MINNESOTA POLLUTION CONTROL AGENCY

520 Lafayette Road North | St. Paul, Minnesota 55155-4194 | 651-296-6300

800-657-3864 | Use your preferred relay service | info.pca@state.mn.us | Equal Opportunity Employer

April 1, 2022

The Honorable Bill Ingebrigtsen
Chair, Senate Environment and Natural Resources Finance Committee
3207 Minnesota Senate Building
95 University Avenue West
St. Paul, MN 55155

The Honorable Carrie Ruud
Chair, Senate Environment and Natural Resources Policy and Legacy Finance Committee
3233 Minnesota Senate Building
95 University Avenue West
St. Paul, MN 55155

The Honorable Foung Hawj
Ranking Minority Member, Senate Environment and Natural Resources Policy and Legacy Finance Committee
2201 Minnesota Senate Building
95 University Avenue West
St. Paul, MN 55155

The Honorable Rick Hansen
Chair, House Environment and Natural Resources Finance and Policy Committee
407 State Office Building
100 Rev. Dr. Martin Luther King Jr. Blvd.St. Paul, MN 55155

The Honorable Patricia Torres Ray
Ranking Minority Member, Senate Environment and Natural Resources Finance Committee
2225 Minnesota Senate Building
95 University Avenue West
St. Paul, MN 55155

The Honorable Josh Heintzeman
Republican Lead, House Environment and Natural Resources Finance and Policy
353 State Office Building
100 Rev. Dr. Martin Luther King Jr. Blvd.
St. Paul, MN 55155

RE: 2022 Pollution Report with estimated volume of air and water pollutant emissions, as required by Minnesota Laws Chapter 116.011

Dear Committee Chairs and Ranking Minority Members:

In keeping with the provisions of Minnesota Laws Chapter 116.011, the enclosed 2022 Pollution Report provides estimates of the total volume of water and air pollution emitted in the previous two calendar years for which data are available. This report also is available on our website at *https://www.pca.state.mn.us/about-mpca/legislative-reports*.

If you have any questions regarding this report, please contact me at 651-757-2031.

Sincerely,

Tom Johnson

This document has been electronically signed

Tom Johnson
Government Relations Director
Commissioner's Office

TJ/MH/cbg

REPORT TO THE LEGISLATURE

APRIL 2022

2022 Pollution Report

A summary of Minnesota's air emissions and water discharges.

MINNESOTA POLLUTION CONTROL AGENCY

Legislative charge

Minn. Statutes § 116.011 Pollution Report

A goal of the Pollution Control Agency is to reduce the amount of pollution that is emitted in the state. By April 1 of each even-numbered year, the Pollution Control Agency shall report the best estimate of the agency of the total volume of water and air pollution that was emitted in the state in the previous two calendar years for which data are available. The agency shall report its findings for both water and air pollution:

(1) In gross amounts, including the percentage increase or decrease over the previously reported twocalendar years; and

(2) In a manner which will demonstrate the magnitude of the various sources of water and air

pollution.History:

1995 c 247 art 1 s 36; 2001 c 187 s 3; 2012 c 272 s 72

Authors

Meghan Hemken
Azra Kovacevic

Contributors/acknowledgements

The report was prepared with assistance from other staff in the MPCA's Municipal, Industrial, Operations, Watershed, and Environmental Analysis and Outcomes divisions. Special thanks to Hassan Bouchareb, Anne Claflin, Mark Ferrey, Marco Graziani, Bruce Monson, Casey Scott, Erik Smith, Michael Smith, and Summer Streets.

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Minnesota Pollution Control Agency

520 Lafayette Road North | Saint Paul, MN 55155-4194 |

651-296-6300 | 800-657-3864 | Or use your preferred relay service. | Info.pca@state.mn.us

This report is available in alternative formats upon request, and online at www.pca.state.mn.us.

Document number: lrp-ear-1sy22

Contents

Executive summary

Every two years, the Minnesota Pollution Control Agency (MPCA) uses the most recent data available to estimate the total amount of pollution emitted into our air and discharged to our water resources. The MPCA also estimates the percentage increase or decrease over the previous two calendar years, and the relative contributions of the various sources of pollution.

This report also includes information on emissions of toxic air pollutants, greenhouse gas emissions, nonpoint source water pollutants, and contaminants of emerging concern. While it is still not possible to quantify the amounts of all of these pollutants released in the environment, the agency is working to understand the effects of these pollutants on human health and the environment and to develop strategies to reduce their presence in Minnesota's air and water.

Air emissions

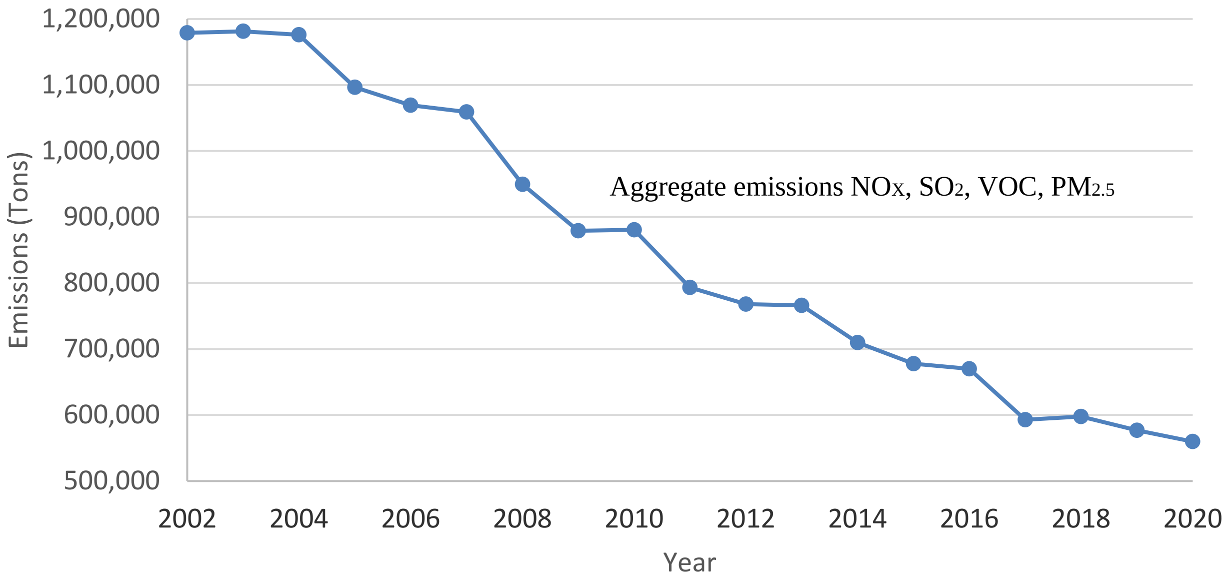
In this report, the MPCA details statewide emissions of pollutants to Minnesota's air, including criteria air pollutants (pollutants with national ambient air quality standards), greenhouse gases, and other air toxics.

Criteria air pollutants

Criteria emissions from larger facilities with air permits are available every year; however, emissions from other sources are only available every three years. 2017 is the latest year with statewide emissions data for these sources.

Figure 1 shows estimated total statewide emissions of four major criteria air pollutants from 2002 to 2020. During this time, estimated emissions of these pollutants have decreased by over 50%. While this report is focused on statewide total emissions, some air pollutants are emitted disproportionately in areas of concern. Figure 2-1 shows the disproportionate impact from air emissions experienced by people living in areas of Environmental Justice (EJ) concern. For more information on MPCA's work around EJ see our webpage at: [MPCA and environmental justice | Minnesota Pollution Control Agency (state.mn.us)]

Figure 1. Minnesota statewide emissions trends



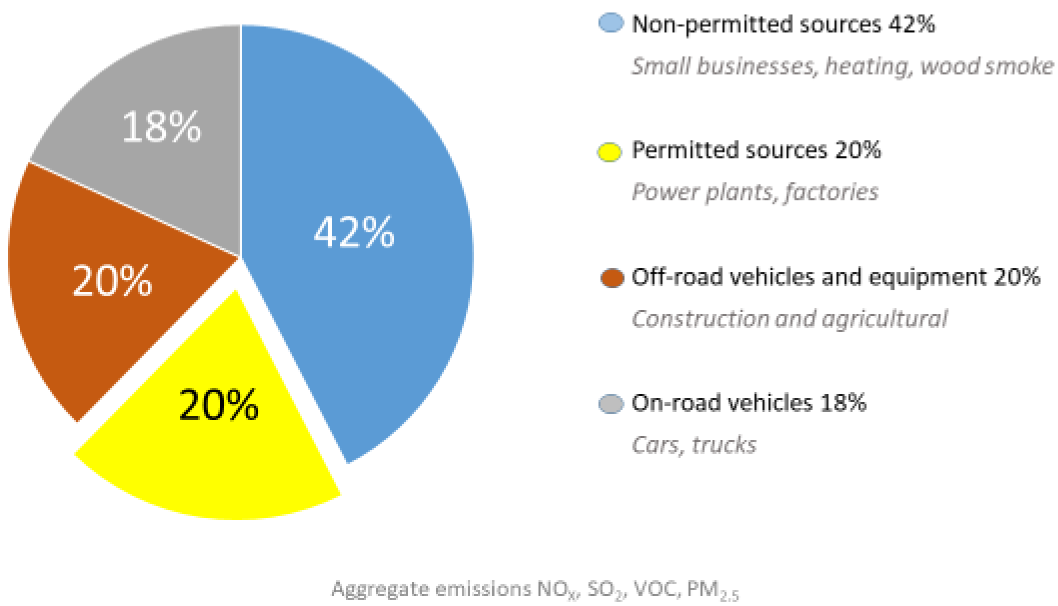
Emissions in 2002, 2005, 2008, 2011, 2014 and 2017 were calculated from all sources, including mobile, non-permitted and permitted sources. For in-between years, mobile and non-permitted estimates were held constant, therefore any changes for those years are solely due to permitted sources. Prior to 2012, $PM_{2.5}$ *emissions were calculated every three years. In 2012, MPCA started calculating emissions annually for all permitted sources. It is therefore important not to place undue emphasis on yearly changes. Fire and biogenic emissions are not included in the totals because they vary greatly from year to year.*

Since 2002, overall emissions have been decreasing. This is generally due to improvements in pollution control technology, governmental regulations, facilities voluntarily reducing emissions and changes to estimation methodologies. All criteria emission estimates from permitted sources further decreased between 2018 and 2020. Changes at utilities and mining companies resulted in decreases in all criteria pollutants. Mining production decreased significantly in 2020 compared to 2018; many mines were idled during 2020 due to low demand and COVID 19 shutdowns and economic slowdown. In 2019, sulfur dioxide emissions from utilities significantly decreased; specifically Xcel Energy's Sherburne Generating Plant burned one million tons of coal less compared to 2018, and Minnesota Power – Boswell plant retired two coal burning units.

Since 2018, emissions from manufacturing have also decreased across all pollutants. This decrease is likely due to slowed economic growth and COVID 19 shutdown during the past couple of years. The most recent finalized statewide emission estimates are from 2017.

In 2017, most air pollution came from smaller, widespread sources, including vehicles, small businesses and construction equipment. Figure 2 shows a breakdown of 2017 statewide emissions.

Figure 2. Sources of criteria air pollutant emissions in Minnesota, 2017

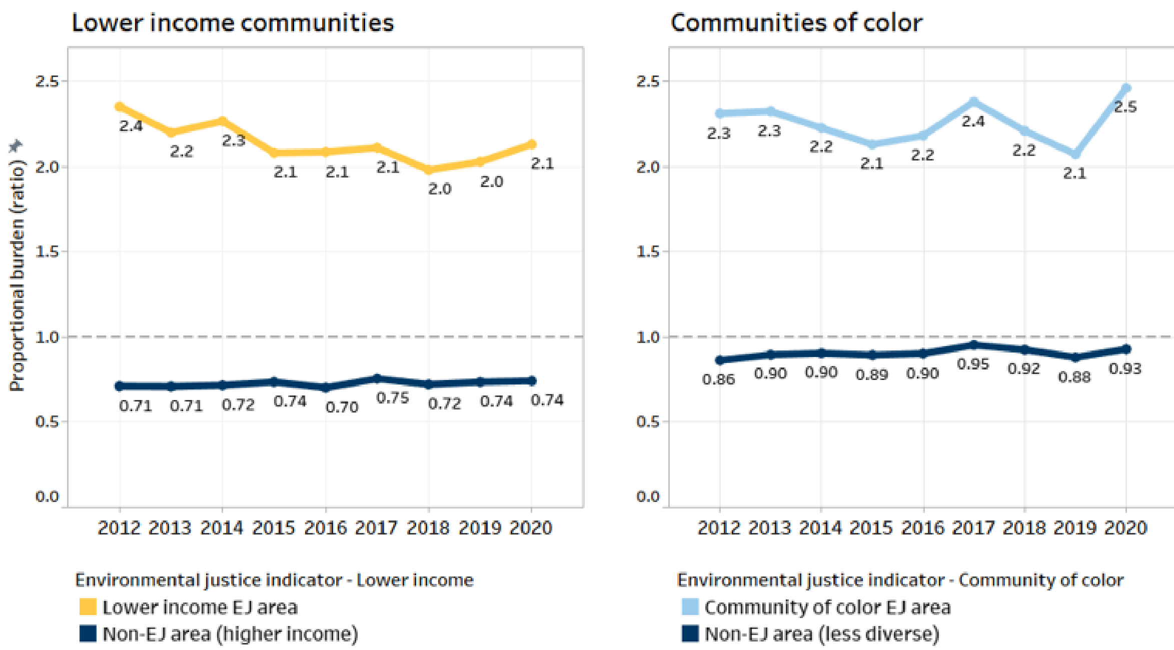


Slightly over 40% of Minnesota emissions come from non-permitted sources, such as auto-body shops, gas stations, and home heating and air conditioning systems. Individually, these are small sources, but when combined, contribute significantly to overall emissions. On-road vehicles, such as cars and trucks, make up 18% of emissions in Minnesota. Off-road vehicles and agricultural and construction equipment contribute 20% of total emissions in Minnesota. Emissions from permitted sources, typically power plants and large industrial factories, make up 20% of total statewide emissions.

Lead, mercury and other air toxics are pollutants that can be toxic at very low concentrations. In 2017, 9.6 tons of lead were emitted into the air. Additionally in 2017, 1543 pounds of mercury were emitted in Minnesota. These pollutants have also trended downward, with about a 40% statewide decrease in air emissions of lead from 2014 to 2017 and a 36% decrease in mercury during the period from 2014 to 2017.

Figure 2-1 shows that air pollution is worse in EJ communities due to a greater concentration of emissions sources, including factories, businesses, and many small sources like gas stations, cars, trucks and buses. This metric, proportional burden, compares air emissions from factories and businesses in EJ versus non-EJ communities. To estimate the proportional burden, statewide and subgroup emissions of combined NOx, $PM_{2.5}$, SO_2 and VOC were calculated and compared to statewide median emissions. A ratio of one indicates a perfectly equitable scenario, and ratios above one indicate that the subgroup is experiencing higher emissions. The data show that EJ communities are above the ratio of 1, and air emissions are about 50% higher in EJ communities.

Figure 2-1. Inequities in reported emissions for permitted facilities (A higher proportional burden of total emissions [NOx, SO_2, VOC and $PM_{2.5}$])



*Proportional burden is a ratio of the subgroup's median emissions divided by the statewide median emissions. A score above 1.0 indicates the subgroup experiences higher emissions than would be expected in a perfectly equitable scenario.
*Communities are represented as Census Tracts.
*Near is defined as emissions released within a 1/2 mile of a Census Tract.

Greenhouse gases

In Minnesota, the MPCA estimates greenhouse gases (GHGs) for electric generation, transportation, agriculture, and the industrial, residential, commercial, and waste sectors. The most recent emission inventory for GHGs was completed in 2018. Since 2005, Minnesota's total greenhouse gas emissions have declined by about 8% and are currently not on track to meet the goals of the Next Generation Energy Act of 2007 (NGEA) (Minn. Stat. § 216H.02). NGEA called for a GHG reduction goal of 15% below 2005 emissions by 2015, and longer-term goals for 2025 (30% below 2005 emissions) and 2050 (80% below 2005 emissions). In 2019, Governor Walz established the Climate Change Subcabinet and Advisory Council to identify policies and strategies to put Minnesota back on track to meeting our climate goals. The MPCA and other agencies have worked together through the Climate Change Subcabinet to develop a draft Climate Action Framework reflecting our collective expertise and years of engagement with Minnesotans. This Framework identifies near-term actions we must take to achieve our state's long-term goal of a carbon-neutral, resilient and equitable future. Continued public input around six goals – clean transportation, climate-smart natural and working lands, resilient communities, clean energy and efficient buildings, healthy lives and communities, and a clean economy – will shape the final Climate Action Framework to be released in mid-2022. Framework documents and opportunities for participation are available online at mn.gov/framework.

Air toxics

Air toxics are estimated every three years, with the latest statewide estimates available from 2017. Air toxics from permitted sources are complete for 2020 and will be discussed elsewhere in the report.

There may be differences in the total emission figures for a given year discussed in this report versus past MPCA emission reports because data may be updated in MPCA's emission inventory due to corrections or changes in methodology.

MPCA continues to work with our state, federal, local and non-profit partners to reduce neighborhood air pollution from all sources and pollutants. Minnesota's future emissions may be influenced by:

- **Future installation of NO_x controls**. Emissions from taconite facilities decreased due to production decreases and installation of NO_x controls required by federal rules from 2018 to 2020. MPCA has estimated that when the installation of NO_X controls is completed, it will result in NO_X emissions reductions of just under 11,000 tons per year (from a baseline of 23,500 tons per year to an estimated 12,700 tons per year). These actions would also decrease air toxics emissions.
- **Continued decreases in on-road mobile emissions.** On-road emissions of both criteria pollutants and air toxics have continued to decrease over the years due to federal Corporate Average Fuel Economy (**CAFE**) standards. In July 2021, Minnesota adopted the Clean Cars Minnesota rule. The regulation requires vehicles sold in Minnesota to produce less pollution. It also increases the availability of electric vehicles on the Minnesota market. The Clean Cars rule allows the state to take more meaningful steps towards reducing emissions and improving the environment
- **Decreasing emissions from electric utilities.** Over the past decade there has been a significant decrease in emission from electric utilities due to reductions in coal use, and increased use of renewable energy. Emissions from utilities should continue to decrease due to increases in renewable energy sources such as wind and solar; increases in energy efficiency; and power plant modernization. Expected lowering of ozone and PM2.5 standards will further reduce emissions from all sources.

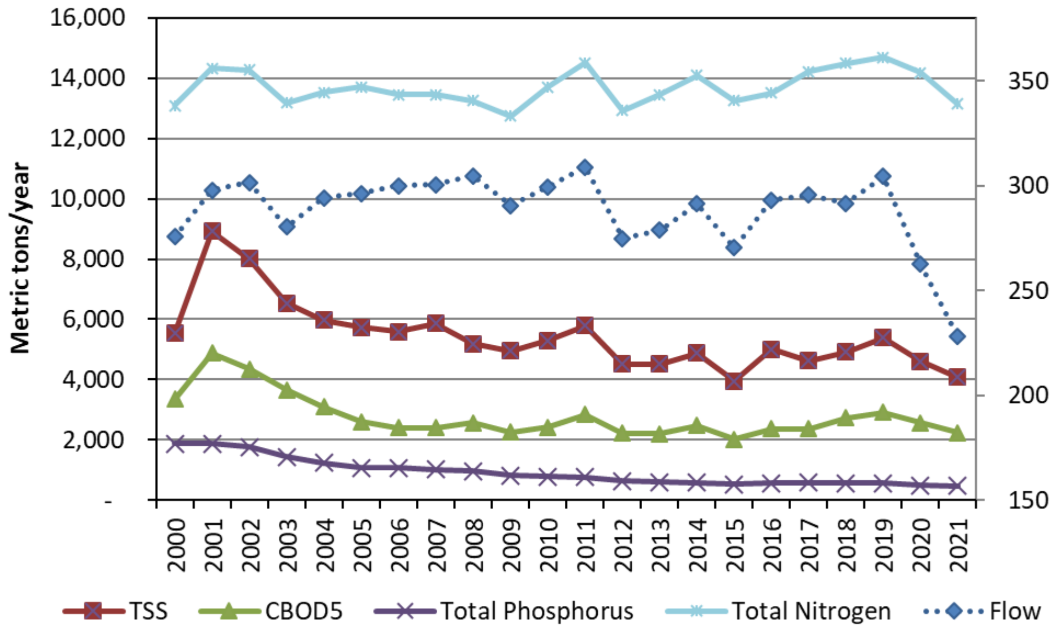
Water discharges

In this report, the MPCA provides estimates of discharges to surface water from point sources of pollution — primarily municipal and industrial wastewater treatment facilities. The report also describes progress in watershed monitoring and assessment, to understand the conditions in our surface waters, and agency efforts to reduce nonpoint sources of pollution. A final section highlights ongoing efforts in the state to monitor and address contaminants of emerging concern in Minnesota's waters.

