

2016 Pollution Report to the Legislature

A summary of Minnesota's air emissions and water discharges



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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Foreword

State law requires the Minnesota Pollution Control Agency (MPCA) to estimate the total amounts of air and water pollution emitted in the state during the most recent two calendar years for which data are available. The statute further directs the MPCA to estimate the percentage increase or decrease over the previous two calendar years, and to estimate the relative contributions of the various sources of these emissions and discharges to the environment.

The report, first produced in 1996, has evolved to include new kinds of information, such as discharges of toxic air pollutants, greenhouse gas emissions, and emerging issues of concern as these data have become available. Advantages and limitations of this report are presented below to add context for interested parties.

Advantages of the inventory approach

- § This is the only MPCA report that specifically asks for an accounting of emissions and discharges. Such inventories are inherently important, as understanding emission amounts and sources is fundamental in protecting the environment and human health.
- § The report attempts to track trends year to year, which is valuable if data are reliable.
- § The report covers both air and water pollutants in one document, instead of separate reports, highlighting the potential for cross-media impacts.
- § The report shows relative contributions of various pollution sources to the total.

Challenges of the inventory report approach

- § There is currently no completely reliable way to quantify the volumes of water pollutants released by nonpoint sources in the form of polluted runoff, such as city streets, construction sites and farm fields. This is a major gap in inventorying pollutants discharged. However, local watershed managers reporting to statewide data management systems like eLINK have enabled better estimates of pollutant loads from nonpoint sources. Reasonable estimates of benefits from preventing soil loss and reducing phosphorus from implementation of best management practices (BMPs) may now be made statewide and are discussed in this report. Monitoring approaches such as the MPCA's Watershed Pollutant Load Monitoring Network, which is designed to monitor statewide water quality on a watershed scale, are also aiding understanding of the relative contribution of pollutants from various sources.
- § Aggregating data into total volumes or mass lacks the important context of relative risk. Pollutants emitted in smaller amounts can have a greater impact than some emitted in tremendously larger amounts. Volume or mass figures are not able to indicate whether such emissions and discharges are acceptable or unacceptable from a risk perspective.
- § The most current pollutant emissions and discharge data are usually at least two years behind real time, sometimes more, depending on the type of pollutants. Air emission estimates are frequently revised as industrial output models and factors used to estimate emissions are refined. Also, the number of facilities included varies from year to year. Therefore, year-to-year comparisons are not always reliable.

Outlook

Several important national, regional and state actions affecting water pollutant discharges and air pollutant emissions now are listed below.

§ **Minnesota's statewide buffer initiative:** Minnesota passed legislation in 2015 for a statewide buffer initiative. Fifty-foot buffers will now be mandated along public lakes and rivers, along with smaller strips along ditches. The agencies leading implementation of the state buffer law are Minnesota Department of Agriculture (MDA) and Minnesota Board of Water and Soil Resources (BWSR) with support from the Minnesota Department of Natural Resources (MDNR), and the MPCA.

The Buffer Initiative will protect Minnesota's water resources from erosion and runoff pollution by establishing 110,000 acres of perennial vegetative cover adjacent to Minnesota's waters. This proposal was crafted with input from agriculture groups, environmental groups, local government groups, legislators from both parties, and landowners.

§ **Community listening sessions on water infrastructure needs:** Minnesota communities will need an estimated \$10 billion over the next 20 years for new water infrastructure projects to replace aging wastewater and drinking water systems, upgrade treatment facilities to meet higher standards, and expand systems to accommodate growth. Both rural and metro communities face serious challenges to making these improvements to their infrastructure. To better understand these challenges, state representatives held meetings in Detroit Lakes, Willmar, Worthington, Hibbing, Rochester, Pine City, Golden Valley, and Hastings to find out the specific concerns of more than 80 communities. Commissioners from MPCA and MDH, the executive director of the Public Facilities Authority and a senior policy advisor to Governor Dayton participated in the meetings held in late 2015. Many communities shared the same concerns, which were grouped into four main categories: cost-related problems, work force issues, need for creativity/ flexibility and policy changes.

§ **Agency focus on watershed approach:** The MPCA employs a watershed approach to restoring and protecting Minnesota's rivers, lakes, and wetlands. During the 10-year cycle, the MPCA and its partner organizations work on each of the state's 80 major watersheds to evaluate water conditions, establish priorities and goals for improvement, and take actions designed to restore or protect water quality. When a watershed's 10-year cycle is completed, a new cycle begins. The primary feature of the watershed approach is that it focuses on the watershed's condition as the starting point for water quality assessment, planning, implementation, and measurement of results. This approach may be modified to meet local conditions, based on factors such as watershed size, landscape diversity, and geographic complexity (e.g., Twin Cities metro area).

- **Progress on watershed assessment and monitoring:** Minnesota's watershed approach starts with Intensive Watershed Monitoring (IWM) around the state. The MPCA has now initiated or completed IWM in 69 of the state's 80 major watersheds — that is 86 percent of the state's watersheds. Assessments follow two years of intensive water chemistry and biological community monitoring. Assessments are made for beneficial uses such as drinking water, recreation use, and healthy aquatic biota. Assessments are complete in 49 watersheds or 61 percent of the state's major watersheds.

- **Progress on Watershed Restoration and Protection Strategies (WRAPS):** Based on the watershed assessment, a watershed restoration and protection strategy (WRAPS) is completed. Each WRAPS
 - summarizes scientific studies of the watershed
 - identifies impairments and water bodies in need of protection
 - identifies biotic stressors and sources of pollution (both point and nonpoint)
 - includes development of a Total Maximum Daily Load ([TMDLs](#)) for impairments that determines the sources of pollution and the reductions needed to meet water quality standards
 - includes an implementation table which contains strategies and actions designed to achieve and maintain water quality standards and goals

There are six completed WRAPS studies and work in all but one of the other watersheds is underway with monitoring, watershed modeling, biological stressor work and/or a WRAPS project in progress.

§ **Swimmable, Fishable, Fixable?** A 2015 MPCA report provides evidence that agricultural and urban runoff is contributing significantly to the impairment of Minnesota’s lakes, rivers and streams. [Swimmable, fishable, fixable?](#) is a new study which takes an in-depth look at the lakes and streams in the state’s major drainage areas.

§ **Innovative approaches for achieving municipal permit requirements cost effectively:** A recent MPCA legislative report highlights innovative approaches implemented by the agency and municipalities to develop and achieve permit requirements cost effectively. The report’s purpose is to share information with municipalities about permitting-related activities that have occurred over the past year and that are anticipated for the near future, to:

- Foster awareness of and engagement in MPCA initiatives that may affect municipalities; and
- Promote coordination and dialogue between the MPCA and municipalities on permitting and water quality improvement efforts.

The report is available at: <https://www.pca.state.mn.us/sites/default/files/lrwq-wwprm-lsy16%20.pdf>

§ **River Eutrophication Standards:** Minnesota’s river eutrophication standards (RES) were adopted in August 2014 and approved by the United States Environmental Protection Agency (US EPA) in January 2015 to protect aquatic life from negative impacts of excess suspended algae in rivers and streams. RES complement the agency’s lake eutrophication standards (LES), which were approved in 2008, providing comprehensive protection of aquatic life from the effects of too much algae. More information on RES can be found at: <https://www.pca.state.mn.us/water/phosphorus-wastewater>

§ **Clean Power Plan in Minnesota:** In August 2015, the US EPA finalized the Clean Power Plan, a national rule aimed at reducing carbon dioxide (CO₂) emissions from existing fossil fuel-fired power plants. The rule would result in a 32 percent reduction (from 2005 levels) in CO₂ emissions from existing plants by 2030, and would require states to submit compliance plans to US EPA no later than September 6, 2018. The MPCA has been engaging technical stakeholders, including the regulated utilities, on the Clean Power Plan since its proposal in June 2014, and believes Minnesota is well-positioned to respond to the rule’s requirements. On February 9, 2016, the U.S. Supreme Court issued a stay of the rule, temporarily halting implementation of the rule at the federal level as it is reviewed by the courts. The MPCA has continued its extensive outreach and engagement efforts, however, which included a series of eight community listening sessions around the state in February

and March of 2016, and continued dialogue with technical stakeholders. The MPCA will continue stakeholder engagement and technical analysis of the rule to ensure that Minnesota is well-positioned to respond to any possible outcome when lawsuits on the Clean Power Plan are resolved.

§ **Focus on Small Diverse Air Pollution Sources:** Small, widespread sources of air emissions – like cars, trucks, wood burning and solvent use – are significant contributors to pollution in Minnesota. These types of sources do not have the same oversight as larger facilities with air quality permits such as factories or power plants.

To help address these many small sources that collectively have a big impact, the MPCA is working together with others to reduce emissions through voluntary efforts. The MPCA contracted with Environmental Initiative, a Minnesota non-profit, to facilitate Clean Air Minnesota—a collaborative group of business representatives, government organizations, and nonprofit groups. These members and other partners are identifying, evaluating, and implementing projects to improve air quality, in addition to tracking and reporting emissions from their reduction efforts. Clean Air Minnesota also serves as the stakeholder group for Minnesota’s participation in the U.S. EPA’s voluntary Ozone and PM Advance Programs.

Examples of projects implemented in recent years include providing grants to small businesses to reduce VOC emissions; education and awareness of the impacts of air quality on health; education and outreach to reduce the impacts of recreational wood burning; and installing control equipment on diesel vehicles to reduce their emissions. Collectively the programs resulted in an estimated 297 tons of emissions reductions over the past two years.

Future efforts in the next year include raising awareness of these efforts including continuing grants to small businesses; implementing a wood burning equipment change-out program in Northeast Minnesota to replace older, higher-emitting heating equipment with cleaner, more efficient models; and continuing efforts to reduce emissions from diesel engines.

§ **Silica sand rulemaking:** The MPCA is continuing to work towards crafting rules, as directed by the Legislature, to control particulate matter emissions from silica sand facilities. The MPCA has worked collaboratively with the DNR and EQB to get input from an advisory committee made up of key stakeholders. A revised preliminary draft rule was made available on February 26, 2016 (at <https://www.pca.state.mn.us/sites/default/files/aq-rule4-071.pdf>). This preliminary draft ties regulatory requirements to the amount of silica sand shipped. The rule intends that smaller facilities have requirements that consist mainly of best management practices for dust control, while large facilities must meet more stringent requirements. The rule also envisions requiring certain sources to conduct ambient air monitoring for silica particles. After considering the input and completing our rule development process, the agency hopes to formally propose a rule later in 2016.

§ **Mercury rulemaking:** In September 2014, the MPCA completed rulemaking to reduce mercury emissions from Minnesota facilities. The rules require mercury emission reduction planning and annual emission reporting for sources emitting more than three pounds per year of mercury. The rules also incorporate federal standards and compliance language for electric generating units and incinerators. Minnesota’s mercury emission inventory decreased by about 120 pounds due to improved data, and actual mercury emissions will continue to decrease in the future when the mercury reduction plans required by the rule are finalized and implemented. The MPCA conducted this rulemaking because two-thirds of Minnesota’s lakes and rivers are impaired due to mercury, mostly deposited from the air.

