Pollution

April 2018

2018 Pollution Report to the Legislature

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 two calendar 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

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On the cover: Cars, trucks and other mobile sources continue to be a major source of air pollutant emissions, including greenhouse gases, in urban areas across Minnesota. Deicing salt needed for safe traffic flow in Minnesota winters is a cause of chloride-impaired streams, prompting advances in "smart salting" by state and local government snowplow drivers.

Minnesota Pollution Control Agency

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Contents

Executive summary

Every two years, the Minnesota Pollution Control Agency (MPCA) uses the most recent data available to estimate the total amounts 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 emerging contaminants of 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.

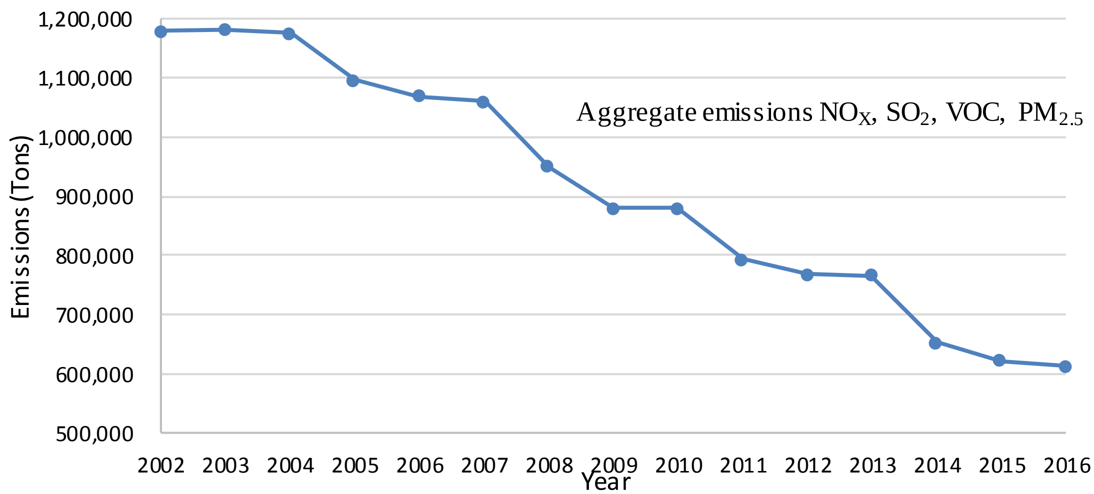
Air emissions

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.

Emissions from larger facilities are available every year; however, emissions from other sources are only available every three years. It is important to note that the 2014 data presented in this report are draft and once finalized emissions become available they may differ significantly from current estimates. Initial estimates are recalculated based on federal economic data and other factors influencing emission sources.

Figure 1 provides estimated total statewide emissions of four major criteria air pollutants from 2002 to 2016. During this time, estimated emissions of these pollutants have been reduced by almost 50%. While this report is focused on statewide total emissions, MPCA understands that some air pollutants are emitted disproportionately in areas of concern.

Figure 1. Minnesota statewide emissions trends



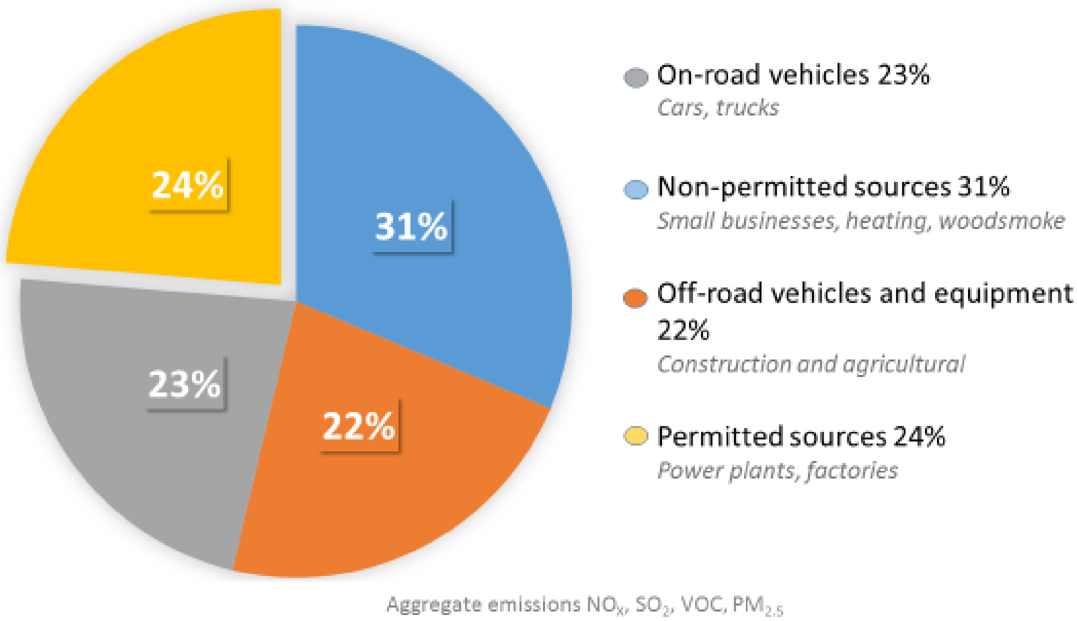
Emissions in 2002, 2005, 2008, 2011 and 2014 are from all sources, including mobile, non-permitted and permitted sources. Subsequent yearly emissions changes are due entirely to permitted sources. Mobile and non-permitted estimates were held constant for in-between years. Prior to 2012, $PM_{2.5}$ emissions 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, and changes to estimation methodologies. Most criteria pollutant emission estimates from permitted sources decreased between 2014 and 2016. Changes at utilities and mining companies resulted in major decreases in sulfur dioxide and nitrogen oxide emissions. Mining production was down in 2016 compared to both 2014 and 2015, resulting in lower emissions. In 2015, Xcel Energy – Black Dog Plant switched from burning coal to natural gas, and Xcel Energy – Sherburne Generating Plant installed new control equipment, which decreased emissions significantly. Minnesota Power – Bowell Energy Center also burned less coal than in 2014.

In 2016, all facility criteria emissions continued to decrease except for ammonia. Ammonia emissions increased slightly from 2015. This increase in likely due to the inclusion of new and updated emission factors for combustion processes. Statewide draft emission estimates for 2014 across all sources have decreased in comparison to 2011. The states and the U.S. Environmental Protection Agency (EPA) have taken steps to increase transparency and collaboration among the different state and federal organizations. As a result, for the 2014 emission inventory, a number of methodological improvements were implemented for many categories including solvent use and industrial/commercial/institutional combustion.

In 2014, most air pollution came from smaller, widespread sources, including vehicles, small businesses and construction equipment. Figure 2 shows a breakdown of draft 2014 statewide emissions.

Figure 2. Sources of criteria air pollutant emissions in Minnesota, 2014



A third 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 about 23% of emissions in Minnesota. Off-road vehicles and agricultural and construction equipment contribute 22% of total emissions in Minnesota. Emissions from permitted sources, typically power plants and large industrial factories, make up about a quarter of total statewide emissions.

Lead, mercury and other air toxics are pollutants that can be toxic at very low concentrations. In 2014, an estimated 17 tons of lead and more than 2000 (draft number) pounds of mercury were emitted in Minnesota. These pollutants have also trended downward, with about 12% statewide decrease in air emissions of lead from 2011 to 2014 with a 16% decrease in mercury during the same period.

In Minnesota, the MPCA estimates greenhouse gases (GHGs) for electric generation, transportation, agriculture, industrial, residential, commercial, and waste sectors. The most recently completed emission inventory for GHGs was in 2014. Since 2005, Minnesota's total greenhouse gas emissions have declined by about 4% and are currently not on track to meet the goals of the Next Generation Energy Act. Air toxics are estimated every three years, with latest draft estimates available from 2014. Statewide emissions have decreased for all source types compared to 2011 emissions.

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. Detailed and updated air emissions data can be found at https://www.pca.state.mn.us/2018-pollution-report.

Future emissions of pollution to Minnesota's air may be influenced by a number of factors, including:

- Emissions from electric utilities should continue to decrease due to increases in renewable energy sources such as wind and solar, increased energy efficiency, power plant modernization that includes retirement of less efficient, older coal plants, and increased use of natural gas.
- Emissions from taconite facilities are expected to decrease due to future installation of NO_x controls under federal rules and improved measurement methods.
- Continued decreases in on-road mobile emissions due to more stringent federal vehicle tailpipe standards as fleets turn over both in light duty and heavy-duty vehicles.

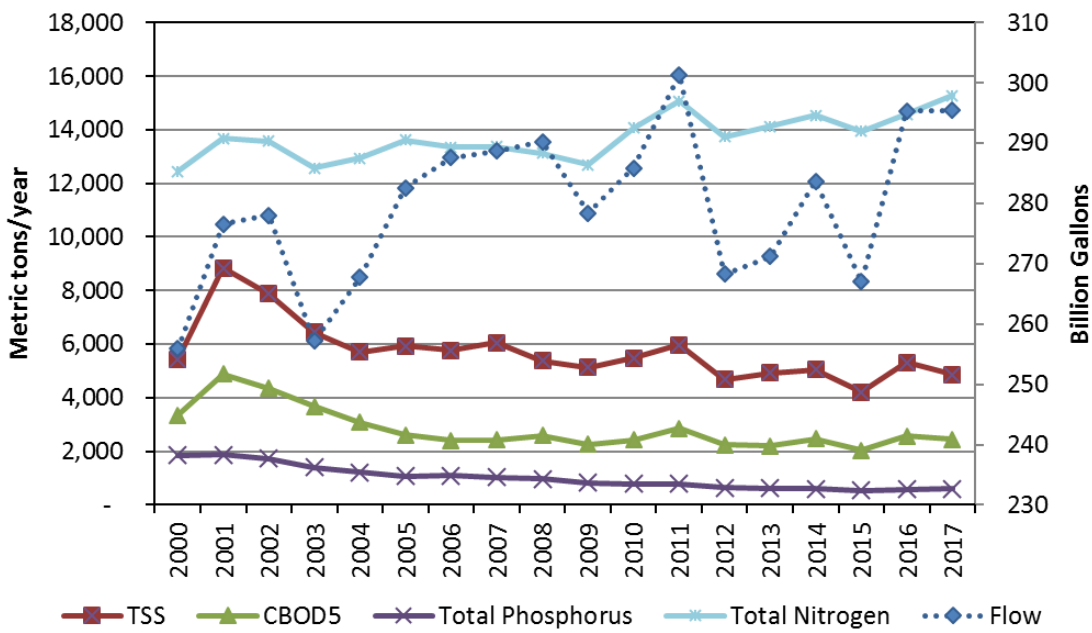
Water discharges

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

Overall pollutant loads to receiving waters are based on a combination of effluent flow and pollutant concentrations in the effluent. Loads are calculated by combining facility-reported flow and concentration data. If facility-specific data are not available, loads are estimated with information based on facilities with similar waste streams or other 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 2000-2017. 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 facilities, 2000-2017



Overall, effluent flows tend to fluctuate based on precipitation. 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. Regulatory policies implemented over the past 15 years have promoted 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 increased algae growth in Minnesota's lakes and streams.

With the exception of total nitrogen levels, which have increased in wastewater discharges, facilities have also decreased:

- Total suspended solids, which are sediment and other particles that cloud the water.
- Carbonaceous biochemical oxygen demand, which is a measurement of how pollutants can deplete 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. Mercury reduction in wastewater is a result of successful source reduction programs and installation of treatment technologies for mercury removal, where necessary. On average, the data show a 42% reduction in mercury loads from a 3.86 kilogram per year baseline in 2005/2006. Direct discharges of mercury in wastewater are very small compared to atmospheric sources of pollution.

Minnesota has made significant progress in cleaning up point sources of water pollution but it is the nonpoint sources of pollution from rainfall or snowmelt moving over or through the ground carrying natural or human-made pollutants into lakes, streams or wetlands that now pose the greater challenge for prevention and cleanup. Many of the stresses from nonpoint sources of pollution that affect Minnesota's surface and groundwater resources are the result of choices that people make every day such as lawn care practices, farming practices, watercraft operation and waste disposal. The daily decisions that homeowners, developers, farmers 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 include runoff from agricultural fields, feedlots, urban areas, and on-site sewage treatment (septic) systems. Nonpoint sources are most significant during periods of high precipitation and medium to high stream flow. Further improvements are needed in both point sources and nonpoint sources of pollution in order to achieve goals set in federal and state law for protecting human health and the environment.

