reaches have nitrate levels high enough to potentially harm aquatic life.

If nitrate concentrations are reduced by about 40% in rivers and vulnerable groundwaters in the Mississippi River basin, Minnesota will meet its goals for state-line TN load reductions and most in-state targets for protecting drinking water and aquatic life.

The progress indicators for nitrate concentration show a greater mix of results than for phosphorus.

Between 2008 and 2022, river nitrate concentrations have shown no trend in most (86.5%) of the 52 MPCA-monitored sites across the state. Where trends have been detected, nitrate concentrations have been increasing at five sites (10%) and decreasing at two sites (4%).

Figure ES-1-4. Typical proportions of TN constituents in waters impacted by human activity.



In upper aquifers, which are geologically vulnerable across agricultural and urban parts of the state, nitrate concentration trends (2007–2023) have been decreasing (improving) in 24% of ambient monitoring and domestic wells while increasing (worsening) in 3% of tested wells. However, most wells (73%) show no trend during recent years. More monitoring is needed to better understand groundwater nitrate trends over time.

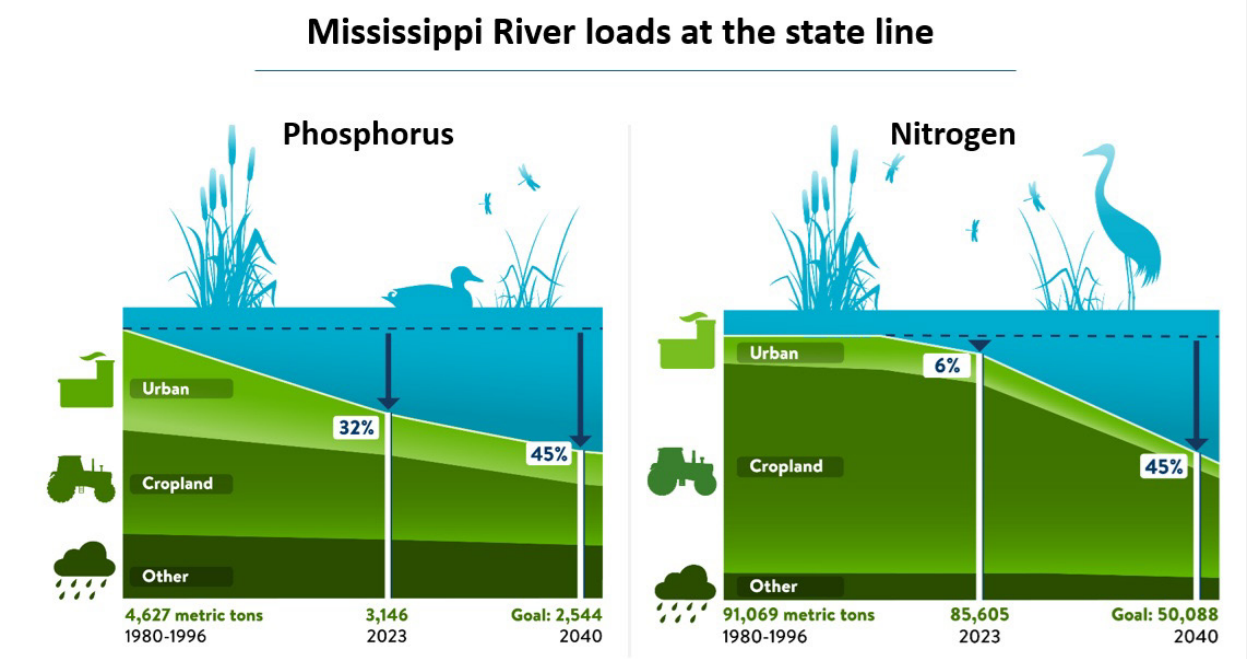
Mississippi River Basin goals and progress

Most of Minnesota's nutrient losses flow out of the state via the Mississippi River Basin (Figure ES-5). Nutrients in the Mississippi River account for 83% of TN loads and 74% of total phosphorus (TP) loads leaving Minnesota. For the Mississippi River, the national-level Gulf Hypoxia Task Force established load reduction goals of 45% for both TN and TP based on average conditions between 1980 and 1996. Minnesota applies the 45% reduction goal at various monitoring points between the Twin Cities and the state line with Iowa.

Figure ES-1-5. Mississippi River Basin within Minnesota (blue), also showing the largest tributary, the Minnesota River.

Minnesota is making progress. Recent estimates based on river monitoring results and validated with best management practice (BMP) adoption information indicate improvement since the baseline period of 1980–1996, with a 32% load reduction in TP and a smaller and less certain load reduction of about 6% in TN (Figure ES-6). About two-thirds of the TP load reduction is attributed to point source wastewater improvements, while the rest is attributed to agricultural and urban nonpoint source reductions.