- § **Minnesota Residential Wood Use Survey:** Based largely on recent surveys, the MPCA estimates residential wood combustion accounted for 22% of the estimated fine particle emissions. While survey methods have evolved over time, the MPCA, MDNR and US Forest Service have frequently surveyed people about residential wood harvesting and burning. Most recently, Minnesota households were asked about how much wood they harvested and burned from April 2014 through March 2015 in their wood stoves, fireplace inserts, fireplaces, forced-air furnaces, boilers and backyard fire rings. This survey found substantially more residential wood burning than reported in recent surveys, particularly for heat. Statewide, more wood is burned for heat than for pleasure. In the seven-county metro region, more wood is burned for pleasure (and to dispose of branches in backyard recreational equipment) than for heat. The metro region was estimated to burn more wood per acre than less densely populated regions. A report of the initial survey findings will be made available from MPCA in April 2016.
- § **New federal regulations for residential wood heaters:** In February 2015, the US EPA established federal air pollutant emission standards for the manufacture and sale of previously unregulated new residential wood burning hydronic heaters (boilers) and forced-air furnaces. At the same time, US EPA finalized rules revising the 1989 federal pollutant emission standards for the manufacture and sales of new residential wood stoves and fireplace inserts. Conventional fireplaces and outdoor recreational wood burning equipment are not regulated. All models manufactured, offered for sale and sold must be EPA-certified. This involves testing to demonstrate that emissions limits are met and to give consumers consistently reported efficiency information. The emission standards are phased in with stricter limits effective in 2020. The emission standards will not affect wood heaters already installed in peoples' homes, but as households replace their existing wood heaters with better performing heaters, they may need less wood to heat and wood smoke emissions, per cord of wood burned, should be lower.

Introduction and Summary

The Minnesota Pollution Control Agency (MPCA) is required to submit a report to the Legislature of the volume of pollution emitted or discharged to the state's air and water resources every two years. The basis of the MPCA's 2016 Pollution Report is the 2012 MPCA Greenhouse Gas Inventory, the 2011 and 2014 Minnesota Criteria Pollutant Emission Inventories, the 2011 Air Toxics Emission Inventory, the 2000-2015 Water Quality National Pollutant Discharge Elimination System (NPDES) Discharge Monitoring Reports and Board of Water and Soil Resources eLINK database.

Annual emission and discharge estimates are one important component of tracking progress on air and water pollution, and for tracking performance and relative contributions of pollution sources. The MPCA also regularly prepares reports on the physical, chemical and biological conditions measured in the environment, and on pollutants of special concern to human health and the environment. These reports and others are available on the Internet and are referenced throughout this document for readers who would like additional context and information.

The MPCA provides public access to ambient water quality monitoring data, surface water discharge monitoring data, and air emissions data. These data are available for viewing and downloading at the MPCA's Environmental Data Access web page.

<http://www.pca.state.mn.us/eda>

Air Emissions

In this report, the MPCA reports on emissions of major air pollutants including criteria air pollutants (pollutants with national ambient air quality standards), greenhouse gases and air toxics.

The MPCA reports data from the Minnesota Criteria Pollutant Emission Inventory. The major air pollutants summarized in this report include particulate matter, ammonia (NH₃), sulfur dioxide (SO₂), nitrogen oxides (NO_x), volatile organic compounds (VOCs), carbon monoxide (CO) and lead (Pb). Emissions of criteria pollutants from large facilities are estimated every year with data from 2014 currently available. However, emissions from smaller sources are estimated every three years with 2011 estimates the most recent available.

There are a few changes to the 2011 statewide emission inventory from past reported inventories. For one, EPA estimated onroad emissions using a new version of the Motor Vehicles Emissions Simulator (MOVES) model. MOVES is an emission model for mobile sources that estimates emissions at the county and state level for criteria air pollutants, greenhouse gasses, and air toxics. In addition, biogenic (natural) emissions have been separated into a unique category in 2011 and are no longer part of the nonpoint category.

About Air Emission Inventories

Minnesota state rules and statutes require that MPCA along with other state agencies meet the highest levels of transparency and accountability. MPCA Emission Inventory staff frequently receives emission inventory questions and data requests. The requests come from all levels of government, industry and the general public.

In an attempt to respond to questions more rapidly and consistently, the MPCA Emission inventory staff is creating interactive workbooks that contain air quality data. Some advantages of using workbooks include quick data updates, a faster response rate to questions and better data insight.

Air emission inventory data will be made available on the state, county and facility level for multiple years and pollutants. Users will have hands-on access to emissions data and the ability to manipulate charts and graphs. MPCA Emission Inventory staff hopes to have the workbooks available in the spring of 2016 at the following website:

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

Emissions for six greenhouse gases (CO₂, nitrous oxide, methane, hydrofluorocarbons, perfluorocarbons and sulfur hexafluoride) are reported in terms of CO₂ equivalents (CO₂e). The most recent statewide emissions inventory completed for greenhouse gases in Minnesota is from 2012.

The Minnesota Air Toxics Emission Inventory estimates emissions of individual air toxics including compounds such as benzene, formaldehyde, acrolein, mercury and polycyclic organic matter. There is some overlap between the Minnesota Air Toxics Emission Inventory and the estimates for VOCs and particulate matter in the Minnesota Criteria Pollutant Emissions Inventory because many air toxics are components of these broader categories. The most recent inventory of air toxics emissions is from 2011.

Table 1 provides estimated total statewide emissions of the major air pollutants from 2010 to 2014. The percent change from 2012 to 2013, and 2013 to 2014 is provided in the final two columns. 2011 emissions are from all sources including mobile, nonpoint, fire, biogenic and point sources. Subsequent yearly emissions changes are due entirely to point sources. Mobile, nonpoint, biogenic and fire emissions estimates were held constant. It is therefore important not to place undue emphasis on yearly changes. Emissions also fluctuate as a result of changes and improvements in the inventory and other factors such as the economy and weather.

Table 1: Minnesota Air Pollution Emission Estimates, 2010-2014 (Thousand Tons)

Pollutant	2010	2011	2012	2013	2014	2012-2013 % change	2013-2014 % change
Greenhouse gases**	160,500	158,800	154,500			-1.1	-2.7
Particulate matter (PM ₁₀)***	500	501	496	496	497	-0.14	0.23
Sulfur dioxide (SO ₂)	77	71	56	55	57	-2.63	3.39
Nitrogen oxides (NOx)	350	345	338	338	342	-0.13	1.16
Volatile organic compounds (VOCs)	1,075	1,074	1,073	1,073	1,074	0.01	0.02
Carbon monoxide (CO)	2,192	2,193	2,192	2,192	2,193	0.01	0.01
Particulate matter (PM _{2.5})***		200	200	200	201	-0.21	0.66
Ammonia (NH ₃)		210	209	209	210	-0.06	0.47
Total Criteria**** Pollutants (not including CO ₂)	4,193	4,184	4,157	4,154	4,161	-0.05	0.17

*2011 mobile, nonpoint fire and biogenic emission estimates were used in the 2010-2014 emission estimates. The only changes are from point sources.

**Greenhouse gas emission estimates include net imported electricity. Data are not available for 2013 or 2014, so percent change is for 2010 and 2011. Greenhouse gas emissions are reported as CO₂ equivalents.

***PM₁₀ and PM_{2.5} emissions represent only direct emissions; secondary formation is not included.

**** Does not include PM_{2.5} and NH₃ in the 2011 - 2014 totals.

Most of the criteria pollutant emission estimates from point sources decreased slightly between 2012 and 2013, while they increased slightly between 2013 and 2014. Starting in 2012, MPCA started calculating PM_{2.5} and NH₃ emissions annually for all permitted point sources. These pollutants are included in the table above. Continued economic growth and an increase in manufacturing contributed to a slight increase in overall emissions in 2014. Xcel Energy's Sherburne Generating Plant power boiler re-started operations during the 2013 calendar year which also contributed to increase in emissions.

In 2014, SO₂ and NO_x emissions increased due in part to Sherburne Generating Plant coming back on line in 2013. For the 2011 estimate of mobile onroad sources, EPA relied on the new MOVES model. 2011 onroad emission estimates are lower than in 2008. EPA updated methodology including the use of new and additional source classification codes (SCCs). Final emissions were also aggregated differently than in previous years.

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.

Despite the importance of the secondary formation in creating particulate matter and some other pollutants, estimated air emissions data in this report are only based on direct releases from sources into the atmosphere. Secondary formation occurs when emissions of volatile gases break down or combine and form fine particles and other pollutants downwind of the emission source. There is currently no reliable methodology for quantifying secondary formation.

Lead, mercury and other air toxics are pollutants that can be toxic at very low concentrations. In 2014, 19 tons of lead and an estimated 2,304 pounds of mercury were estimated to have been emitted in Minnesota.

Water Discharges

Owners or operators of any disposal system or point source are required by Minnesota Statutes, Chapter 115.03(7) 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 2016 Annual Pollution Report examines the 2000 to 2015 period for which DMR data are available.

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, 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 over multiple years will become more reliable.

This year's report contains surface water discharge data from municipal and industrial wastewater point sources for flow and five measures of water pollution covering the years 2000-2015. Summaries of pollutant loads discharged by 945 facilities including 581 domestic wastewater and 364 industrial facilities are included.

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 waste stream and facility type characteristics. 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. 2015 effluent flow and pollutant loading estimates for NPDES permitted facilities exclude once through non-contact cooling water data from power generation facilities. Extremely large volumes of (primarily) river water are used by the power industry for cooling purposes. These once through non-contact cooling waters are discharged with the addition of heat, but 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 as “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 per day and account for approximately 85 percent of the volume of 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.

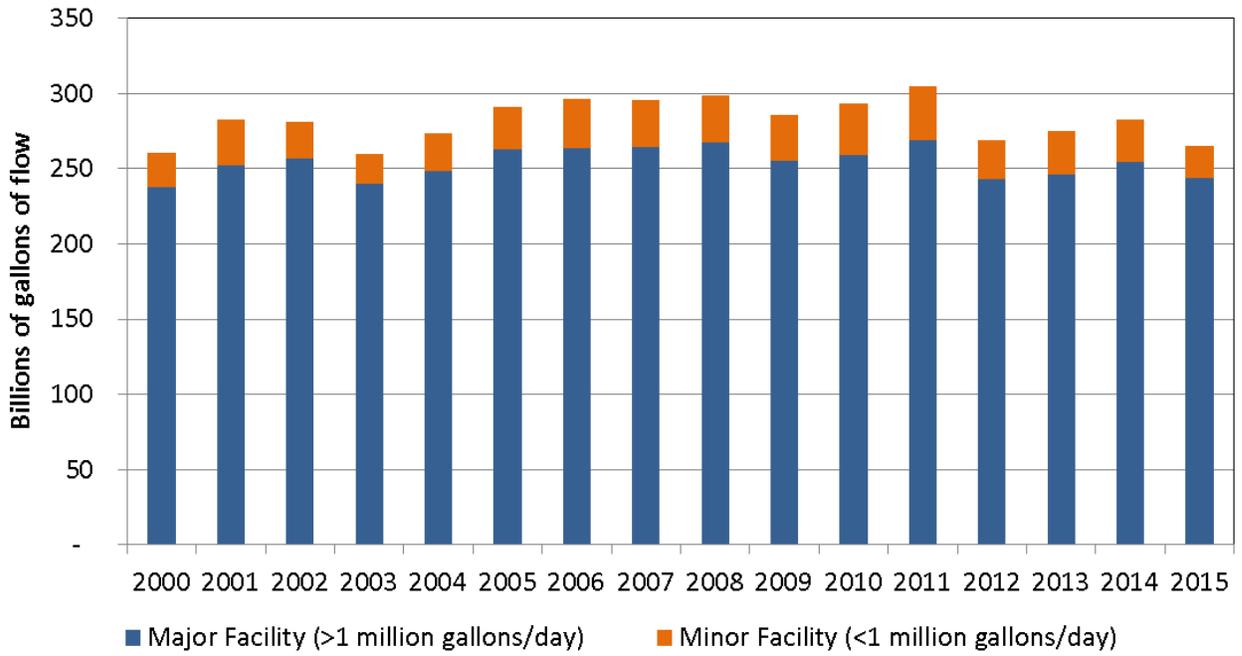
Five common chemical parameters found in wastewater treatment plant effluent are highlighted in this report, including: total suspended solids (TSS), biochemical oxygen demand (BOD), total phosphorus (TP), total nitrogen (TN) and mercury (Hg). Table 2 summarizes effluent pollutant loading estimates from NPDES point sources for 2010-2015 by pollutant. The annual percent change is shown in parentheses.