Although there is no completely reliable way to quantify volumes of water pollutants released by nonpoint sources, the Board of Water and Soil Resources (BWSR) tracks Clean Water Fund projects and estimates pollutant reductions associated with them. From 2000 to 2017, more than 6,872 best management conservation practices have been installed, resulting in a reduction of about 116,675 pounds of phosphorus and 121,394 tons of sediment across the state.

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

- **Wastewater treatment infrastructure —** Minnesota's wastewater systems are aging. Significant investments will be needed to replace failing infrastructure and upgrade treatment facilities to meet higher standards and expand systems to accommodate growth. Both rural and metro facilities face serious challenges to make these improvements to their infrastructure.
- **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 both Lake Winnipeg 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, 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.
- **River eutrophication standards —** First adopted in 2014, these standards are designed to protect aquatic life from the negative impacts of excess algae in rivers and streams. More restrictive limits associated with these standards have the potential to further reduce pollutants from wastewater facilities.
- **Clean Water Fund investment —** Clean Water Fund 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, Clean Water Funds available for implementation are not keeping pace with 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 2016. Draft 2014 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 draft estimates available for 2014. 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 2014 are included in this report. Federal and state rules require MPCA to estimate GHG emissions from permitted sources each year. Starting in 2011, small permitted sources started 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 draft 2014 Minnesota Air Toxics Emission Inventory.

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 finalized 2014 air emissions will be available online on the MPCA website in the spring of 2018. 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 2008. 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:

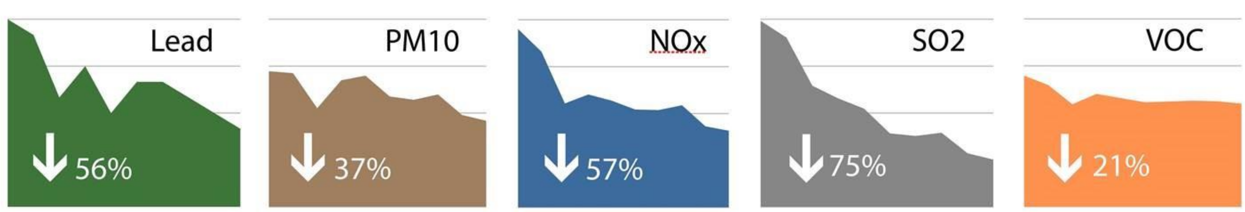
- *Particulate matter less than 10 microns in diameter (PM_{10})* is a broad class of chemically and physically diverse substances that exist as discrete particles (liquid droplets or solids) over a wide range of sizes. EPA currently has National Ambient Air Quality Standards for particulate matter in 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. NO_x 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 NO_x, 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 2016. The figure below shows emission trends for permitted sources since 2005. 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. Mining production has also decreased over the last few years, further reducing emissions.

Figure 4. Minnesota permitted source emissions 2005-2016



There has been a reduction in all criteria pollutant emissions from 2008 to 2014 (the most recent years we have 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

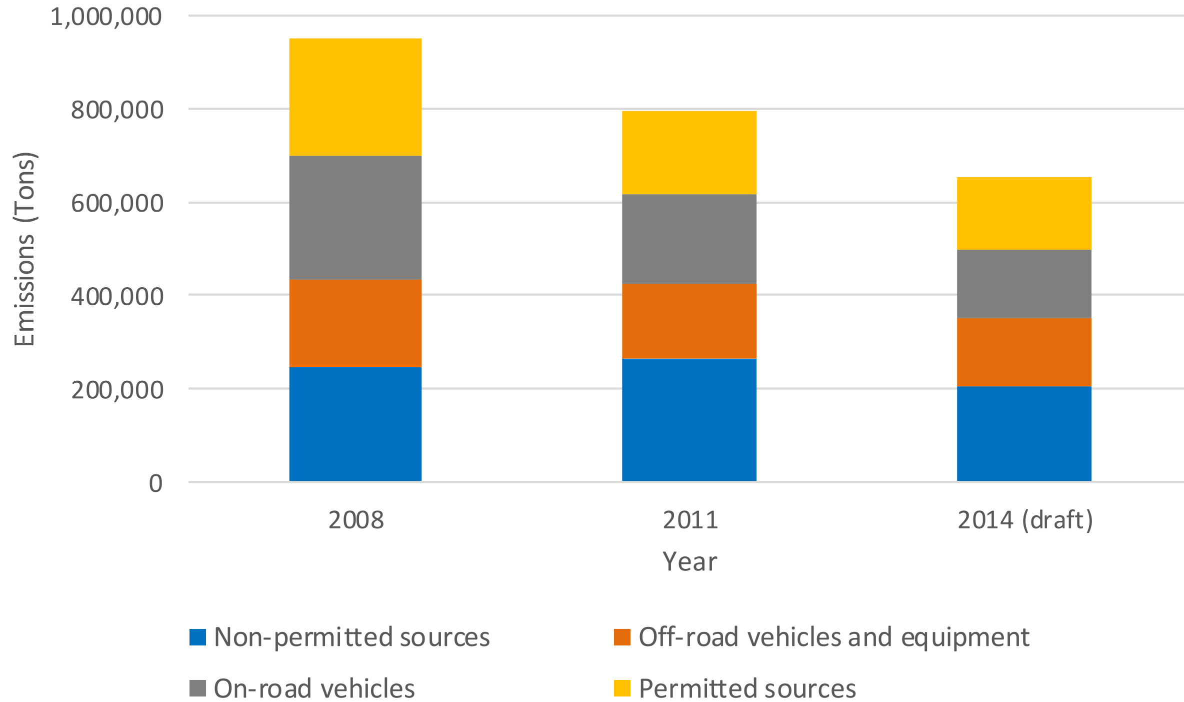


Table 1 shows statewide emissions for major criteria air pollutants and percent changes from 2014 to 2016. Despite the importance of secondary formation in creating particulate matter and some other pollutants, it is important to note that estimated air emissions data in this report are only based on direct releases from sources into the atmosphere. Emissions decreased for all pollutants from 2014 to 2016.

Table 1. Minnesota Air Pollution Emission Estimates 2014 to 2016 (tons)

Pollutant	2014	2015	2016	2014-2016 % change*
Particulate matter (PM_{10})**	1,092,636	1,088,264	1,087,039	-0.5
Sulfur dioxide (SO_2)	46,374	34,351	30,652	-34
Nitrogen oxides (NOx)	256,815	241,113	237,792	-7
Volatile organic compounds (VOCs)	224,296	224,175	223,755	-0.2
Particulate matter ($PM_{2.5}$)**	125,440	121,316	120,963	- 4
Lead (Pb)	17	17	15	-7
Total Criteria Pollutants	3,060,840	3,023,578	3,014,359	-1.5

* Draft 2014 mobile and nonpoint emissions estimated were used in the 2014 to 2016 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

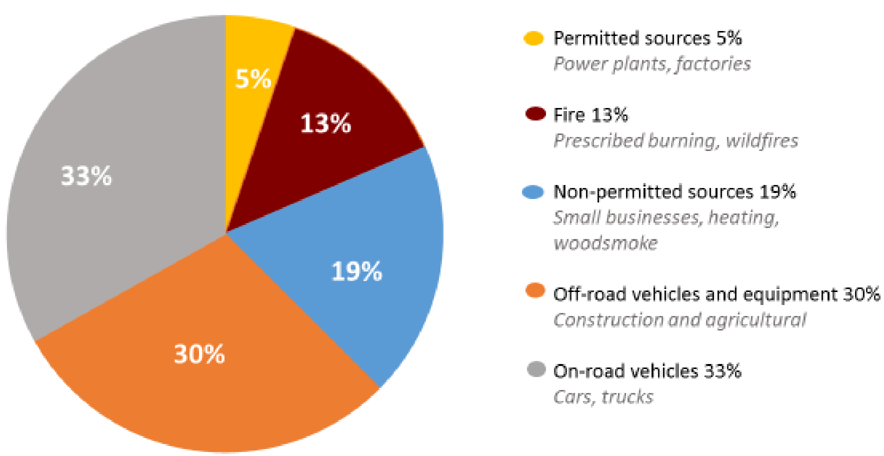
The EPA defines air toxics as pollutants that cause or may cause cancer or other serious health effects, such as reproductive effects or birth defects, or adverse environmental and ecological effects.

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 inventory for Minnesota is 2011; however, 2014 draft data are available and will be the focus of this report. 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 2014 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 2014 draft statewide emissions from directly emitted air toxics pollutants. It does not include secondarily formed pollutants. Once finalized 2014 data is available, the breakdown of air toxics categories may change. Non-permitted sources include very small stationary sources such as auto body shops and dry cleaners. These account for 19% of 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 over 60% of total emissions. Large permitted facilities contributed 5% and fires accounted for 13% 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 largely uncontrolled by human activity.

Figure 6. Sources of air toxics emissions in Minnesota, 2014

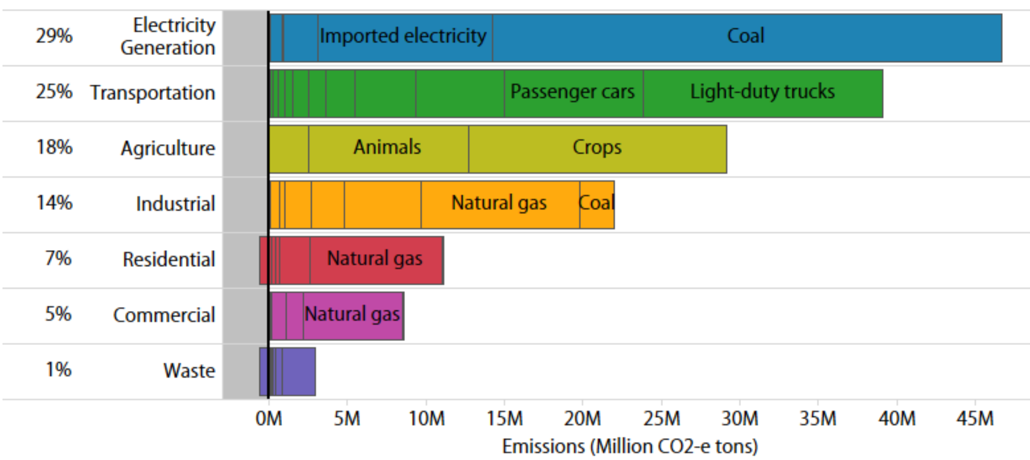


For more details about 2014 air toxics emissions, please visit the online application. This application will be updated with 2014 data once finalized emissions become available. MPCA developed multiple workbooks containing permitted sources, statewide and county level emissions. End users have hands-on access to emissions data, which they can view and use in an interactive format. Web applications contain statewide data going back to 2008.

Greenhouse gases

Greenhouse gases (GHGs) warm the atmosphere and surface of the planet, leading to alterations in the earth's climate. Many greenhouse gases occur naturally, but burning fossil fuels and other human activities are adding these gases to the natural mix at an accelerated rate. In 2014, Minnesota's GHG emissions were estimated to be 158.3 million CO_2e tons. CO_2e compares the global warming potential of emissions of different gases to the impact of the emission of one ton of CO_2. Most of Minnesota's GHG emissions are the result of using fossil fuel energy for electricity generation, transportation, heating, and other uses. Figure 7 shows GHG emissions by economic sector. The largest source of emissions is from the generation of electricity. GHG emissions from electricity generation include emissions from electricity generated in other states to meet Minnesota's net electricity demand. Over half of the GHG emissions from the transportation sector are from passenger and light-duty vehicles. Other significant sources include heavy-duty trucks, aviation, and natural gas transmission in pipelines.