Figure ES-1-6. Minnesota's annual phosphorus and nitrogen loads in the Mississippi River near the state border during an average flow year in the past (1980–1996), current (2023), and NRS-projected future (2040).



Notes: "Other" includes sources such as atmospheric deposition, nonagricultural rural runoff, streambank erosion, animal feedlots, and septic systems (MPCA 2013).

Lake Winnipeg Basin goals and progress

About 22% of the TP and 13% of TN statewide loads leave Minnesota through the Red and Rainy rivers, contributing to the nutrient enrichment and eutrophication of Lake Winnipeg.

To meet Lake Winnipeg water quality goals, in 2020 the International Red River Watershed Board adopted final load targets for TN and TP in the Red River at the border of the United States of America and Canada. The goals represent load reductions of about 53% and 50% of TN and TP loads, respectively, from the 1996–2000 average. A final target date has not yet been determined by Manitoba, and the Minnesota NRS uses a provisional date of 2040 planning timeframe in the interim. Because relatively few in-state waters in the Red River Basin are impaired by nutrients, the primary water quality drivers for these large nutrient reductions in this part of the state are the goals for Lake Winnipeg.

TN loads in the Red River may have decreased slightly at the Canadian border since the late 1990s baseline period, but more monitoring is needed over time to confirm this trend. TP loads have not shown improvement since the baseline period; more likely, they have increased slightly (7%).

Minnesota also contributes a relatively small amount of nutrients from the Rainy River into Lake Winnipeg, which first flows into Lake of the Woods. The load reduction strategy for the Rainy River in Minnesota is to address nutrient loads through the total maximum daily load for the Lake of the Woods eutrophication impairment, which aims for a 17.3% phosphorus reduction going into the lake. Phosphorus levels in the Rainy River have decreased since 2005 and are now nearing the goal.

Lake Superior Basin goals and progress

About 4% of TN and TP loads leave Minnesota through tributaries flowing into Lake Superior. The NRS references a previously established no-net phosphorus increase goal. The 2025 NRS also identifies a no-

net-increase goal for TN loads into Lake Superior. Recent monitoring and modeling suggest that loads from combined Minnesota tributaries average 245 metric tons per year (MT/yr) for TP and 2,670 MT/yr for TN. Further research is needed to better understand nitrogen impacts on nearshore areas as Lake Superior waters warm.

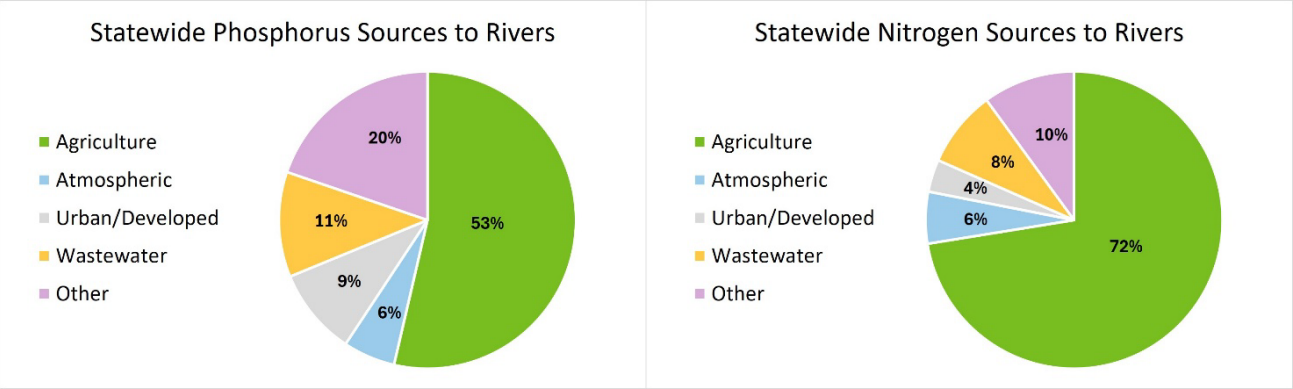
Trend analyses on the largest Minnesota tributary to Lake Superior, the St. Louis River, show a 16% and 14% decrease in TP and TN loads, respectively, between 2011 and 2023. Continued monitoring of tributaries to Lake Superior will verify if the no-net-increase goals for Lake Superior are met.

Priority Management Areas

Priority sources

The state-level nutrient source assessments are based on the averages of two modeling efforts from 2014 and 2024 (Figure ES-7). The priority sources vary greatly across the state and the major river basins (Table ES-1), and priority sources for local waters within each drainage basin are often different than the basin-scale source. Priority sources at the eight-digit hydrologic unit code (HUC-8) scale or smaller are determined through watershed planning efforts.

Figure ES-1-7. The estimated statewide sources of phosphorus (left) and nitrogen (right) to Minnesota rivers, based on the averages of two different source assessments.