Flow

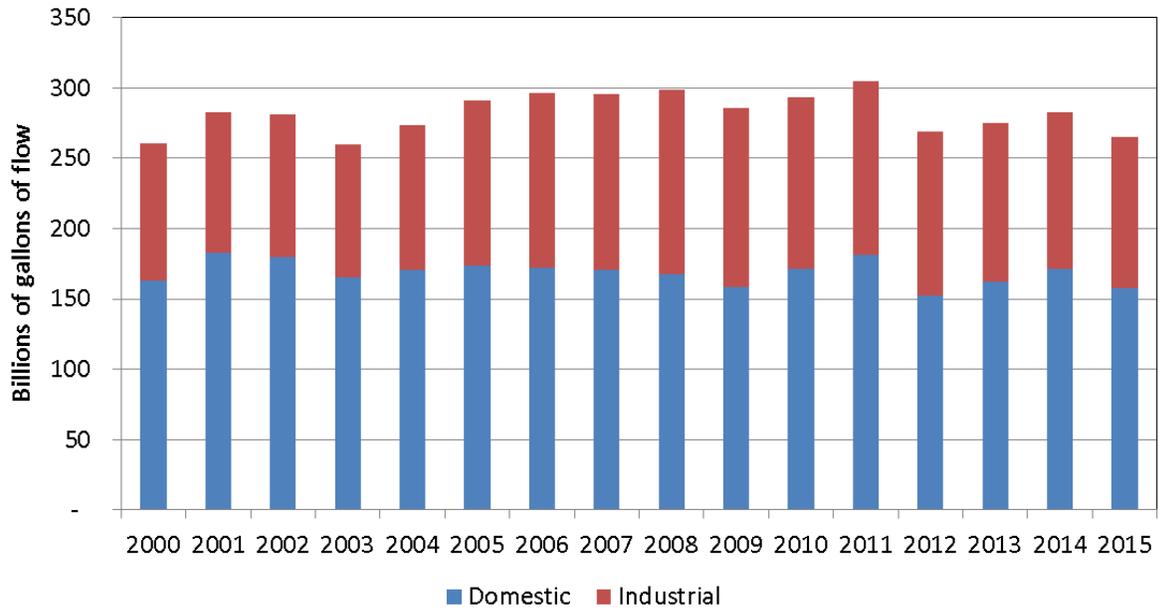
Effluent flow volumes are also included this report. Flow is the total volume of effluent discharged. Although flow is not a regulated pollutant, it is a useful gauge of overall facility performance because of the direct relationship between pollutant loading and effluent flow volume. For example, if 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.

Overall wastewater flow volumes have fluctuated from a low of 260 billion gallons in 2003 to a high of 305 billion gallons per year in 2011. Since the year 2000 major facilities have discharged approximately 90 percent of wastewater. Municipal wastewater treatment facilities discharged 63percent of wastewater flow from 2000 through 2004. Since 2005 the proportion of municipal wastewater flow has declined to 60 percent 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 hydrologic trends in subsequent years, wastewater flows have remained relatively modest. From 2012 to 2015, surface water discharges reported by the wastewater sector have averaged 274 billion gallons per year, a 4 percent reduction from the long-term average.

Annual Wastewater Flow by Facility Size



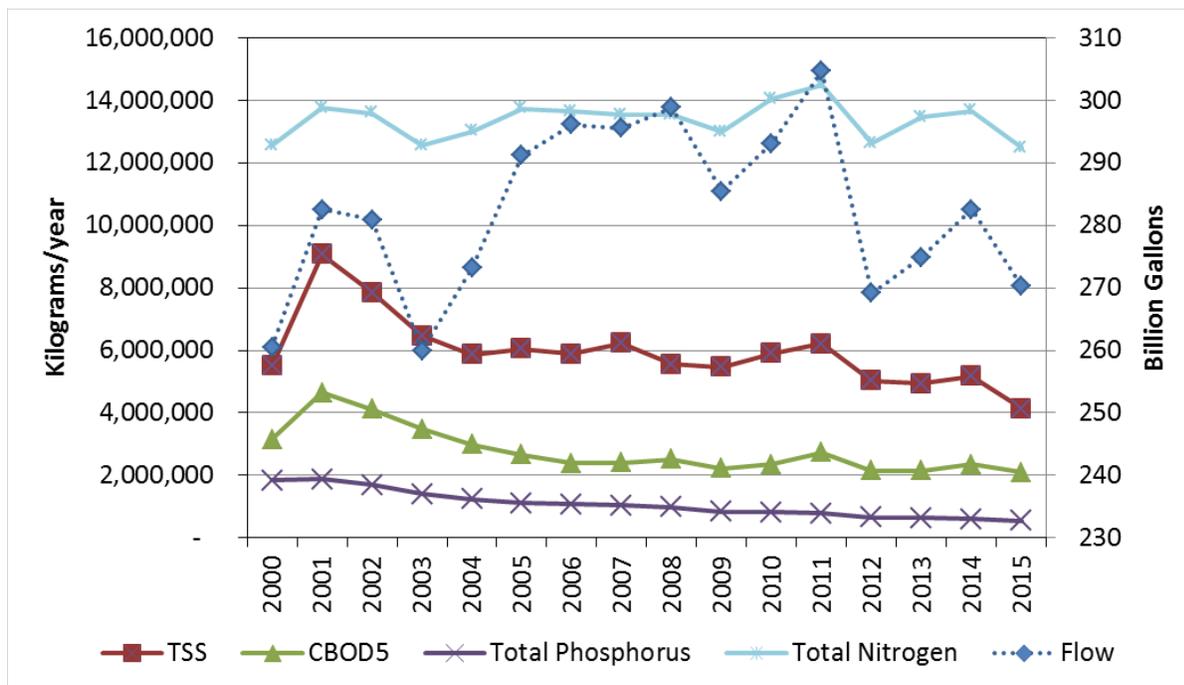
Annual Wastewater Flow by Facility Type



Pollutant Loading Trends

Flow and pollutant loading trends from wastewater treatment facilities are shown in the two figures below and Tables 2 through 5. The magnitude of statewide mercury loads, measured in kilograms rather than metric tons, is shown in the second figure.

Pollutant Loading Trends from NPDES Wastewater Facilities, 2000-2015



Mercury Loading Trends From NPDES Wastewater Facilities 2000 – 2015

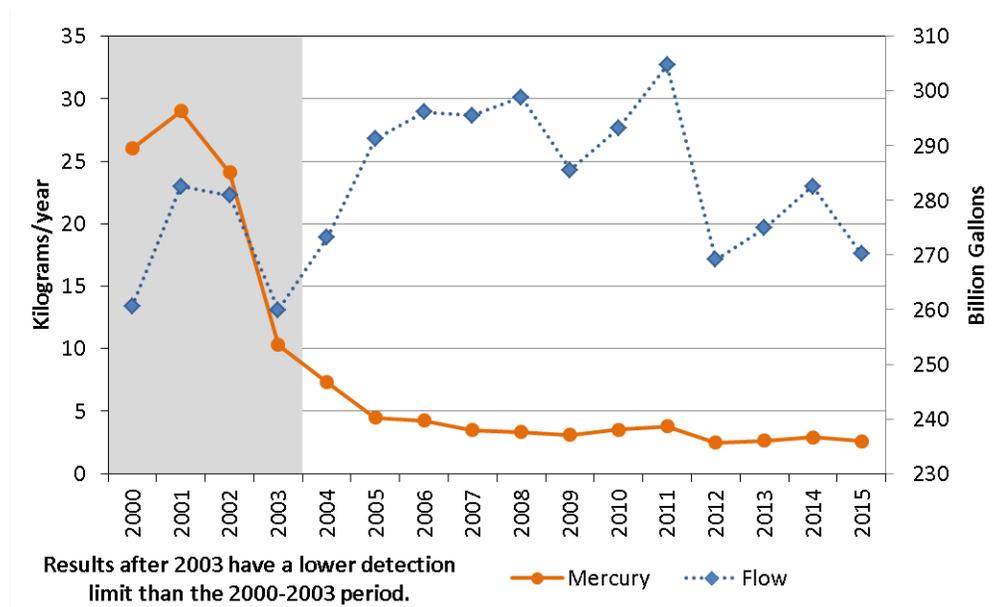


Table 2 shows pollutant effluent flow and loading trends from 2000 through 2015. Effluent flow is reported in billion gallons per year. Pollutant loads for TSS, CBOD₅, TP and TN are reported in metric tons per year. Pollutant loads for mercury are reported in kilograms per year.

Overall, effluent flows tend to fluctuate based on climatic and market conditions. TSS loads increased in 2001 and 2002 but have otherwise remained fairly stable at approximately 6,000 metric tons per year. CBOD₅ loads have declined from three to four thousand metric tons per year during the 2000 to 2004 period to an average load of 2,400 tons per year since 2005. Significant TP reductions have been achieved since 2000. TN loads have remained stable at approximately 13,000 metric tons per year. Significant mercury load reductions have been achieved.

Table 2: Annual Flow and Pollutant Load Estimates from Minnesota Wastewater Treatment Facilities (million gallons, metric tons and kilograms per year) 2000-2015

	Flow (MG/year)	TSS (MT/year)	CBOD (MT/year) ¹	TP (MT/year)	TN (MT/year)	Hg (Kg/year) ²
2000	260,549	5,475	3,146	1,838	12,509	26.0
2001	282,591	9,054	4,639	1,872	13,712	29.0
2002	280,912	7,825	4,095	1,695	13,419	24.1
2003	259,947	6,455	3,470	1,401	12,388	10.3
2004	273,188	5,881	3,010	1,233	12,854	7.3
2005	291,191	5,969	2,631	1,103	13,567	4.5
2006	296,126	5,873	2,369	1,067	13,533	4.2
2007	295,559	6,215	2,389	1,039	13,513	3.5
2008	298,845	5,542	2,512	987	13,367	3.3
2009	285,516	5,464	2,224	843	12,845	3.1
2010	293,130	5,897	2,345	812	13,841	3.5
2011	304,710	6,207	2,724	781	14,250	3.8
2012	269,139	5,017	2,159	653	12,277	2.5
2013	274,912	5,046	2,172	633	13,193	2.6
2014	282,576	5,246	2,353	598	13,666	2.7
2015	270,239	4,140	2,087	544	12,488	2.7

¹Industrial facilities are excluded from CBOD load calculations due to lack of data.

²Peat mining facilities are excluded from mercury calculations due to unreliability of flow and mercury data.

Readers of this report will note that with the exception of nitrogen wastewater pollutant loadings are progressing downward over time, despite ongoing population growth and more users on community wastewater systems with surface water discharges in Minnesota. Wastewater flow volumes will continue to grow with projected population increases in coming decades, especially in urban areas (see chart below). State and local officials will need to continue their diligence to ensure that municipalities have effective treatment facilities and capacity for growth, to continue Minnesota’s legacy of wastewater operator excellence and water quality improvement.