Figure 7. 2014 sector GHG emissions, storage sources, and sector percent of total

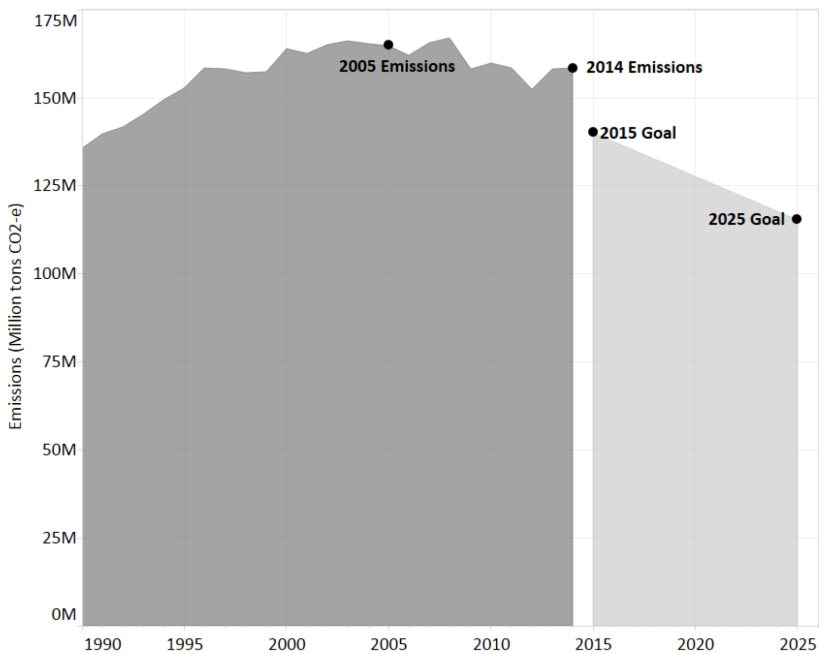


Trends in Minnesota's greenhouse gas emissions

Trends in emissions over time let us see the effects of policies and other factors that might change emissions. Since 2005, Minnesota's total greenhouse gas emissions have declined by about 4%. Each economic sector shows a unique trend in emissions.

The Next Generation Energy Act of 2007 (Minn. Stat. § 216H.02) established a 2015 GHG emission reduction goal 15% below 2005 emissions, and longer-term goals for 2025 (30% below 2005 emissions), and 2050 (80% below 2005 emissions).

Figure 8. Minnesota's GHG emissions 1990-2014 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 website: https://www.pca.state.mn.us/air/climate-change-minnesota

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. Consult the Minnesota Department of Health (MDH) Fish Consumption Advisory for guidelines to specific lakes and rivers at http://www.health.state.mn.us/divs/eh/fish/eating/sitespecific.html.

Mercury emissions are transported through the atmosphere and deposited by rain into Minnesota's lakes and rivers. Of the waters tested in the state, roughly two-thirds are impaired for mercury. 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 93% reduction in mercury from all human sources including emissions originating from outside of Minnesota. The MPCA is working to meet the 93% reduction in the state by following the mercury TMDL implementation plan, developed by stakeholders in 2009. 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 from accomplishing the goals of the statewide TMDL implementation plan. The TMDL demonstrated that mercury deposition was essentially 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

10% 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. 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. MPCA's scientific research into the unusually high mercury concentrations in fish 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) MPCA staff and collaborating academic scientists are continuing to analyze the large acquired dataset. MPCA will pursue additional funding from other sources for the remainder of the research.

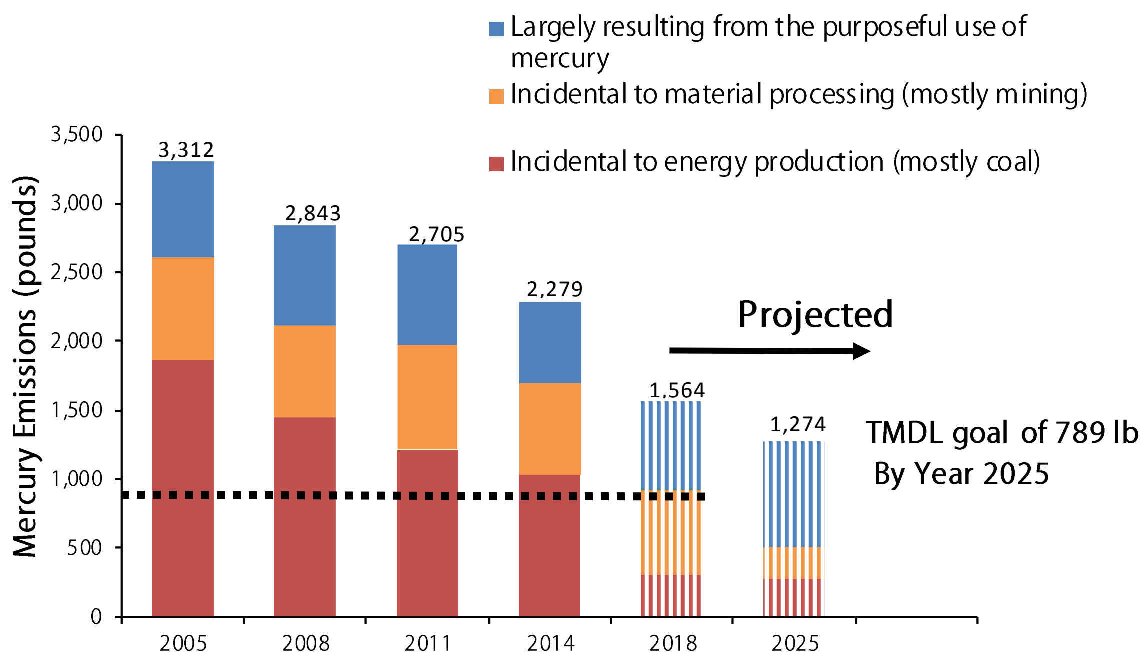
Sector activities and reductions

A number of efforts are in place to reduce mercury emissions. The state's power utilities achieved reductions ahead of schedule achieving the goals of the Minnesota Mercury Emissions Reduction Act of 2006 and the mercury TMDL. The 2016 emissions are draft and currently being analyzed, and therefore not included in this report. It is estimated that electric utilities emitted an approximate 173 pounds of mercury in 2016 and are estimated to represent the smallest of the three source categories. This is a remarkable decrease from 1,867pounds emitted in 2005.

The taconite mining sector continues its research to test possible mercury-reduction technologies and is required to submit reduction plans to the MPCA in December 2018. The plans will describe how the goals of the TMDL will be met by year 2025.

The MPCA continues to work to improve the confidence interval of the mercury emissions inventory through partnerships and research. Research to improve emissions estimates with crematories is complete and a new emission factor developed. Additional work has been identified with industries such as waste haulers, appliance recyclers and other metal smelters.

Figure 9. Mercury emission from Minnesota sources: 2005 through 2014

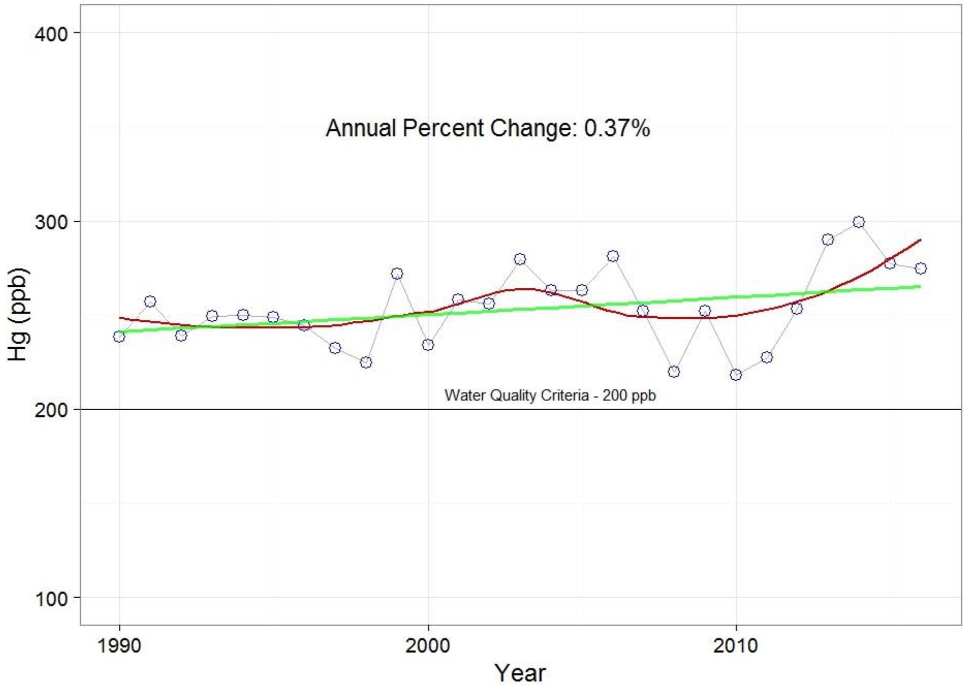


Mercury concentration in Minnesota fish

The trend in fish-mercury concentrations reported in previous versions of this report focused on 1982 to the present. However, a re-examination of the data showed fish collection prior to 1990 was focused on lakes in northern Minnesota, a region where mercury concentrations are generally higher than the state average and that a long-term trend analysis could be biased if the pre-1990 samples were included. As a result, MPCA scientists are now using walleye and northern pike collected since 1990 to examine the change in mercury concentrations in lakes over time.

What progress has been made? The 27-year fish-mercury trend from 1990 to 2016 shown in Figure 10 indicates a different pattern than has been reported in previous years. Data from lakes sampled starting with 1990 as the baseline year show an upward trend in average mercury concentration. The increase, 0.37% per year on average, is significant. Minnesota's water standard for mercury in edible fish tissue – 200 parts per billion (ppb) – is shown for reference on the figure, because it is the threshold above which lakes and streams are impaired. The standard protects humans for consumption of one meal per week of fish caught in Minnesota. MPCA scientists plan to update the fish mercury trend analysis after an additional five years of data are available. More explanation of the mercury trends in fish is available in the 2018 Clean Water Fund Performance Report http://www.legacy.leg.mn.

Figure 10. Trend of mercury in northern pike and walleye from Minnesota lakes: 1990-2016



References/web links

For more information on mercury, see the following websites:

MPCA's mercury emission inventory: https://www.pca.state.mn.us/sites/default/files/wq-iw4-02g5.pdf

MPCA's mercury webpages: https://www.pca.state.mn.us/quick-links/mercury

UN Environment, Global Mercury Partnership: http://web.unep.org/chemicalsandwaste/global-mercury-partnership

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 major goal of the MPCA's water quality program is to enable Minnesotans to protect and improve the state's rivers, lakes, wetlands and groundwater so that they support healthy aquatic communities and designated public uses such as fishing, swimming and drinking water. The key strategies for accomplishing this goal include regulating point source discharges, controlling nonpoint sources of pollution, and assessing water quality to provide data and information to make sound environmental management decisions.

Point sources consist mainly of municipal and industrial wastewater discharges. Point sources have the greatest potential to impact the environment during periods of low precipitation and low stream flow. Nonpoint sources include runoff from agricultural fields, feedlots, urban areas, and on-site sewage treatment (septic) systems. Nonpoint sources are most significant during periods of high precipitation and medium to high stream flow.

Minnesota has been largely successful in controlling end-of-pipe discharges to our state's waters from wastewater treatment plants and industries. However, at the same time, the challenges posed by nonpoint sources of pollution are increasing as land use changes and population expands. The federal Clean Water Act requires states to adopt water quality standards to protect the nation's waters. 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.

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 that fails 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 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 compiled using compliance tracking data systems maintained by MPCA data specialists.