Notes: "Other" represents streambank erosion, nonagricultural rural runoff, and forest. Percentages are rounded to nearest percent.

Table ES-1. Priority sources at the major river basin scale within the state of Minnesota, with the highest priority sources in bold.

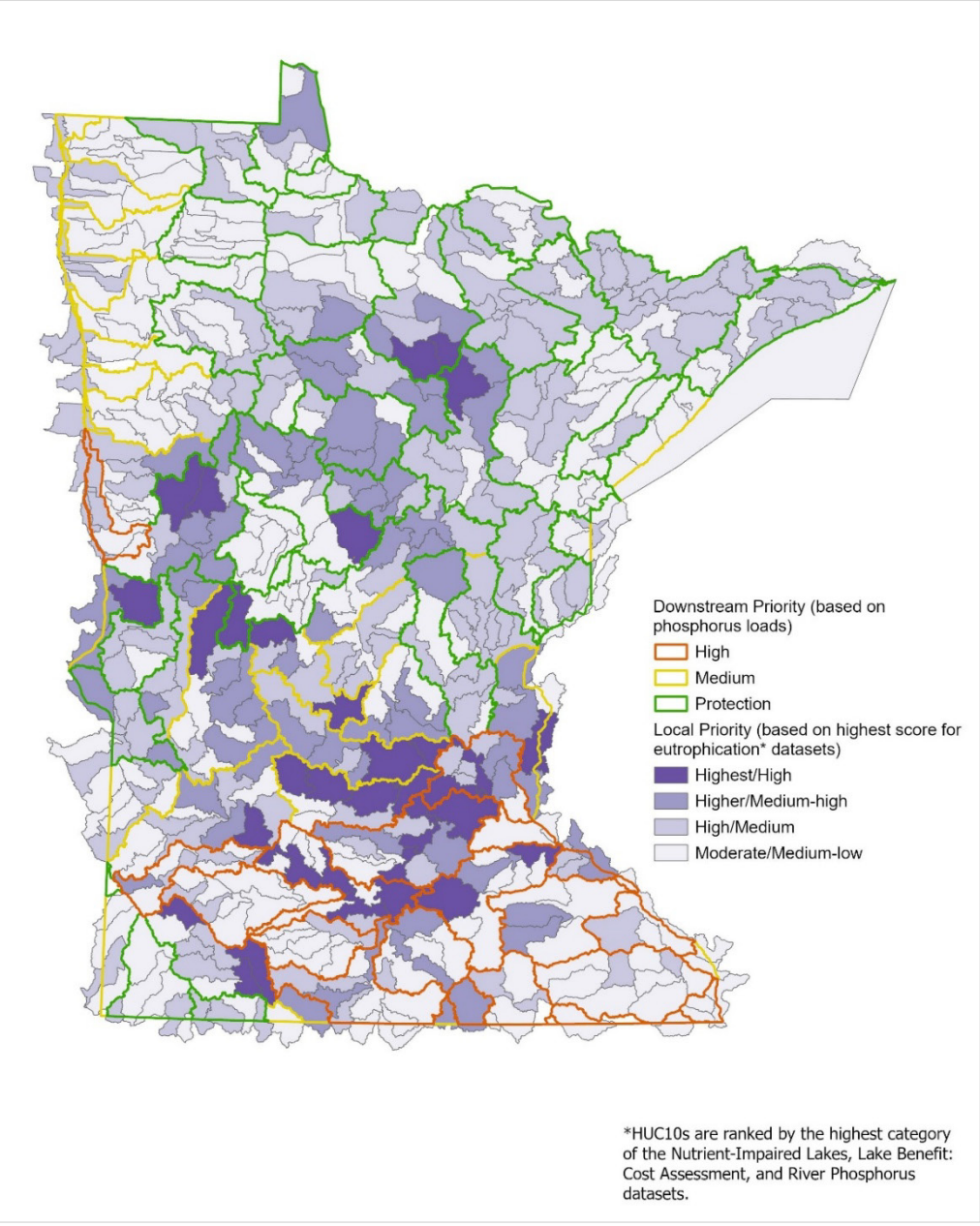
Major basin	Priority phosphorus sources	Priority nitrogen sources
Mississippi River	**Cropland runoff**, wastewater point sources, and streambank erosion	**Cropland leaching loss to tile drainage** and groundwater, wastewater point sources
Lake Superior	**Nonagricultural rural runoff**, wastewater point sources, and streambank erosion	**Nonagricultural rural runoff**, wastewater point sources
Lake Winnipeg	**Cropland runoff**, nonagricultural rural runoff	**Cropland** and other rural runoff and atmospheric sources

Agricultural sources are a priority in the Mississippi River Basin (contributing an estimated 78% TN and 56% TP) and the Lake Winnipeg Basin (51% TN and 53% TP). Conversely, in the more forested Lake Superior Basin, combined sources such as streambank erosion, nonagricultural runoff, and forested lands contribute a higher fraction of the nutrient loads to waters.