Pollutant loads from wastewater treatment facilities are calculated by combining effluent flow data with reported pollutant concentrations, or estimated pollutant concentrations where facility-specific data are not available. Estimated concentrations used to calculate pollutant loads are based on categorical assumptions that account for the characteristics of the waste stream and the type of facility. Concentration estimates are based on effluent data from similar waste streams and facility types when available, and in some cases estimates are based on best professional judgment. Pollutant loads calculated from measured wastewater flows and observed concentrations are considered to be highly reliable while less confidence is warranted for pollutant loads derived from estimated concentrations.

The chart below shows pollutant effluent flow and loading trends for four measures of wastewater pollution from 2000-2021. The four pollutants are total suspended solids (TSS), carbonaceous biochemical oxygen demand ($CBOD_5$), total phosphorus, and total nitrogen. Effluent flow is reported in billion gallons per year. Pollutant loads for TSS, $CBOD_5$, total phosphorus, and total nitrogen are reported in metric tons per year.

Figure 3. Pollutant loading trends from Minnesota wastewater treatment facilities, 2000-2021



Generally, effluent flows tend to fluctuate based on precipitation. Lower flows during the very dry year of 2021 correlate with lower pollutant loading. The overall health of the economy also affects the amount of industrial production, which in turn affects industrial effluent flows and the amount of industrial effluent treated at municipal wastewater treatment facilities. With the exception of total nitrogen levels, which have increased in wastewater discharges, facilities have generally decreased their pollutant loads.

Regulatory policies implemented over the past two decades have promoted the reduction of total phosphorus discharged by wastewater treatment facilities, which has led to significant improvements in water quality. Total phosphorus is the primary pollutant associated with excess algal growth in Minnesota's lakes and streams. Facilities have also decreased their loads of the following:

- Total suspended solids, which include sediment and other particles that cloud the water.
- Carbonaceous biochemical oxygen demand, which is a measurement of the potential to deplete levels of dissolved oxygen needed by fish and other aquatic life.

Facilities throughout Minnesota have made significant investments in technology, equipment, and training that have led to these improvements.

Wastewater treatment facilities have also significantly reduced direct discharges of mercury to Minnesota's waters. Mercury is a toxic element that accumulates in fish tissue and presents a risk to fish eating populations. Many higher fish eating populations are tribal communities, exercising treaty fishing rights, and other non-white populations, making mercury in fish an EJ issue. Mercury reduction in wastewater is a result of successful source reduction programs at entities like dental offices and installation of treatment technologies at wastewater treatment plants for mercury removal, where necessary. On average, the data show a 62% reduction in mercury loads from a 4.02 kilogram per year baseline in 2005/2006. Direct discharges of mercury in wastewater are very small compared to atmospheric sources of pollution.

While Minnesota has made significant progress reducing many pollutants discharged in wastewater, pollutants like nitrogen, sulfate, chloride, and PFAS are difficult to remove with current technologies an remain an area where progress is needed.

Nonpoint sources of pollution, like rainfall or snowmelt moving over or through the ground and carrying natural or human-made pollutants into lakes, streams or wetlands now pose the greater challenge for prevention and cleanup. Many nonpoint sources of pollution that affect Minnesota's surface and groundwater resources are the result of choices that people make every day such as farming practices, lawn care practices, watercraft operation, and waste disposal. The daily decisions that farmers, homeowners, developers, and businesses make regarding land uses are crucial to protecting water resources from the effects of nonpoint source pollution.

Point sources have the greatest potential to impact the environment during periods of low precipitation and stream flow. Nonpoint sources, including runoff from agricultural fields, feedlots, urban areas, and on-site sewage treatment (septic) systems, are most significant during periods of high precipitation and stream flow. Further pollutant reductions are needed from both point sources and nonpoint sources to achieve goals set in federal and state law for protecting human health and the environment.

In 2008, Minnesota voters approved the Clean Water Land and Legacy Amendment to the state constitution, increasing the state's sales tax by three-eighths of a percent until 2024. According to the law, 33% of the money is dedicated to a Clean Water Fund (CWF), which has provided for significant additional investment to address both point and nonpoint source pollution. Minnesota agencies released the sixth Clean Water Fund Performance Report in 2022, which documents how CWFs are being spent and how much progress has been made. The MPCA also publishes a Healthier Watersheds: Tracking the Actions Taken webpage to document reductions in both point and nonpoint water pollution.

Future discharges of point source pollution to Minnesota's waters will be influenced by a number of factors, including the following:

- **Wastewater Treatment Infrastructure** — Minnesota's wastewater systems are aging. Significant investments are needed to replace failing infrastructure and upgrade treatment facilities to meet more stringent standards and expand systems to accommodate growth. Both rural and metro facilities face serious challenges to make these improvements to their infrastructure. The past several bonding bills considerably increased funding levels to the Water Infrastructure Fund for affordable and pollution based grants, which helped many projects move forward into construction. Furthermore, the recently passed Infrastructure Investment and Jobs Act will provide significant funding to the Clean Water State Revolving Fund, a key source of funding for new and upgrading wastewater infrastructure. The exact state allotments are not yet set, but MPCA expects an additional $660 million over the next 5 years.
- **Nutrient Reduction Strategy** — Multiple state and federal agencies developed the Minnesota Nutrient Reduction Strategy in 2014 to address excess levels of nutrients— primarily phosphorus and nitrogen — in Minnesota's waters. Reduction goals for phosphorus and nitrogen outlined in the strategy are designed to protect both Minnesota waters and downstream waters, including Lake Winnipeg, the Great Lakes and the Gulf of Mexico. Nitrate loads leaving Minnesota via the Mississippi River contribute to the oxygen-depleted "dead zone" in the Gulf of Mexico. A 2013 study on Nitrogen in Minnesota Surface Waters indicated that more than 70% of nitrate is coming from cropland, with the rest coming from sources such as wastewater treatment plants, septic and urban runoff, forests and the atmosphere. A five-year progress report on Minnesota's Nutrient Reduction Strategy was published in 2020. In 2022, the MPCA is planning to begin the process of considering changes to Minnesota's aquatic life water quality standards. This will include new nitrate aquatic life toxicity standards, revisions to

existing ammonia standards, and may include revisions to Minnesota Rules relating to state water discharge restrictions to support implementation. These standards will help meet the nitrogen goals laid out in the strategy. The river eutrophication standards adopted in 2015 have already helped achieve reductions in phosphorus.

- **Clean Water Fund Investment** — CWF dollars resulting from passage of the Clean Water, Land and Legacy Amendment will continue to accelerate the implementation of practices to improve and protect Minnesota's water resources. However, CWFs available for implementation are not sufficient to meet the demand from local governments and landowners.

Air pollutant emissions overview

Thousands of chemicals are emitted into the air. Many of these are air pollutants that can directly or indirectly affect human health, reduce visibility, cause property damage and harm the environment. For these reasons, the MPCA attempts to reduce the amount of pollutants released into the air. In order to understand the sources of air pollution and to track the success of reduction strategies, the MPCA estimates the emissions of certain air pollutants released in Minnesota.

The Minnesota Emission Inventory estimates emissions from permitted facilities every year in order to fulfill Minnesota rules. In addition, federal rules require the MPCA to estimate emissions every three years from three other principal source categories: non-permitted sources, mobile sources, and fire sources. Biogenic sources include emissions from natural sources such as soils and vegetation. This report only includes manmade sources. Overall, the Minnesota Emission Inventory includes emissions from four principal source categories.

1. *Permitted sources:* Typically large, stationary sources with relatively high emissions, such as electric power plants and refineries. A "major" source emits a threshold amount (or more) of at least one criteria pollutant, and must be inventoried and reported.
2. *Non-permitted sources:* Typically stationary sources, but generally smaller sources of emissions than point sources. Examples include dry cleaners, gasoline service stations and residential wood combustion. These sources do not individually produce sufficient emissions to qualify as point sources. For example, a single gas station typically will not qualify as a point source, but collectively the emissions from many gas stations may be significant.
3. *Mobile sources:* Mobile sources are broken up into two categories: *on-road* vehicles and *off-road* sources. *On-road vehicles* include vehicles operated on highways, streets and roads. *Off-road* sources include off-road vehicles and portable equipment powered by internal combustion engines. Lawn and garden equipment, construction equipment, aircraft and locomotives are examples of off-road sources.
4. *Fires:* Fire emissions are produced by inadvertent or intentional agricultural burning, prescribed burning or forest wild fires.

Criteria pollutants — The 1970 Clean Air Act identified six major air pollutants that were present in high concentrations throughout the United States known as "criteria pollutants." These air pollutants are particulate matter ($PM_{2.5}$ and PM_{10}), sulfur dioxide (SO_2), nitrogen oxides (NO_x), ozone (O_3), carbon monoxide (CO) and lead (Pb). The Minnesota Criteria Pollutant Emission Inventory estimates emissions of five criteria pollutants (PM_{10}, SO_2, NO_x, CO and Pb) as well as a group of ozone precursors called volatile organic compounds (VOCs). Emissions estimates for large facilities are available for 2020. 2017 emissions are available for non-permitted, mobile and fire sources.

$PM_{2.5}$ and ammonia (which is tracked because it contributes to $PM_{2.5}$ formation) yearly emission calculations for permitted facilities started in 2012, while non-permitted, mobile, and fire are still calculated on a three-year cycle, with latest estimates available for 2017. Fire emissions depend on many factors including type of fire, ecosystem conditions, and weather. As a result, fire emissions vary greatly from year to year. Similarly, biogenic emissions are widespread and contribute to background air pollution concentrations. They are impacted by vegetation, temperature and solar radiation. Biogenic emission estimates are not included in this report.

Greenhouse gases — Increases in ambient levels of greenhouse gases can lead to global climate change. The MPCA tracks and reports emissions for six greenhouse gases (carbon dioxide [CO_2], nitrous oxide, methane, hydrofluorocarbons, perfluorocarbons and sulfur hexafluoride) in terms of CO_2 equivalents (CO_2e). CO_2e compares the warming potential of different gases to the impact of CO_2. Emission estimates for 2018 are included in this report. Federal and state rules require the MPCA to estimate GHG emissions from permitted sources each year. Starting in 2011, small permitted sources began reporting GHG emissions. In 2012, all permitted point sources began submitting GHG emissions to the MPCA.

Air toxics — Many other air pollutants are released in smaller amounts than most of the criteria pollutants, but may still be toxic. The EPA refers to chemicals that can cause serious health and environmental hazards as hazardous air pollutants or air toxics. Air toxics include chemicals such as benzene, formaldehyde, acrolein, mercury and polycyclic aromatic hydrocarbons (PAHs). Air toxic emissions from all sources are estimated every three years. Minnesota data comes from the 2017 Minnesota Air Toxics Emission Inventory and 2020 permitted sources.

With each new inventory, improvements are made in terms of pollutants covered, source categories included, and the accuracy of emission estimates. Therefore, changes in the way emissions are calculated may affect trends, even if there was no real increase or decrease in emissions.

The reader may note differences in the total emission figures for a given year discussed in this report, versus previous emission reports the MPCA has published, because data may be updated in past emission inventories due to corrections or changes in methodology.

This report shares summarized statewide emissions of air pollutants. A detailed breakdown of 2017 air emissions is available online on the MPCA website. MPCA has developed multiple workbooks containing permitted source, statewide and county-level emissions. The applications contain permitted source data going back to 2006 and statewide data starting in 2011. The workbooks are a way for MPCA to share data in an automated, interactive and user-friendly format.

For more information, see the following websites:

https://www.pca.state.mn.us/air/air-emissions

https://www.pca.state.mn.us/air/statewide-and-county-air-emissions

https://www.pca.state.mn.us/air/point-source-air-emissions-data

Criteria air pollutant emissions

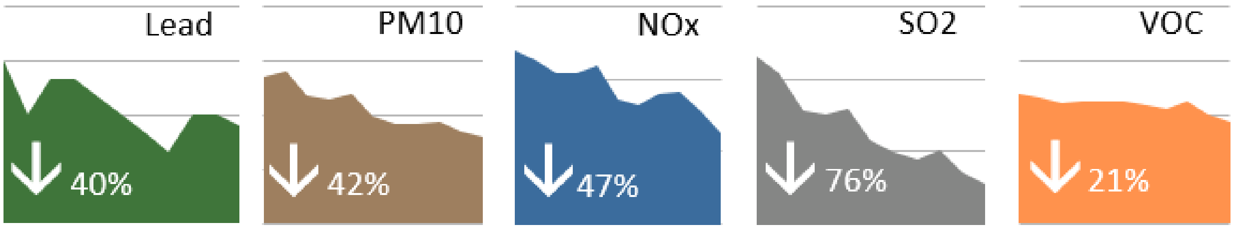
Minnesota's Emission Inventory Rule requires all facilities in Minnesota that have an air emissions permit to submit an annual emission inventory report to the MPCA. The report quantifies emissions of the following regulated pollutants:

- *Particulate matter less than 10 microns in diameter (PM_{10})* is a broad class of chemically and physically diverse substances that exist as discrete particles (liquid droplets or solids) over a wide range of sizes. EPA currently has National Ambient Air Quality Standards for particulate matter in two size classes, $PM_{2.5}$ and PM_{10}. $PM_{2.5}$ and PM_{10} are associated with numerous adverse health effects. Fine particles are the major cause of reduced visibility in parts of the United States. In addition, when particles containing nitrogen and sulfur deposit onto land or waters, they may affect nutrient balances and acidity. Finally, different types of particulate matter, for example black carbon (soot) and sulfate particles, play a role in climate change.

- *Sulfur dioxide (SO_2)* belongs to the family of sulfur oxide gases and forms when fuel containing sulfur (mainly coal and oil) is burned and during gasoline production and metal smelting. Short-term exposures to SO_2 is linked with adverse respiratory effects. SO_2 also reacts with other chemicals in the air to form tiny sulfate particles and acids that fall to earth as rain, fog, snow, or dry particles. Acid rain damages the environment, accelerates the decay of buildings and monuments and is a major component of haze.
- *Nitrogen oxides (NO_x)* are made up of two primary constituents: nitric oxide (NO) and nitrogen dioxide (NO_2). NO is a colorless, odorless gas that is readily oxidized in the atmosphere to NO_2. NO_2 exists as a brown gas that gives photochemical smog its reddish-brown color. NOx forms when fuel is burned at high temperatures. NO_2 exposure is linked with adverse respiratory effects. It is also a major precursor both to ozone and to fine particulate matter ($PM_{2.5}$). Deposition of nitrogen can lead to many environmental problems including fertilization, acidification of terrestrial, wetland and aquatic systems, increased visibility impairments and others. Nitrous oxide (N_2O), another component of NOx, is a greenhouse gas.
- *Volatile organic compounds (VOCs)* are compounds containing the elements carbon and hydrogen that exist in the atmosphere primarily as gases because of their low vapor pressure. VOCs are defined in federal rules as chemicals that participate in forming ozone. Many VOCs are also air toxics and can have harmful effects on human health and the environment.
- *Carbon monoxide (CO)* is a colorless and odorless toxic gas formed when carbon in fuels is not burned completely. A major source of CO is motor vehicle exhaust. Exposure to elevated CO levels is associated with impaired visual perception and work capacity among others, and can lead to death. At concentrations commonly found in the ambient air, CO does not appear to have adverse effects on plants, wildlife or materials. However, CO is oxidized to form carbon dioxide (CO_2), a major greenhouse gas and it contributes to the formation of ground-level ozone.
- *Lead (Pb)* is a naturally occurring element. Major sources of lead emissions were motor vehicles and industrial sources. Since lead in gasoline was phased out, air emissions and ambient air concentrations have decreased dramatically. Currently, metals processing (lead and other metals smelters) and aircraft using leaded fuel are the primary sources of lead emissions. There are no known safe levels of lead in the body. Chronic exposure or exposure to higher levels can result in multiple effects, including damage of the kidneys and nervous system in both children and adults. Elevated lead levels are also detrimental to animals and to the environment.

The Minnesota Criteria Pollutant Emission Inventory is complete for permitted sources through 2020. Figure 4 shows emission trends for permitted sources since 2010. These emissions have decreased significantly over the past decade largely due to governmental regulations and industry efforts to reduce emissions. As mentioned elsewhere in this report, emissions of nitrogen oxides and sulfur dioxide have decreased significantly in the past decade due to facilities switching from coal to natural gas and installing new pollution controls on their units. Further emission decreases across all sectors have been due to economic slowdown and measures taken during the COVID 19 pandemic.

Figure 4. Minnesota permitted source emissions 2010-2020



There has been a reduction in all criteria pollutant emissions from 2010 to 2020 (the most recent years with emission estimates from all sources). Figure 5 shows the statewide total in emissions from nitrogen oxide, sulfur dioxide, volatile organic compounds and particulate matter. Emissions from all source types (mobile, non-permitted and permitted sources) have decreased by about a third since 2008.

Figure 5. Criteria air pollutant statewide emission trends

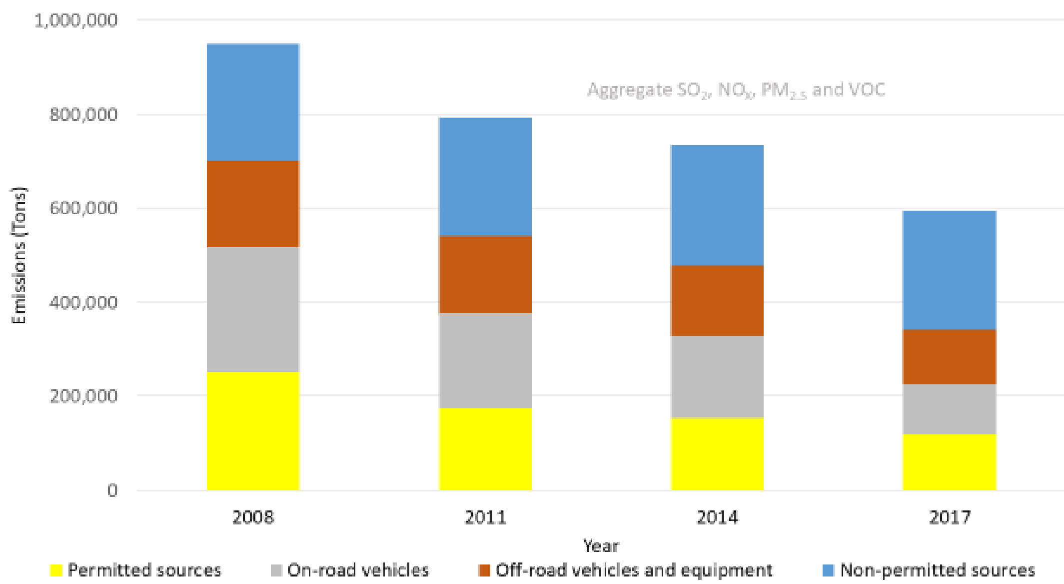


Table 1 shows statewide emissions for major criteria air pollutants and percent changes from 2018 to 2020. Despite the importance of secondary formation in creating particulate matter and some other pollutants, it is important to note that estimated air emissions data in this report are only based on direct releases from sources into the atmosphere. Emissions decreased for all pollutants from 2018 to 2020. Significant decreases happened for SO_2 because of electric utilities shutting down coal burning units and lower taconite production in mines during the last couple of years.