Growth Projections for Municipal Wastewater Flow and Minnesota Households (2005-2035)

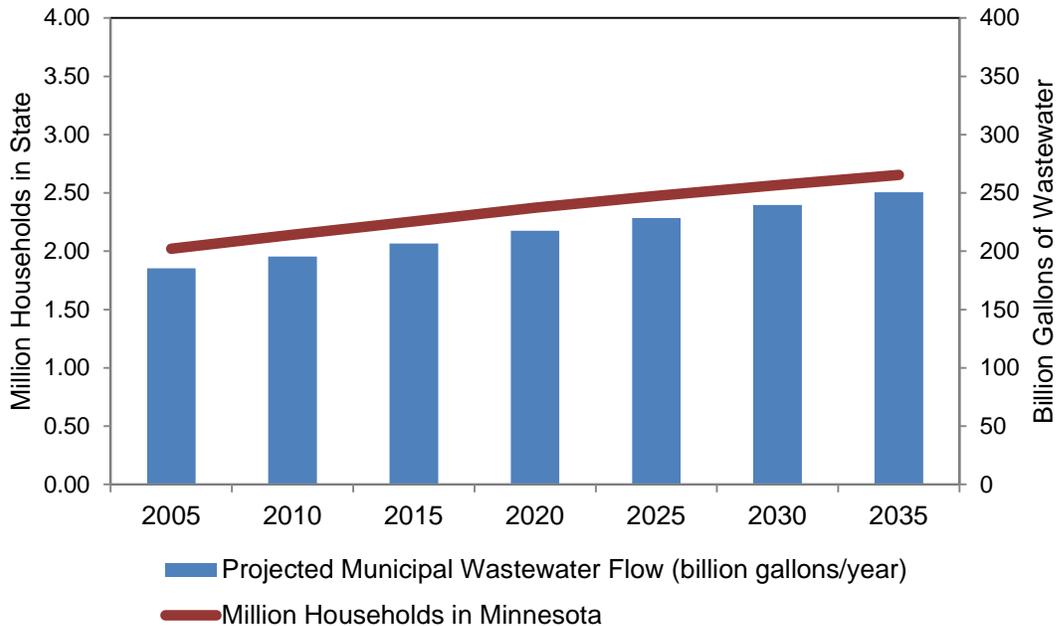


Table 3 shows the annual percent change in flow and pollutant loads. 2001 stands out as a year that saw significant increases in the loading of all pollutants, probably as a result of the significant flooding which occurred that year. Excluding 2001, the year-to-year percent change data show the following:

- § An average 5 percent per year decline in annual TSS loads
- § An average 5 percent decline in annual CBOD₅ loads
- § An average 8 percent decline in annual TP loads
- § No change in annual TN loads
- § An average 12 percent decline in annual mercury

Table 3: Annual Percent Change in Flow and Pollutant Loads from Minnesota Treatment Facilities, 2010-2015

	Flow (%)	TSS (%)	CBOD (%)	TP (%)	TN (%)	Hg (%)
2000						
2001	8%	65%	47%	2%	10%	11%
2002	-1%	-14%	-12%	-9%	-2%	-17%
2003	-7%	-18%	-15%	-17%	-8%	-57%
2004	5%	-9%	-13%	-12%	4%	-29%
2005	7%	1%	-13%	-11%	6%	-39%
2006	2%	-2%	-10%	-3%	0%	-5%
2007	0%	6%	1%	-3%	0%	-17%
2008	1%	-11%	5%	-5%	-1%	-5%
2009	-4%	-1%	-11%	-15%	-4%	-7%
2010	3%	8%	5%	-4%	8%	14%
2011	4%	5%	16%	-4%	3%	8%
2012	-12%	-19%	-21%	-16%	-14%	-34%
2013	2%	1%	1%	-3%	7%	6%
2014	3%	4%	8%	-6%	4%	1%
2015	-4%	-21%	-11%	-9%	-9%	0%

Table 4 on the next page shows the annual percent change in flow and pollutant loading from a baseline defined as the average of the years 2000 and 2001. From 2002 to 2015 percent change from baseline data show:

- § No change in effluent flows
- § An average 43 percent decrease in TSS loads
- § An average 46 percent decrease in CBOD₅ loads
- § An average 71 percent decrease in TP loads
- § An average 5 percent increase in TN loads
- § An average 90 percent reduction in mercury loads

Table 4: Annual Percent Change in Flow and Pollutant Loading from Minnesota Treatment Facilities from 2000-2001 Baseline Average

	Flow (%)	TSS (%)	CBOD (%)	TP (%)	TN (%)	Hg (%)
2000-01 Baseline	271,570 (MG/year)	7,265 (MT/year)	3,892 (MT/year)	1,855 (MT/year)	13,111 (MT/year)	28 (Kg/year)
2002	3%	8%	5%	-9%	2%	-12%
2003	-4%	-11%	-11%	-24%	-6%	-63%
2004	1%	-19%	-23%	-34%	-2%	-73%
2005	7%	-18%	-32%	-41%	3%	-84%
2006	9%	-19%	-39%	-42%	3%	-85%
2007	9%	-14%	-39%	-44%	3%	-87%
2008	10%	-24%	-35%	-47%	2%	-88%
2009	5%	-25%	-43%	-55%	-2%	-89%
2010	8%	-19%	-40%	-56%	6%	-87%
2011	12%	-15%	-30%	-58%	9%	-86%
2012	-1%	-31%	-45%	-65%	-6%	-91%
2013	1%	-31%	-44%	-66%	1%	-90%
2014	4%	-28%	-40%	-68%	4%	-90%
2015	0%	-43%	-46%	-71%	-5%	-90%

A number of additional sources of variation, both up and down, 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, 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.

Chapter 1: 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.

Criteria pollutants—The 1970 Clean Air Act identified six major air pollutants that were present in high concentrations throughout the United States called “criteria pollutants.” These air pollutants are particulate matter (PM_{2.5} and PM₁₀), sulfur dioxide (SO₂), nitrogen oxides (NO_x), ozone (O₃), carbon monoxide (CO) and lead (Pb). The Minnesota Criteria Pollutant Emission Inventory estimates emissions of five criteria pollutants (PM₁₀, SO₂, NO_x, CO and Pb). Ozone is not directly emitted, so a group of ozone precursors called volatile organic compounds (VOCs) is included instead. Emissions estimates for large facilities are available for 2014. Nonpoint, mobile, fire and biogenic (natural) source emissions are available for 2011.

PM_{2.5} and ammonia (which contributes to PM_{2.5} formation) used to be estimated every three years. Emissions for large facilities have been estimated annually since 2012, while nonpoint, mobile, fire and biogenic emissions are still calculated every three years, with latest estimates available for 2011. New additions to the 2011 statewide emission inventory include the separation of biogenic emissions into a distinct source category. Fire emissions depend on many factors including type of fire, ecosystem conditions and weather and can vary greatly from year to year. Biogenic emissions come from natural sources such as vegetation. EPA estimates biogenic sources from vegetation and soils, emissions from other natural sources such as volcanos and lightning are not included. Biogenic emissions are estimated using a model which utilized spatial information on land use and vegetation and combines it with temperature and solar rotation. Biogenic emissions are found everywhere in the environment and are contributors to background air chemistry. Because of their widespread presence, they need to be accounted for in the photochemical models. In this report, biogenic and fire emissions will be discussed separately from other source categories. The Criteria Pollutant Emissions section also includes a summary of the MPCA’s Air Quality Index (AQI) data for 2014 and 2015.

Greenhouse gases—Increases in ambient levels of greenhouse gases have led to a changing global climate. The MPCA tracks and reports emissions for six greenhouse gases (CO₂, nitrous oxide, methane, hydrofluorocarbons, perfluorocarbons and sulfur hexafluoride) in terms of CO₂ equivalents (CO₂e). CO₂e compares the warming potential of different gases to the impact of CO₂. Emission estimates for 2012 are included in this report. New federal and state rules require MPCA estimate GHG emissions from point sources. Starting in 2011, small point sources started reporting GHG emissions. In 2012, all permitted point sources submitted GHG emissions to the MPCA using the CEDR electronic reporting system. More information is available on climate change and greenhouse gases at the following link:
<https://www.pca.state.mn.us/air/climate-change>

Air toxics—Many other air pollutants are released in smaller amounts than most of the criteria pollutants, but are still 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 organic matter. Minnesota data come from the 2011 Minnesota Air Toxics Emission Inventory.

In 2014, the emission inventory rule ([Minn. R. 7019.3000 subp. 3](#)) was amended to include new rules for mercury air emissions. The rule requires facilities that emit more than three pounds of mercury per year submit an annual mercury inventory to the MPCA.

This report is limited to a summary and discussion of emissions of various air pollutants in Minnesota. Please see the following MPCA report for a more detailed discussion of air pollution trends and emissions.

Air Quality in Minnesota: 2015 Report to the Legislature

<https://www.pca.state.mn.us/air/reports-legislature>

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 (PM₁₀)
- § sulfur dioxide (SO₂)
- § nitrogen oxides (NO_x)
- § volatile organic compounds (VOCs)
- § carbon monoxide (CO)
- § lead (Pb)

The emission inventory is used to track the estimated pollutant emissions of each facility and to determine the type and quantity of pollutants being emitted into the atmosphere. Ozone is a criteria pollutant that is not directly emitted, so a group of ozone precursors called VOCs is included instead. Starting in 2012, MPCA also began estimating PM_{2.5} and ammonia annually. Prior to 2012, these emissions were estimated every three years.

The Minnesota Criteria Pollutant 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 four other principal source categories: nonpoint sources, mobile sources, fire and biogenic. Overall, the Minnesota Criteria Pollution Emission Inventory includes emissions from five principal source categories.

- 1. Point 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. Nonpoint 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; onroad vehicles and nonroad sources. Onroad vehicles include vehicles operated on highways, streets and roads. In 2011, EPA used a new MOVES model to estimate onroad emissions. MOVES2014 estimates were combined and presented differently from previous years. Nonroad 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 nonroad sources.

4. **Fires:** Fire emissions are defined as emissions produced by inadvertent or intentional agriculture burning, prescribed burning or forest wild fires. As in 2008, EPA estimated 2011 emissions using the Satellite Mapping Automated Reanalysis Tool for Fire Incident Reconciliation version 2 (SFv2). SFv2 uses multiple fire information data sources for the development of fire emission inventory data.

5. **Biogenic:** Biogenic sources include emissions from natural sources such as soils and vegetation.

The Minnesota Criteria Pollutant Emission Inventory is complete for point sources through 2014. Emission estimates are available for nonpoint, mobile, fire and biogenic sources for 2011. When 2014 summary data are given, they include nonpoint, mobile, fire and biogenic data from 2011 and point source data from 2014. This report presents trend data for point sources from 2010-2014.

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.

In addition, despite the importance of secondary formation for some pollutants (e.g., PM_{2.5}), estimated air emission data in this report are based on direct releases from sources into the atmosphere.