Priority watersheds

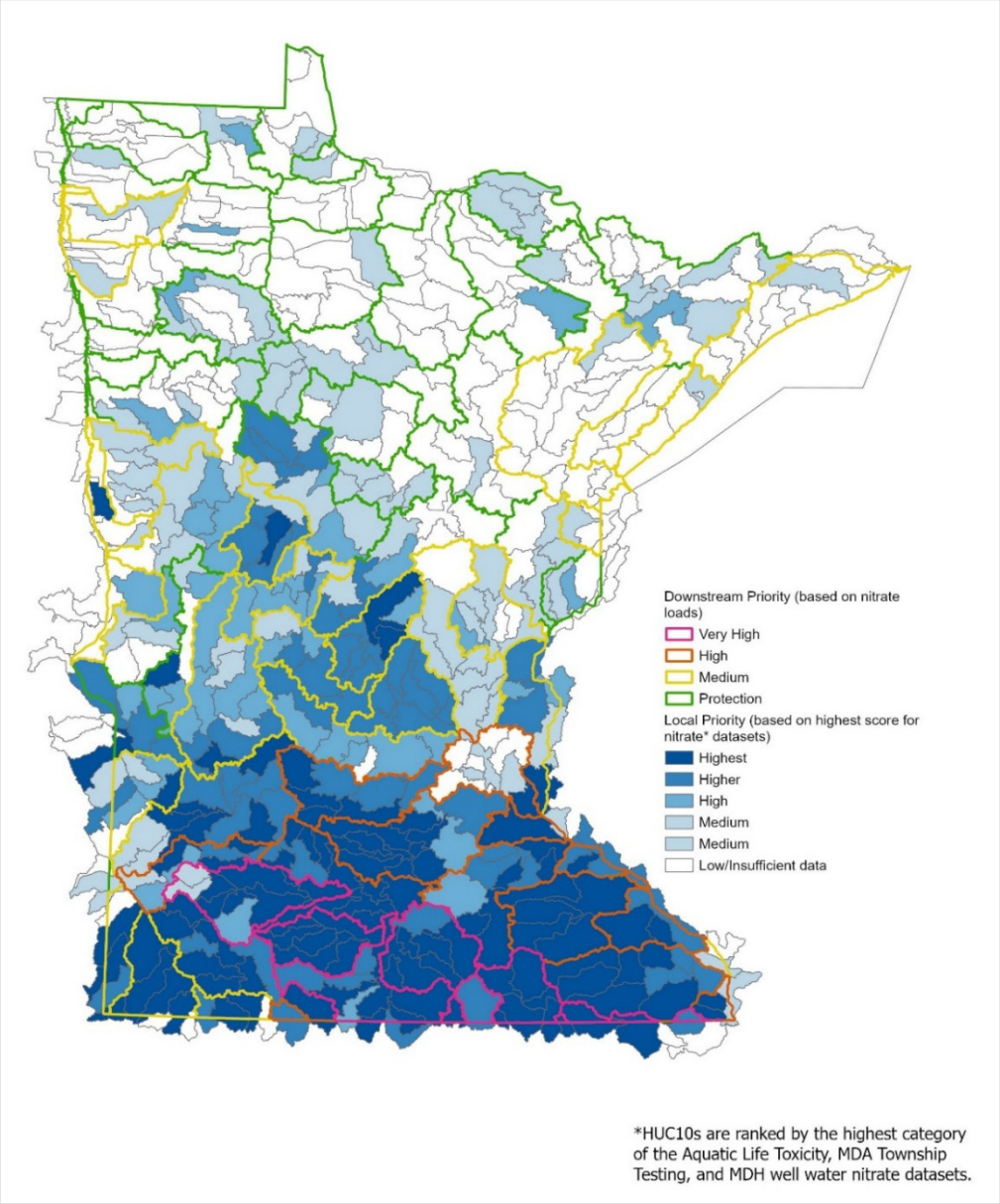
Priority watersheds have either a high nutrient yield (loads normalized to area) that reaches the state line or are considered a high priority for one or more of the in-state nutrient reduction needs. Priority watersheds for phosphorus reduction are more common in the southern half of the state, while phosphorus lake protection needs are more common in the north (Figure ES-8).

Figure ES-1-8. Highest category phosphorus priority watersheds for both protection and restoration, along with the priority watersheds contributing TP loads downstream of Minnesota.



Priority watersheds for nitrogen are mostly in southern Minnesota, as well as in the sandy soil region of central Minnesota that is vulnerable to elevated groundwater nitrate levels (Figure ES-9).

Figure ES-1-9. Highest-category nitrate priority HUC-10 watersheds for drinking water and aquatic life, along with the priority watersheds contributing TN loads downstream of Minnesota.