Table 1. Minnesota air pollution emission estimates 2018 to 2020 (tons)

Pollutant	2018	2019	2020	2018-2020 % CHANGE
Particulate matter (PM_{10})**	387,032	385,217	384,016	-0.8
Sulfur dioxide (SO_2)	31,655	22,589	18,213	-42.5
Nitrogen oxides (NO_x)	217,059	207,999	197,722	-8.9
Volatile organic compounds (VOCs)	233,581	231,622	230,416	-1.4
Particulate matter ($PM_{2.5}$)**	115,569	114,408	113,389	-1.9
Lead (Pb)	11	11	10	-2.3
Total Criteria Pollutants	984,907	961,846	943,767	-4.2

* 2017 mobile and nonpoint emissions estimated were used in the 2018 to 2020 emissions estimates. The only changes are from point sources.

** PM_{10} and $PM_{2.5}$ emissions represent only direct emissions; secondary formation is not included.

Air toxics

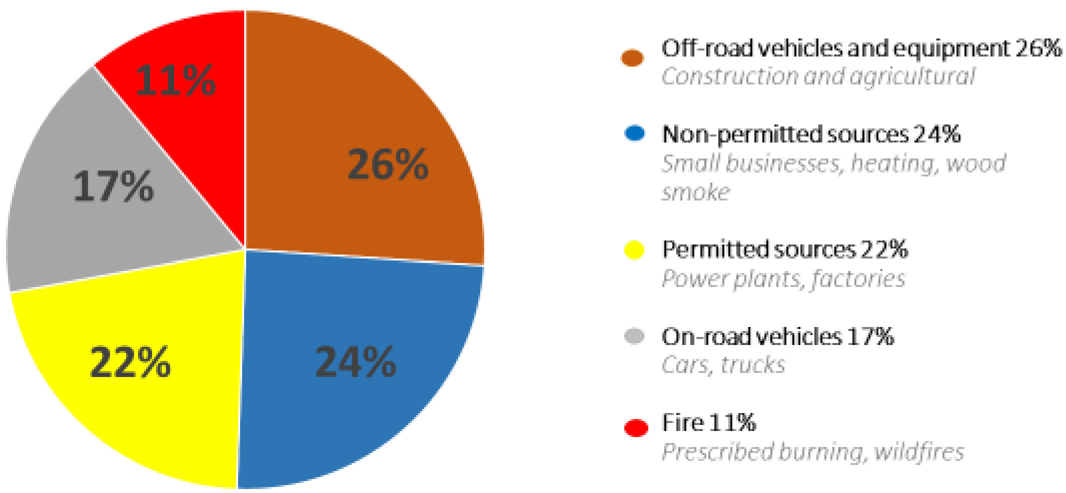
The EPA defines air toxics as pollutants that cause or may cause cancer or other serious health effects, such as reproductive effects or birth defects, or adverse environmental and ecological effects.

The Minnesota Air Toxics Emission Inventory estimates emissions of air toxics from all sources every three years. The majority of pollutants with MPCA emission estimates are part of EPA's hazardous air pollutant group. The most recent completed statewide inventory for Minnesota is 2017 and 2020 permitted sources. The inventory includes four principal source categories: permitted, non-permitted, mobile and fire sources.

MPCA staff compiled the emissions estimates for permitted and the majority of non-permitted sources in the 2017 inventory. Emissions for wildfires and prescribed burning were obtained from EPA. The results for aircraft (including ground support equipment), locomotives and commercial marine vessels were also estimated by EPA. For all off-road equipment and on-road vehicles, MPCA used estimates from EPA's national inventory.

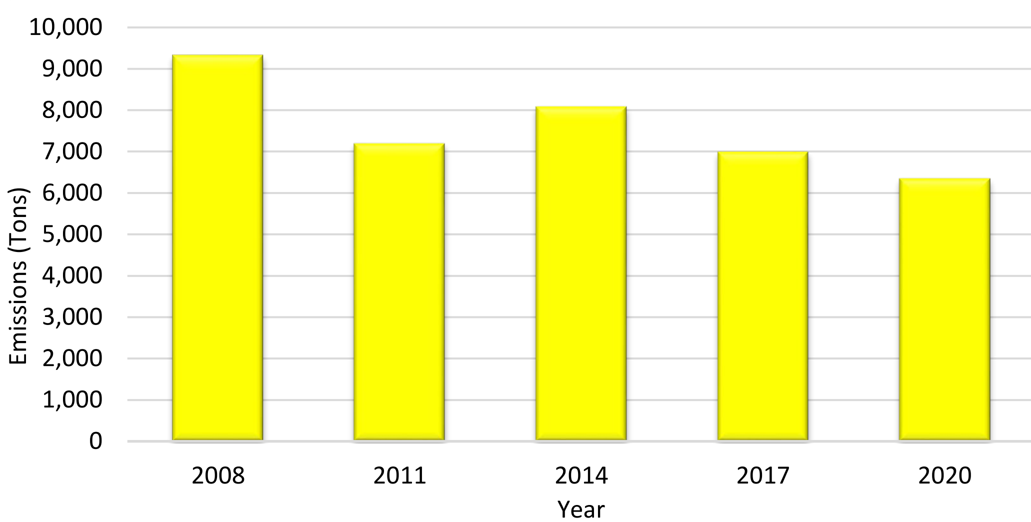
The following chart summarizes 2017 statewide emissions from directly emitted air toxics pollutants. It does not include secondarily formed pollutants. Non-permitted sources include very small stationary sources such as auto body shops and dry cleaners. These account for quarter of total emissions. Mobile sources, including both on-road vehicles such as cars and trucks and off-road equipment such as recreational vehicles and agriculture equipment, account for about 43% of total emissions. Large permitted facilities contributed 22% and fires accounted for 11% of the total. Biogenic emissions are not included in the breakdown because they depend on many environmental factors such as weather, background and ecosystem conditions that are generally not influenced by human activity.

Figure 6. Sources of air toxics emissions in Minnesota, 2017



The chart below shows total air toxics emissions for permitted sources. Since 2008, emissions have been on a general downward trend. Emissions decreased further from 2017 to 2020.

Figure 7. Air toxics from permitted sources 2008 – 2020



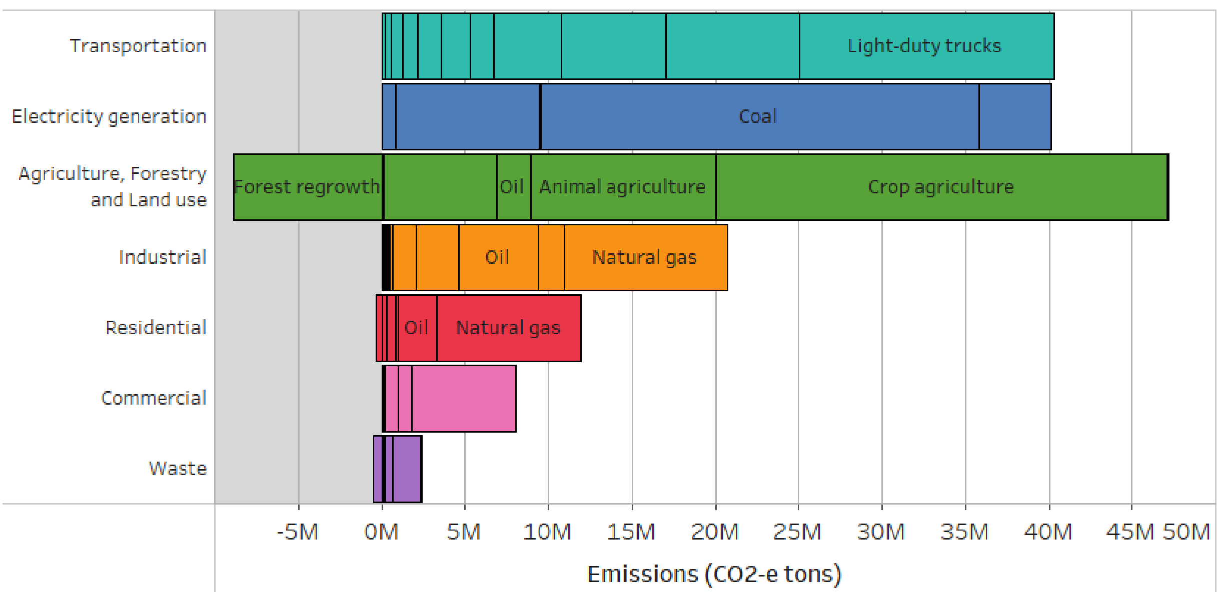
For more details about 2020 permitted sources air toxics emissions, please visit the online application here: https://www.pca.state.mn.us/air/permitted-facility-air-emissions-data. MPCA developed multiple workbooks containing permitted sources, statewide and county level emissions. End users have hands-on access to emissions data, which they can view and use in an interactive format. Web applications contain statewide data going back to 2011.

Greenhouse gases and climate change

Greenhouse gases (GHGs) warm the atmosphere and surface of the planet, leading to alterations in the earth's long-term temperature and weather patterns. While many greenhouse gases occur naturally, burning fossil fuels and other human activities are the main drivers of climate change. Our climate is changing, and these shifts are already affecting our economy, cities and towns, unique and cherished ecosystems, and health and well-being.

The MPCA estimates Minnesota's 2018 GHG emissions to be 161 million CO_2e tons. Most of Minnesota's GHG emissions result from using fossil fuels, and the largest sources of emissions are from the generation of electricity and transportation. More than 70% of the GHG emissions from the transportation sector are from light-duty trucks, passenger vehicles and medium to heavy-duty trucks. Agricultural activities emit large amounts of GHGs or may store carbon in our environment, which reduces the impact of emissions.

Figure 8. 2018 Sources of GHG emissions and carbon sequestration by economic sector

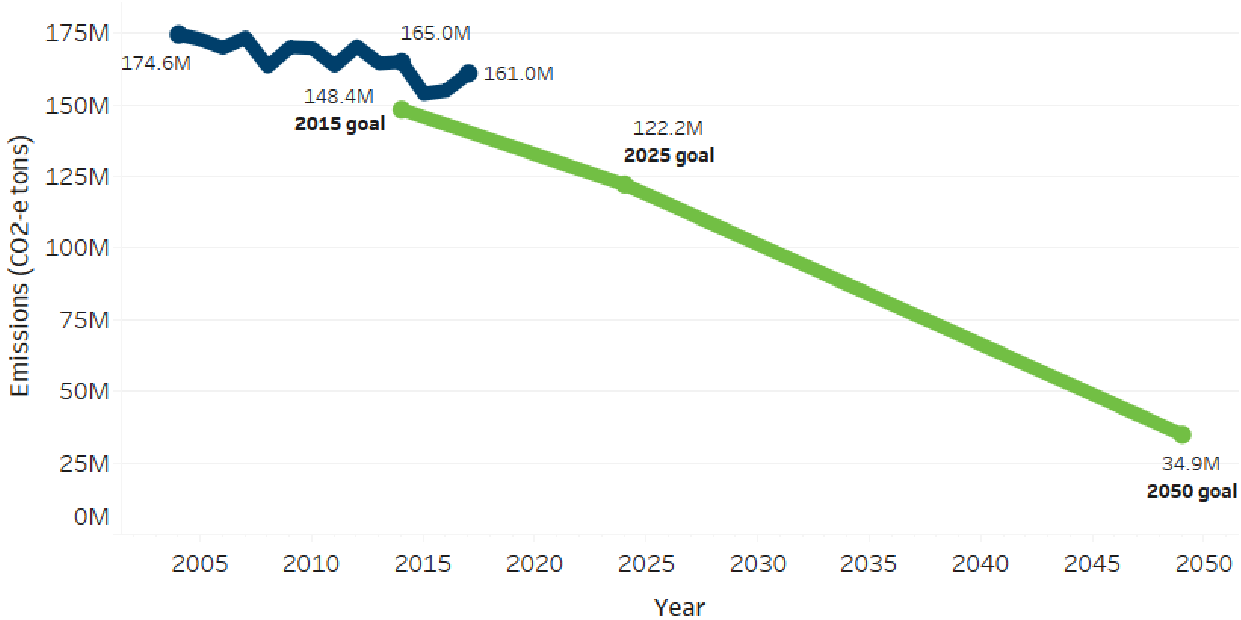


Trends in Minnesota's greenhouse gas emissions

In 2007, Governor Pawlenty signed the Next Generation Energy Act (NGEA) to reduce carbon emissions and support energy efficiency and renewable energy in Minnesota. The NGEA set statutory goals to reduce GHG emissions from 2005 levels by 15% by 2015, 30% by 2025 and 80% by 2050.

Compared to 2005, Minnesota's 2018 total GHG emissions are about 7.8% lower, and we are not on track to meet the NGEA goals. Each economic sector shows unique trends in emissions, which can be explored in more detail with our online data tool at: www.pca.state.mn.us/air/greenhouse-gas-emissions-data.

Figure 9: Minnesota's GHG emissions 2005-2018 and goals



References/web links

For more information on climate change in Minnesota, greenhouse gas emissions, and initiatives to reduce emissions and adapt to a changing climate, see the following websites:
www.pca.state.mn.us/air/climate-change-minnesota

www.pca.state.mn.us/air/greenhouse-gas-emissions-data

mn.gov/climate

climate.state.mn.us/state-actions

Mercury

Exposure to mercury can harm the nervous system, posing the greatest risk to a developing fetus and fish-eating wildlife. For most Minnesotans, eating fish contaminated with unhealthy levels of mercury poses the greatest risk of exposure. While fish are a desired source of protein and other nutrients, citizens are advised to limit their consumption of larger predatory fish in order to limit exposure to mercury. Consult the Minnesota Department of Health (MDH) Fish Consumption Advisory for guidelines to specific lakes and rivers at: https://www.health.state.mn.us/communities/environment/fish/

Mercury emissions are transported through the atmosphere and deposited by rain into Minnesota's lakes and rivers. Minnesota's Draft 2022 Impaired Waters List includes 6,168 water quality impairments in 2,904 different bodies of water. Of the waters tested, mercury is the cause of 1,671 impairments in 1,316 different lakes and rivers. To achieve necessary reductions of mercury in fish, the MPCA developed a statewide mercury total maximum daily load (TMDL) study. The TMDL establishes a goal of a 93% reduction in mercury from all human sources, both those inside and outside Minnesota's borders. Minnesota is working to achieve the goal within the state by following the mercury TMDL implementation plan, developed by stakeholders in 2009. To accomplish the reductions specified in the TMDL, the MPCA proposed and later adopted rules regarding mercury reduction plans in Minn. R. 7007.0502. These rules established mercury emissions reductions for certain sources of mercury air emissions to bring both public and privately owned facilities into line with the statewide mercury TMDL reduction goals. In order to evaluate the progress of reducing mercury in our waters, mercury emissions inventories are developed and tracked, and the subsequent response in fish tissue is documented.

All lakes and rivers within Minnesota will benefit from the reduced mercury emissions that will be achieved by accomplishing the goals of the statewide TMDL implementation plan. The TMDL demonstrated that mercury deposition was fairly uniform throughout the state and that deposition represented 99% of the mercury source to lakes and rivers in the state. Despite the uniform deposition of mercury, about 27% of Minnesota surface waters may not meet the water quality standard after the mercury emissions goal is achieved, because these waters are more efficient at concentrating mercury into fish. Mercury in fish is expected to decrease as mercury deposition is decreased, although the lag time between source reduction and reductions in the fish is unknown. Other factors, such as the presence of wetlands, land-use practices, and climate, also influence the amount of mercury pollution that is converted to methylmercury and accumulates in aquatic food chains.

Scientists understand some of the factors that cause this enhanced mercury accumulation, but not well enough to know the relative importance of each factor and what actions could reduce the enhanced mercury accumulation. The MPCA's scientific research into the unusually high mercury concentrations in fish tissues in some Minnesota rivers was funded by the Legislative-Citizen Commission on Minnesota Resources (LCCMR) in 2014 and continued through June 2017 (https://www.lccmr.leg.mn/projects/2014-index.html#201403j). The goal of the study was to better understand the probable causes of high mercury levels in fish in watersheds where atmospheric deposition alone does not account for the high mercury levels in order to determine what additional measures can be taken to reduce mercury levels in those watersheds. Results indicated the dominant cause of high mercury in the food webs differ among the rivers and even within rivers. Organic carbon has a predominant role in transporting mercury, but inhibits uptake by the food web. In rivers with high suspended solids concentrations, mercury binds to the solids resulting in high unfiltered mercury concentrations; however, methylmercury concentrations were not correlated to suspended solids and instead were associated with the dissolved organic carbon. Methylation rates of mercury to methylmercury did not correlate well to methylmercury concentrations in water, which was attributed to demethylation processes that are difficult to quantify.

The MPCA is beginning to work on a TMDL for the St. Louis River and Cloquet River – two rivers that are more highly methylating and for which the most data are currently available. This TMDL may provide a template path for reducing mercury in other highly methylating waters, for more information: https://www.pca.state.mn.us/water/st-louis-river-watershed-mercury-tmdl.

Sector activities and reductions

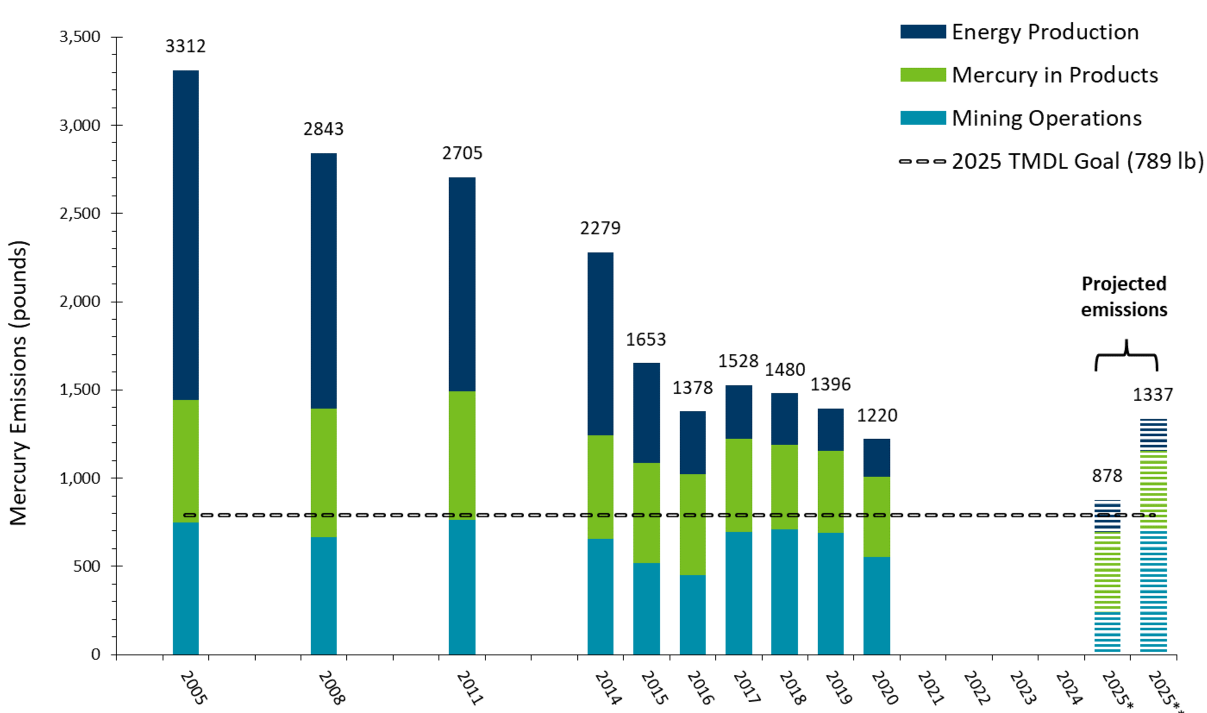
A number of efforts are in place to reduce mercury emissions. State statutes and rules, along with national standards for mercury and air toxics emissions from coal-fired utility boilers, have resulted in significant reductions in emissions of mercury and other pollutants in Minnesota. In 2006, Minnesota passed the Mercury Emissions Reduction Act (MERA), which set a schedule for the largest coal-fired utility boilers in the state to reduce mercury emissions by 90% from 2005 levels. As of 2015, all Minnesota utilities have achieved full compliance with MERA. To get there, they retrofitted some coal plants with improved pollution controls, switched some to natural gas, and shut down others. The changes these facilities made to reduce mercury emissions also brought 75-80% reductions in emissions of haze-forming pollutants as well as significant reductions in greenhouse gases. Utilities continue to shut down coal plants in Minnesota as they rely more on renewable energy and natural gas. Several of the remaining coal plants in Minnesota will close in the 2020s. It is estimated that electric utilities emitted approximately 94 pounds of mercury in 2020 and now represent the smallest of the three source categories. This is a decrease from 1,716 pounds emitted by electric utilities in 2005.