Find more information on the Minnesota Criteria Pollutant Emission Inventory:

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

See the MPCA Environmental Data Access web site to download MPCA emission estimates for criteria pollutants and air toxics including county level emissions for 2011:

<https://www.pca.state.mn.us/quick-links/eda-air-quality-data>

Find more information on criteria air pollutants in the following EPA website:

<https://www.epa.gov/criteria-air-pollutants>

See the EPA's National Emissions Inventory Browser to download EPA criteria pollutant emission estimates:

<http://www3.epa.gov/ttnchie1/net/2011inventory.html>

Air Quality Index (AQI)

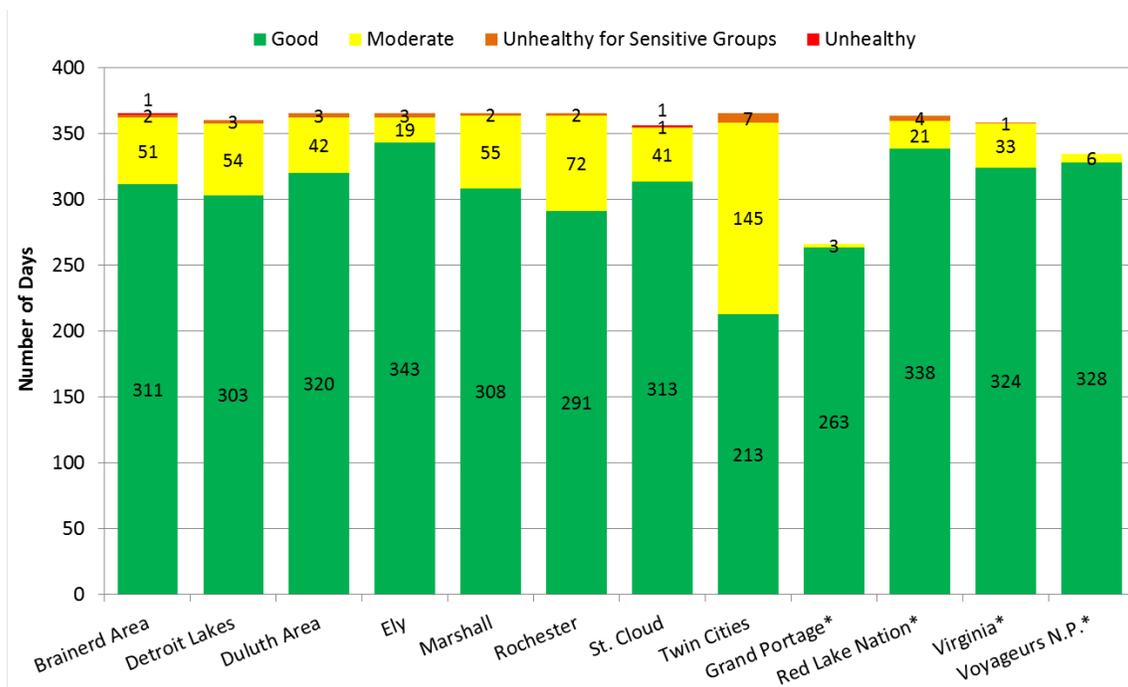
The Air Quality Index, or AQI, was developed by EPA to provide a simple, uniform way to report daily air quality conditions. Minnesota’s AQI is based on measurements of six pollutants: fine particles (PM_{2.5}), PM₁₀, ground-level ozone (O₃), sulfur dioxide (SO₂), nitrogen dioxide (NO₂) and carbon monoxide (CO). An AQI value is calculated for each pollutant, but the pollutant with the highest AQI value is reported as the overall AQI for that hour and reporting area. AQI values are updated hourly and posted on the MPCA’s website at <http://www.pca.state.mn.us/aqi>.

Air quality is ranked as good, moderate, unhealthy for sensitive groups (USG) and unhealthy for all. Ozone and fine particle pollution are the key drivers of the overall AQI. If it is suspected through forecasting or monitoring that ozone or fine particles may be unhealthy for sensitive groups or higher, the MPCA issues an Air Pollution Health Alert to the news media and to individuals who have signed up to receive the alerts by e-mail. Alerts allow the public to be proactive about protecting their health and reducing their own contributions to emissions and exposure to pollution.

AQI Color Legend



2015 Air Quality Index Days by Category and Reporting Region
Based on ozone and fine particles (PM_{2.5})

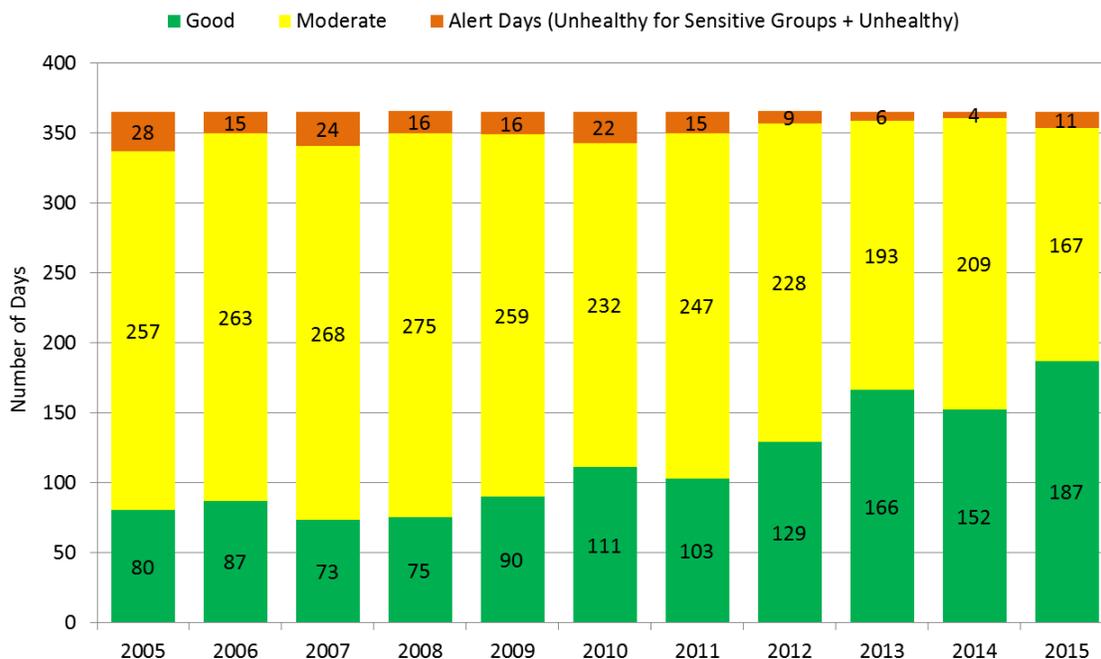


*The AQI in Grand Portage, Red Lake Nation, and Virginia only includes PM_{2.5}. The AQI in Voyageurs Natl. Park only includes ozone.

In 2015, across all areas of the state, the majority of days were rated good for air quality. Ely experienced the highest number of good air quality days (343) compared to the Twin Cities metropolitan area which experienced lowest number of good air quality days (213). The lower number of good AQI days in the Twin

Cities compared to other areas of the state is an expected result, as the AQI is based on pollutants which are most abundant in urban areas. Statewide the number of good AQI days has been increasing over time. This suggests that overall air quality is improving.

Statewide Air Quality Index Days by Year, 2005-2015 Based on Ozone and Fine Particles (PM_{2.5})



Note: These results are calculated using the current AQI category breakpoints. The breakpoints for PM_{2.5} and ozone were revised in 2012 and 2015, respectively.

In 2015, across Minnesota, the AQI reached the unhealthy for sensitive groups or unhealthy categories on 11 days. Fine particle pollution was the driver for eight of these days. Ozone was the driver for three of these days. On one day, both ozone and fine particle pollution reached the unhealthy for sensitive groups category. The majority of the high AQI days in 2015 were associated with the transport of wildfire smoke into Minnesota from Canada and the Western United States. In recent years, transported wildfire smoke has become a leading contributor to high AQI days in Minnesota. More detailed information about the 2015 high AQI days is available in following table.

Table 5: Days Reaching the Unhealthy for Sensitive Groups or Unhealthy AQI Categories, 2015

	Brainerd Area	Detroit Lakes	Duluth Area	Ely	Marshall	Red Lake Nation	Rochester	St. Cloud	Twin Cities	Event Description
2/7/2015									108	Local winter time stagnation event.
2/8/2015									114	
5/27/2015					113					Warm temperatures and evidence of transported wildfire smoke contributed to elevated ozone. Monitors in Sioux Falls and Brookings South Dakota also impacted.
6/9/2015				114					107	Heavy smoke from fires in Canada contributed to elevated PM _{2.5} and ozone. Mostly sunny skies and afternoon temperatures near 90°F contributed to elevated ozone.
6/10/2015				108						
7/3/2015	115	130				106				Heavy smoke from fires in Canada contributed to elevated PM _{2.5} . Independence Day fireworks displays also contributed to elevated PM _{2.5} .
7/4/2015	152	148	102			131		159	147	
7/5/2015	136	124				132		145	132	
7/6/2015			112	105		111	118		113	
7/7/2015			105				114		105	
8/28/2015					119					Presence of wildfire smoke may have contributed to elevated ozone concentration.

Note: Values in the table reflect the maximum AQI result for that date.

Ozone

Fine Particles (PM_{2.5})

References/web links

For more information on AQI, see the following websites:

<https://www.pca.state.mn.us/air/current-air-quality-index>

<http://airnow.gov/index.cfm?action=aqibasics.aqi>

<http://airnow.gov/index.cfm?action=pubs.index>

Particulate Matter

Particulate matter 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. Some particles are seen as soot or smoke while others are so small they can only be detected with an electron microscope.

EPA currently has National Ambient Air Quality Standards (NAAQS) for particulate matter in two size classes, PM_{2.5} and PM₁₀. PM_{2.5}, also known as fine particulate matter, includes particles with diameters less than or equal to 2.5 microns. PM₁₀, which is also known as inhalable particulate matter, includes particulate matter smaller than or equal to 10 microns. PM_{2.5} and PM₁₀ are associated with numerous adverse health effects, which are briefly described in the following sections. Health researchers have identified adverse health effects from a range of different sizes of particulate matter. Over time, federal particulate matter regulations have shifted to focus on smaller-sized particles.

Particulate matter also causes adverse impacts to the environment. 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. This can result in the depletion of nutrients in the soil, damage to sensitive forests and farm crops, and diversity changes in ecosystems. Particulate matter also causes soiling and erosion damage to materials and buildings. Finally, different types of particulate matter, for example black carbon (soot) and sulfate particles, play a role in climate change by altering cloud formation and precipitation and depending on the type of particle and location, contributing to global warming or cooling.

PM_{2.5}

Fine particles are an aerosol including solid particles and liquid droplets in the air that vary in size, composition and origin. Fine particles contain sulfate, nitrate, ammonium, elemental carbon, organic carbon-containing chemicals, minerals, trace elements and water.

Studies have shown that ambient PM_{2.5} concentrations are linked with increased hospital admissions and deaths from cardiovascular and respiratory problems. Elevated PM_{2.5} concentrations are also associated with a number of adverse effects including heart attacks; atherosclerosis; acute and chronic bronchitis; asthma attacks; respiratory symptoms; and reduced lung growth rate and lung function and increased respiratory illness in children.

Emissions data and sources

PM_{2.5} concentrations in the air are the result of many manmade and natural sources of emissions. PM_{2.5} can be directly emitted to the air in the form of small particles. Examples of these “directly” emitted PM_{2.5} particles include the smallest particles created from mechanical, grinding or abrasion processes, blowing dust and the soot from combustion processes such as diesel engines, fires and wood burning. MPCA estimates these types of emissions in the direct PM_{2.5} emission inventory.

The MPCA estimate for statewide direct emissions of PM_{2.5} in 2014 is 200,000 tons. 35 percent or 70,000 tons come from fire emissions. Fire emissions include wildfire, agricultural and prescribed burning emissions. Fire combustion can have a negative impact on visibility, air quality and human health. These emissions can travel long distances and affect the air quality and human health far from their origin. In addition, the inventory shows that a large portion of PM_{2.5} emissions are related to the soils found in the earth’s crust, such as from agricultural tilling. In reality, only a small fraction of the PM_{2.5} concentrations measured in typical air result from these “crustal” emission sources.

Much of Minnesota’s PM_{2.5} air pollution results from secondary sources in Minnesota and other states that release “precursor” gases such as sulfur dioxide, nitrogen oxides, ammonia, or carbon-containing chemicals to the atmosphere. Depending on the weather conditions, these precursor gases will undergo chemical

reactions in the air to form “secondary” PM_{2.5}. At least half of the ambient fine particles measured in the Twin Cities and Rochester, and a proportionally larger fraction of the ambient PM_{2.5} measured in rural areas, were a result of secondary formation from “precursor” gases.

Sources of directly emitted PM_{2.5} are shown in the graphic below.

Major Sources of Direct Fine Particulate (PM_{2.5}) Emissions in Minnesota



The graphic above shows the percentage of total directly emitted fine particulate emissions from primary source categories in Minnesota. The graphic excludes fire emissions and does not include secondarily formed PM_{2.5} which can comprise a large portion of PM_{2.5} found in the air. Sources contributing less than 10% are not listed. Point source data are from 2014 emission inventory, all other data are from the 2011 emission inventory.

A large portion of direct emissions, about 42 percent, come from suspended soils released from agricultural tilling. Another 22 percent of emissions result from residential wood burning and 12 percent can be attributed to large point sources such as electric utilities. Smaller categories include combustion of fuels in nonroad and onroad sources.