Nutrient Reduction Strategies

The 2025 NRS documents substantial progress during the past decade. Yet challenges in meeting water quality goals remain, including cost, technology limitations, and federal policy. The cost of reaching NRS goals is estimated to be well above $1 billion annually.

The 2014 NRS identified an aspirational 2040 final goal timeframe, but Minnesota will fall short of meeting NRS goals by 2040 without additional measures in place to accelerate the pace of change. The NRS recommends pursuing steady incremental progress through existing tools while adding initiatives aimed at systemic change that could shift the trajectory. The 2025 NRS builds on foundational

advancements already made and identifies where work should be intensified and how success can be achieved (see Chapter 8 for more details).

Watershed-based strategies

Minnesota has a rich history of water planning, which coalesced into the Minnesota Water Management Framework (described in Chapter 6). The framework is organized at the major watershed scale (i.e., HUC-8) and includes five steps:

1. Monitoring, assessment, and characterization
2. Problem investigation and applied research
3. Restoration and protection strategy development
4. Developing comprehensive watershed management plans (CWMPs)
5. Implementation

Steps 1–3 have been completed in all 80 major watersheds in Minnesota, through watershed monitoring that is in its second 10-year cycle, and through the development of Watershed Restoration and Protection Strategies (WRAPS) that are now being updated. The Water Management Framework also includes Groundwater Restoration and Protection Strategies (GRAPS) that address groundwater nitrate. Step 4 is complete for most planning areas, including 54 comprehensive local water plans through the One Watershed, One Plan (1W1P) process and 31 watershed plans in the Twin Cities Metro Area. Step 5 is ongoing.

The NRS identifies HUC-8 watershed outlet load reduction planning targets for both nitrogen and phosphorus that will collectively achieve goals at state lines. These targets can be used with the following NRS tools to plan and implement nutrient reductions for local and downstream waters, as described in Chapter 7:

- Watershed nutrient balance maps show areas with potential cropland surplus nutrients.
- Nutrient reduction efficiencies information for agriculture practices to reduce nitrogen and phosphorus, along with estimated costs per acre.
- River nutrient concentration trends in Minnesota rivers.
- BMP adoption tracking.
- Watershed and lake ecological health scores.
- Treated wastewater effluent nutrient levels throughout Minnesota.
- Modeled estimates of nutrient load reduction from past practices and example scenarios of practice combinations to achieve NRS goals.
- Watershed pollutant load and concentration monitoring results throughout Minnesota.

To meet NRS goals, Minnesota needs to maintain and expand ongoing local conservation practice delivery through comprehensive local watershed planning tailored to local conditions and situations. The Minnesota Water Management Framework will require considerably more support to address the needed landscape-scale changes.

The 2025 NRS recommends that Minnesota invest in developing and strengthening support for the Water Management Framework planning and implementation steps through:

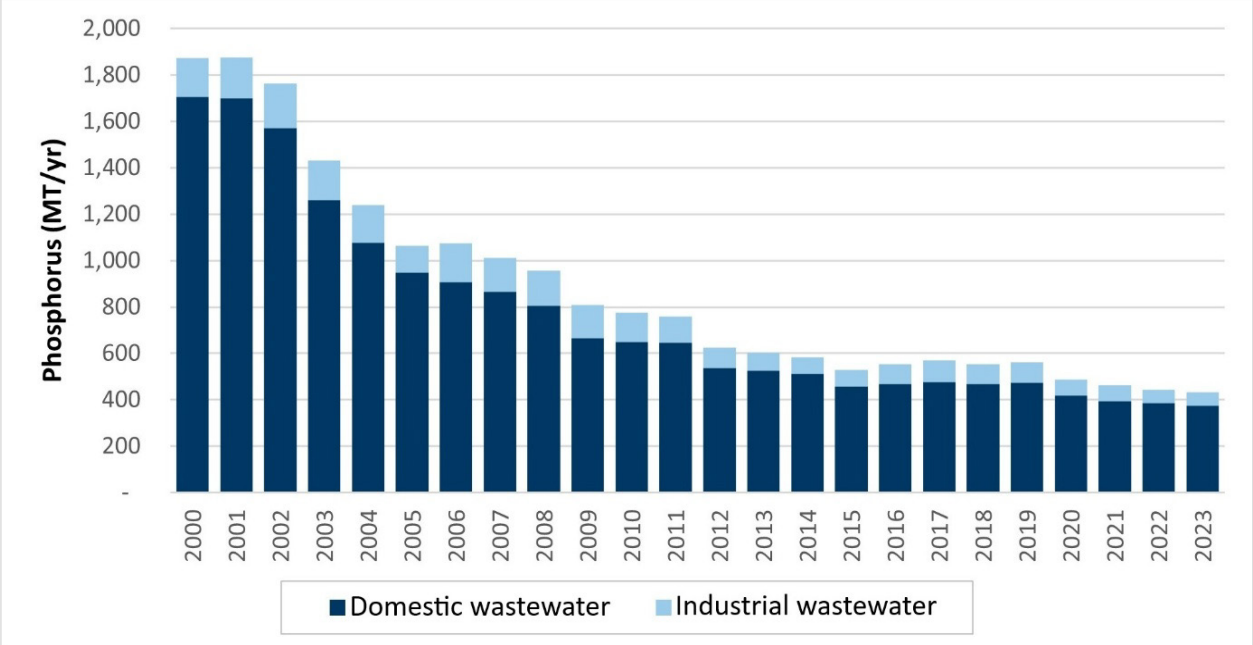
- Increasing workforce capacity and training for local government and private industry staff to help landowners adopt new conservation practices and actions.
- Streamlining practice delivery, reporting, and funding systems to facilitate accelerated practice adoption.