Emissions from mercury use in various products also saw a decrease in 2020 as a result of additional research to improve emission estimates from solid waste collection and processing. The previous mass balance study on waste incinerators was updated to include recent years of ash testing data. The addition of this new data allowed the MPCA to improve the emissions factor used and resulted in roughly a 75 pound decrease in mercury emissions, even as the amount of solid waste collected and processed increased by roughly 19%, from the previous estimate. This continues a general downward trend since 2014. The MPCA continues to work to improve the confidence interval of the mercury emissions inventory through partnerships and research.

Conversely, emissions from the taconite mining sector have remained relatively flat, dropping from 750 pounds in 2005 to 688 pounds in 2019. Emissions further decreased to 552 pounds in 2020, but this was a temporary decrease due to some facilities idling during parts of 2020 in response to the Covid-19 pandemic. Per Minn. R. 7007.0502, the taconite mining sector submitted mercury reduction plans to the MPCA in December 2018. The MPCA received eight plans, each varying in the amount of mercury reductions proposed. Two facilities submitted plans with proposed reductions meeting the required 72% reduction specified in Minn. R. 7007.0502, two facilities submitted alternative plans with proposed reductions less than the 72%, and four facilities submitted alternative plans with no proposed reductions but further evaluation beginning in mid-2020.

Despite significant reductions from some sectors, the MPCA projects that the state will not meet the plan's 2025 statewide reduction goal. Meeting that goal will require significant reduction of mercury emissions from the taconite mining sector and further reductions from mercury use in various products.

Figure 10. Mercury emission from Minnesota sources: 2005 through 2020



* This projection is based on the ferrous mining/processing industry in northern MN meeting the required 72% reduction specified in Minn. R. 7007.0502.
** This projection is based on the ferrous mining/processing industry's proposed reductions in each mercury reduction plan applied to the baseline emissions as calculated by MPCA.

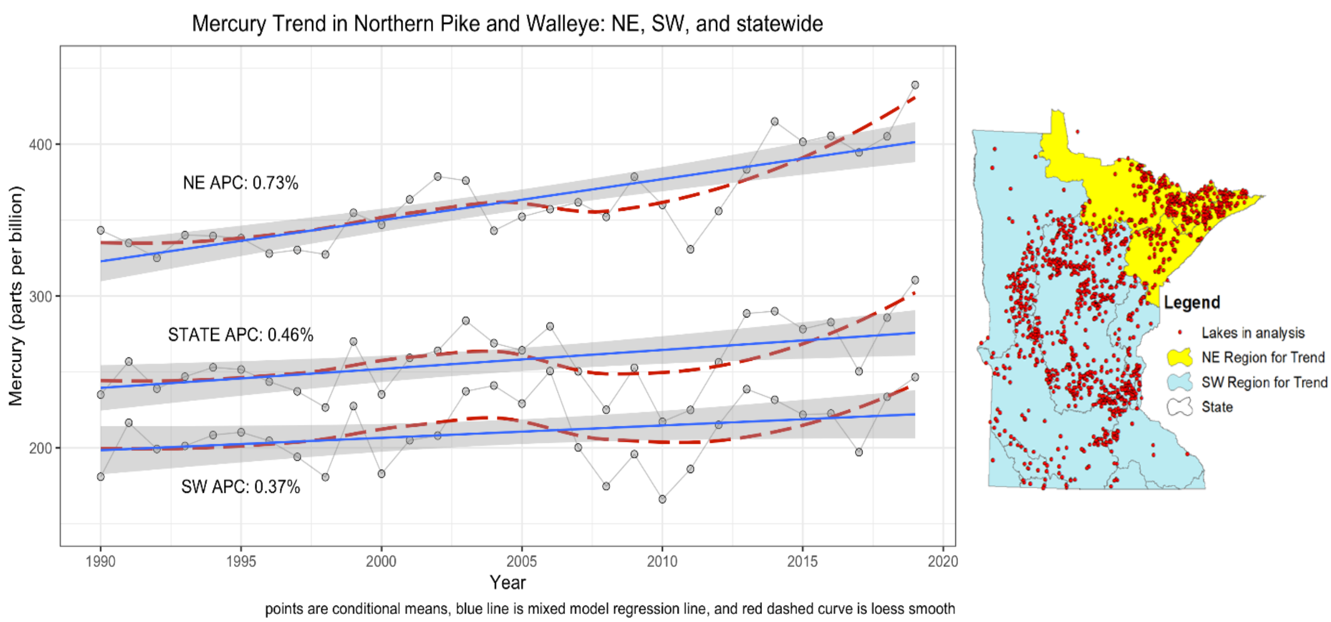
Mercury concentration in Minnesota fish

MPCA scientists use walleye and northern pike collected since 1990 to examine the change in mercury concentrations in lakes over time. The 30-year fish-mercury trend from 1990 to 2019, shown in Figure 11, indicates an increasing average mercury concentration based on standardized-length walleye and northern pike from 1,177 lakes throughout the state (shown in Figure 11 map). The mean increase of mercury concentration was 0.46% per year, which is equivalent to a 14% increase over three decades (middle trend line in Figure 11). The rate of increase is higher in the Rainy and Superior basins in NE Minnesota (yellow area in Figure 11 map), where data show a 0.73% per year increase, equivalent to a 22% increase over three decades. These increases have occurred over a period when mercury emissions and concentrations in the air have dropped by more than 80%. MPCA scientists hypothesize the rising trend in fish has been caused by factors related to our changing climate. Effects like increasing precipitation, along with more intense storms followed by dry periods, lead to more transport of mercury to surface waters, and the greater fluctuations in water levels allow for more methylation of mercury.

Minnesota's water quality standard for mercury in edible fish tissue – 200 parts per billion (ppb) – is the threshold above which lakes and streams are impaired and warrant a fish consumption advisory. The standard protects humans for consumption of one meal per week of fish caught in Minnesota.

Additional explanation of the mercury trends in fish is available in the [2022 Clean Water Fund Performance Report](). MPCA scientists plan to update the fish mercury trend analysis after an additional five years of data are available, or potentially sooner if appropriate and sufficient data are available.

Figure 11. Trend of mercury in northern pike and walleye from Minnesota lakes: 1990-2019. State trend is the mean trend at mean latitude for fish collections (46 degrees). NE is Superior and Rainy basin. SW includes all other basins. APC is annual percent change.



Regional, national, and international efforts

Mercury pollution from outside the state still impacts fish and waterbodies in Minnesota, and reductions outside of Minnesota remain important. Mercury emitted into the atmosphere can become a global pollutant, which is why mercury deposition and fish mercury concentrations have not significantly declined despite large reductions in North American mercury emissions from human sources. However, while emission inventories indicate global increases in mercury emissions, ambient air mercury concentrations across the United States have fallen due to federal and state regulatory actions and market forces, indicating that local mercury reductions continue to be important. MPCA data show that increases in global mercury emissions are being offset by decreases in local emissions. Still, more reductions are needed globally and locally to reduce fish mercury concentrations for the long term.

While the baseline year for Minnesota's Statewide Mercury TMDL is 1990, the year 2005 is used as the baseline year in the Implementation Plan for the TMDL. In order to apply Minnesota's reduction goals to national and regional emissions, the MPCA used 2005 as a baseline in its calculation due to the poorer quality and availability of emissions data for 1990. Within the TMDL implementation plan the final goal of 789 pounds is a 76% reduction from the 2005 baseline. There is also an interim 2018 goal of 1,464 pounds, a 56% (average) reduction from the 2005 baseline. These percentages (56% and 76% respectively) were applied to the 2005 regional and national emissions estimates to develop comparable regional and national "goals". Minnesota met our 2018 reduction goals, but more work is needed to meet the 2025 goal. Regional/national mercury emission reductions have also surpassed the interim 2018 goal and nearly meet the 2025 goal already. Regionally, meaning the States of Minnesota, Michigan, Wisconsin, North Dakota, South Dakota, and Iowa, there has been a 74% reduction from the 2005 baseline (22,170 pounds in 2005 compared to 5,715 pounds in 2017). Nationally, there has been a 71% reduction from the 2005 baseline (225,491 pounds in 2005 compared to 65,668 pounds in 2017).

Furthermore, Minnesota continues to promote mercury emission reductions within the state as well as regionally, nationally, and globally. Recently, Minnesota worked with states and provinces surrounding the Great Lakes to renew commitment to mercury reductions. At its 2021 annual meeting, the Great Lakes Commission adopted an updated policy resolution supporting mercury pollution monitoring, research, and reduction in the Great Lakes-St. Lawrence River basin. The resolution was unanimously passed by all commission member states and provinces: Illinois, Indiana, Michigan, Minnesota, New York, Ohio, Ontario, Pennsylvania, Québec, and Wisconsin. The resolution:

- States the multiple ecological, social, and economic benefits of the Great Lakes and St. Lawrence River for the United States and Canada.
- Asserts that mercury pollution harms these benefits and the health of communities throughout the region, specifically noting that disadvantaged communities and other vulnerable populations are at higher risk and generally experience disproportionate effects from mercury contamination.
- Acknowledges that while governments in the United States and Canada at all levels – tribes, states, provinces, and federal governments – are acting to reduce mercury use and emissions, there is more that can be done. In addition, changes in climate and weather patterns are likely to impact where mercury comes from and where it ends up.
- Offers suggestions and support for actions to understand and reduce mercury pollution.

The resolution replaces the previous mercury policy from 2010, and is available in full on the commission's policy resolution webpage (https://www.glc.org/work/advocacy/resolutions/).

References/web links

For more information on mercury, see the following websites:

MPCA's mercury reduction plan: https://www.pca.state.mn.us/water/plan-reduce-mercury-releases-2025

Great Lakes Commission, 2021 Mercury Resolution: https://www.glc.org/work/advocacy/resolutions/

Great Lakes Commission, 2021 Issue Brief - Mercury Contamination in the Great Lakes Basin: https://www.glc.org/library/2021-glc-issue-brief-mercury

UN Environment, Global Mercury Assessment 2018: https://www.unenvironment.org/resources/publication/global-mercury-assessment-2018

Minamata Convention on Mercury: http://mercuryconvention.org/

Water pollutant discharges overview

Minnesota's rivers, streams and lakes provide great natural beauty, and supply the water necessary for recreation, industry, households, agriculture and aquatic life. The goals of the MPCA's water programs are to maintain and improve water quality, ensure water quality meets statewide goals, and to reduce and prevent pollution from all sources. The key strategies for accomplishing these goals includes regulating point source discharges, controlling nonpoint sources of pollution, and assessing water quality to provide data and information to make sound environmental management decisions.

The federal Clean Water Act requires states to adopt water quality standards to protect the nation's waters. The MPCA has adopted standards to protect the state's abundant and diverse water resources from the impacts of excess nutrient, sediment and organic material as well as toxic pollutants. These standards define how much of a pollutant can be in a surface or groundwater supply while still allowing it to meet its designated uses, such as for drinking water, fishing, swimming, irrigation, aquatic life or industrial purposes. Standards are used to assess the condition of water bodies, develop restoration and protection plans and set discharge limits for regulated entities such as wastewater treatment plants.

For each pollutant that causes a water to fail to meet state water quality standards, the federal Clean Water Act requires the MPCA to conduct a TMDL study. A TMDL study identifies both point and nonpoint sources of each pollutant to waters that fail to meet water quality standards. While lakes, rivers and streams may have several TMDLs, each determining the limit for a different pollutant, the state has moved to a watershed approach that addresses multiple pollutants and sites within a watershed to more efficiently complete TMDLs. Many of Minnesota's water resources cannot currently meet their designated uses because of pollution from a combination of point and nonpoint sources.

Wastewater discharges

Owners or operators of any disposal system or point source are required by Minnesota law to obtain permits, maintain records and make reports of any discharges to waters of the state. These self-monitoring reports submitted to MPCA are commonly referred to as Discharge Monitoring Reports (DMRs). DMR data are reviewed using compliance tracking data systems maintained by MPCA data specialists.

Consistent with the state's overall watershed approach, the MPCA's water quality program continues to evolve from a predominantly concentration-based, facility-by-facility regulatory approach to one that emphasizes managing total pollution loads to Minnesota's watersheds. Due to the five-year permit cycle, however, for select pollutants, some permits have yet to be modified to incorporate the monitoring and reporting requirements necessary to enable efficient, computerized calculations of total annual pollutant loadings. As the MPCA reissues permits and conducts ongoing review of data, it will continue to build capability in this area and the assessment of pollutant trends by watersheds over multiple years will become more reliable.

Overall pollutant loads are calculated by combining effluent flow data with reported pollutant concentrations, or estimated pollutant concentrations where facility specific data are not available. Estimated concentrations used to calculate pollutant loads are based on categorical assumptions that account for the characteristics of the waste stream and the type of facility. Concentration estimates are based on effluent data from similar waste streams and facility types when available, and in some cases estimates are based on best professional judgment. Effluent flow and pollutant loading estimates for National Pollution Discharge Elimination System (NPDES) permitted facilities such as wastewater treatment plants exclude once-through non-contact cooling water data from power generation facilities—large volumes of (primarily) river water used for cooling purposes. These once-through non-contact cooling waters are discharged with the addition of heat, and with only minor additions of other pollutants. Pollutant loads associated with these discharges were largely present in the waterbodies before the waters were withdrawn for cooling purposes so reporting them as wastewater pollutants would be misleading.

Pollutant loads calculated from measured wastewater flows and observed pollutant concentrations are considered to be highly reliable while less confidence is warranted for pollutant loads derived from estimated concentrations. The degree of confidence in each loading estimate can be expressed as the proportion of the load derived from observed values compared to the proportion derived from estimated values. The loading graphs in this report are color coded by 'Observed' and 'Estimated' to serve as a confidence measure for each pollutant load measure.

Prior to 2014, the wastewater sections of the MPCA's Pollution Reports to the Legislature were based on data reported by approximately 99 major wastewater dischargers. These are facilities permitted to discharge at least 1 million gallons of treated wastewater per day and account for approximately 85% of the volume of treated wastewater discharged to waters of the state. Reports now include data from all surface water dischargers, regardless of size. The inclusion of smaller facilities provides a more complete measure of pollutant loads since non-major facilities can collectively impact water quality. Figure 12 shows the distribution of municipal wastewater facilities by size.

Figure 12. Distribution of municipal wastewater facilities by size

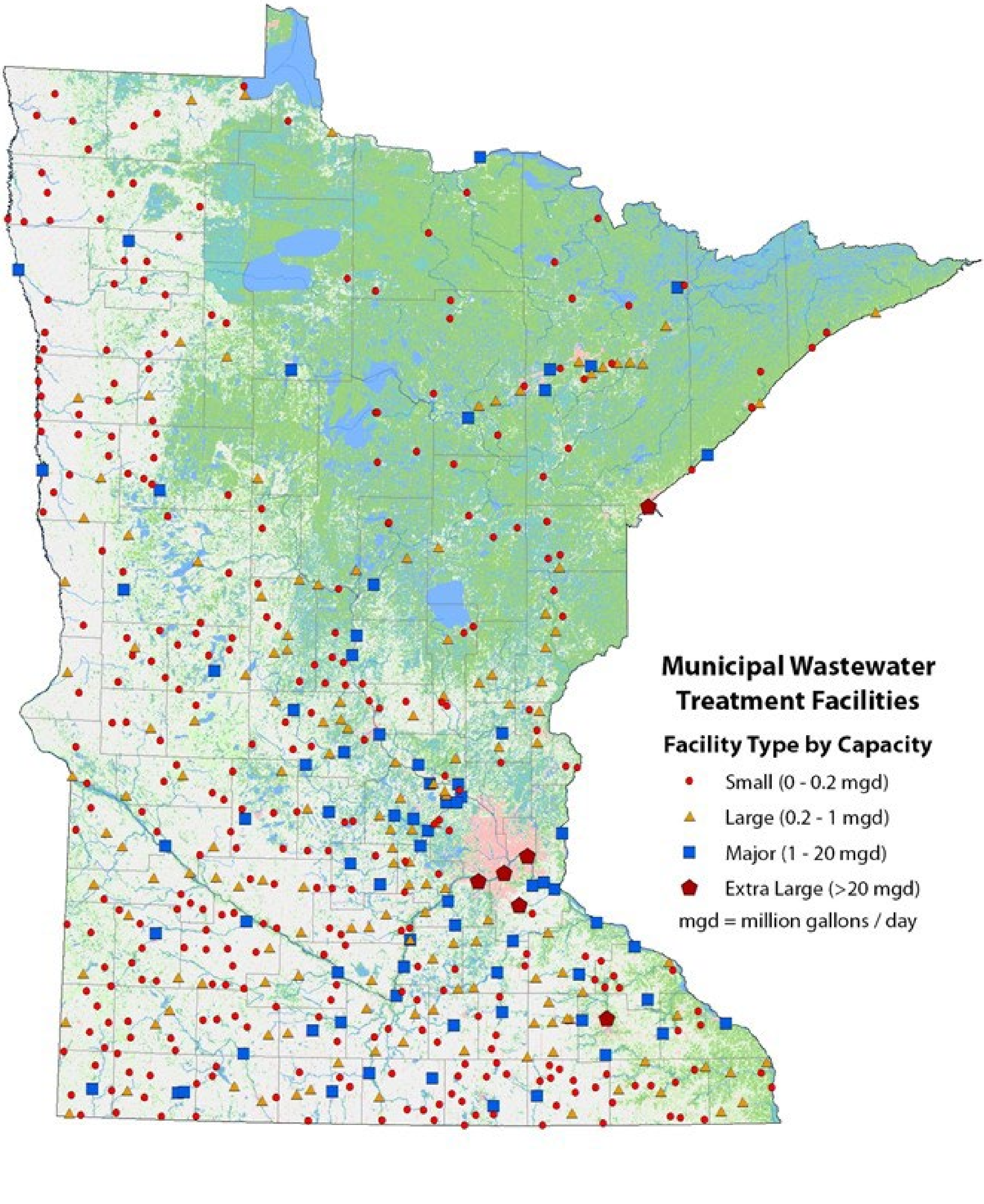
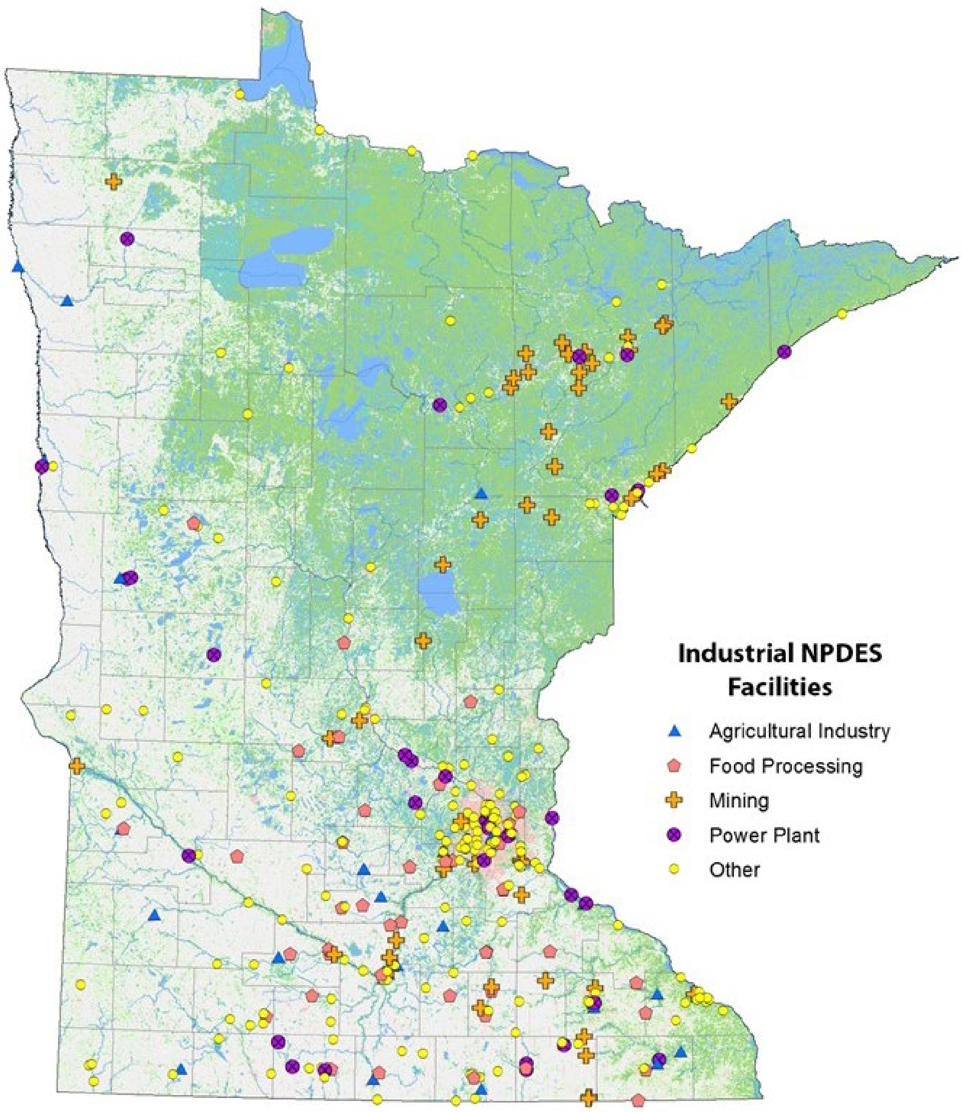


Figure 13 below shows the distribution of industrial discharges by type. Facilities are grouped in the following broad categories: agricultural industry, food processing, mining (metallic and non-metallic), power plants, and other.