Trends

Statewide PM_{2.5} emissions are estimated every three years. PM_{2.5} emissions were estimated for the first time in 2002, and the latest estimates are from 2011. In 2008, statewide emissions were around 212,000 and 200,000 tons in 2011. MPCA estimates PM_{2.5} emissions annually for all permitted point sources, the most recently finalized emissions are for 2014. These estimates are included in the totals.

Statewide PM_{2.5} estimated emissions have decreased somewhat from 2008. The decrease is likely to methodology changes in certain categories. For example, EPA estimated 2011 onroad emissions using MOVES2014. The tool was updated and altered compared to earlier MOVES versions. Given the ongoing improvements in the estimation methods it is understandable that the emission estimates have changed.

References/web links

For more information on PM_{2.5}, see the following websites:

<https://www.pca.state.mn.us/air/fine-particle-pollution>

<http://www3.epa.gov/pm/>

<http://www3.epa.gov/airtrends/pm.html>

PM₁₀

PM₁₀ includes all particles with aerodynamic diameters less than 10 microns. PM_{2.5} is a subset of PM₁₀ emissions. Based on monitoring data, roughly half of the mass of Minnesota's ambient PM₁₀ particles are of particles within the PM_{2.5} size and so the direct and secondary formation and the health effects discussed for PM_{2.5} have relevance for PM₁₀. However, ambient PM₁₀ includes a much higher fraction of crustal materials. PM₁₀ has been linked to cardiovascular and respiratory health effects. PM₁₀ particles are generally emitted from sources such as vehicles traveling on unpaved roads; agricultural tilling; materials handling; crushing and grinding operations, and windblown dust. The larger of these particles can settle from the atmosphere within hours. Their spatial impact is typically more limited (compared to PM_{2.5}) because they tend to fall out of the air near where they were emitted.

Emissions data and sources

The MPCA estimate for statewide direct emissions of PM₁₀ in 2014 is about 500,000 tons of which about 84,000 tons or 17 percent are due to emissions from wildfires, agricultural and prescribed burning. Fire emissions depend on many environmental conditions and can significantly impact overall annual emissions.

Major Sources of Direct (PM₁₀) Emissions in Minnesota



The graphic above shows the percentage of direct PM₁₀ emissions from major source categories in Minnesota. The graphic excludes fire emissions and does not include secondarily formed PM₁₀. Point source data are from 2014 emission inventory, all other data are from the 2011 emission inventory.

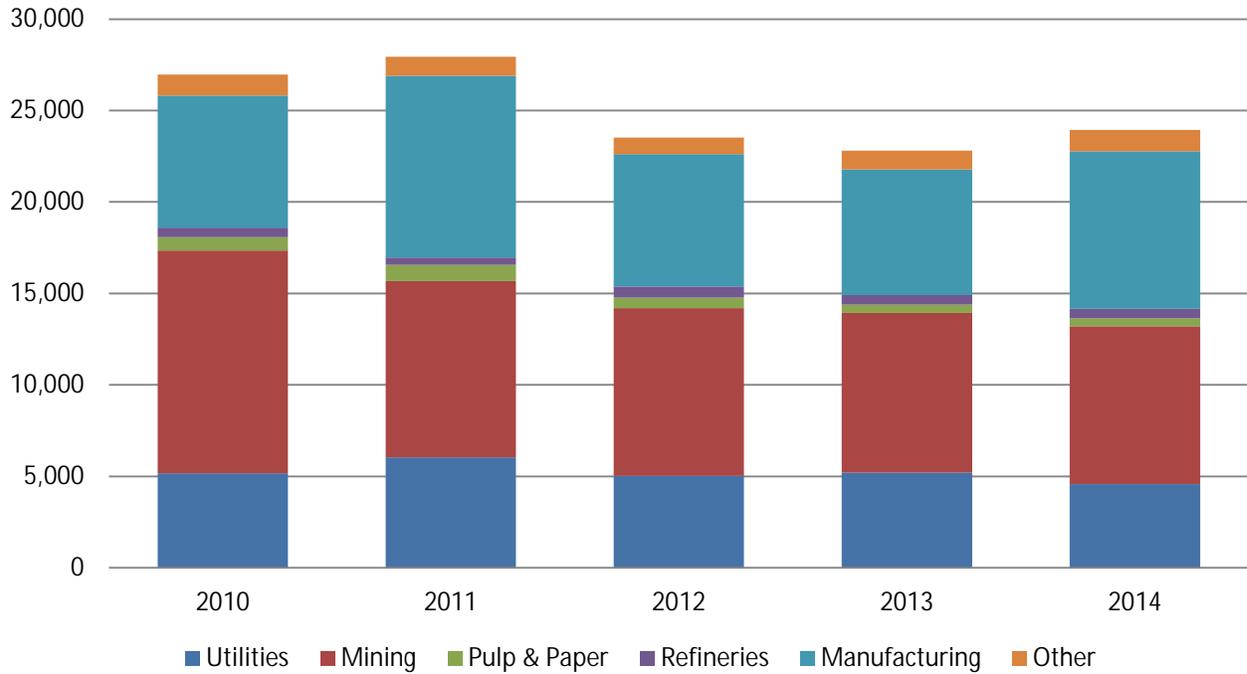
About 66 percent of the mass of direct primary PM₁₀ emissions come from agricultural practices, mainly tilling. Another 7 percent is emitted from residential wood burning and 6 percent comes from large point sources such as electric utilities. The remainder comes from nonpoint sources which include construction, residential, commercial, and industrial fuel combustion, and combustion of fuels in nonroad and onroad sources.

PM₁₀ particles formed secondarily in the atmosphere from chemical reactions involving gaseous pollutants and are not accounted for in these graphs.

Trends

In 2014, point sources contributed six percent to the total state PM₁₀ emissions (excluding fire emissions). In 2010 there were reductions in coal burning, however, taconite production increased to pre-2006 levels, resulting in PM₁₀ emissions near the levels seen in 2008. PM₁₀ emissions continued to decrease for 2011 and 2012 due to reduced coal use by some facilities such as Minnesota Power's Taconite Harbor Energy Center and North Shore Mining – Silver Bay. Verso Paper Corp – Sartell permanently shut down because of a fire which further reduced emissions. In addition, there was an overall drop in all emissions due to power boiler shutdown at Xcel Energy – Sherburne Generating Plant for the entire 2012 calendar year. In 2013, emissions decreased due to a decrease in manufacturing. Emissions rebounded to 2012 levels in 2014.

PM₁₀ Point-Source Emission Trends by Sector in Minnesota, 2010-2014



References/web links

For more information on PM₁₀, see the following website:

<http://www3.epa.gov/pm/>

Ammonia

Ammonia is a colorless gas with a distinctive odor. The main source of ammonia gas in the air is livestock waste and fertilizer application. Exposure to ammonia in the air can be irritating to the eyes, throat and breathing passages. Exposure to higher concentrations of ammonia can cause burns.

Federal rules direct the MPCA to track emissions of ammonia because it is a major contributor to fine particle (PM_{2.5}) formation. Ammonia combines with sulfur dioxide and nitrogen oxides to form ammonium sulfate and ammonium nitrate particles. These particles make up half of fine particle mass in urban areas in Minnesota and at least three quarters of fine particle mass in rural areas.

Emissions data and sources

The MPCA estimate for statewide emissions of ammonia in 2014 is about 210,000 tons. Of that about six percent or 13,000 tons are attributed to fire emissions. Ammonia emissions are emitted from prescribed and wild fires. The percentage breakdowns in the figure below are based on emissions total excluding fire emissions. The majority of ammonia emissions came from livestock waste which accounted for 56 percent; the other significant contributor was fertilizer application which made up 40 percent of emissions.

Major Sources of Ammonia (NH₃) Emissions in Minnesota



The graphic above shows the percentage of ammonia emissions from major source categories in Minnesota. The graphic excludes fire emissions. Sources contributing less than 10% are not listed. Point source data are from 2014 emission inventory, all other data are from the 2011 emission inventory.

Trends

Statewide ammonia emissions are estimated every three years. Ammonia emissions were included in the emission inventory for the first time in 2002. In 2008, Minnesota ammonia emissions were estimated at 200,000 tons. In 2011, the estimate is 210,000 tons. In 2014, the MPCA estimated ammonia emissions for all permitted point sources. Those estimates are included in the totals.

Statewide ammonia emissions have increased slightly since 2008; this is because of methodology changes for certain source categories.

References/web links

For more information on how ammonia affects fine particle formation see the section on PM_{2.5}.

Sulfur Dioxide

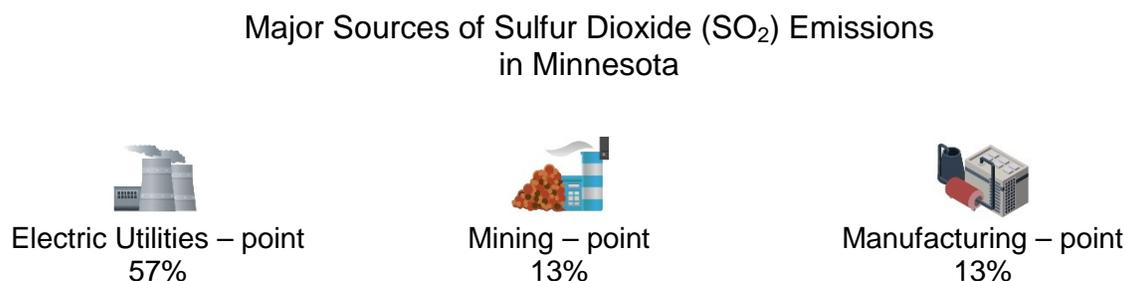
Sulfur dioxide (SO₂) belongs to the family of sulfur oxide gases. In Minnesota, sulfur oxide gases are formed when fuels containing sulfur (mainly coal and oil) are burned and during gasoline production.

Elevated SO₂ is linked to negative human health outcomes. Scientific evidence links short-term exposures to SO₂ with adverse respiratory effects including bronchoconstriction and increased asthma symptoms. Studies show a connection between exposure to SO₂ and increased visits to emergency departments and hospital admissions for respiratory illness. Children, asthmatics, and the elderly are particularly at risk. SO₂ also reacts with other chemicals in the air to form tiny particles. These particles penetrate deeply into the lungs and can cause or worsen respiratory disease, aggravate existing heart disease, and cause premature death. The particles formed from SO₂ also degrade visibility.

SO₂ can also cause significant environmental damage. SO₂ reacts with other substances in the air to form sulfuric acid, which falls to earth as rain, fog, snow, or dry particles. State and federal acid rain actions in the 1980s and 1990s greatly reduced the potential for damage to Minnesota's forests and crops, soil, lakes, streams, buildings, and monuments. Sulfate deposition from SO₂ emissions has also been shown to increase the conversion of mercury to methylmercury, the only form of mercury that accumulates in fish.

Emissions data and sources

The MPCA estimate for statewide emissions of SO₂ in 2014 is 57,000 tons. About 10 percent of emissions or 6,000 tons is attributed to fires. Fire emissions depend on many factors including type of fire, ecosystem conditions and species and have great variability between years. For these reasons, fire emissions are not included in the graphic below.



The graphic above shows the percentage of sulfur dioxide emissions from major source categories in Minnesota. The graphic excludes fire emissions. Sources contributing less than 10% are not listed. Point source data are from 2014 emission inventory, all other data are from the 2011 emission inventory.