- Making programs that streamline the installation of agriculture practices easy to initiate and fund, especially for drainage water management and treatment practices.
- Strengthening private industry involvement and public-private partnerships.
- Replicating existing successful elements of local and regional soil health programs.
- Expanding opportunities to implement practices that provide multiple ecosystem and economic benefits.
- Reaching absentee landowners with conservation and soil health strategies/incentives.
- Connecting practices and goals identified in the NRS with WRAPS Updates, CWMP through the 1W1P program, Twin Cities Metro Area watershed plans, and GRAPS.
- Increasing support to local watershed organizations for data and analysis, technical training, and tracking and decision-support tools.

Wastewater strategies

The wastewater sector has achieved substantial reductions in phosphorus since 2000, cutting loads in treated effluent by 76% (Figure ES-10). The 2014 NRS outlined a plan to address nitrogen in treated effluent, which contributed about 8% of the statewide nitrogen load to rivers. The first step was monitoring effluent nitrogen levels. Nitrogen monitoring in Minnesota treatment facilities is now widespread. The next steps in nitrogen reduction have begun to be implemented, following MPCA's introduction of a Wastewater Nitrogen Reduction Strategy in the spring of 2024. The strategy is a phased approach that will begin with adding nitrogen limits to wastewater permits for new, expanding, or significantly upgraded facilities. The strategy will also eventually include a state discharge restriction of 10 mg/L TN. Using nitrogen management plans and existing wastewater infrastructure, cities and industry will denitrify and remove nitrogen while aiming to maintain past phosphorus improvements.

Figure ES-1-10. Statewide domestic and industrial wastewater TP annual discharges, 2000–2023.



While this strategy will result in NRS wastewater goals being met, it will require substantial investment in infrastructure. Initially, lower-cost approaches and focusing on facilities that impact streams impaired by nitrate should be emphasized. Over time, higher-cost approaches will likely be needed to reduce nitrate from wastewater discharge, as described in Chapter 4. In addition, Minnesota is working to expand opportunities for nutrient trading across the state to help offset the costs of wastewater nutrient reduction.

Cropland strategies

Nutrient reduction from cropland is especially needed in the following situations:

- Nitrate leaching reduction in areas with vulnerable groundwater under row crop production, including sandy soils, karst geology, and other shallow soils above bedrock.
- Nitrate loss reduction to surface waters in tile-drained lands under row crop production.
- Phosphorus overland runoff reduction in priority watersheds draining into lakes and rivers with eutrophication concerns.

The primary means of reducing nutrient losses from agricultural fields is by installing and adopting practices, often called BMPs, designed to keep nutrients on fields and out of waterways. These practices also include changes to cropping rotations and vegetative cover.