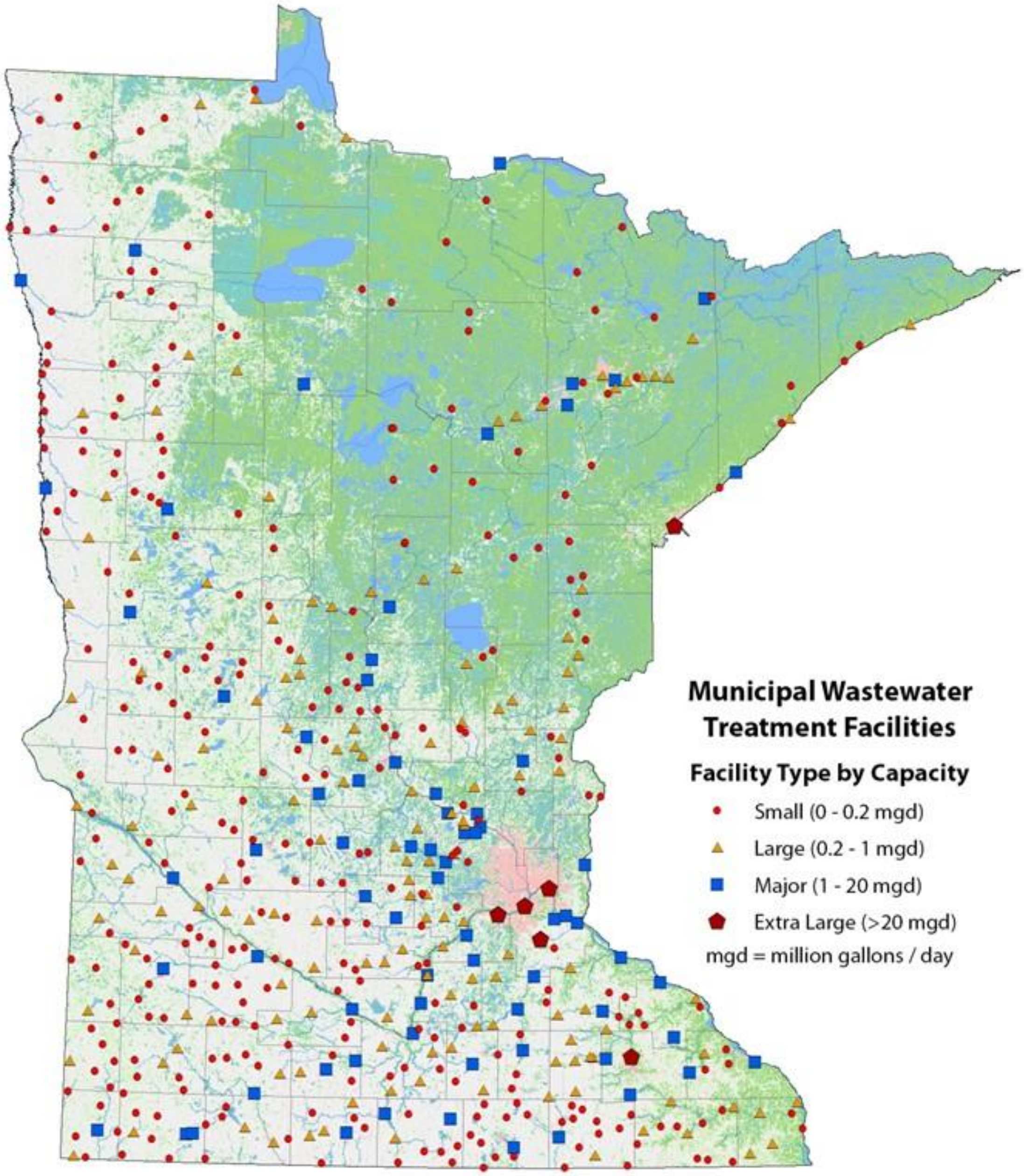
The MPCA's water quality program continues to evolve from a predominantly concentration-based, facility-by-facility regulatory approach to one that emphasizes managing total pollution discharges to Minnesota's watersheds. The current report represents a continuing effort to improve the MPCA's capacity to accurately perform loading analyses. Due to the five-year permit cycle, however, some permits have yet to be modified for select pollutants 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 over multiple years will become more reliable.

Overall pollutant loads to receiving waters are based on a combination of effluent flow and pollutant concentrations in the effluent. Loads are calculated by combining facility-reported flow and concentration data. If facility-specific data are not available, loads are estimated with information based on facilities with similar waste streams or other best professional judgment. Effluent flow and pollutant loading estimates for National Pollution Discharge Elimination System (NPDES) permitted facilities 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 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.

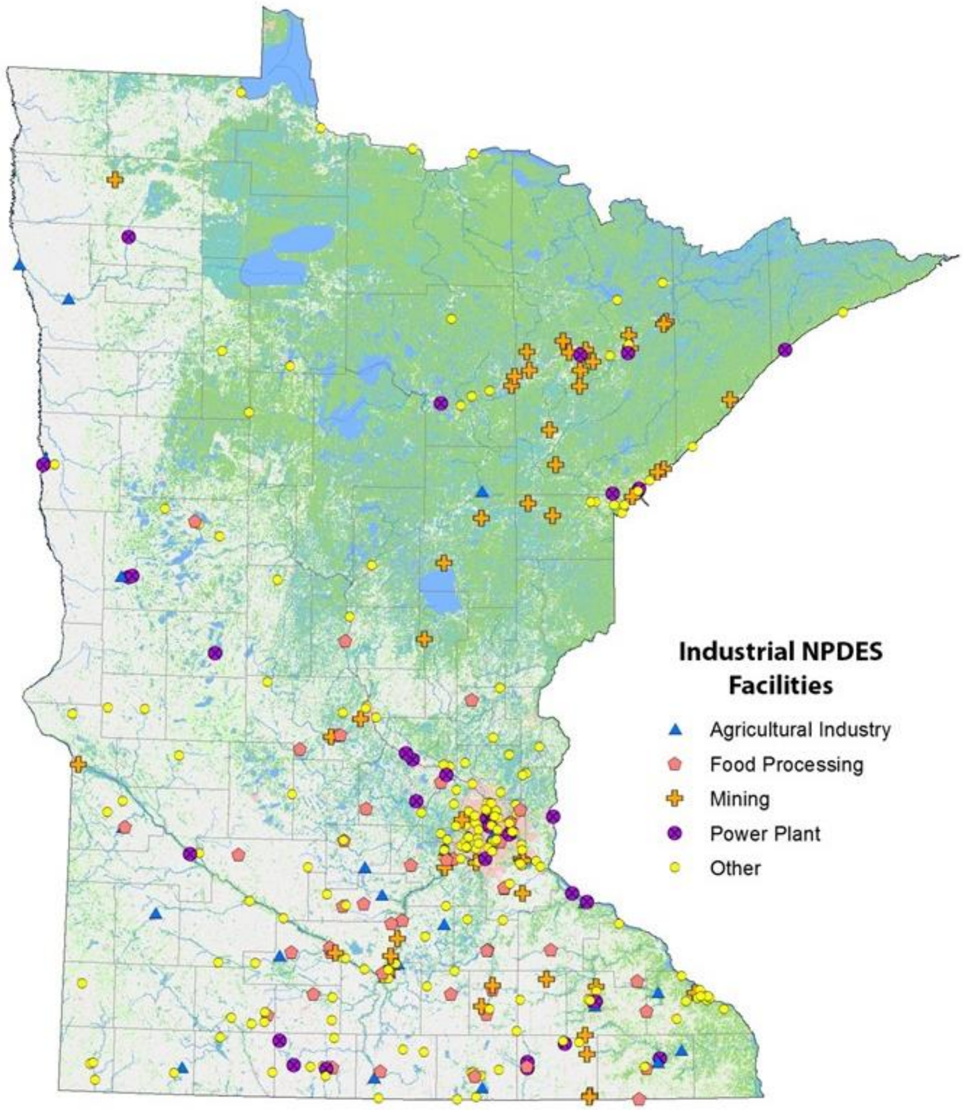
Prior to 2014, the wastewater sections of the MPCA's Pollution Reports to the Legislature were based on data reported by approximately 99 major wastewater dischargers. These are facilities permitted to discharge at least 1 million gallons of treated wastewater per day and account for approximately 85% 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 non-major facilities provides a more complete measure of pollutant loads since non-major facilities can collectively impact water quality. Figure 11 shows the distribution of municipal wastewater facilities by size.

Figure 11. Distribution of municipal wastewater facilities by size



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

Figure 12. Distribution of industrial wastewater dischargers by type



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.

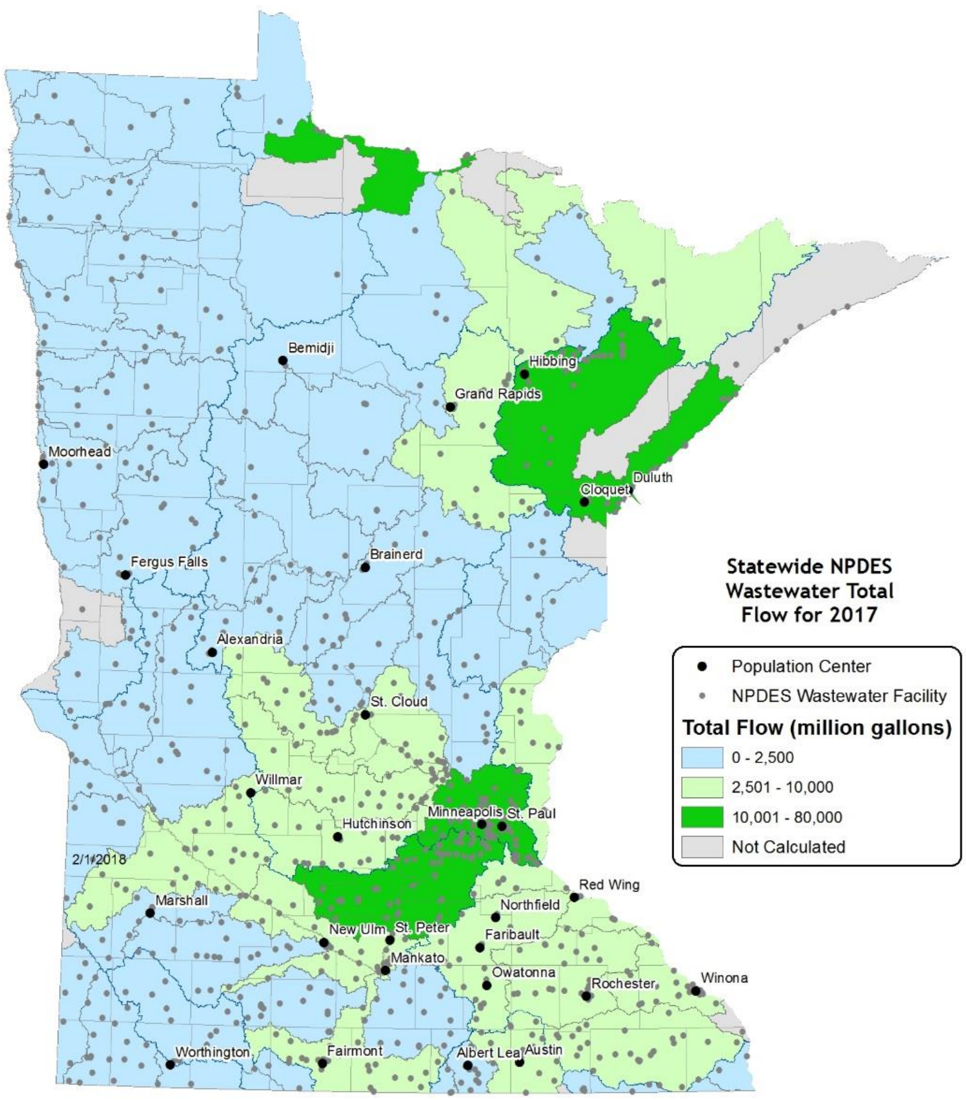
Effluent flow volumes are also included this report. Although flow is not a regulated pollutant, it is a useful gauge of overall facility performance because of the direct relationship between pollutant loading and effluent flow volume. For example, if effluent flow and pollutant loading show proportional 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 summarizes effluent pollutant loading and flow volume estimates for municipal and industrial wastewater treatment facilities in Minnesota from 2000 to 2017.

Flow

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 2013 through 2017 was 283 billion gallons/year. Since the year 2000, major facilities have discharged approximately 78% of the total treated wastewater. Municipal wastewater treatment facilities discharged 64% of the total treated wastewater from 2000 through 2004. Since 2005, the proportion of municipal wastewater flow has declined to 59% of the total. Wastewater flow reductions have occurred since 2011. 2012 was a particularly dry year, which affected the volume of water being processed by municipal wastewater treatment facilities. However, despite increasing precipitation and higher stream flows in subsequent years, changes in wastewater flows remained relatively modest. From 2014 to 2017, surface water discharges reported by the wastewater sector have averaged 286 billion gallons per year, a slight increase from the long-term average.

Figure 13. Minnesota wastewater effluent flow for 2017



Point source pollutant loading trends

Figure 14 shows pollutant effluent flows and loading trends for TSS, $CBOD_5$, total phosphorus and total nitrogen from 2000 – 2017. Mercury trends from wastewater treatment facilities are shown in Figure 22 on page 35. Overall, effluent flows tend to fluctuate based on the amount of rainfall and snow melt. 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. 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.

$CBOD_5$ 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--Significant total phosphorus reductions have been achieved since 2000.

Total nitrogen loads: Increased—Total nitrogen loads have increased from 13,000 metric tons per year in 2000/2001 to 15,000 metric tons per year in 2016/2017. The long-term 2000 -2017 average phosphorus effluent load is 13,700 metric tons per year.

Mercury loads: Decreased—Significant mercury load reductions have been achieved. Mercury loads prior to 2005 are excluded because of changes in the ability to detect mercury in effluent.