Figure 13. Distribution of industrial wastewater dischargers by type



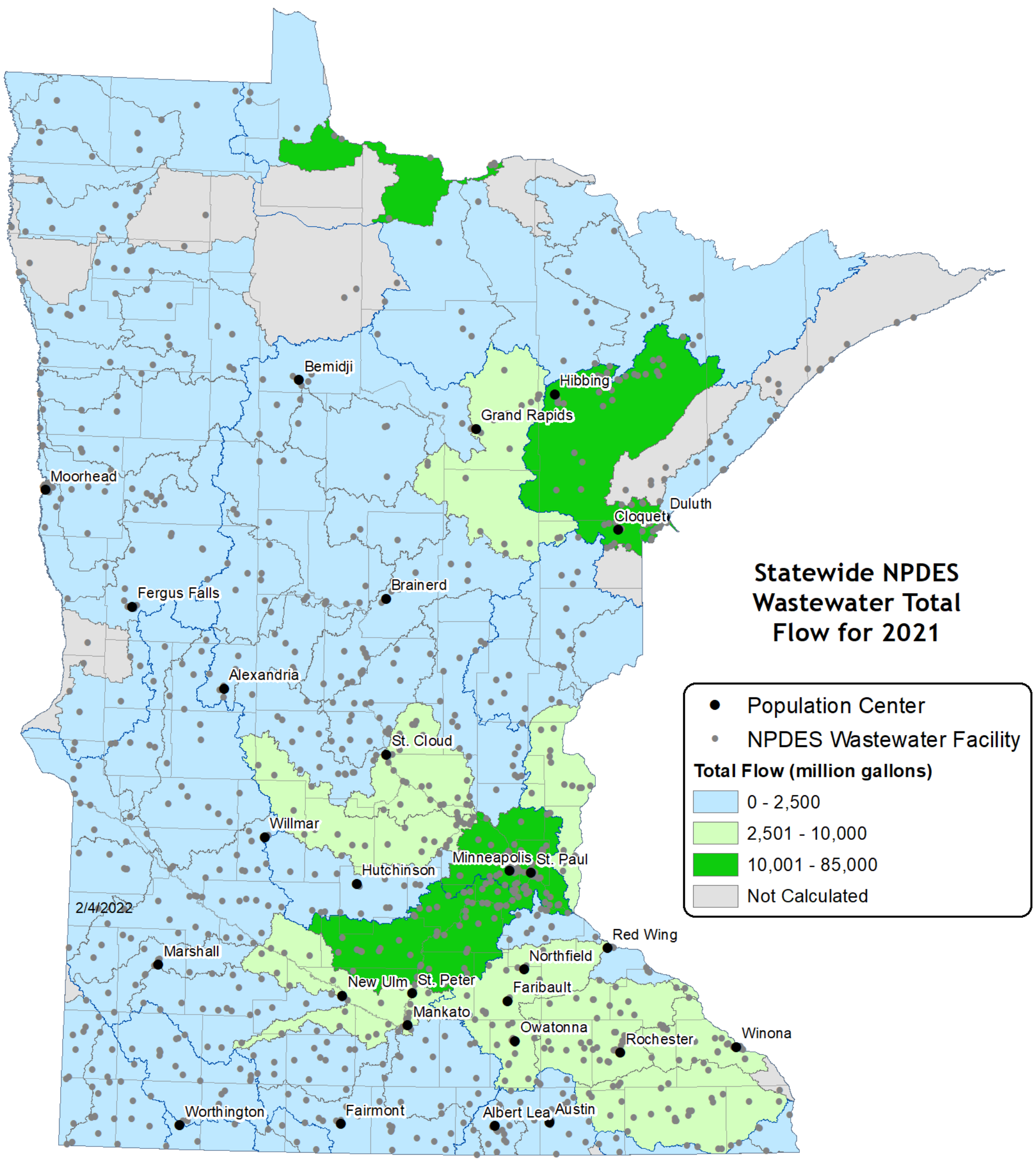
Flow

Effluent flow, while not a regulated pollutant, is a useful gauge of overall facility performance because of the direct relationship between pollutant loading and effluent flow volume. For example, if effluent flow and pollutant loading show proportional annual increases, it is an indication that overall effluent concentrations have remained stable and the loading increase is attributable to the increase in flow. Conversely, if the pollutant load showed consistent annual decreases despite an increase in effluent flow volume, the concentration has likely decreased and the effluent quality has improved. Table 2 on page 27 summarizes effluent pollutant loading and flow volume estimates for municipal and industrial wastewater treatment facilities in Minnesota from 2000 to 2021.

Overall, wastewater flow volumes have fluctuated from a baseline of 270 billion gallons per year in 2000/2001 to a peak of 304 billion gallons per year in 2011. Average effluent flow from 2017 through

2021 was 10 billion gallons/year less than effluent flow during the previous five years. Since the year 2000, facilities with the potential to discharge greater than 1 million gallons per day, called major facilities, have discharged approximately 78% of the total treated wastewater in the state. Municipal wastewater treatment facilities discharged 61% of the total treated wastewater from 2000 through 2004. Since 2005, the proportion of municipal wastewater flow has declined to 59% of the total. Peak wastewater flows of 304 billion gallons/year were reported in 2011. Year 2012 was a particularly dry year in which the volume of municipal wastewater discharged was lower. However, despite increasing hydrologic trends in subsequent years, changes in wastewater flows remained relatively modest. From 2014 to 2019, surface water discharges reported by the wastewater sector have averaged 287 billion gallons per year, a slight increase from the long-term average.

Figure 14. Minnesota wastewater effluent flow for 2021



Point source pollutant loading trends

Five common chemical parameters found in wastewater treatment plant effluent are highlighted in this report: total suspended solids (TSS), carbonaceous biochemical oxygen demand ($CBOD_5$), total phosphorus, total nitrogen and mercury.

The charts below show pollutant effluent flows and loading trends for TSS, CBOD, total phosphorus, total nitrogen and mercury from 2000 – 2021. Pollutant loads are calculated from reported effluent flows and pollutant concentrations. Mercury trends from wastewater treatment facilities are shown in Figure 23 on page 40. Overall trends include:

TSS loads: Stable — TSS loads increased in 2001 and 2002 but have otherwise remained fairly stable at approximately 5,000 metric tons per year with a recent slight decrease.

$CBOD_5$ loads: Declined — Loads have declined from loads ranging from 3,000 to 4,000 metric tons per year during the 2000 to 2004 period to an average load of 2,400 tons per year since 2005.

Total phosphorus loads: Declined — Total phosphorus loads have decreased significantly from 1,800 metric tons per year during the 2000 to 2002 period to less than 600 metric tons per year since 2014.

Total nitrogen loads: Stable — Total nitrogen loads have fluctuated slightly over the years, but have remained close to the baseline of 13,500 metric tons per year in 2000/2001. Nitrogen loads peaked at almost 14,300 metric tons per year in 2018/2019. The long-term average nitrogen effluent load is 13,500 metric tons/year.

Mercury loads: Declined — Significant mercury load reductions have been achieved from 4 kg per year in the 2005 to 2006 time period to 2.35 kg per year in 2018/2019. Mercury loads prior to 2005 are excluded because of changes in the ability to detect mercury in effluent.

Figure 15. Pollutant loading trends from Minnesota wastewater facilities, 2000-2021

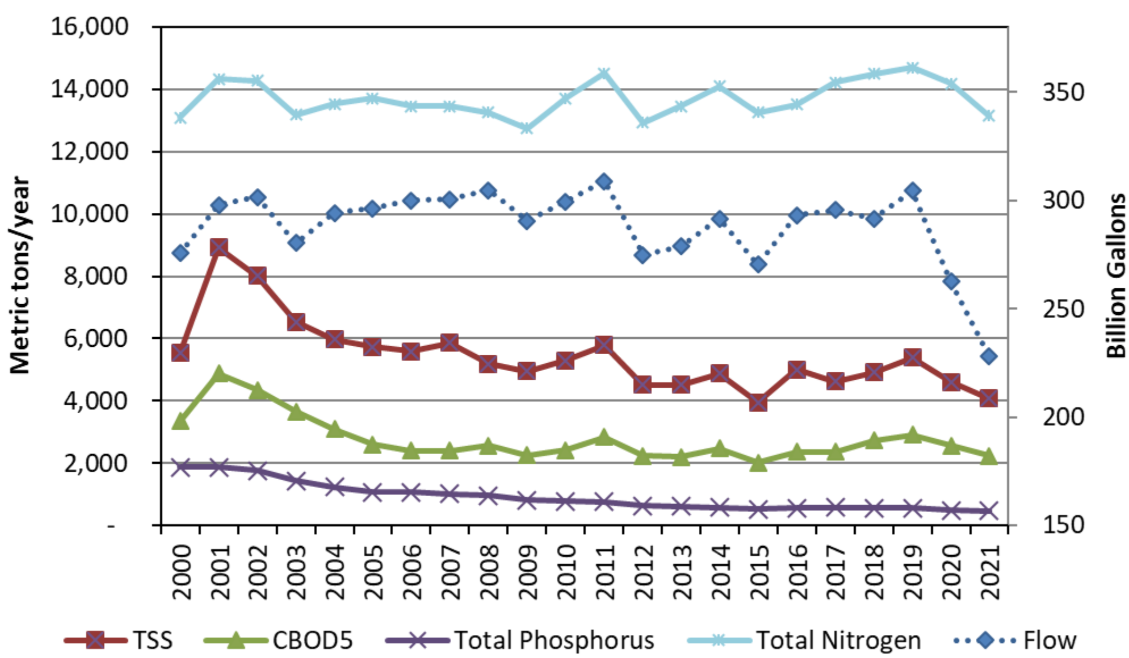


Table 2 shows pollutant effluent flow and loading trends from 2000 through 2021. Effluent flow is reported in billion gallons per year. Pollutant loads for TSS, $CBOD_5$, total phosphorus, and total nitrogen are reported in metric tons per year. Pollutant loads for mercury are reporting in kilograms per year.

Table 2. Annual total flow and pollutant load

	Flow (MG/year)	TSS (MT/year)	TP (MT/year)	CBOD (MT/year)[1]	TN (MT/year)	Hg (Kg/year)[2]
2000	275,669	5,538	3,342	1,873	13,098	
2001	297,826	8,928	4,885	1,876	14,340	
2002	301,571	8,005	4,351	1,764	14,286	
2003	280,483	6,534	3,664	1,432	13,185	
2004	294,312	5,975	3,085	1,238	13,532	
2005	296,272	5,726	2,604	1,064	13,716	4.8
2006	300,005	5,586	2,400	1,074	13,467	4.5
2007	300,537	5,857	2,406	1,011	13,456	3.8
2008	304,782	5,187	2,571	956	13,244	3.5
2009	290,529	4,947	2,253	807	12,745	3.2
2010	299,450	5,283	2,417	775	13,707	3.6
2011	309,012	5,779	2,841	759	14,523	3.7
2012	274,899	4,509	2,228	625	12,935	2.6
2013	278,714	4,519	2,198	603	13,470	2.9
2014	291,508	4,875	2,468	583	14,101	3.4
2015	270,410	3,940	2,025	528	13,269	2.9
2016	293,235	5,013	2,373	554	13,512	2.6
2017	295,650	4,614	2,357	577	14,234	2.6
2018	291,690	4,914	2,734	553	14,510	2.6
2019	304,358	5,394	2,903	561	14,705	2.6
2020	262,470	4,613	2,556	487	14,191	1.9
2021	227,977	4,079	2,235	462	13,155	1.7

[1]Industrial facilities are excluded from CBOD5 load calculations due to lack of data.
[2]Peat mining facilities are excluded from mercury calculations due to unreliability of flow and mercury data.

Table 3 shows flow-weighted mean concentration (FWMC) trends from 2000 through 2021. FWMC is calculated by dividing the annual load by the annual flow and is a measure of the overall performance of wastewater dischargers. All FWMCs are reported in milligrams per liter (mg/L), except for mercury which is reported in nanograms per liter (ng/L). TSS FWMCs have declined from 6.6 mg/L in the years from 2000 to 2004 to 4.5 mg/L from 2017 to 2021. $CBOD_5$ FWMCs have declined from approximately 3.6 mg/L in the 2000 to 2004 period to approximately 2.3 mg/L since 2014. Total phosphorus FWMCs have declined from approximately 1.7 mg/L in the 2000 to 2003 time period to approximately 0.52 mg/L in from 2017 to 2021. Total nitrogen FWMCs have remained stable at 12 mg/L since 2000. Mercury concentrations declined from approximately 3.8 ng/L in 2005 to approximately 2 ng/L since 2015.

Table 3. Annual flow-weighted mean concentration

	TSS (mg/L)	CBOD (mg/L)	TP (mg/L)	TN (mg/L)	Hg (ng/L)
2000	5.31	3.20	1.80	12.55	0.00
2001	7.92	4.33	1.66	12.72	0.00
2002	7.01	3.81	1.55	12.52	0.00
2003	6.15	3.45	1.35	12.42	0.00
2004	5.36	2.77	1.11	12.15	0.00
2005	5.11	2.32	0.95	12.23	4.26
2006	4.92	2.11	0.95	11.86	3.98
2007	5.15	2.12	0.89	11.83	3.35
2008	4.50	2.23	0.83	11.48	3.01
2009	4.50	2.05	0.73	11.59	2.93
2010	4.66	2.13	0.68	12.09	3.15
2011	4.94	2.43	0.65	12.42	3.20
2012	4.33	2.14	0.60	12.43	2.46
2013	4.28	2.08	0.57	12.77	2.73
2014	4.42	2.24	0.53	12.78	3.09
2015	3.85	1.98	0.52	12.96	2.82
2016	4.52	2.14	0.50	12.17	2.31
2017	4.12	2.11	0.52	12.72	2.31
2018	4.45	2.48	0.50	13.14	2.37
2019	4.68	2.52	0.49	12.77	2.26
2020	4.64	2.57	0.49	14.28	1.91
2021	4.73	2.59	0.54	15.25	2.02

Table 4 shows the annual percent change in flow and pollutant loads. The year 2001 stands out due to significant increases in the loading of all pollutants, probably as a result of the significant flooding that year. Excluding 2001, the year-to-year percent change data show the following:

- An average 3% per year decline in annual TSS loads
- An average 3% decline in annual $CBOD_5$ loads
- An average 7% decline in annual total phosphorus loads
- 0% change in annual total nitrogen loads
- An average 5% decline in annual mercury loads

Table 4. Percent change in annual flow and pollutant loads

	Flow (%)	TSS (%)	CBOD (%)	TP (%)	TN (%)	Hg (%)
2000						
2001	8%	61%	46%	0%	9%	
2002	1%	-10%	-11%	-6%	0%	
2003	-7%	-18%	-16%	-19%	-8%	
2004	5%	-9%	-16%	-14%	3%	
2005	1%	-4%	-16%	-14%	1%	
2006	1%	-2%	-8%	1%	-2%	-5%
2007	0%	5%	0%	-6%	0%	-16%
2008	1%	-11%	7%	-5%	-2%	-9%
2009	-5%	-5%	-12%	-16%	-4%	-7%
2010	3%	7%	7%	-4%	8%	11%
2011	3%	9%	18%	-2%	6%	5%
2012	-11%	-22%	-22%	-18%	-11%	-32%
2013	1%	0%	-1%	-4%	4%	12%
2014	5%	8%	12%	-3%	5%	19%
2015	-7%	-19%	-18%	-9%	-6%	-15%
2016	8%	27%	17%	5%	2%	-11%
2017	1%	-8%	-1%	4%	5%	1%
2018	-1%	6%	16%	-4%	2%	1%
2019	4%	10%	6%	1%	1%	-1%
2020	-14%	-14%	-12%	-13%	-4%	-44%
2021	-13%	-12%	-13%	-5%	-7%	-8%

Table 5 shows the annual percent change in flow and pollutant loading from a baseline defined as the average of the years 2000 and 2001. Percent change since 2002 from baseline data show:

- An average 1% increase in effluent flows
- An average 27% decrease in TSS loads
- An average 36% decrease in $CBOD_5$ loads
- An average 56% decrease in total phosphorus loads
- No change in total nitrogen loads
- An average 33% reduction in mercury loads (baseline 2005-06 due to change in detection level)

Table 5. Percent change in annual (values) from baseline

	Flow (%)	TSS (%)	CBOD (%)	TP (%)	TN (%)	Hg* (%)
2000-01	283,743	7,368	4,115	1,883	13,544	4
Baseline	(MG/year)	(MT/year)	(MT/year)	(MT/year)	(MT/year)	(Kg/year)
2002	5%	11%	6%	-6%	4%	
2003	-2%	-10%	-11%	-24%	-4%	
2004	3%	-17%	-25%	-34%	-1%	
2005	3%	-21%	-37%	-43%	0%	3%
2006	5%	-23%	-42%	-43%	-2%	-3%
2007	5%	-19%	-41%	-46%	-2%	-18%
2008	6%	-28%	-37%	-49%	-3%	-25%
2009	1%	-32%	-45%	-57%	-7%	-31%
2010	4%	-27%	-41%	-59%	0%	-23%
2011	8%	-20%	-31%	-59%	6%	-19%
2012	-4%	-38%	-46%	-67%	-6%	-45%
2013	-3%	-38%	-47%	-68%	-2%	-38%
2014	2%	-33%	-40%	-69%	3%	-27%
2015	-6%	-46%	-51%	-72%	-3%	-38%
2016	2%	-31%	-42%	-70%	-2%	-45%
2017	3%	-36%	-43%	-69%	4%	-44%
2018	2%	-32%	-34%	-71%	6%	-44%
2019	6%	-25%	-29%	-70%	7%	-44%
2020	-8%	-36%	-38%	-74%	3%	-59%
2021	-20%	-44%	-46%	-75%	-4%	-62%

* Mercury baseline is 2005-2006 due to change in detection level.

Variability in the quality and quantity of available effluent data can potentially impact annual comparisons.

- The loading calculations incorporate data interpretation decisions that can legitimately be made in a variety of ways. This typically applies to the classification of waste-stream and facility types for the assignment of categorical concentrations. There are also select facilities that report highly inconsistent values for some parameters and are excluded until the questionable values can be verified.
- Reporting requirements can vary with each permit issuance resulting in variation in parameters, limit types, and reporting periods and making year-by-year comparisons difficult. Additionally, when a facility does not monitor a pollutant in a month that it discharges, the concentration for that month is presumed to be the average annual concentration.
- Wastewater treatment facilities regularly experience variations in influent strength, influent flow, and facility performance that may not be fully reflected in the data used to generate this report.