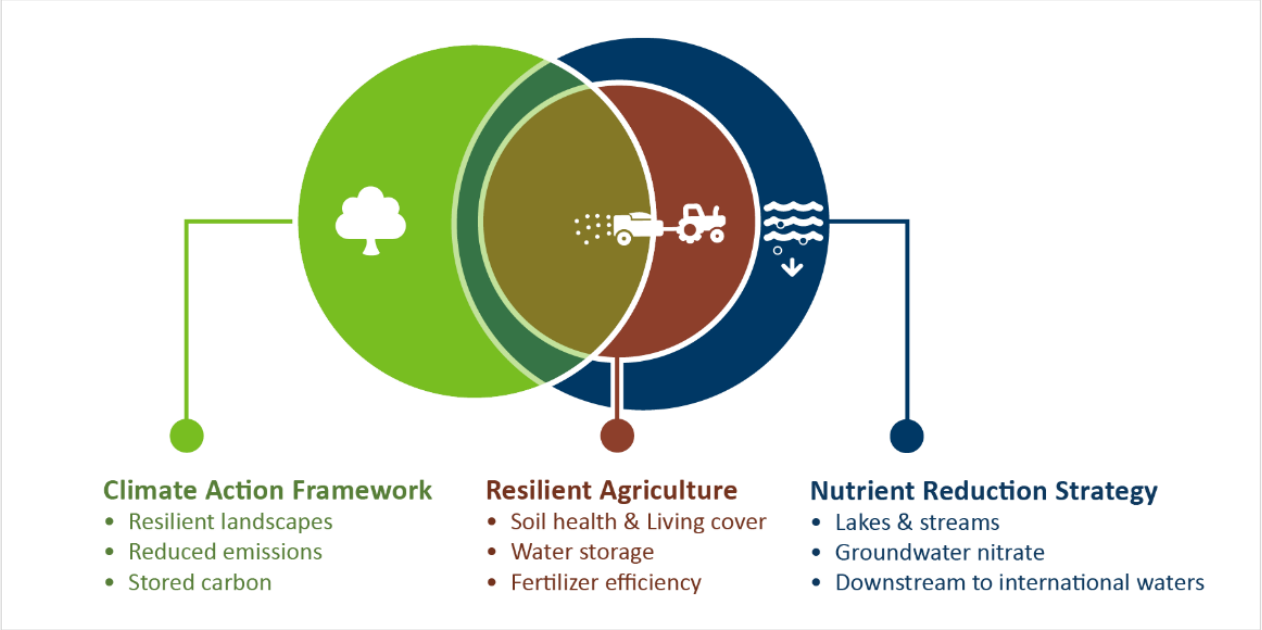
When developing the 2025 NRS, the UMN conducted an extensive literature review of the research on these practices to determine the nutrient reduction effectiveness of practices in Minnesota and locations with similar climates. While no single practice will work on every acre or solve all nutrient loss, most land can use one or more of the 22 practices identified as being able to reduce nitrate losses (by 4% to 94%, depending on the practice) or one or more of the 20 practices identified as being able to reduce phosphorus runoff (by 5% to 75%, depending on the practice).

Besides protecting water quality from nutrient runoff, many of the practices also support co-benefits, such as improved air quality, soil health, carbon storage, long-term agricultural productivity, farm profitability, farm field resilience to precipitation extremes, reduced flooding, and expanded habitat for wildlife and pollinators. Water quality benefits can include improved drinking water, reduced algae in nearby water bodies, and enhanced fisheries and recreation in lakes, rivers, and oceans. Minnesota will build on its recent efforts to develop frameworks for climate action, soil health, and water storage, and associated funding, by promoting practices that help address overlapping ecosystem and agricultural goals (Figure ES-11).

Practices that are effective at protecting water quality and providing other benefits include:

- Conservation crop rotation (i.e., adding small grains like oats or perennials into rotations)
- Perennial crops and pastures as working lands
- Cover crops
- Reduced tillage methods, such as strip-till
- In-field nutrient management (fertilizer and manure precision/efficiency)
- Drainage water recycling (storing and irrigating drainage waters)
- Wetland installation

Figure ES-1-11. Overlapping multiple benefits from strategies aiming for climate action, resilient agriculture, and nutrient loss reduction into waters.



Nutrient reduction efficiencies expected from the UMN review of practices were incorporated into Minnesota's watershed modeling tools to estimate the combined scale of adoption that could potentially reach NRS goals. This confirmed that, while there is no single correct combination of practices to achieve Minnesota's nutrient reduction goals, millions more acres of practices will need to be installed across the state to achieve significant nutrient reductions (Figure ES-12).

Cropland Implementation

Figure ES-1-12. Example scenario showing the magnitude of change needed to achieve nutrient reduction goals in the Mississippi River Basin.

Successful implementation of cropland practices will require building on Minnesota's existing voluntary and regulatory foundations. Continuing implementation of laws, rules, and permits affecting cropland that were adopted during the past decade is expected. Commitment and collaboration among local, state, federal, and private sector organizations, along with individuals, will also be necessary. In addition to the initiatives previously described to strengthen support for the Water Management Framework, the following strategies are emphasized for the cropland sector:

- **Continuous living cover (CLC) campaign**. Nitrogen reduction goals cannot be achieved without transformative changes in crop system rotations and maintaining living cover for more months each year. To accelerate the transition to perennials, pasture, small grains, and harvested cover crops, the NRS recommends creating a work group to develop a CLC campaign to establish the next million acres of CLC.

- **Support and expand existing successful agricultural practice improvement programs**. Minnesota's existing Agriculture Water Quality Certification Program should be expanded to help meet both local and statewide water quality goals. Statewide and local soil health initiatives and the related Minnesota Office of Soil Health programs should continue and expand. The NRS encourages continued work by private industry to promote nitrogen BMPs.
- **Increase research and development**. Advancing nutrient reduction in croplands requires the continuation of a strong research program. Minnesota will need to invest in studying cropland nutrient reduction techniques, systems, technologies, and co-benefits, as well as support demonstration projects and pilot programs.