Figure 14. Pollutant loading trends from Minnesota wastewater facilities, 2000-2017

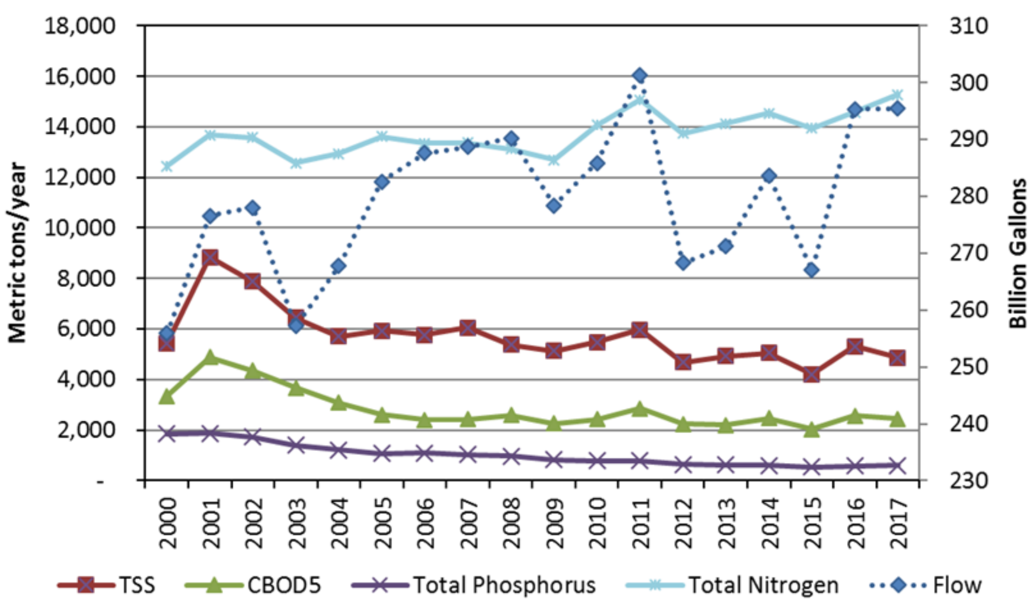


Table 2 shows pollutant effluent flow and loading trends from 2000 through 2017. Effluent flow is reported in billion gallons per year. Pollutant loads for TSS, $CBOD_5$, total phosphorus and total nitrogen are reported in metric tons per year. Pollutant loads for mercury are reported in kilograms per year.

Table 2. Annual total flow and pollutant load

	Flow (MG/year)	TSS (MT/year)	Total phosphorus (MT/year)	$CBOD_5$ (MT/year)[1]	Total nitrogen (MT/year)	Mercury (Kg/year)[2]
2000	258,476	5,429	1,841	3,350	12,457	-
2001	280,737	8,836	1,860	4,893	13,673	-
2002	281,585	7,881	1,733	4,355	13,582	-
2003	260,201	6,430	1,405	3,664	12,572	-
2004	271,917	5,708	1,224	3,087	12,948	-
2005	289,444	5,916	1,080	2,605	13,606	4.2
2006	293,900	5,757	1,089	2,402	13,348	3.9
2007	294,131	6,045	1,027	2,419	13,367	3.2
2008	295,388	5,368	971	2,577	13,132	2.8
2009	283,705	5,136	823	2,259	12,684	2.6
2010	292,249	5,473	794	2,428	14,069	3.0
2011	303,759	5,967	776	2,851	15,067	3.2
2012	269,183	4,673	640	2,232	13,747	2.0
2013	273,402	4,687	619	2,205	14,123	2.3
2014	285,805	5,046	599	2,473	14,541	2.8
2015	267,352	4,195	548	2,031	13,951	2.3
2016	294,670	5,310	584	2,557	14,587	2.2
2017	294,588	4,855	592	2,437	15,279	2.2

[1]Industrial facilities are excluded from $CBOD_5$ 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 2017. 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 remained fairly stable at approximately 5 mg/L. $CBOD_5$ FWMCs have declined from approximately 3 mg/L in the 2000 to 2004 period to approximately 2 mg/L since 2005. Total phosphorus FWMCs have declined from approximately 1.5 mg/L in the 2000 to 2003 time period to approximately 0.5 mg/L in from 2014 to 2017. Total nitrogen FWMCs have increased approximately 1 mg/L. Mercury concentrations declined from approximately 4 ng/L in 2005 to approximately 2 ng/L since 2015.

Table 3. Annual flow-weighted mean concentration

	TSS (mg/L)	$CBOD_5$ (mg/L)	Total phosphorus (mg/L)	Total nitrogen (mg/L)	Mercury (ng/L)
2000	5.55	3.42	1.88	12.73	-
2001	8.32	4.60	1.75	12.87	-
2002	7.39	4.09	1.63	12.74	-
2003	6.53	3.72	1.43	12.77	-
2004	5.55	3.00	1.19	12.58	-
2005	5.40	2.38	0.99	12.42	3.79
2006	5.18	2.16	0.98	12.00	3.53
2007	5.43	2.17	0.92	12.01	2.91
2008	4.80	2.30	0.87	11.75	2.54
2009	4.78	2.10	0.77	11.81	2.43
2010	4.95	2.19	0.72	12.72	2.69
2011	5.19	2.48	0.68	13.10	2.76
2012	4.59	2.19	0.63	13.49	1.94
2013	4.53	2.13	0.60	13.65	2.23
2014	4.66	2.29	0.55	13.44	2.63
2015	4.15	2.01	0.54	13.79	2.31
2016	4.76	2.29	0.52	13.08	1.94
2017	4.35	2.19	0.53	13.70	1.98

Table 4 shows the percent change in annual flow and pollutant loads. 2001 stands out as a year that saw significant increases in the loading of all pollutants, probably as a result of the significant flooding that occurred 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% per year decline in annual $CBOD_5$ loads
- An average 7% per year decline in annual total phosphorus loads
- An average 1% per year increase in annual total nitrogen loads
- An average 4% per year decline in annual mercury

Table 4. Percent change in annual flow and pollutant loads

	Flow (%)	TSS (%)	$CBOD_5$ (%)	Total phosphorus (%)	Total nitrogen (%)	Mercury (%)
2000						
2001	9%	63%	46%	1%	10%	-
2002	0%	-11%	-11%	-7%	-1%	-
2003	-8%	-18%	-16%	-19%	-7%	-
2004	5%	-11%	-16%	-13%	3%	-
2005	6%	4%	-16%	-12%	5%	-
2006	2%	-3%	-8%	1%	-2%	-5%
2007	0%	5%	1%	-6%	0%	-18%
2008	0%	-11%	7%	-5%	-2%	-12%
2009	-4%	-4%	-12%	-15%	-3%	-8%
2010	3%	7%	7%	-4%	11%	14%
2011	4%	9%	17%	-2%	7%	6%
2012	-11%	-22%	-22%	-18%	-9%	-38%
2013	2%	0%	-1%	-3%	3%	17%
2014	5%	8%	12%	-3%	3%	23%
2015	-6%	-17%	-18%	-9%	-4%	-18%
2016	10%	27%	26%	7%	5%	-8%
2017	0%	-9%	-5%	1%	5%	2%

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

- An average 5% increase in effluent flows
- An average 22% decrease in TSS loads
- An average 35% decrease in $CBOD_5$ loads
- An average 51% decrease in total phosphorus loads
- An average 6% increase in total nitrogen loads
- An average 35% reduction in mercury loads (baseline 2005-06 due to change in detection level)

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

	Flow (%)	TSS (%)	Total phosphorus (%)	$CBOD_5$ (%)	Total nitrogen (%)	Mercury* (%)
2000-01 Baseline	269,607 (MG/year)	7,133 (MT/year)	1,851 (Mt/year)	4,122 (MT/year)	13,065 (MT/year)	4.05 (Kg/year)
2002	4%	10%	-6%	6%	4%	-
2003	-3%	-10%	-24%	-11%	-4%	-
2004	1%	-20%	-34%	-25%	-1%	-
2005	7%	17%	-42%	-37%	-4%	-
2006	9%	-19%	-41%	-42%	2%	-
2007	9%	-15%	-45%	-41%	2%	-21%
2008	10%	-25%	-48%	-37%	1%	-31%
2009	5%	-28%	-56%	-45%	-3%	-36%
2010	8%	-23%	-57%	-41%	8%	-26%
2011	13%	-16%	-58%	-31%	15%	-21%
2012	0%	-34%	-65%	-46%	5%	-51%
2013	1%	-34%	-67%	-47%	8%	-43%
2014	6%	-29%	-68%	-40%	11%	-31%
2015	-1%	-41%	-70%	-51%	7%	-43%
2016	9%	-26%	-68%	-38%	12%	-46%
2017	9%	-32%	-68%	-41%	17%	-46%

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

A number of additional sources of variation, both up and down, can potentially impact year-to-year 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 (TSS)

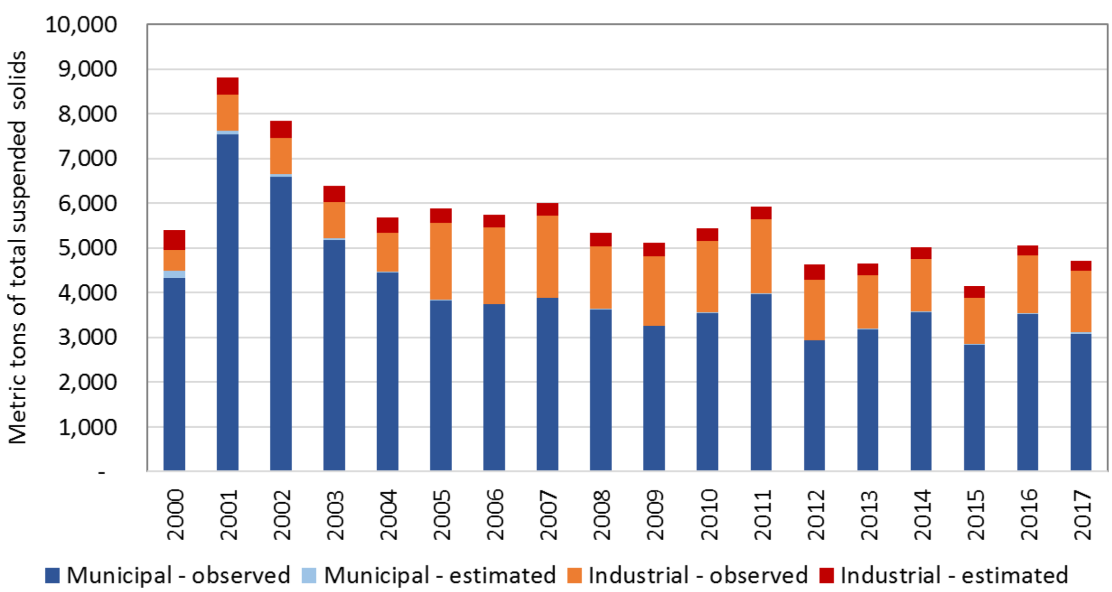
Total suspended solids (TSS) is a measure of the material suspended in water or wastewater. TSS causes interference with light penetration, buildup of sediment, potential degradation of aquatic habitat and harm to aquatic life. Suspended solids also carry nutrients that cause algal blooms that are harmful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

The TSS load for 2017 was 4,855 metric tons, a 2% increase from the 2015-16 average. Long-term average TSS wastewater loading has remained relatively stable over the past decade. On average, the data show an overall 32% reduction in annual TSS loads from a 7,133 metric ton per year baseline in 2000/2001 (Figure 15).

Wastewater TSS data are considered reliable, with 95% of loads resulting from observed data points. On average, 72% of wastewater TSS loads are discharged by major facilities although this proportion has declined from an average of 78% from 2000 through 2003 to an average of 70% from 2004 through 2017. On average, municipal wastewater dischargers accounted for 84% of wastewater TSS loads from 2000 through 2003 while their proportion of wastewater TSS loading declined to an average of 68% from 2004 through 2017. Overall, wastewater TSS loads have declined from an average of 7,144 metric tons per year in the 2000 through 2003 period to an average of 5,160 metric tons per year from 2007 through 2017.

TSS is one of the most frequently monitored pollutants in wastewater. Most facilities have technology-based effluent limits, which, in most cases, are more restrictive than limits needed to meet TSS water quality standards. As a result, most facilities are discharging below a concentration level of concern 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 attached to suspended solids.