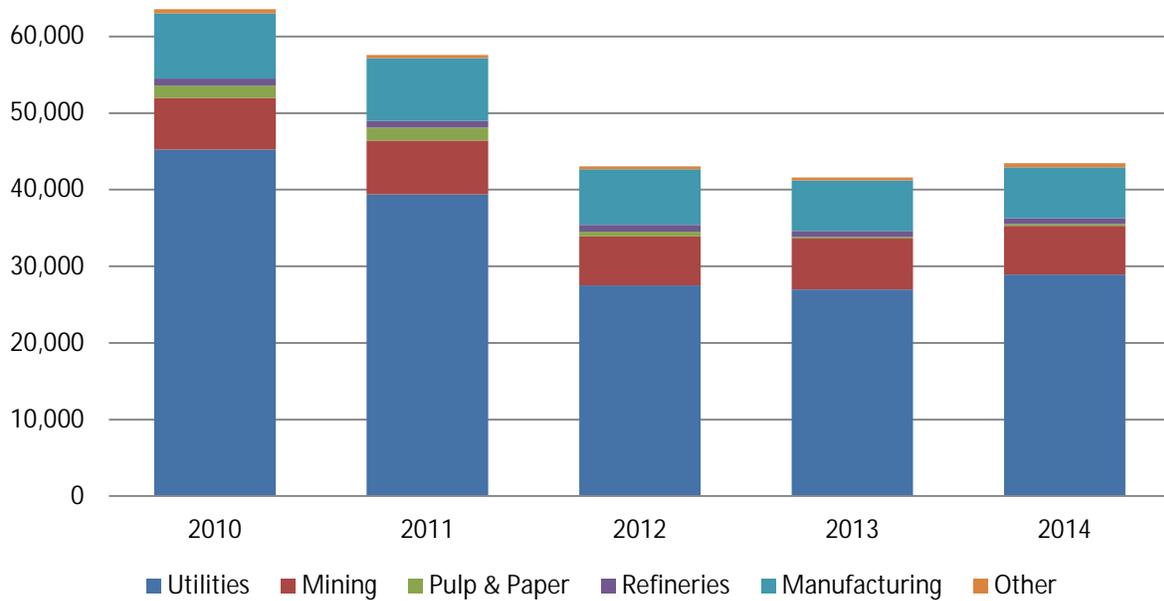
About 57 percent of SO₂ emissions come from coal-burning electric utilities. Another 13 percent come from taconite mining and 13 percent come from manufacturing. Mobile (onroad and nonroad emissions) and nonpoint emissions, which are mostly made up of smaller industrial burning of coal and distillate oil, account for the rest of SO₂ emissions.

Trends

Point sources are the most significant contributor to the total state SO₂ emissions with coal-burning electric utilities the greatest emitters. In 2010, the Xcel Energy Sherburne County Generating Plant decreased the tons of coal burned, further reducing statewide SO₂ emissions. SO₂ emissions continued to decrease in 2011 and 2012 due to reduction of coal use by electric utilities such as Minnesota Power's Taconite Harbor Energy Center. Verso Paper Corp – Sartell permanently shut down because of a fire which reduced emissions of all pollutants. In addition there was a drop in all emissions due to power boiler shutdown at Xcel Energy – Sherburne Generating Plant for the duration of the 2012 calendar year. In 2014, emissions

rebounded to 2012 levels, primarily due to a power boiler at Xcel Energy – Sherburne Generating Plant coming back on line in 2013.

Sulfur Dioxide Point-Source Emission Trends by Sector in Minnesota 2010-2014



References/web links

For more information on sulfur dioxide, see the following websites:

<http://www3.epa.gov/airquality/sulfurdioxide/>

<http://www3.epa.gov/airtrends/sulfur.html>

Nitrogen Oxides

Nitrogen oxides (NO_x) is the generic term for a group of highly reactive gases, all of which contain nitrogen and oxygen. The two primary constituents are nitric oxide (NO) and nitrogen dioxide (NO₂). NO is a colorless, odorless gas that is readily oxidized in the atmosphere to NO₂. NO₂ exists as a brown gas that gives photochemical smog its reddish-brown color. NO_x is reported because NO and NO₂ continuously cycle between the two species. NO_x form when fuel is burned at high temperatures.

Current scientific evidence links short-term NO₂ exposures with adverse respiratory effects including increased asthma symptoms and an increase in other respiratory illnesses. Studies also show a connection between exposure to NO₂ and increased visits to emergency departments and hospital admissions for respiratory illnesses, particularly for children, the elderly, and asthmatics.

NO_x are a major precursor both to ozone and to fine particulate matter (PM_{2.5}). As discussed in the ozone and PM_{2.5} sections of this report, exposure to these pollutants is associated with serious adverse health effects.

High NO_x concentrations also have environmental impacts. Deposition of nitrogen can lead to fertilization, eutrophication, and acidification of terrestrial, wetland and aquatic systems resulting in changes in species number and composition such as the reduction of fish and shellfish populations. Nitrate particles and nitrogen dioxide also increase visibility impairment in areas such as the Boundary Waters Canoe Area Wilderness and Voyagers National Park and urban areas such as Minneapolis and St. Paul. In addition, nitrous oxide (N₂O), another component of NO_x, is a greenhouse gas that contributes to global climate change

Emissions data and sources

The MPCA estimate for statewide emissions of NO_x in 2014 is 340,000 tons. Fire emissions make up about three percent or 11,000 tons. Biogenic emissions which include emissions from natural sources such as soils and vegetation account for eight percent or 28,000 tons. For the first time in 2014, biogenic emissions are included as a separate source category. These emissions are widespread and contribute to background air chemistry. The graphic below shows a breakdown of additional source categories. The percentages are based on emission total excluding fire and biogenic emissions.

Major Sources of Nitrogen Oxide (NO_x) Emissions in Minnesota



The graphic above shows the percentage of nitrogen oxide emissions from major source categories in Minnesota. The graphic excludes fire emissions. Point source data are from 2014 emission inventory, all other data are from the 2011 emission inventory.

Almost a quarter (22 percent) of NO_x emissions comes from onroad gasoline vehicles and trucks. Another 13 percent is attributed to diesel onroad heavy duty trucks. EPA estimated onroad mobile emissions using a new MOVES model. MOVES2014 estimates for 2011 emissions are lower than in 2008. EPA also used new and additional source classification codes (SCCs). SCCs were aggregated at the vehicle and fuel level and did not include road class or emissions type. The nonroad model was not significantly changed. Use of agricultural

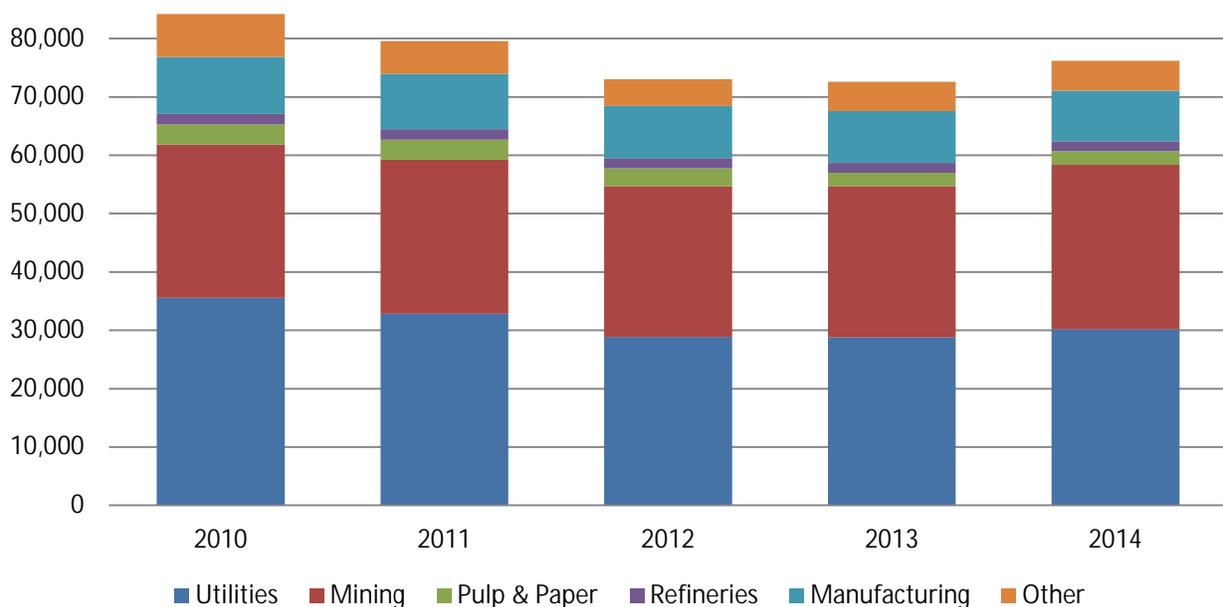
equipment makes up eight percent of the total. Electric utilities contribute nine percent of NO_x emissions, and taconite mining contributes about eight percent.

Trends

Point sources are a significant contributor of the NO_x emissions in Minnesota.

Minnesota NO_x emissions decreased in 2011 and 2012 due to reduction in coal use by large facilities such as Minnesota Power's Taconite Harbor Energy Center and North Shore Mining – Silver Bay. Additionally, there is an overall drop in all emissions due to a power boiler shutdown at Xcel Energy – Sherburne Generating Plant for the duration of the 2012 calendar year and a permanent shutdown of Verso Paper Corp – Sartell due to a fire. In 2013, emissions stayed close to 2012 levels, and increased slightly in 2014. The 2014 increase is likely due the Sherburne Generating Plant coming back on line during the 2013 calendar year.

Nitrogen Oxide Point-Source Emission Trends by Sector in Minnesota, 2010-2014



References/web links

For more information on nitrogen oxides, see the following websites:

<http://www3.epa.gov/airquality/nitrogenoxides/>

<http://www3.epa.gov/airtrends/nitrogen.html>

Ozone

Ozone is a colorless gas composed of three atoms of oxygen. Naturally occurring ozone in the upper atmosphere helps protect the earth's surface from ultraviolet radiation. However, ground-level ozone at elevated concentrations can trigger a variety of health problems.

Breathing air containing ozone can reduce lung function and inflame airways, which can increase respiratory symptoms and aggravate asthma or other lung diseases. Ozone exposure has been associated with increased susceptibility to respiratory infections, medication use, doctor visits, and emergency department visits and hospital admissions for individuals with lung disease. Ozone exposure also increases the risk of premature death from heart or lung disease. Children are at particular risk from ozone because their lungs are still developing and they are more likely to have increased exposure since they are often active outdoors.

Scientific evidence shows that repeated exposure to ground-level ozone has detrimental effects on plants and ecosystems including interfering with plants' ability to produce and store food, damaging the leaves of trees and other plants, and reducing forest growth and crop yields. Cumulative ozone exposure can lead to reduced tree growth; visibly injured leaves; and increased susceptibility to disease, damage from insects and harsh weather. These effects can have adverse impacts on ecosystems, including loss of species and changes to habitat quality, and water and nutrient cycles.

Emissions data and sources

Emissions of ozone are not reported because ozone is not normally emitted directly into the air. Instead, it is created when precursor gases such as nitrogen oxides (NO_x) and volatile organic compounds (VOCs) react in a hot stagnant atmosphere. Since heat and sunlight are needed for ozone to be produced, elevated levels of ozone in Minnesota are normally seen on very hot summer afternoons. Both urban and rural areas may have high levels of ozone since wind carries ozone and its precursors far from the original sources.

Ozone precursors come from a variety of sources. NO_x can form when fuels are burned at high temperatures. The major NO_x sources are combustion processes from highway vehicles and power plants. VOCs are emitted from a variety of sources, including industrial sources, motor vehicles and consumer products. NO_x and VOCs are also emitted by naturally occurring sources such as soil and vegetation. See the nitrogen oxides and volatile organic compounds sections of this report for more information regarding 2014 emissions of ozone precursors.

References/web links

For more information on ozone, see the following websites:

<https://www.pca.state.mn.us/air/ozone>

<http://www3.epa.gov/ozonepollution/>

Volatile Organic Compounds

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. Therefore, only gaseous hydrocarbons that are photochemically reactive and participate in the chemical and physical atmospheric reactions that form ozone and other photochemical oxidants are considered VOCs.