Total suspended solids

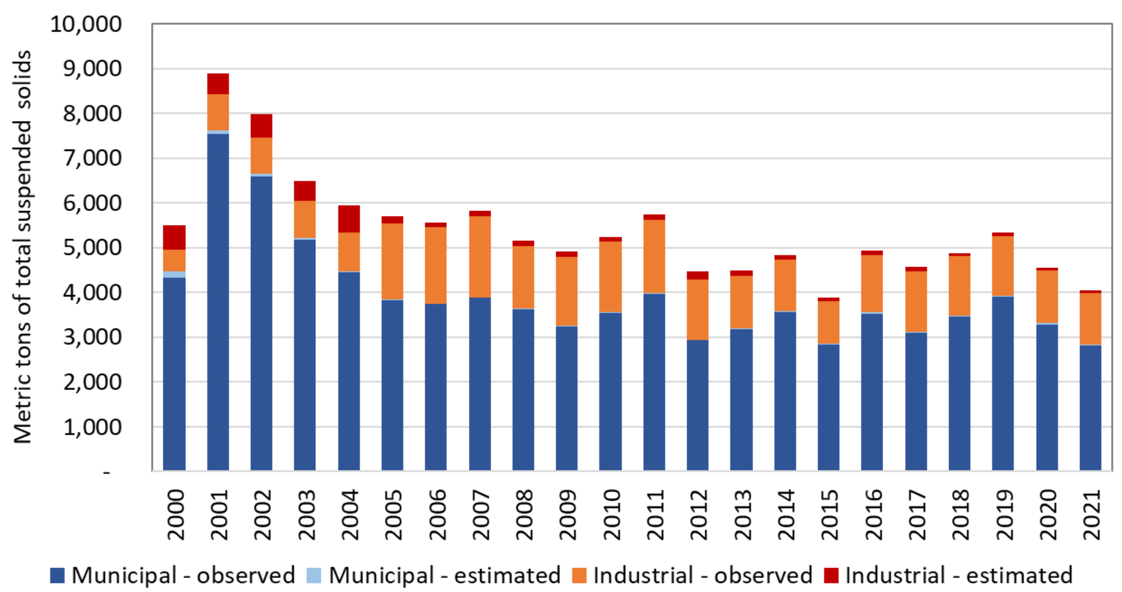
Total suspended solids (TSS) is a measure of the material suspended in water or wastewater. TSS causes interference with light penetration, buildup of sediment, potential degradation of aquatic habitat, and harm to aquatic life. Suspended solids also carry nutrients that cause algal blooms that are harmful to fish and other aquatic organisms.

The TSS load for 2021 was 4,079 metric tons, an 18% increase from the 2019-2020 average. On average, the data show an annual 27% reduction in TSS loads from a 7,368 metric ton per year baseline in 2000/2001.

Wastewater TSS data are considered reliable, with 96% of loads resulting from observed data points. On average, 69% of wastewater TSS loads are discharged by major facilities, although, the proportion of TSS loads discharged by major facilities has declined from an average of 79% from 2000 through 2003 to an average of 69% from 2004 through 2021. On average, municipal wastewater dischargers accounted for 81% of wastewater TSS loads from 2000 through 2003 while their proportion of wastewater TSS loading declined to an average of 70% from 2004 through 2021. Overall, wastewater TSS loads have declined from an average of 7,381 metric tons per year in the 2000 through 2003 period to an average of 4,900 metric tons per year from 2007 through 2021.

It should be noted that TSS is one of the most frequently monitored pollutants in wastewater. Most facility permits contain technology based effluent limits which, for many waterbodies, are more restrictive than TSS water quality standards. As a result, most facilities are discharging below a concentration level of concern, long-term average TSS wastewater loading has remained relatively stable during the past decade, and future wastewater TSS reductions are not generally necessary. Nonetheless, advanced treatment required to meet other effluent limits for pollutants such as phosphorus and mercury may result in further TSS reductions since those pollutants tend to be components of or are attached to suspended solids.

Figure 16. Annual wastewater loading values for total suspended solids (TSS)



Carbonaceous biochemical oxygen demand

When organic wastes are introduced into water, they require oxygen to break down. High concentrations of organic materials characterize untreated domestic wastes and many industrial wastes. The amount of oxygen required for decomposition of organic wastes by microorganisms is known as the biochemical oxygen demand (BOD), while carbonaceous biochemical oxygen demand ($CBOD_5$) is the amount of oxygen required for microorganisms to decompose carbonaceous waste materials. Both BOD and $CBOD_5$ are indicators of the quality of wastewater effluent and the effectiveness of treatment.

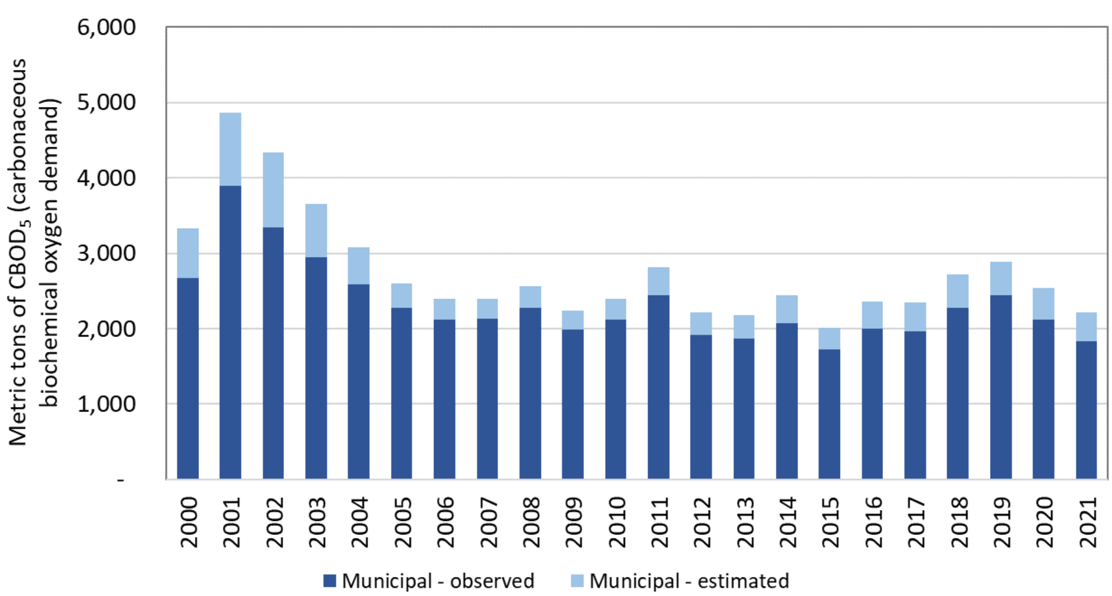
Discharges of high levels of BOD or $CBOD_5$ deplete the oxygen available as oxygen is consumed by bacteria during the decomposition of organic material. Depletion of oxygen deteriorates water quality and impacts aquatic life, including fish and other organisms.

Municipal wastewater treatment facility effluent limitations and reporting requirements are expressed as $CBOD_5$. Industrial dischargers most frequently report BOD which reflects the industry-specific requirements within Federal Regulations. For purposes of this report, $CBOD_5$ was used for load calculations because it provides a more complete data set for municipal loading calculations. Industrial facilities are not included in this calculation because there are too few observations to confidently estimate categorical concentrations. The complete BOD/$CBOD_5$ load could be significantly higher than the currently reported values because industrial flow accounts for nearly half of the flow within the state.

The total municipal $CBOD_5$ load for 2021 was 2,235 metric tons, an 18% decrease from the 2019-2020 average. On average, the data show an annual 46% reduction in $CBOD_5$ loads from a 4,115 metric ton per year baseline in 2000/2001.

Municipal wastewater $CBOD_5$ data are considered reliable, with 83% of values resulting from observed data points. On average, 83% of wastewater $CBOD_5$ loads are discharged by major facilities, although the proportion of $CBOD_5$ loads discharged by major facilities has declined from an average of 89% from 2000 through 2003 to an average of 83% from 2004 through 2021. Overall, wastewater $CBOD_5$ loads have declined from an average of 4,060 metric tons per year in the 2000 through 2003 period to an average of 2,437 metric tons per year from 2007 through 2021.

Figure 17. Annual loading values for municipal wastewater $CBOD_5$



Minnesota Nutrient Reduction Strategy (phosphorus and nitrogen)

Minnesota’s 2014 Nutrient Reduction Strategy identifies relative nutrient (phosphorous and nitrogen) source contributions to surface waters. The strategy also establishes nutrient reduction goals for both point and non-point sources (Table 6). In aggregate, wastewater sources have achieved the desired phosphorus reductions and work to meet local water quality goals is in progress. Permit nitrogen monitoring frequency requirements have increased as first step towards improving overall understanding of the nitrogen concentrations and loads discharged by Minnesota wastewater facilities. New wastewater nitrogen monitoring data reported since 2015 have significantly improved overall understanding of the concentrations and loads discharged by Minnesota’s wastewater treatment facilities. Wastewater nitrogen reductions specified for the Mississippi and Lake Winnipeg drainages have not yet been achieved.

On May 8, 2020, the International Joint Commission (IJC) proposed nutrient concentration objectives and targets for the Red River at the boundary between the United States and Canada to reduce worsening eutrophication in the Red River and Lake Winnipeg. The IJC recommended to the International Red River Board that a nutrient concentration objective of 0.15 mg/L for total phosphorus and a nutrient concentration objective of 1.15 mg/L for total nitrogen, calculated on the basis of a seasonal average from April 1 to October 30, be included in the Board’s current list of Water Quality Objectives. The IJC also recommended that nutrient load targets of 1,400 tons/year for total phosphorus and 9,525 tons/year for total nitrogen, calculated on the basis of a five year running average, also be added to the Board’s current list of Water Quality Objectives. The Board proposed nutrient objectives for the Red River in 2020 to provide important goals and benchmarks for measuring progress.

Table 6. Timeline and reduction goals

Major Basin	Pollutant	2010 – 2025	2025 - 2040
Mississippi River (Includes the Cedar,Des Moines and Missouri Rivers)	Phosphorus	Achieve 45% reductiongoal	Work on remaining reductionneeds to meet water quality standards
	Nitrogen	Achieve 20% reductionfrom baseline	Achieve 45% reduction frombaseline
Lake Winnipeg [a] (Red River only)	Phosphorus	Achieve 10% reductiongoal	Achieve any additional needed reductions identified through international joint efforts with Canada and in-state water quality standards
	Nitrogen	Achieve 13% reductiongoal	
Lake Superior	Phosphorus	Maintain goals, no net increase	
	Nitrogen	Maintain protection	

[a] Timeline and reduction goals to be revised upon completion of the Red River/Lake Winnipeg strategy.

Total phosphorus

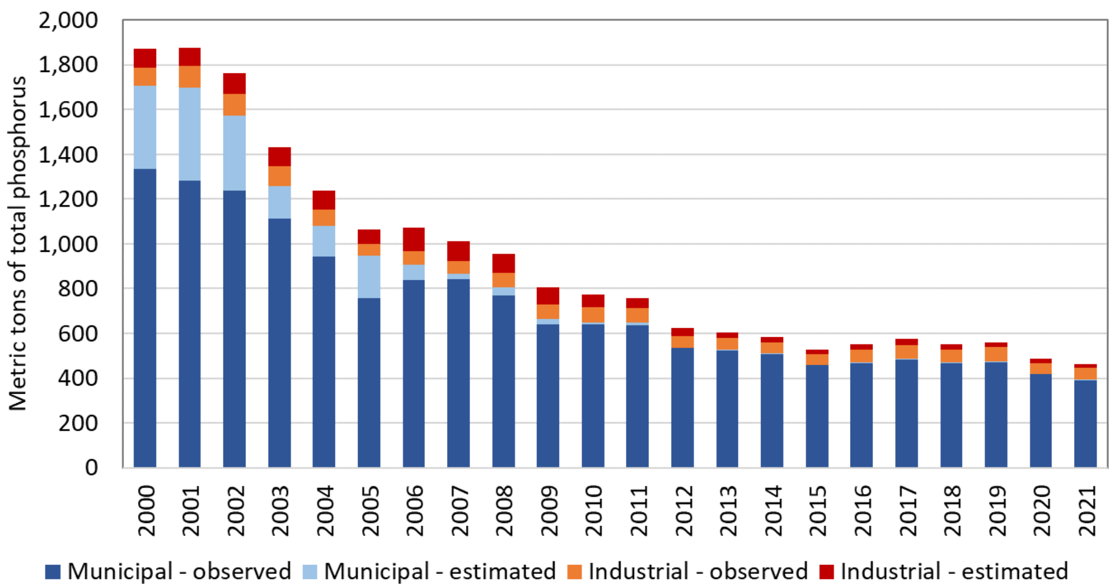
Total phosphorus is the primary pollutant associated with increased algae growth in Minnesota’s lakes and streams. Excess phosphorus from human activities causes algae blooms and reduced water transparency, making water unsuitable for swimming and other activities. Phosphorus is released from both point and nonpoint sources of pollution.

Controlling phosphorus is an important part of protecting Minnesota’s water resources. Considerable reductions in phosphorus from wastewater treatment facilities have been achieved since the MPCA adopted a strategy for addressing phosphorus in National Pollutant Discharge Elimination System (NPDES) permits in 2000. Phosphorus loads were reduced by 56% from 2000-09 and have decreased a further 34% since 2009. Overall, these efforts have resulted in a steady decline of phosphorus pollution (see Figure 18).

The 2021 total phosphorus load for the state was 462 metric tons, which is a decrease of 12% from the 2019 – 2020 average of 524 metric tons. A 75% reduction in total phosphorus loads has been accomplished from a 1,883 metric ton per year baseline in 2000/2001.

Total phosphorus wastewater data are considered reliable, with 87% of loads resulting from observed data points. On average, 78% of wastewater total phosphorus loads are discharged by major facilities; the proportion discharged by major facilities has declined from an average of 87% from 2000 through 2003 to an average of 76% from 2004 through 2021. Municipal wastewater dischargers accounted for 89% of total phosphorus loads from 2000 through 2003 with their proportion of the loading declining to an average of 86% from 2004 through 2021. Overall, wastewater total phosphorus loads have declined from an average of 1,745 metric tons per year in the 2000 through 2003 period to an average of 1,082 metric tons per year from 2004 through 2008 and further to an average load of 589 metric tons per year from 2010 through 2021.

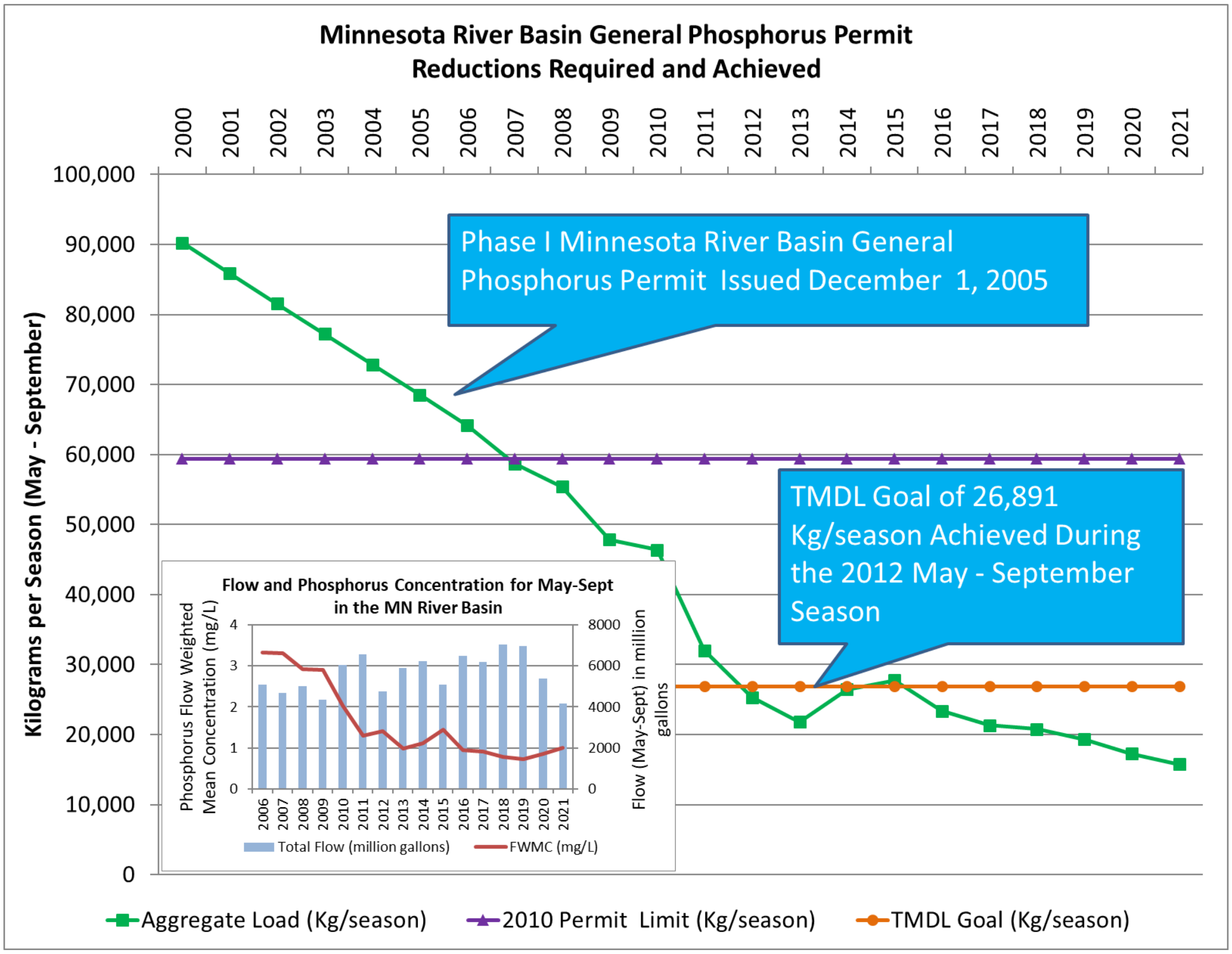
Figure 18. Annual total phosphorus loads from wastewater treatment facilities



Minnesota River Basin phosphorus reductions

Reductions in phosphorus loading to the Minnesota River have also occurred as a result of the Minnesota River Basin General Phosphorus Permit, which was issued on December 1, 2005. The permit was developed as part of the Lower Minnesota River Dissolved Oxygen TMDL that was completed to address a dissolved oxygen impairment in the Lower Minnesota River. The permit required the 40 largest continuously discharging wastewater treatment facilities within the Minnesota River Basin to meet a five-month (May-September) mass phosphorus limit. The permit required incremental reductions over time. The TMDL's phosphorous reduction goal was met in 2012 (see Figure 19).