Figure 15. Annual wastewater loading values for total suspended solids (TSS)



Carbonaceous biochemical oxygen demand ($CBOD_5$)

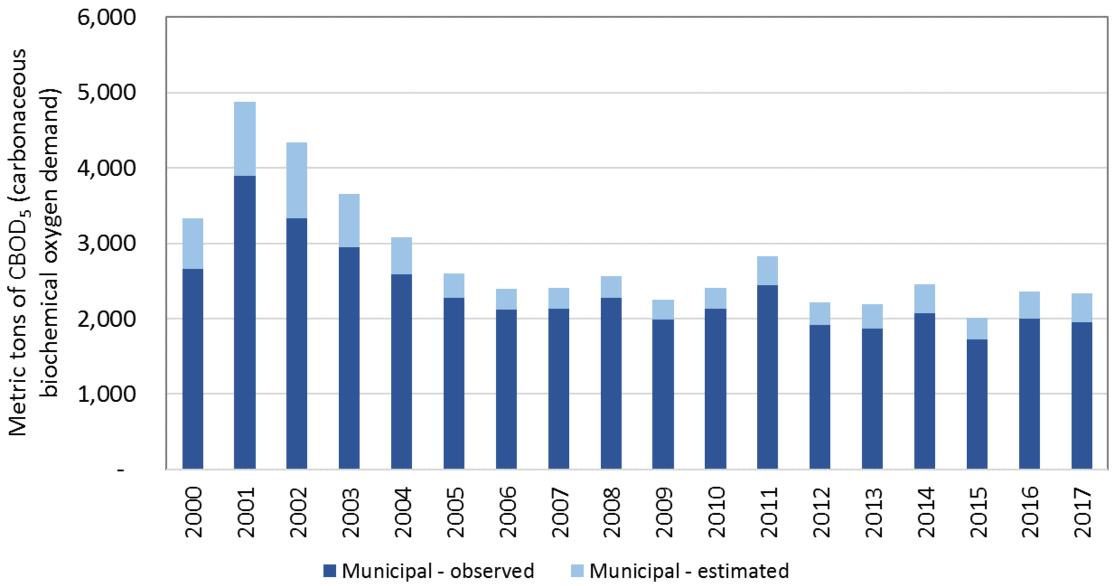
When organic wastes are introduced into water, they require oxygen to break down. The amount of oxygen required for decomposition of organic wastes by microorganisms is known as the biochemical oxygen demand (BOD), while carbonaceous biochemical oxygen demand ($CBOD_5$) is the amount of oxygen required for microorganisms to decompose carbonaceous waste materials. High concentrations of organic materials characterize untreated domestic wastes and many industrial wastes. Both BOD and $CBOD_5$ are indicators of the strength of wastewater effluent and the effectiveness of treatment. A high demand for oxygen causes reduction in the concentration of oxygen in the receiving waters. Depletion of oxygen adversely impacts aquatic life.

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 wastewater $CBOD_5$ load for 2017 was 2,437 metric tons, a 6% increase from the 2015-2016 average. On average, the data show an overall 41% reduction in annual $CBOD_5$ loads from a 4,122 metric ton per year baseline in 2000/2001 (Figure 16).

Municipal wastewater $CBOD_5$ data are reliable, with 84% of values resulting from observed data points. On average, 85% 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 2000-2003 to an average of 83% from 2004-2017. Overall, wastewater $CBOD_5$ loads have declined from an average of 4,066 metric tons per year in the 2000-2003 period to an average of 2,406 metric tons per year from 2007-2017.

Figure 16. Annual loading values for municipal wastewater carbonaceous biochemical oxygen demand ($CBOD_5$)



Minnesota Nutrient Reduction Strategy (phosphorus and nitrogen)

Minnesota's 2014 Nutrient Reduction Strategy identifies relative nutrient (phosphorus and nitrogen) source contributions to surface waters. The strategy also establishes nutrient reduction goals for both point and nonpoint 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. Wastewater nitrogen reductions specified for the Mississippi and Lake Winnipeg drainages have not yet been achieved. The International Red River Board intends to adopt nutrient objectives for the Red River in 2018.

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% reduction goal	Work on remaining reduction needs to meet water quality standards
	Nitrogen	Achieve 20% reduction from baseline	Achieve 45% reduction from baseline
Lake Winnipeg [a] (Red River only)	Phosphorus	Achieve 10% reduction goal	Achieve any additional needed reductions identified through international joint efforts with Canada and in-state water quality standards
	Nitrogen	Achieve 13% reduction goal	
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

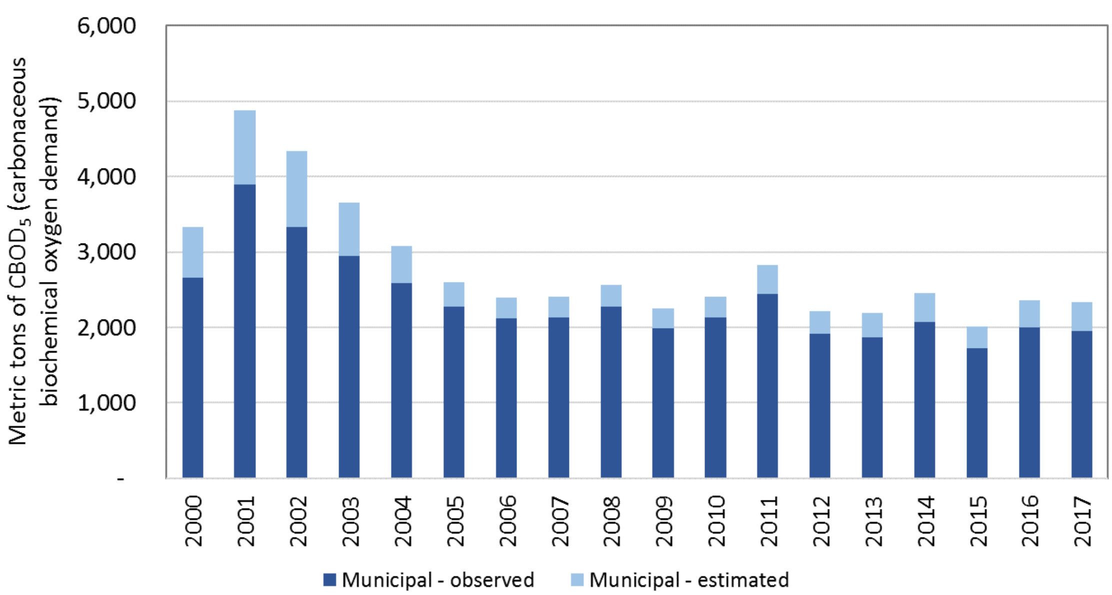
Total phosphorus is the primary pollutant associated with increased algae growth in Minnesota's lakes and streams. Excess phosphorus from human activities causes algae blooms and reduced water transparency, making water unsuitable for swimming and other activities. Phosphorus is released from both point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

Controlling phosphorus is an important part of protecting Minnesota's water resources. Minnesota has had point source effluent limitations for phosphorus since the early 1970s. Considerable reductions in phosphorus from wastewater treatment facilities have been achieved since the MPCA Citizens Board adopted a strategy for addressing phosphorus in NPDES permits in 2000. Phosphorus loads were reduced by 56% from 2000-2009 and have decreased a further 28% since 2009. Overall, these efforts have resulted in a steady decline of phosphorus pollution from point sources (Figure 17).

The 2017 total phosphorus load for the state was 592 metric tons, which increased 5% from the 2015-2016 average of 569 metric tons. A 68% reduction in total phosphorus loads has been accomplished from a 1,851 metric ton per year baseline in 2000/2001.

On average, 82% of wastewater total phosphorus loads are discharged by major facilities although the proportion discharged by major facilities has declined from an average of 87% from 2000-2003 to an average of 79% from 2004-2017. Municipal wastewater dischargers accounted for 91% of total phosphorus loads from 2000 through 2003 with their proportion of the loading declining to an average of 85% from 2004-2017. Overall, wastewater total phosphorus loads have declined from an average of 1,710 metric tons per year in the 2000-2003 period to an average of 1,078 metric tons per year from 2004-2008 and further to an average load of 644 metric tons per year from 2010-2017.

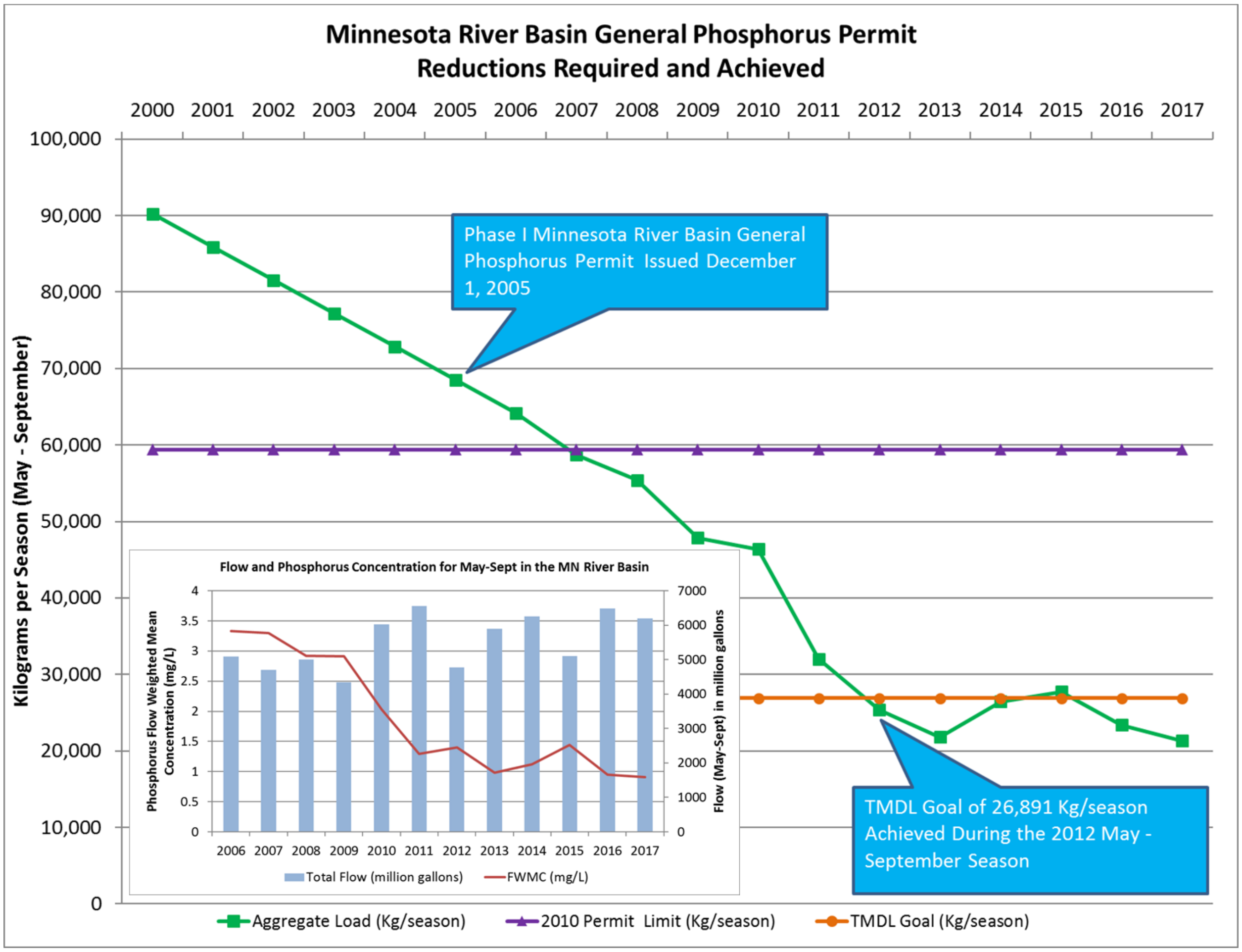
Figure 17. Annual total phosphorus loads from wastewater treatment facilities



Minnesota River Basin phosphorus reductions

Reductions in phosphorus loading to the Minnesota River have also occurred as a result of 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, which 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 apply for coverage and receive a five-month (May-September) mass phosphorus limit. The permit required incremental reductions over time. The TMDL's phosphorus reduction goal was met by 2012 (see graphic below).