Inter-seeded cover crop (*Source*: USDA, L. Betts)

Strategies for other sources

Phosphorus reductions from miscellaneous sources are needed to meet TP goals, and, in some cases, the practices used to achieve these reductions will also help meet TN goals.

- **Feedlots.** MPCA's feedlot program has continued to work to minimize the risk to waters from animal holding and manure storage areas and the land application of manure. Recently, permit requirements to reduce nitrate leaching losses were specified for manure management plans, transferred manure, field inspections, early fall manure applications, winter manure applications, and manure application in vulnerable groundwater areas.
- **Septic systems.** As it did in the 2014 NRS, Minnesota's subsurface sewage treatment system program will continue to serve as the primary strategy in the 2025 NRS to reduce nutrient loads from septic systems. The program has made great progress in the past decade.
- **Forests.** Forested areas cover about 33% of Minnesota, and, although intact forests generally do not export many nutrients, factors like past land use practices or timber harvest can mobilize forest nutrients. Forest preservation, peatland restoration, and good timber harvest practices all help minimize nutrient losses to waters in forested areas.
- **Streambank erosion.** Studies of streambank and other near-channel erosion show that it can contribute substantially to river phosphorus loads. To achieve the final in-state and downstream goals for phosphorus, increasing practices to reduce streambank and gully erosion will be needed.

Protection strategies

Protection strategies are needed in watersheds facing development pressures and land use changes. Areas with lakes that are sensitive to relatively small additions of nutrients, including Lake Superior and Minnesota's many high-quality lakes, are important. 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. WRAPS Updates and CWMPs take into account the local needs for water resource protection of waters that are not impaired but have declining water quality trends or are of high value to local communities.

The Minnesota NRS would fail if it met only the large river phosphorus load reduction goals while not also protecting the many lakes that are currently in relatively good condition but remain highly vulnerable to phosphorus inputs.

Tracking progress

Figure ES-1-13. Measuring progress is multifaceted

The NRS provides for accountability, adaptive management, and ensuring that Minnesota stays on the path to progress in achieving healthy waters. Measuring NRS progress depends on tracking the (1) practices and actions related to on-the-ground efforts, (2) water quality in surface water and groundwater, (3) programs on the state and regional levels that affect nutrients, and (4) the changes in people's level of engagement with NRS efforts (Figure ES-13). Tracking is an ongoing, iterative, and interagency process for the NRS.

Since the 2014 NRS, partners have expanded the water quality monitoring data and tools available for following agriculture practice adoption, watershed planning, and strategy development; these are available at the MPCA's NRS website. New ways to track CLC acreage changes will be developed. To increase NRS flexibility and data access, an NRS dashboard will be developed to serve as a central location for the data used for NRS analysis and the tracking tools displaying that data. The dashboard will also be the primary means of communicating NRS progress to NRS partners and the public. Ultimately, the NRS dashboard will facilitate and provide the foundation for the next major update to the NRS.

Assuring progress

Lake Superior

Since the NRS is a multiple-agency strategy with responsibility shared by leadership from several state organizations that use the NRS as a tool for implementing the improvement measures in the strategy, these organizations are responsible for overseeing NRS implementation. The specific agencies identified to lead various initiatives are noted in Chapter 8. These organizations should develop an economic analysis and a strategy for ongoing funding. While Minnesota currently has partial funding for certain NRS implementation measures, much more funding will be needed both before and after the 2034 end date of the Clean Water, Land and Legacy Amendment Clean Water Fund monies.

Accountability to other states and provinces will be maintained through Minnesota's continued involvement on the Gulf Hypoxia Task Force, the International Red River Watershed Board, the International Rainy-Lake of the Woods Watershed Board, and the Great Lakes Commission.

Conclusion

To address the problem of excess nutrients in waters, Minnesota has built a strong foundation consisting of both voluntary and regulatory programs. Many of the programs are relatively new, and the water quality results of those programs are only beginning to emerge.

Water quality may incrementally improve if we pursue a stay-the-course approach without accelerating the pace of progress. However, Minnesota will fall short of meeting all NRS goals by 2040 without putting additional measures in place to accelerate the pace of change and increase the capacity for change. The NRS recommends pursuing both steady incremental progress through existing tools and adding initiatives aimed at systemic change that could shift the trajectory. With over 20 million acres of rural and urban change or refinement needed, the scale is enormous. Meaningful transformation will take time.

The NRS is science-based. However, the NRS is ultimately a strategy about people. It's about the quality of life for Minnesota's residents. Because the people of Minnesota care, much progress has already been made to reduce nutrients in waters. In the end, the people of Minnesota will determine what priority to place on NRS efforts, the desired rate of progress, and how much they are willing to invest toward solving our state's many nutrient-related challenges.