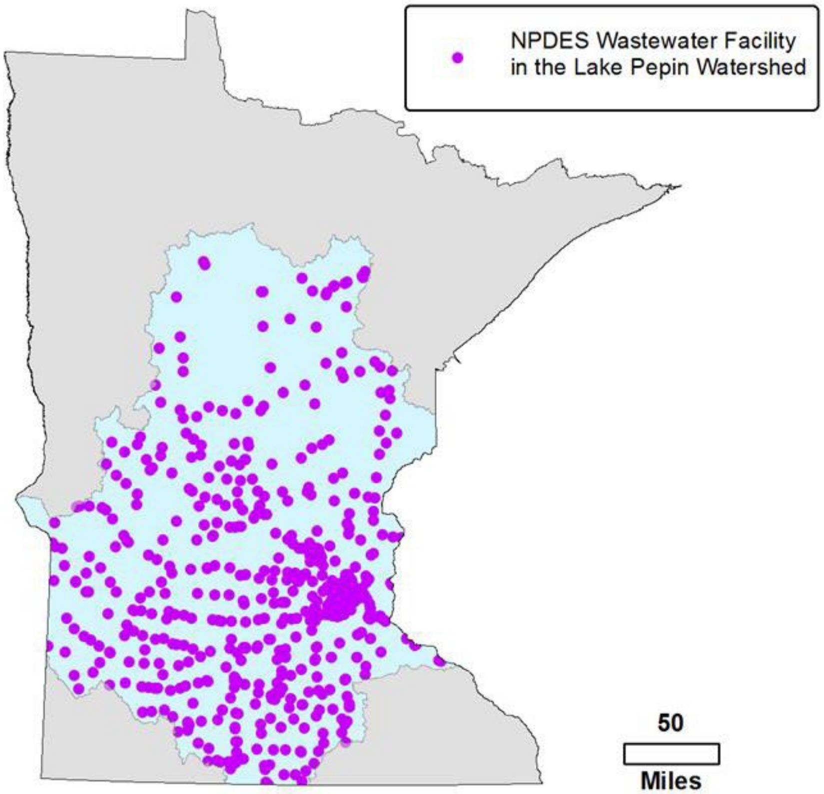
Figure 19. Minnesota River Basin General Phosphorus Permit reductions required and achieved



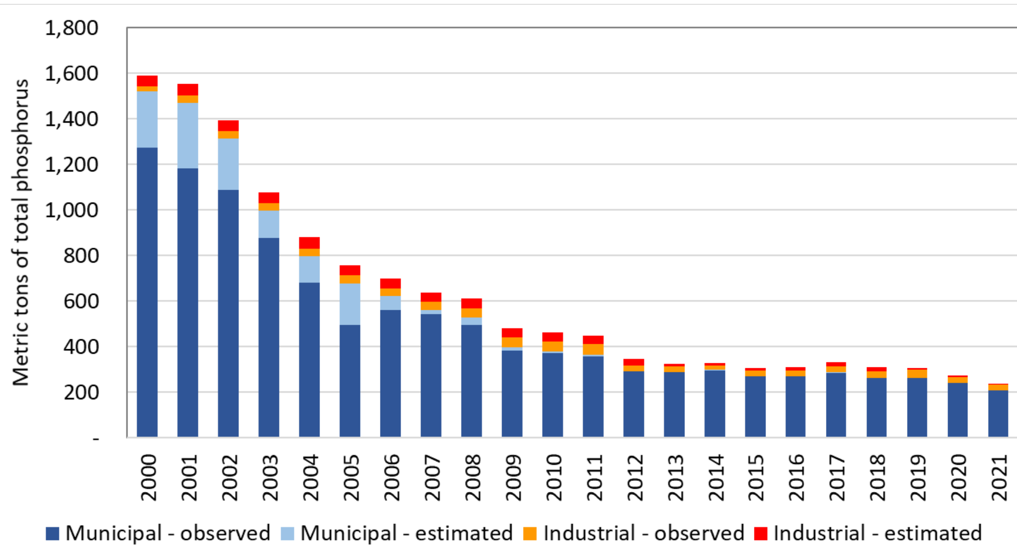
Lake Pepin phosphorus watershed reductions

The Lake Pepin Watershed covers a significant portion of the state and contains 82% of Minnesota residents. Lake Pepin is impaired due to excess nutrients. Phosphorus loads entering the lake have been greatly reduced since the adoption of the lake eutrophication standards in 2008, and since 2010, effluent phosphorus limits have been incorporated into relevant permits to address the nutrient impairment. Increased facility monitoring has also increased the confidence in load values because most municipal loads are now from observed values. Although aggregate total phosphorus loads from Minnesota dischargers have reduced effluent loads below the 600 metric ton per year wastewater point source goal for Lake Pepin, the NPDES permit program's efforts to establish permit limits continues in order to ensure that the load will remain consistent with watershed goals in the future. In 2021, EPA approved a TMDL for the Lake Pepin Watershed.

Figure 20. Wastewater facilities within the Lake Pepin Watershed and annual wastewater loads



Annual wastewater phosphorus loads in the Lake Pepin Watershed



River eutrophication rule and phosphorus discharge limits

Minnesota's river eutrophication standards (RES) were adopted in 2015 to protect aquatic life from the negative impacts of excess suspended algae in rivers and streams. RES complement the lake eutrophication standards which were approved in 2008.

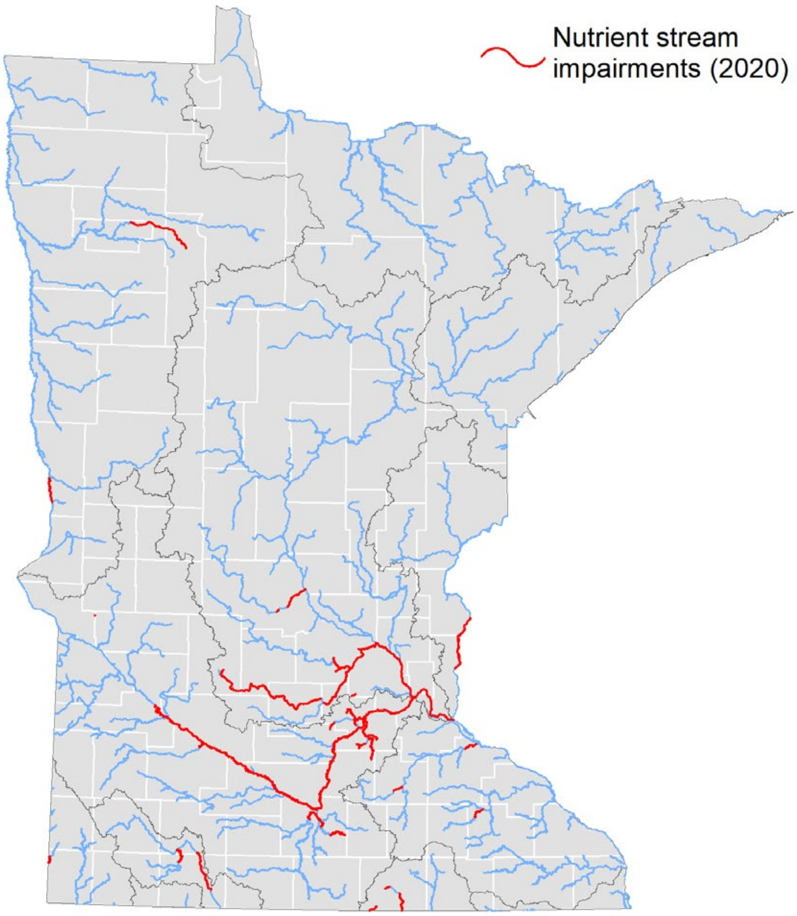
In addition to effluent phosphorus limits required for facilities whose discharges affect lakes, limits have also been established to meet RES water quality targets. Permits for facilities discharging upstream of a waterbody that exceeds RES are evaluated to establish whether more restrictive phosphorus effluent limits are needed. These effluent limit reviews are currently complete for many of the 81 major watersheds statewide. However, effluent limits associated with lakes are often sufficiently protective for nutrient impaired rivers. Limit determinations for individual facilities are based on major watershed scale effluent limit analyses that consider all wastewater discharges simultaneously.

While limits for many pollutants are based on conditions of the immediate receiving water, eutrophication limits must consider water quality in a number of downstream waters. The MPCA outlines the analysis and calculations used to establish necessary phosphorus effluent limits in a procedure document found at the following link: [https://www.pca.state.mn.us/sites/default/files/wq-wwprm2-15.pdf.](https://www.pca.state.mn.us/sites/default/files/wq-wwprm2-15.pdf)

In many cases, multiple facilities discharge upstream of an individual river reach or lake exceeding or potentially exceeding the standard so most of the effluent limit reviews for RES are completed on a watershed scale. This regional multi-facility approach for phosphorus limits is also consistent with MPCA's watershed approach for monitoring, assessment, protection and restoration.

The majority of nutrient impaired streams are in the southern part of the state. There are 53 impaired reaches totaling 814 miles in length. Streams with nutrient impairments on the 2020 approved impairment list are shown in the map below.

Figure 21. Streams with nutrient impairments on the 2020 impaired waters list



Total nitrogen

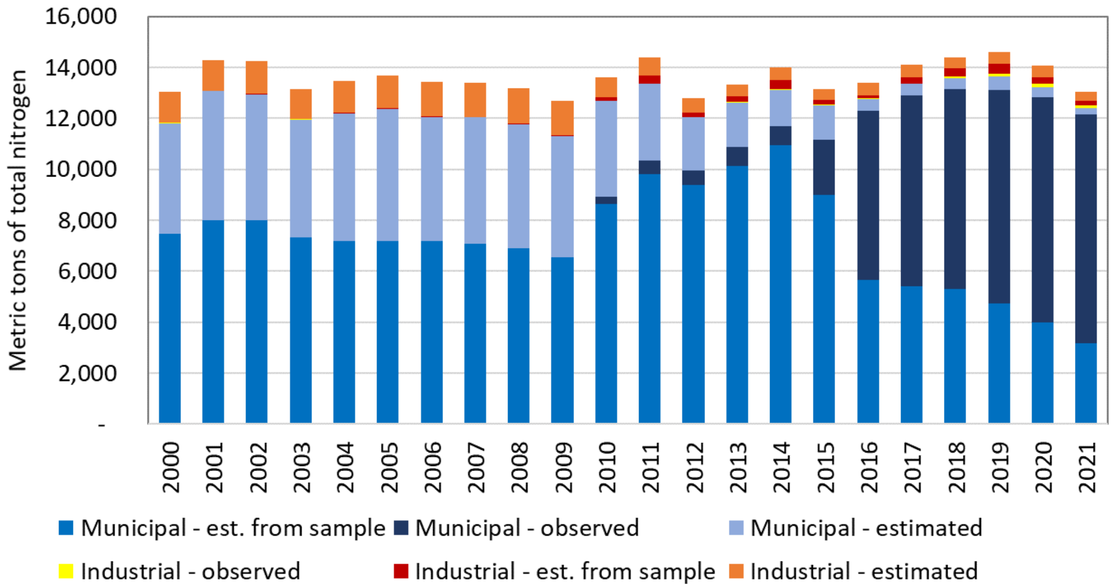
Nitrogen in wastewater generally occurs mostly as either nitrate or ammonia. Nitrogen as ammonia can be toxic to aquatic life, and nitrogen in the form of nitrate can be both a significant problem in drinking water supplies and toxic to aquatic life. Traditionally, permits have required more frequent monitoring for ammonia than for nitrate and/or other nitrogen parameters. As a result, it has been difficult to accurately report the total nitrogen (a measure of all forms of nitrogen including nitrate, nitrite, ammonia, and organic nitrogen) loads from point source discharges.

Minnesota's Nutrient Reduction Strategy defines a total nitrogen load reduction goal of 20% from discharges to the Mississippi River and 13% from dischargers to the Red River by 2025. As a first step in reaching this goal, additional monitoring for the necessary nitrogen parameters was added to permits so that a more accurate calculation of the total nitrogen loading from point source discharges can be established. In 2022, MPCA staff began the process of developing a wastewater nitrogen reduction strategy which will include robust stakeholder participation and coordinated with proposed rulemaking. The rulemaking may propose the adoption of new nitrate aquatic life toxicity standards, revisions to existing ammonia standards, and may include revisions to Minnesota rules relating to state water discharge restrictions to support implementation.

The 2021 wastewater load for total nitrogen was 13,155 metric tons, a 9% increase from the 2019-2020 average.

Confidence in the accuracy of wastewater total nitrogen loading estimates is increasing as the proportion of the loading derived from observed effluent data is increasing. In 2021, 69% of wastewater total nitrogen mass loading was derived from reported effluent monitoring data. On average, 90% of wastewater total nitrogen load is estimated to be discharged by major facilities. Municipal wastewater dischargers account for 92% of total point source nitrogen. The wastewater total nitrogen loads from 2021 have decreased by 4% from the 13,544 metric tons per year from the 2000/2001 baseline load.

Figure 22. Total nitrogen loads from wastewater treatment facilities by year



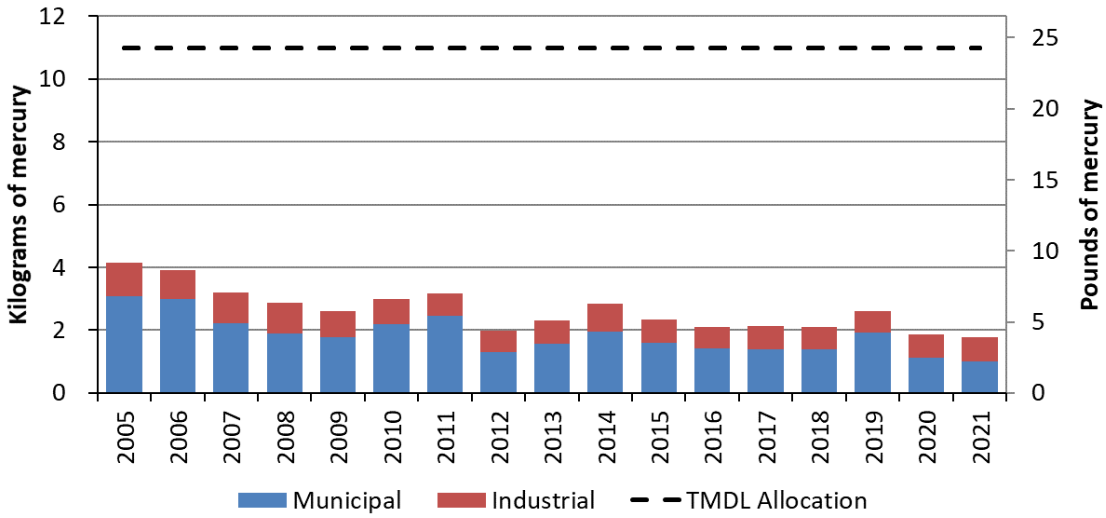
Total mercury

The wastewater mercury load fell below the Statewide Mercury TMDL wasteload allocation in 2003 and has continued to decrease slightly since that time. The wastewater mercury load for 2021 was 1.75 kg, a 23% decrease from the 2019-2020 average of 2.2 kg. Mercury reduction in wastewater is a result of successful source reduction programs and installation of treatment technologies for mercury removal, when appropriate. On average, the data show a 32% reduction in mercury loads from a 4.05 kg per year baseline in 2005/2006.

Total mercury wastewater data are considered moderately reliable with 64% of values resulting from observed data points. Mercury load estimates prior to 2005 are considered unreliable due to the use of analytical methods with limited detection capabilities. Analytical laboratories started to provide more precise mercury detection methods since 2003 or so, even so low level mercury data reported since 2005 is considered to be more reliable.

On average, major wastewater dischargers have accounted for 66% of total mercury loads since 2005. Municipal wastewater dischargers are estimated to account for 74% since 2005. Overall, wastewater total mercury loads are estimated to have declined from 4.77 kilograms per year in 2005 to 1.75 kilograms per year in 2021.

Figure 23. Total wastewater mercury loads by year



Nonpoint source pollution

While significant progress has been made to reduce point sources of water pollution more reductions are needed from nonpoint sources of pollutants – natural and human-made pollutants carried by rain or snowmelt into lakes, rivers, wetlands and groundwater.

Over the past few years, more regulatory controls for such sources as feedlots, septic systems and stormwater have been implemented, but other sources of nonpoint source pollution are diffuse and can be difficult to assess and manage. Much of the effort to control unregulated nonpoint sources of pollution thus far has consisted of financial incentives to encourage voluntary adoption of best management practices. The section below briefly outlines efforts made possible by the Clean Water Land and Legacy Amendment (CWLLA) and estimates associated pollutant reductions. Also highlighted is a statewide program that provides incentives for farmers to adopt agricultural best management practices to improve water quality and recent progress in watershed monitoring and assessment.

Clean Water Fund (CWF)

The Minnesota Legislature appropriated $261.0 million for Fiscal Years 2020-2021 and $256.8 million for Fiscal Years 2022-2023 to the CWF. Project funds are used for water-quality monitoring and assessment, watershed restoration and protection strategies and drinking water protection activities. Implementation activities, for nonpoint source, point source, and groundwater, comprise the largest portion (~71%) of spending in watersheds statewide. Since passage of the CWLLA in 2008, all 80 watersheds in Minnesota have benefitted from CWF supported activities.

Minnesota agencies released the most recent *Clean Water Fund Performance Report* in January 2022 to provide a high-level overview of Minnesota's investment to restore and protect the quality of the state's water resources. The report details how spending and progress are occurring across Minnesota. For a link to past reports and more information on the CWF, see the following link: http://www.legacy.leg.mn/funds/clean-water-fund.

Minnesota Agricultural Water Quality Certification Program

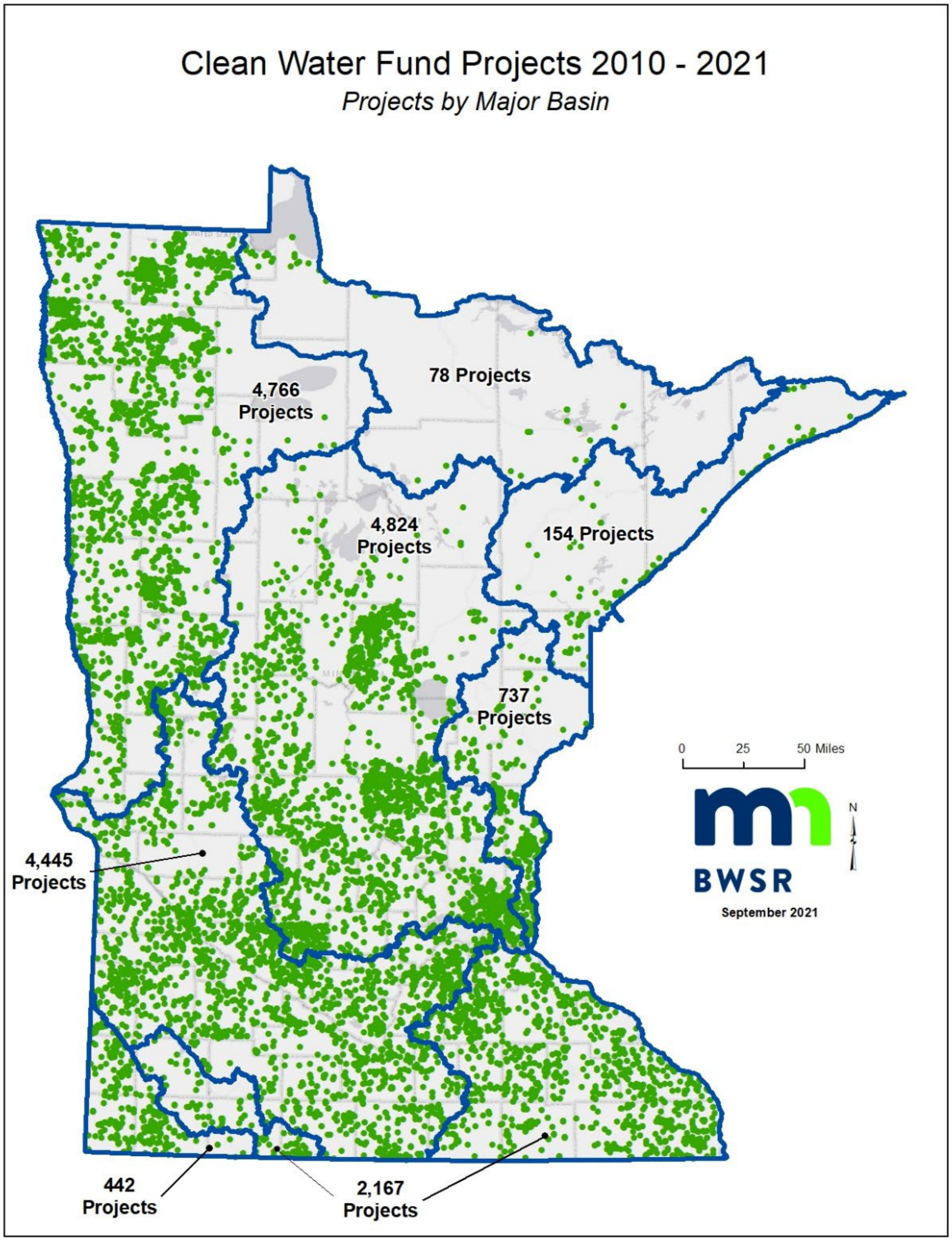
The Minnesota Agricultural Water Quality Certification Program is a statewide voluntary program designed to expedite the on-farm adoption of agricultural conservation practices that protect water quality. The program is a state and federal partnership with the state contribution coming from the CWF. In total, this program has certified more than 815,000 acres on over 1,165 producers across Minnesota, adding more than 2,350 new conservation practices to the landscape in approximately six years of statewide operation. Farmers and landowners who implement and maintain approved farm management practices are certified, and they obtain regulatory certainty, i.e. they will be deemed in compliance with any new water quality rules or laws for the 10 subsequent years. These farmers also receive priority for technical and financial assistance. More information about the Agricultural Water Certification Program can be found at the following link: http://www.mda.state.mn.us/protecting/waterprotection/awqcprogram.aspx.