Figure 18. Minnesota River Basin General Phosphorus Permit reductions required and achieved

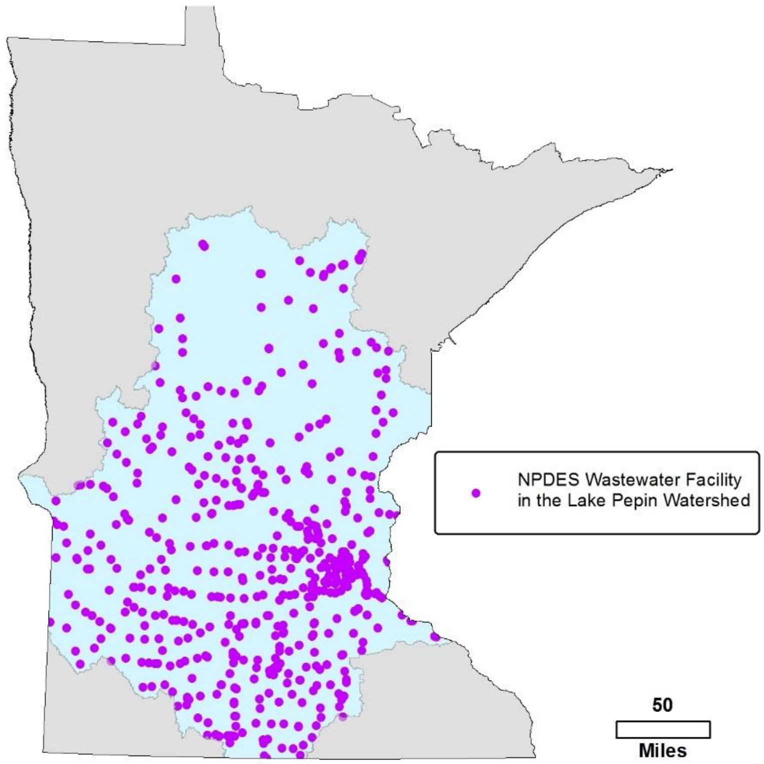


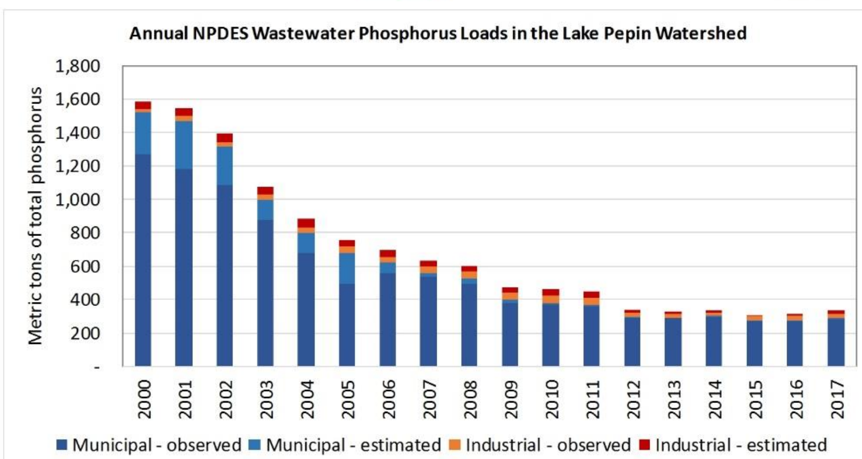
Lake Pepin phosphorus watershed reductions

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 and, although a TMDL has not yet been completed, effluent phosphorus limits designed to address the impairment have been incorporated into permits since 2010.

Phosphorus loads entering the lake have been greatly reduced since the adoption of lake eutrophication standards in 2008. 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 is in the process of implementing permit limits to ensure that the load will remain consistent with watershed goals in the future.

Figure 19. Wastewater facilities within the Lake Pepin Watershed





River eutrophication rule and phosphorus discharge limits

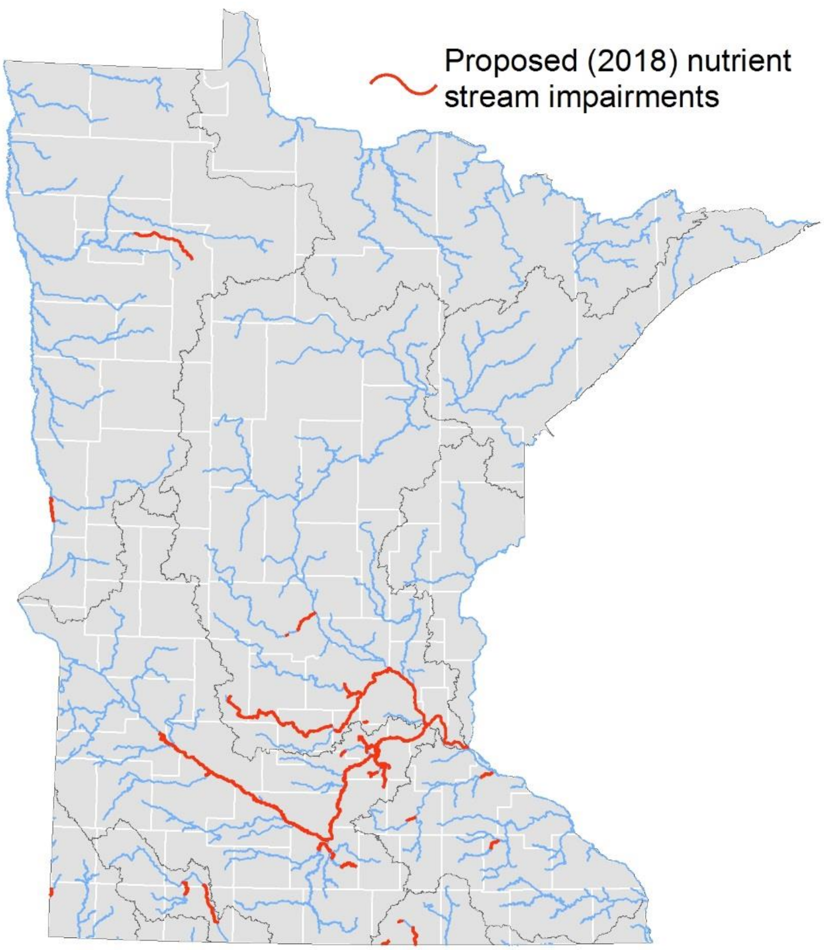
Minnesota's river eutrophication standards (RES) were adopted in 2014 to protect aquatic life from the negative impacts of excess algae in rivers and streams. RES are applicable in conjunction with lake eutrophication standards, which were approved in 2008.

In addition to effluent phosphorus limits required for new or expanding discharges and for facilities whose discharges affect lakes, limits are increasingly being established to meet specific water quality targets in rivers and streams. Facilities discharging upstream of a waterbody that exceeds river eutrophication standards have greater potential to receive a more restrictive limit upon reissuance. 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. This regional multi-facility approach for phosphorus limits is also consistent with MPCA's watershed approach for monitoring, assessment, protection and restoration.

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

The majority of nutrient-impaired streams are in the southern part of the state. There are 50 impaired reaches totaling 769 miles in length. All streams with nutrient impairments are shown on the map below, and are also listed on the proposed 2018 nutrient stream impairment list.

Figure 20. Streams with nutrient impairments on the 2018 proposed impairment list



Total nitrogen

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

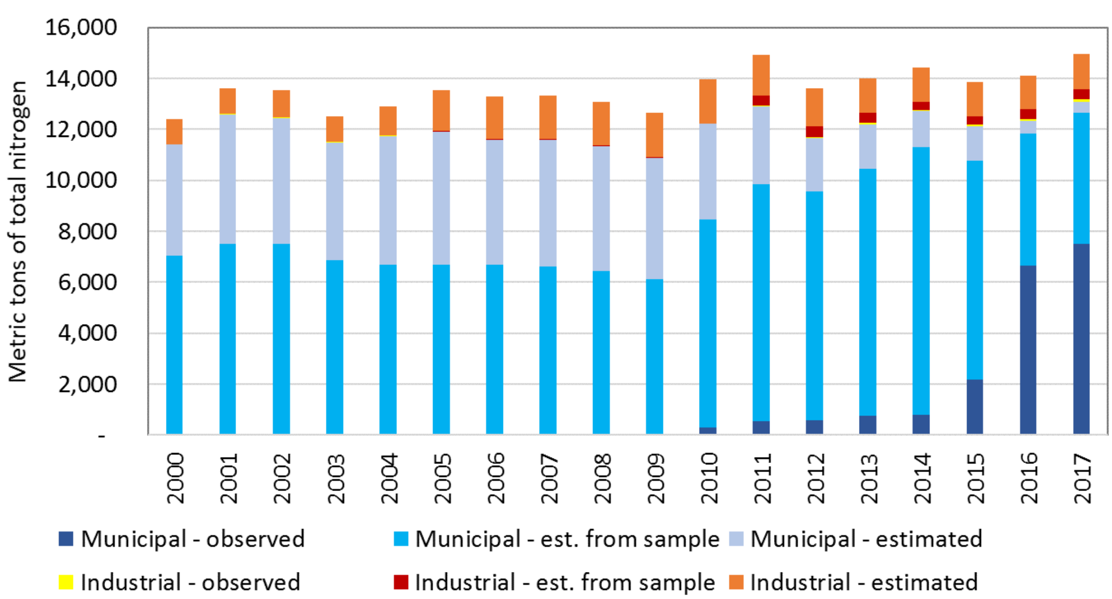
Minnesota's Nutrient Reduction Strategy defines a total nitrogen load reduction goal of 20% from discharges to the Mississippi River and 13% from discharges to the Red River by 2025. As a first step in reaching this goal, additional monitoring for the necessary nitrogen parameters will be added to permits so that a more accurate calculation of the total nitrogen loading from point source discharges can be established. Once total nitrogen loadings can be accurately defined, initial total nitrogen reductions efforts will be made through source reduction work.

The 2017 wastewater load for total nitrogen was 15,279 metric tons, a 7% increase from the 2015-2016 average.

Total nitrogen wastewater data are moderately reliable, with only 63% of loads resulting from observed data points. On average, 91% of wastewater total nitrogen loads are estimated to be discharged by major facilities. Municipal wastewater dischargers account for 81% of total nitrogen. 2017 wastewater total nitrogen loads have increased by 17% from the 13,065 metric tons per year from the 2000/2001 baseline load (Figure 21).

Total nitrogen concentrations are not currently collected on a widespread basis and the majority of observed loads come from very large municipal facilities. Almost all existing total nitrogen wastewater data are from Metropolitan Council Environmental Services facilities. Increased monitoring by smaller facilities will provide a more accurate calculation of nitrogen loads in the future.

Figure 21. Total nitrogen loads from wastewater treatment facilities by year



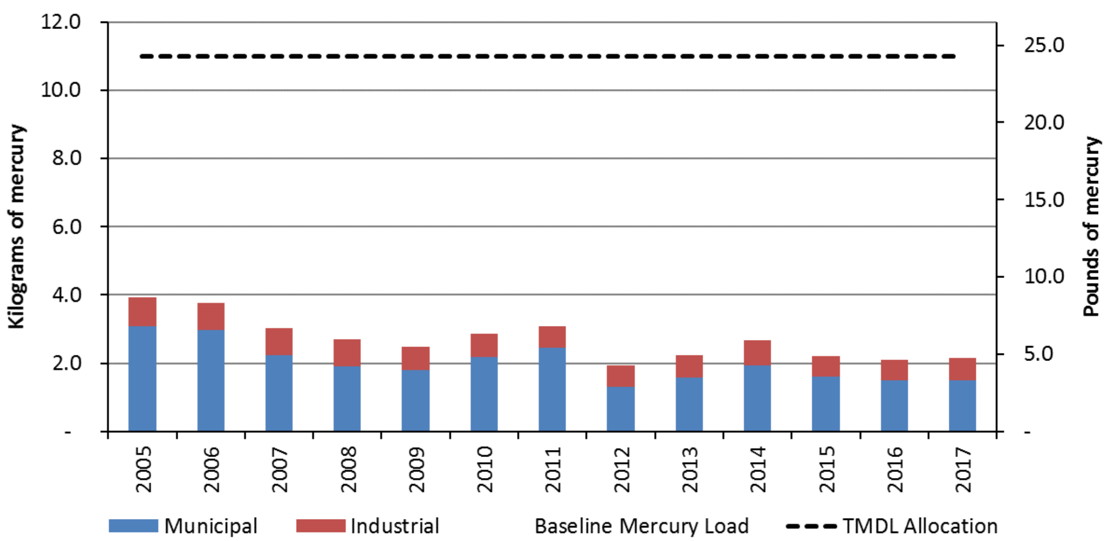
Total mercury

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 2017 was 2.2 kilograms, a 2% increase from the 2015-16 average of 2.3 kilograms. 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 46% reduction in mercury loads from a 4.05 kilogram 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 beginning around 2003. Low-level mercury data reported since 2005 is considered to be more reliable.

On average, major wastewater dischargers have accounted for 65% of total mercury loads since 2005. Municipal wastewater dischargers are estimated to account for 70% since 2005. Overall, wastewater total mercury loads are estimated to have declined from 4.2 kilograms per year in 2005 to 2.2 kilograms per year in 2017. In pounds, this translates to about 5 pounds of mercury per year, compared to about 1,500 pounds per year of air emissions.

Figure 22. Total wastewater mercury loads by year



Nonpoint source pollution

Minnesota has made significant progress in cleaning up point sources of water pollution as measured by discharges of pollutants in municipal and industrial wastewater. It is the nonpoint sources of pollutants--natural and human-made pollutants carried by rain or snowmelt into lakes, rivers, wetland and groundwater that now pose the greater challenge and opportunity for prevention and cleanup. Both point and nonpoint sources of pollution must be controlled to achieve goals set in federal and state law for protecting human health and the environment.

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 work to control unregulated nonpoint sources of pollution thus far has used financial incentives to encourage voluntary adoption of best management practices. The section below briefly outlines recent projects funded by the Clean Water Land and Legacy Amendment and estimates associated pollutant reductions. Also highlighted is a new 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

The Minnesota Legislature appropriated $228.3 million for Fiscal Years 2016-2017 and $201.4 million for Fiscal Years 2018-2019 to the Clean Water Fund. Project funds are used for water-quality monitoring and assessment, watershed restoration and protection strategies and drinking water protection activities.

Minnesota agencies released the most recent Clean Water Fund Performance report in February 2018 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 the report and more information on the Clean Water Fund, 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 new statewide voluntary program designed to expedite the on-farm adoption of agricultural best management practices that protect water quality. The program is a state and federal partnership. In total, this program has certified over 300,000 acres on 500 farms across Minnesota, adding 900 new conservation practices to the landscape in approximately two years of statewide operation. Farmers and landowners who implement and maintain approved farm management practices are certified and in turn obtain regulatory certainty for a 10-year period. Regulatory certainty means certified producers are deemed to be in compliance with any new water quality rules or laws during the period of certification. 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:

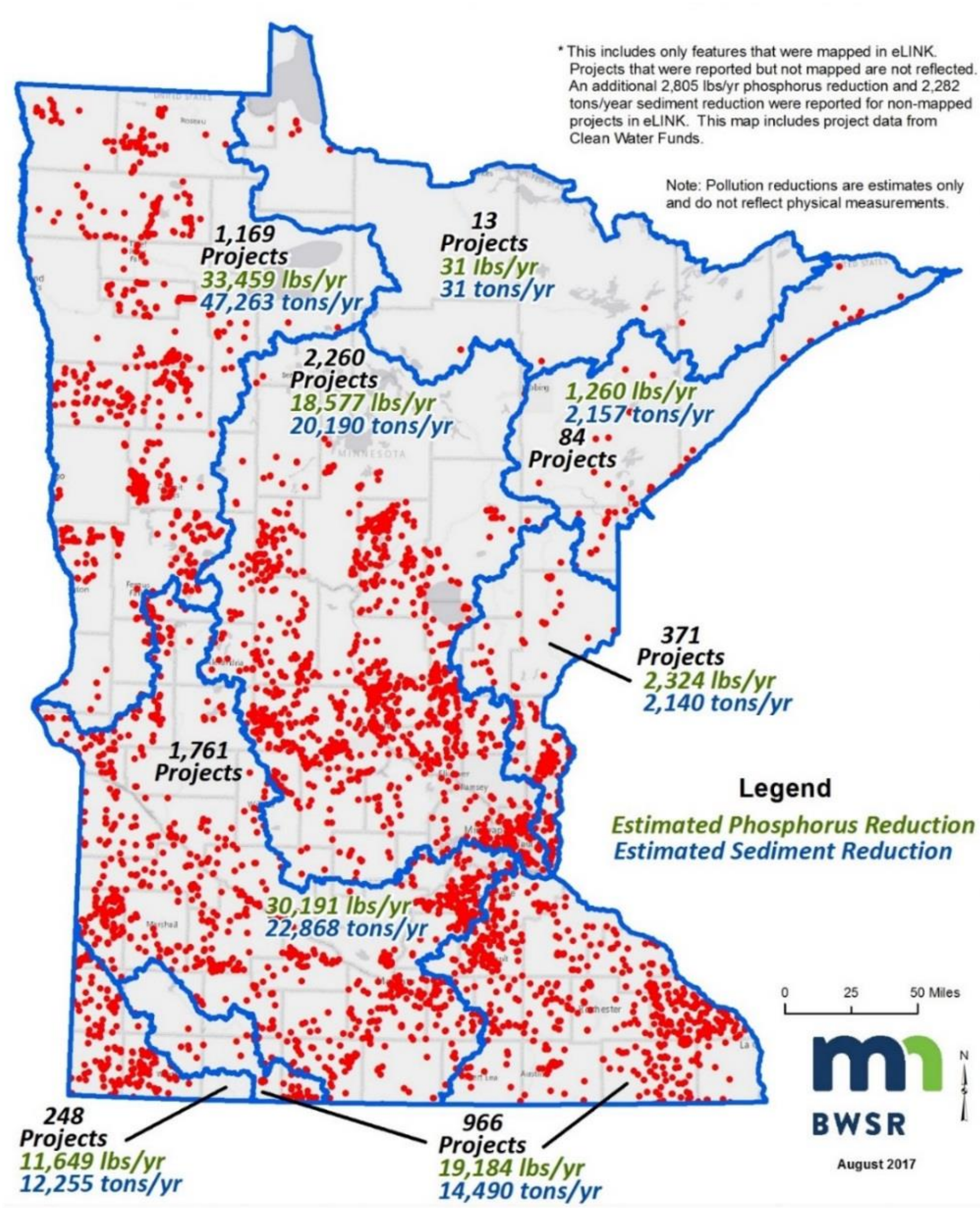
http://www.mda.state.mn.us/protecting/waterprotection/awqcprogram.aspx.

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.

BWSR tracks the number of nonpoint source best management practices (BMPs) implemented with Clean Water funding and the estimated pollutant load reductions associated with these practices. There is currently no completely reliable way to quantify the volumes of pollutants released by runoff from nonpoint sources such as city streets, construction sites and farm fields. However, local watershed managers reporting to statewide data management systems have enabled better estimates of pollutant loads from nonpoint sources. With funding from the Clean Water Land and Legacy Amendment, 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 Clean Water Fund projects and the estimated phosphorus and sediment reductions associated with them. In total, more than 6,872 best management conservation practices have been installed, resulting in a reduction of about 116,675 pounds of phosphorus and 121,394 tons of sediment across the state from 2010-2017. While these reductions do not represent all of best management practices implemented on the land in Minnesota, they demonstrate the improvements resulting from Clean Water Fund 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 23. Clean Water Fund projects and estimated pollution reductions by major basin, 2010-2017



Progress in watershed monitoring and assessment

Clean Water Fund investment is enhancing monitoring of Minnesota's waters and our understanding of the relative contributions of pollutants from various sources and waters.

State and local partners began intensive sampling and assessment of lakes and streams in all the major watersheds in a 10-year cycle, which began in 2008. To date, 93% of major watersheds are completely monitored and the six final watersheds began monitoring in 2017.

Clean Water Fund investment is improving our understanding of the relative contributions of pollutants from various sources and waters. One example is the Minnesota Watershed Pollutant Load Monitoring

Network, which was designed to measure and compare pollutant load information from Minnesota's rivers and streams and track 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

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, these efforts are demonstrating the extent to which these 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. Concern is growing over the potential health effects of these chemicals for humans and the environment. The work summarized here is often accomplished through collaboration with the USGS, MDH, the University of Minnesota, St. Cloud State University, and the University of St. Thomas.

Aquatic toxicity profiles

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 begun developing 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.

Lake and river studies

Large-scale monitoring of lakes (2012, 2017) and rivers and streams (2010, 2014) 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 (WWTPs), 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 rivers and streams is planned for 2020.

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) may be present at concentrations of concern in Minnesota fish. 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 treatment of stormwater can reduce contaminant concentrations.

Other special studies

A study of 25 WWTPs in 2009 confirmed that wastewater effluent is a major contributor of pharmaceuticals, alkylphenols, and other chemicals to surface water, highlighting the fact that WWTPs are not designed to remove such chemicals from wastewater. 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. https://www.pca.state.mn.us/water/pollutants-emerging-concern.

PFAS

Poly- and perfluoroalkyl substances (PFAS, also known as PFCs) are manmade chemicals used to manufacture products that are heat- and-stain resistant and repel water. PFAS used in emulsifier and surfactant applications are found in fabric, carpet and food-paper coatings, coatings for smartphone and computer screens, floor polish, waxes, cosmetics and hair care, dental floss, fire-fighting foam, compostable food ware, adhesives, and certain insecticides. PFAS are persistent in the environment and known to bioaccumulate in humans and biota. In general, greater PFAS chain length results in longer half-lives and greater potential toxicity in humans. PFAS have been found in animals and people all over the globe.

In Minnesota, 3M manufactured perfluorooctane sulfonate (PFOS) and perfluorooctanoic acid (PFOA) from approximately 1950 until they were phased out in 2002. During that time, large volumes of PFAS were released into the Mississippi River in effluent from the 3M Cottage Grove wastewater treatment plant. In addition, four sites in Washington County were identified where 3M disposed of PFAS wastes. These are in Oakdale, Woodbury and Cottage Grove, and at the former Washington County Landfill in Lake Elmo, and have resulted in a 100-square-mile plume of PFC-contaminated groundwater.

MPCA investigations also detected PFOS at elevated concentrations in fish taken from Pool 2 of the Mississippi River and downstream, as well as in east metro area lakes. In addition, PFOS has also been found in fish from other metro area lakes, most with no known connection to 3M's manufacturing or waste disposal. Mississippi River Pool 2, which received 3M Cottage Grove effluent during the years of PFOS and PFOA manufacturing, is listed as impaired due to PFOS. Follow-up testing of fish and water has shown an overall decline in Pool 2 PFOS concentrations in fish, with elevated levels remaining in the lowest reach of the pool near the 3M Cottage Grove plant.

See 2012 report on fish, water, sediment, and invertebrate sampling at http://www.pca.state.mn.us/index.php/view-document.html?gid=19516

Although PFOS and PFOA have been phased out, there are an estimated 3,000 – 5,000 other PFASs in production. PFAS can enter the environment during manufacture, distribution, use, and disposal of products. In addition to fish tissue, PFAS have been found:

- In shallow groundwater wells
- In the influent, effluent and biosolids of wastewater treatment plants
- In ambient air
- In blood of bald eagles
- In tree swallows
- In household dust
- In landfill leachate and gas

Several findings of elevated PFOS concentrations have been traced to chrome-platers using PFOS-containing products in plating or for chrome mist suppression.

Most occurrence and toxicity studies have focused on PFOS and PFOA, two PFAS which have been phased out of production. However, many other PFAS continue to be produced and used in high volumes; some of these PFAS can breakdown to PFOS or PFOA, resulting in continued environmental contamination.

In May 2016, the EPA announced the results of a multi-year review of its health-based guidance for drinking water exposure to PFOS and PFOA, and lowered its health benchmark from 300 nanograms per liter (ng/l) to 70 ng/L. In May 2017, the MDH tightened its health-based guidance for PFOS and PFOA even further, down to 27 ng/L and 35 ng/L respectively. More information on health risks is at this link: http://www.health.state.mn.us/divs/eh/hazardous/topics/pfcshealth.html

In addition, emerging evidence indicates widespread environmental contamination by other PFAS. For example, GenX is a new PFAS produced to replace PFOA in nonstick cookware that has shown to be persistent and bioaccumulative. Limited toxicity studies indicate GenX may be linked to pancreas, liver, and testicular cancer. GenX is just one example of a newly discovered PFAS. The environmental presence and potential human health and ecotoxicological effects of emerging PFAS are unknown.

These growing concerns have led an international group of PFAS researchers to propose restrictions on production and use of fluorinated chemicals and promote development of non-fluorinated alternatives. The "Madrid Statement" of 230+ signatory scientists is provided at this link: https://ehp.niehs.nih.gov/wp-content/uploads/123/5/ehp.1509934.alt.pdf

A counterpoint from the FluoroCouncil, an American Chemistry Council affiliate representing fluorochemical manufacturers, can be viewed at: https://fluorocouncil.com/PDFs/The-FluoroCouncil-Counterpoint-to-the-Madrid-Statement.pdf