Nonpoint Source BMPs Implemented with Clean Water Funding

The Minnesota Board of Water and Soil Resources (BWSR) is the primary state agency responsible for nonpoint source implementation and works in partnership with local governments. Local governments— cities, counties, watershed districts, and soil and watershed conservation districts— work directly with individual landowners and communities to implement best management practices that help reduce polluted runoff from agricultural field and city streets.

With funding from the CWLLA, the implementation of practices to improve and protect Minnesota's water resources has accelerated. The map on the next page shows the location of state CWF projects. In total, more than 17,613 best management and conservation practices have been installed, resulting in a reduction of about 271,237 pounds of phosphorus and 264,665 tons of sediment across the state from 2010-2021. Figure 23 shows the number and location of CWF projects by major basin. While these reductions do not represent all of best management practices implemented on the land in Minnesota, they demonstrate the improvements resulting from CWF investment. Although funding has increased, and implementation of practices and projects continues to grow, the total request for projects has remained three times greater than available funds.

Figure 24. CWF projects by major basin, 2010-2021



Progress in watershed monitoring and assessment

The CWF investment is enhancing monitoring of Minnesota's waters and improving our understanding of the relative contributions of pollutants from various sources and waters. In 2008, state and local partners began intensive sampling and assessment of lakes and streams in all the major watersheds in a 10-year cycle and so all major watersheds in Minnesota have now been assessed. The Minnesota Watershed Pollutant Load Monitoring Network measures and compares pollutant load information from Minnesota's rivers and streams and tracks water quality trends. This long-term program utilizes state and federal agencies, universities, and local partners to collect water quality and flow data to calculate pollutant loads. To learn more about Minnesota's Watershed Pollutant Load Monitoring Network, see the following link: https://www.pca.state.mn.us/water/watershed-pollutant-load-monitoring-network

Contaminants of emerging concern and PFAS

The MPCA monitors pharmaceuticals, personal care products, industrial, and other wastewater-associated chemicals in Minnesota's groundwater, lakes, and streams. Although it is not yet possible to quantify the amounts released to the environment because not all of the wastewater dischargers in the state are monitoring these constituents in their effluent, the MPCA's ambient monitoring efforts demonstrate the extent to which these unregulated chemicals are found in Minnesota's surface and groundwater. Most of these chemicals lack established standards or benchmarks for comparing concentrations and characterizing their risk to human health. Concern is growing over the potential health effects of these chemicals for humans and the environment, as well as other unregulated chemicals such as per- and polyfluoroalkyl substances (PFAS). Additional information regarding MPCA's work on contaminants of emerging concern can be found here: https://www.pca.state.mn.us/water/contaminants-emerging-concern. The work summarized here is accomplished through collaboration with the United States Geologic Survey (USGS), Minnesota Department of Health (MDH), the University of Minnesota, St. Cloud State University, and the University of St. Thomas.

Lake and river studies

Large-scale monitoring of lakes (2012, 2017) and rivers and streams (2010, 2014, 2021) shows many pharmaceuticals, personal care products, detergents, and other commercial or industrial chemicals are present in most of Minnesota's surface water. Much of this contamination can be attributed to wastewater treatment plants, subsurface sewage treatment systems, or agricultural land use. However, these contaminants often appear at remote locations without apparent sources. The next large-scale sampling of lakes is planned for 2022.

Groundwater monitoring

The MPCA monitors the state's groundwater annually for the presence of medications, detergents, and other organic chemicals used in industry or found in personal care or household products. The agency tests 40 wells in its ambient groundwater network each year for these types of chemicals. This work has found low levels of a variety of these chemicals in the state's groundwater.

Precipitation study

A 2016 study found antibiotics, anti-corrosives, bisphenol A, DEET, and other chemicals in samples of snow, rain, and air. While the study did not determine the source of these contaminants to the atmosphere, the results suggest that atmospheric transport of these contaminants may partially explain their appearance at remote surface water locations in Minnesota.

Fish studies

A 2014 screening study indicated that chlorinated paraffins (CPs) are present at concentrations of concern in some Minnesota fish. CPs are known to be highly toxic to aquatic invertebrates, which are important food sources in aquatic ecosystems. CPs can also cause tumors in fish and eggshell thinning in ducks. Toxicity to humans is not well studied, but studies in laboratory rats and mice have shown the potential to cause liver, thyroid, and kidney cancer. CPs are widely used in a variety of products, including fire retardants, plastics, sealants, adhesives, and coatings. In 2015, over 350 fish representing a variety of species were collected from 43 waters (13 rivers, 30 lakes) in six of Minnesota's seven ecoregions. Short-, medium- and long-chain CPs were detected in fish fillets from 62% of rivers and 27% of lakes.

Groundwater at wastewater land application sites

In 2016, the MPCA and USGS completed a groundwater contaminant study of large drainfields, municipal rapid infiltration basins and a septage land application site. A total of 34 different contaminants were detected in the shallow groundwater adjacent to these systems, including pharmaceuticals, flame-retardants, corrosion inhibitors, fragrances, and pesticides. No individual contaminant exceeded a concentration of 1 part per billion, nor did they exceed available drinking water guidelines, screening values or standards. However, most of the chemicals lack established standards or benchmarks for comparing concentrations and characterizing their risks.

Stormwater

In 2016, stormwater was tested at nine locations in the Twin Cities Metro Area for a broad suite of pharmaceuticals and other wastewater-associated chemicals. The results of this investigation show that stormwater is an important contributor of these contaminants to surface water, and that it is important to reduce the prevalence of these constituents in stormwater.

Aquatic toxicity profiles

Most of the work done to evaluate risks from contaminants of emerging concern is focused on their potential harm to people, especially through the possibility they may be present in drinking water. However, fish and other aquatic life are exposed continually to contaminants of emerging concern. Characterizing risks to aquatic life from exposure to these chemicals is complex and difficult in the absence of formal standards or other benchmarks. Some have endocrine-active characteristics, mimicking hormones in ways that could adversely affect reproduction, behavior, or physiology in wildlife, aquatic organisms, and possibly humans. Most of these chemicals have not undergone full toxicity evaluations.

The MPCA has developed Aquatic Toxicity Profiles (ATPs) to provide an overview of chemical- specific information including chemical properties, occurrence, toxicity, and production volumes. ATPs can help prioritize chemicals for monitoring and follow-up study.

Other special studies

A study of discharges from 25 wastewater facilities in 2009 confirmed that wastewater effluent is a major contributor of pharmaceuticals, alkylphenols, and other chemicals to surface water, highlighting the fact that most wastewater treatment facilities are not designed to remove such chemicals. Focused lake studies from 2008 through 2013 demonstrated the widespread presence of these chemicals in both urban and rural lake water. Biological effect studies, done in conjunction with MPCA's sampling investigations, consistently indicate physiologic and genetic impacts on fish exposed to surface water with low concentrations of these chemicals.

A two year study of disinfection byproducts in finished wastewater is scheduled for completion in 2022. This study, which focuses on toxic chemicals that are produced when wastewater is disinfected through chlorination, will provide insight to the types and amounts of these chemicals entering our surface water via wastewater treatment plants.

Microplastics are another pollutant of emerging concern. Microplastics are small (<5 millimeters) pieces of plastic that were either manufactured or produced by the breakdown of larger plastics in the environment. Multiple studies have detected their presence in surface water, drinking water, consumer products, and other media. Few studies have been conducted in Minnesota regarding environmental contamination of microplastics. The legislature provided CWF funding to the agencies to begin to look at microplastics in Minnesota. This work was delayed by the pandemic, but the MPCA will, in coordination with UMD and USGS, begin sampling in 2022 in a selection of surface waters and groundwater. The key goals of the sampling are to 1. Identify or develop appropriate sampling and analytical methods for the collection of microplastics from surface water, groundwater, and drinking water sources and 2. Pilot the collection of samples from selected waters to determine the feasibility and effectiveness of the method(s) identified above.

PFAS

Introduction

Per and poly-fluoro alkyl substances, or PFAS, are a large group of manmade chemicals containing at least one fully fluorinated carbon. Invented in the 1930s, PFAS are desirable in commercial and industrial applications because of their unique chemical traits like durability. However, that durability also means that they do not readily break down over time in the environment and are not easily removed through conventional pollution treatment at facilities like wastewater treatment plants and easily transfer from the atmosphere to surface water, soil, and biota. The extreme persistence of PFAS in the environment has led to the nickname of "forever chemicals."

PFAS are unlike other classes of environmental contaminants because of the number of unique structures in the group, their persistence in the environment, and their widespread use. There are currently over 5,000 PFAS structures included in the EPA's master list of structurally defined PFAS, and over 9,000 identified PFAS chemistries. New PFAS are being invented, used in industry, incorporated into commercial products, and released to the environment every day. Most industrial and commercial products do not disclose the inclusion of PFAS in their formulations. As toxicologists have more access to data on the toxicity of each individual PFAS, they find that more of these substances can cause adverse health impacts (including increased risk of cancer, immune system dysfunction, and effects on developing fetuses) at very low levels of exposure. PFAS have been found in animals and people all over the globe.

In February 2021, Minnesota published Minnesota's PFAS Blueprint, which charts a strategic path forward to tackle issues related to PFAS pollution. This document was developed by the MPCA, MDH, DNR, and Minnesota Department of Agriculture (MDA). Representatives from these agencies and others meet regularly in a PFAS Lateral Team to discuss ongoing PFAS related work. MPCA now employs a PFAS Coordinator to support PFAS work and planning efforts.

PFAS manufacturing

In Minnesota, 3M started manufacturing PFAS in 1950. The company has produced many PFAS including two that are globally recognized as potent toxicants: perfluorooctane sulfonate (PFOS) and perfluorooctanoic acid (PFOA). PFOS and PFOA were phased out of production in 2015, but production of other PFAS is ongoing and releases of these compounds have continued. Where PFAS are produced or used in manufacturing, they are released to the environment – this includes locations like the 3M Cottage Grove facility, which continues to release PFAS in their effluent and potential past air emissions from their hazardous waste incinerator (due to the difficulty of achieving complete destruction of PFAS). It is well known that four sites in Washington County were identified where 3M disposed of PFAS wastes – Oakdale, Woodbury and Cottage Grove, and at the former Washington County Landfill in Lake Elmo. 3M's disposal of these PFAS-containing wastes has resulted in a 150-square-mile plume of PFAS-contaminated groundwater and surface water.

There are numerous secondary manufacturers of PFAS-containing products in Minnesota. Like primary production facilities, these facilities have the potential to release toxicologically significant quantities of PFAS to the environment via releases to air, soil, and surface water.

PFAS in fish and game

Hunting and fishing are cherished activities in Minnesota, with long-standing cultural significance for many populations. Nearly all of Minnesota is ceded territory, with Tribal nations that pre-date the establishment of the state of Minnesota retaining hunting, fishing, and gathering rights. Beyond providing opportunities to engage in cultural heritage, entertainment, and enjoyment of the outdoors, these activities also provide healthy sources of food for many Minnesotans. In some cases, locally harvested fish and game are relied on as a key component of a family's diet. Unfortunately, continued research on PFAS in fish and wildlife has indicated that some PFAS – particularly PFOS – can accumulate in commonly consumed tissues of fish and game, potentially to levels causing exposure concerns for those consuming the meat.

Ensuring that the fish and game harvested in Minnesota are safe for consumption is an important goal of MDH, MPCA and DNR. The interagency fish contaminant monitoring program collects fish from lakes and rivers throughout Minnesota with the cooperation of the DNR Fisheries and MPCA Biomonitoring teams. The primary role of the program has been to analyze fish tissue for levels of mercury and polychlorinated biphenyls (PCBs), but Minnesota has provided and received occasional funding that has enabled some additional analysis for PFAS, with a primary focus on PFOS. The data gathered support the MDH's Fish Consumption Guidelines and MPCA's assessment of waters for impairment and development of water quality standards for aquatic consumption. In addition to fish monitoring, DNR conducts additional ad hoc monitoring of animals like deer and waterfowl by working with hunters in areas with known contamination, as funding and capacity allows. These monitoring projects provide the basis for any issuance of guidance or regulation by MDH or MPCA.

PFAS contamination in fish is pervasive across Minnesota: 84% of the Metro lakes and 22% of the non-metro lakes sampled to date had fish with detectable levels of PFOS. Of the lakes with a known PFAS source nearby, all lakes had fish with detectable levels of PFOS, in both Metro and non-metro waters. Recent detections of PFOS in smelt from Lake Superior has motivated additional research into PFAS levels in fish from Lake Superior and its major tributaries. In 2021, 300 fish were collected in the Lake Superior basin and will be analyzed for their PFAS levels. Due to backlogs in lab capacity to analyze PFAS in fish, the results from this study are not expected until early 2023.

MDH advises that people eat no more than four servings per week of any pan fish due to concerns over PFOS. There is currently a recommendation to consume no more than one meal per month of smelt from Lake Superior. MDH also issues more restrictive PFOS-based fish consumption advice at a number of lakes and rivers due to PFOS contamination in those waterbodies. Fish consumption advice can be found on MDH's website: https://www.health.state.mn.us/communities/environment/fish/.

So far, monitoring of PFAS in deer collected near areas of known surface water contamination has not shown elevated levels of PFAS in venison. There are therefore not deer-consumption advisories listed for PFAS in Minnesota as there are in other states like Wisconsin, Michigan and Maine. DNR's monitoring of PFAS in waterfowl (ducks and geese) is ongoing.

There are concerns that other members of the PFAS family may also be especially bioaccumulative in fish and game. For example, chloroperfluoropolyether carboxylates (ClPFPECAs) are replacement PFAS for PFOA. According to the New Jersey Department of Environmental Protection, this subfamily of chlorinated PFAS may be an order of magnitude more bioaccumulative than PFOS in fish tissues.[1] Like many currently used "replacement" PFAS, these chlorinated PFAS are not detectable using standard analytical methods and would go unseen in Minnesota fish, game, surface water, air, and drinking water despite ongoing PFAS monitoring efforts.

PFAS in the ambient environment

Minnesota has monitored for PFAS in surface water, groundwater, air, and sediment around the state. The Minnesota Groundwater Protection Act (Minn. Stat. ch. 103H) splits the ambient groundwater quality monitoring responsibilities between the MDA and MPCA, with each agency maintaining their own ambient groundwater-monitoring network that, combined, provides good spatial coverage of groundwater quality conditions across the state. The MPCA's ambient groundwater monitoring primarily targets aquifers in urbanized parts of the state and contaminants included in monitoring generally do not include agricultural compounds like pesticides. The shallow wells, which have a median depth of 22 feet, comprise an "early warning system" and allow MPCA to understand what chemicals can readily be transported to the groundwater and identify emerging trends in groundwater quality. The deep wells, which primarily are domestic wells installed in the Prairie du Chien-Jordan aquifer, provide information on the quality of the water that is consumed by Minnesotans and information about how quickly any contamination from the surface is percolating downward.

MPCA has also been able to do some sporadic sampling of the ambient well monitoring network for PFAS. In 2013, with limited targeted follow-up in 2017, MPCA was able to include 13 PFAS analytes in the analysis of groundwater samples. The results of PFAS monitoring are available in a report on MPCA's website.[2] This report shows that PFAS were detected in most groundwater in the state, with PFBA being the most frequently detected PFAS (found in almost 70% of all sampled wells). In 2013, PFOA was detected in 30% of sampled wells, PFOS was detected in 12% of sampled wells, and PFHxS was detected in 11% of sampled wells. An additional special sampling of the whole network was completed in 2019, and included 33 PFAS analytes. Preliminary analysis shows that 17 of the 33 analytes were detected. PFBS was detected in 42.4% of the groundwater wells in 2019, higher than the 9% presence seen in 2013, likely due to a change in methods that allowed detection of lower concentrations. Three PFAS (PFOA, PFOS, and PFHxS) were detected at least once at concentrations above MDH's health-based guidance. Samples with detections were primarily in shallow monitoring wells, but some detections were in deeper monitoring wells.[3] Funding for PFAS monitoring in the Ambient Groundwater Well Network has not been specifically provided. MPCA has done the sampling as resources become available. To continue monitoring for PFAS in this network, additional funding would be needed.

In 2021, MPCA conducted its first pilot study of PFAS levels in ambient air and precipitation. In this year-long study, the agency collected air (gas and particulate phase) at four sites across the state. One rural monitoring site in greater Minnesota was selected as a reference site, and three urban sites were selected near known or potential emission sources. In addition, wet and dry (aqueous) deposition samples were collected at two of the four sites. Results of this study are presented in detail in a pending report. Overall, the study finds PFAS are present in ambient air in both the gas and particulate phase, and in wet and dry deposition, statewide. Though concentrations of PFAS in ambient air do not exceed risk-based inhalation thresholds determined by MDH, due to ongoing deposition of PFAS from the

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[1] https://www.nj.gov/dep/srp/srra/listserv_archives/2022/20220118_srra.html

[2] MPCA. (n.d.) Groundwater data. https://www.pca.state.mn.us/water/groundwater-data

[3] Additional information is available on request from the MPCA (memo: 2019 Ambient Groundwater Sampling Results)

atmosphere back to the earth's surface, the levels of PFAS in the atmosphere may still pose a danger to the surface water, groundwater, and soils around the state.

The MPCA has completed several investigations into the levels of PFAS in the ambient environment downstream of the 3M Cottage Grove production facility in Pool 2 of the Mississippi. See 2012 report on fish, water, sediment, and invertebrate sampling at http://www.pca.state.mn.us/index.php/view-document.html?gid=19516

For more information on historic studies of PFAS in the ambient environment, see Minnesota's PFAS Blueprint: https://www.pca.state.mn.us/waste/minnesotas-pfas-blueprint.

PFAS source identification and reduction

MPCA is currently working with regulated facilities to eliminate or reduce PFAS releases into the environment. In 2021, MPCA launched the development of a PFAS Monitoring Plan, which lays out a path forward for PFAS monitoring at solid waste, wastewater, and stormwater facilities, hazardous waste landfills, facilities with air emissions, and sites in the Brownfield or Superfund programs. The draft plan does not establish facility-specific requirements, but outlines how the MPCA plans to prioritize locations for PFAS monitoring and what the monitoring will entail. More information about the PFAS Monitoring Plan development process and implementation timeline are available on MPCA's website: https://www.pca.state.mn.us/waste/mpca-pfas-monitoring-plan.

There are a number of initiatives currently underway to compile information about PFAS sources to commercial and industrial users, describe source reduction strategies, and educate the public about PFAS and PFAS-containing products. These include one-time projects that were funded through the legislature in the 2021-2022 budget.

Thanks to funding from the LCCMR, MPCA is also in the process of completing a broad study that will evaluate and characterize PFAS concentrations in land-applied biosolids and compost; leaching from those wastes; and subsequent movement of PFAS into water and food. See link for more information. (https://www.lccmr.leg.mn/proposals/2020/originals/098-b.pdf)

Federal action on PFAS

In 2021, the EPA acknowledged that "PFAS pollution is a public health emergency." The EPA published their "PFAS Roadmap," which (in a similar manner to Minnesota's PFAS Blueprint), lays out a path forward on key regulatory actions. The PFAS Roadmap lays out a number of dates for when the agency commits to finalizing actions like regulations of PFAS in drinking water (under the Safe Drinking Water Act), regulations of PFAS under the Superfund Program (under the Comprehensive Environmental Response, Compensation, and Liability Act), and regulation of PFAS in products (under the Toxic Substances Control Act). EPA's PFAS roadmap actions can be found here: https://www.epa.gov/pfas/pfas-strategic-roadmap-epas-commitments-action-2021-2024