Many VOCs are also air toxics and can have harmful effects on human health and the environment. However, VOCs are regulated as a criteria pollutant because they are precursors to ozone. See the sections on ozone and air toxics for related human health and environmental effects.

Emissions data and sources

The MPCA estimate for statewide emissions of VOCs in 2014 is 1,074,000 tons. VOCs are emitted from a variety of sources including industrial facilities, motor vehicles, consumer products, fires and biogenic sources. Biogenic emissions from natural sources such as vegetation and soils account for 55 percent of the total or 600,000 tons. They are ubiquitous in the environment. Fire emissions account for 18 percent or 190,000 tons. Both biogenic and fire emissions vary from year to year and are dependent on many factors including temperature, weather and ecosystem conditions. The graphic below shows other Minnesota sources of directly emitted VOCs in 2014. The percentages shown in the table below are estimated without including fire and biogenic emissions in the total.



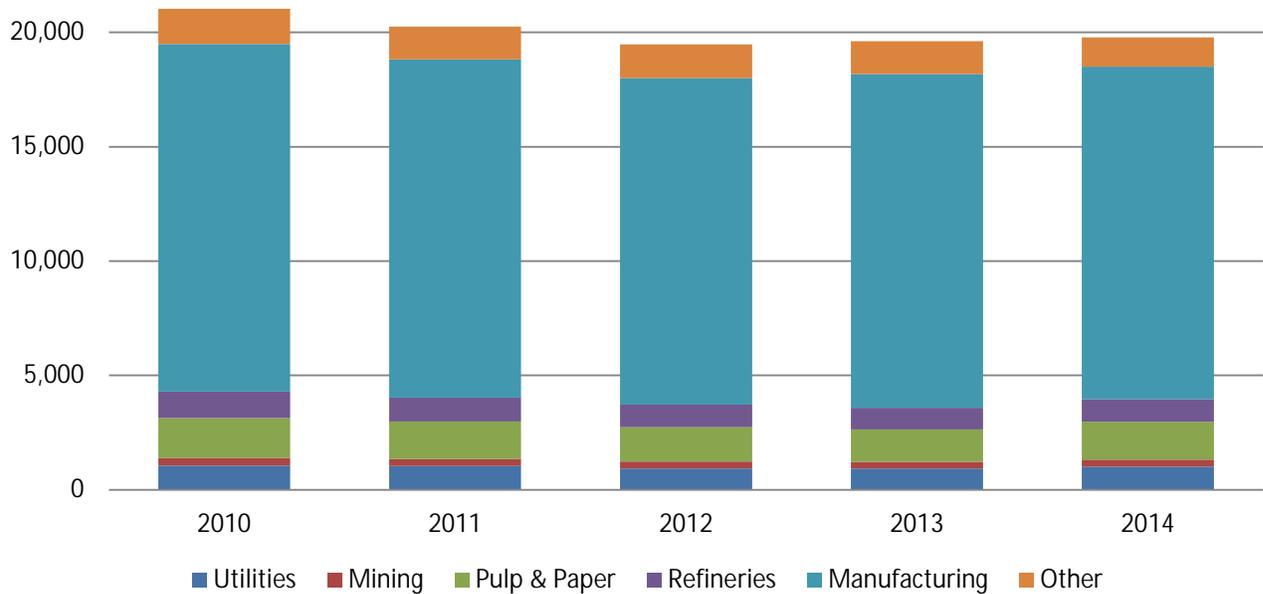
The graphic above shows the percentage of VOC emissions from major source categories in Minnesota. The graphic excludes fire emissions and does not include secondarily formed VOCs. Point source data are from 2014 emission inventory, all other data are from the 2011 emission inventory.

Nonroad sources, in particular recreational vehicles such as snowmobiles, boats and ATVs account for 20 percent of total emissions. Onroad gasoline light duty vehicles and trucks emit 21 percent. Residential wood burning from stoves, boilers and campfires accounts for 11 percent. VOC emission from solvent use such as gas stations and auto body shops makes up 15 percent and the rest is from large point sources.

Trends

Point sources are not a significant contributor of VOC emissions in the state. Emissions had been gradually decreasing since 2004 due mainly to decreases in the manufacturing sector; however, a rebounding economy resulted in higher VOC emissions from manufacturing in 2010. In 2011 and 2012 VOC emissions from the manufacturing sector decreased, resulting in an overall drop in statewide VOC emissions. In 2013 and 2014 VOC emissions increased only slightly due to increases in manufacturing.

Volatile Organic Compound Point-Source Emission Trends By Sector in Minnesota, 2010-2014



References/web links

For more information on volatile organic compounds, see the sections on ozone and air toxics.

Carbon Monoxide

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. Higher levels of CO generally occur in areas with heavy traffic congestion and during the colder months of the year.

CO enters the bloodstream and reduces the delivery of oxygen to the body's organs and tissues. The health threat from CO is most serious for those who suffer from cardiovascular disease. At higher concentrations it also affects healthy individuals. Exposure to elevated CO levels is associated with impaired visual perception, work capacity, manual dexterity, learning ability and performance of complex tasks. Prolonged exposure to high levels 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 (CO₂), a major greenhouse gas and contributor to global climate change. CO also contributes to the formation of ground-level ozone.

Emissions data and sources

The MPCA estimate for statewide emissions of CO in 2014 is 2,200,000 tons. Fire emissions make up 38 percent or 820,000 tons. Biogenic sources contribute about five percent or 100,000 tons. Both fire and biogenic emissions vary annually and are not included in the graphic below.

Major Sources of Carbon Monoxide (CO) Emissions In Minnesota



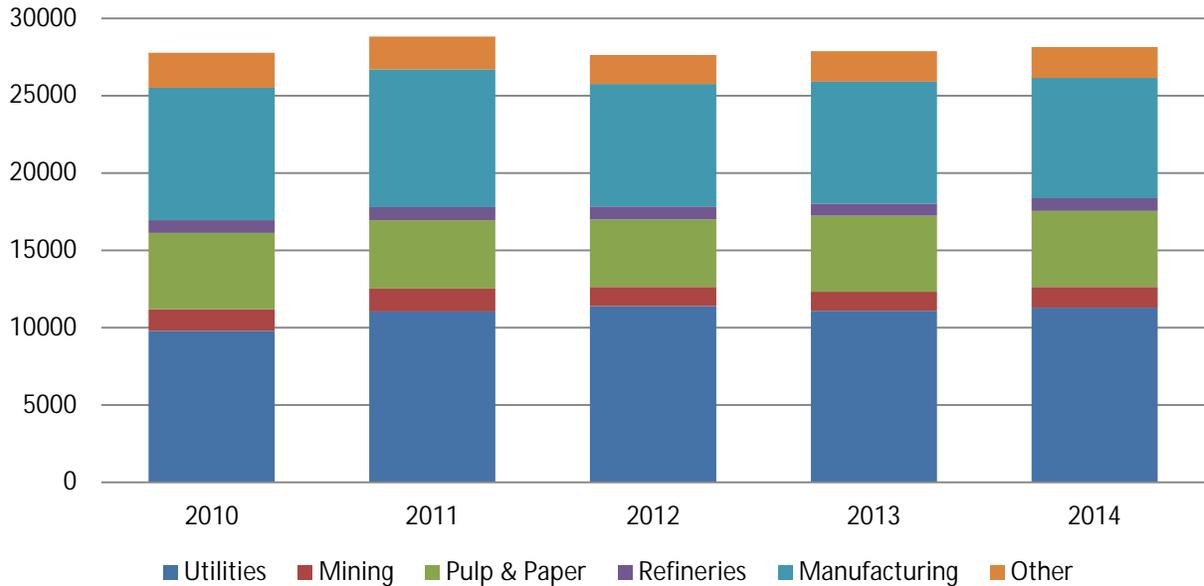
The graphic above shows the percentage of carbon monoxide emissions from major source categories in Minnesota. The graphic excludes fire emissions and biogenic sources. Point source data are from 2014 emission inventory, all other data are from the 2011 emission inventory.

The largest percentage (48 percent) of CO emissions comes from the combustion of gasoline in light duty vehicles and trucks. In 2011, EPA used a new MOVES model to estimate onroad emissions. MOVES2014 estimates for 2011 emissions are much lower than in 2008. Residential wood combustion emitted 15 percent of emissions. Seven percent of emissions come from recreational equipment and seven percent is attributed to lawn and garden equipment.

Trends

Point sources did not contribute greatly to the total Minnesota CO emissions in 2014. In 2010, CO emissions from point sources were slightly higher than past years due to increased emissions from electric utilities, mining and manufacturing. In 2011 through 2014, CO emissions have had only small changes due to variability in emissions from electric utilities and mining.

Carbon Monoxide Point-Source Emission Trends By Sector
in Minnesota, 2010-2014



References/web links

For more information on carbon monoxide, see the following websites:

<http://www3.epa.gov/airquality/carbonmonoxide/>

<http://www3.epa.gov/airtrends/carbon.html>

<http://www.health.state.mn.us/divs/eh/indoorair/co/index.html>

Mercury

The MPCA continues its focus on mercury in the environment. A goal of the MPCA's strategic plan is that Minnesota reduces its contribution to regional, national and global air pollution.

Mercury is a naturally occurring metal. Exposure to mercury can harm the nervous system. It can also harm the heart, kidneys, lungs, and immune system. For most Minnesotans, eating fish contaminated with too much mercury poses the greatest risk of exposure. While fish provide a healthy source of protein and other nutrients, citizens are advised to limit their consumption of older and larger predatory fish. Consult the Minnesota Department of Health Fish Consumption Advisory for guidelines to specific lakes and rivers at <http://www.health.state.mn.us/divs/eh/fish/eating/sitespecific.html>

Most of the mercury in Minnesota's environment comes from air pollution. Minnesota's environment becomes contaminated with mercury when it falls on land or water from the air. Because mercury vapor can be transported long distances in the atmosphere, most of the mercury in Minnesota originates outside of the state. Similarly, most of Minnesota's emissions are deposited in other states and countries. Within Minnesota, mercury is emitted from burning coal, processing materials such as taconite ore, using it in products and the eventual disposal of those products.

Sector activities and reductions

A number of efforts are in place to reduce mercury emissions. When the state's power utilities embarked on state-ordered efforts to reduce mercury in the mid-1990s, emissions from Minnesota's coal-fired utilities were about 1,850 pounds per year. By 2013, mercury emissions were about 870 pounds and they are expected to be less than 200 pounds by 2025. The utilities are well ahead of the scheduled reductions laid out in the Minnesota Mercury Emissions Reduction Act of 2006.

The MPCA completed its work with the University of Minnesota and partners in the funeral industry to improve the estimate of mercury emissions coming from crematoria in Minnesota. The estimated mercury emissions are based on the results of the study which quantify mercury in grams per person from dental amalgam restorations in the sample group. The result of the study is an estimate of 95 lb of mercury from this sector in 2014 which is approximately 33% less than the amount MPCA has previously estimated. Following the research the stakeholders will continue to discuss potential emission reduction strategies and explore further action if needed.

MPCA staff conducted a training workshop for state and local compliance and enforcement staff in the spring of 2013. The workshop focused on mercury-containing products and components in the salvage, scrap, and demolition industries, including items found in vehicles, appliances, and HVAC equipment.

The taconite mining sector continues its research to identify possible mercury-reduction technologies, in cooperation with the MDNR. The facilities completed medium and longer term testing of activated carbon injection control for mercury in 2013 and has continued to test other pollution control technology. This information will inform the reduction plans that the facilities would submit in 2016 under the MPCA's mercury air emission rule.

Total Maximum Daily Load (TMDL) studies and related rulemaking

The MPCA developed a state-wide mercury Total Maximum Daily Load (TMDL) study and US EPA approved it in 2007. The TMDL study assessed the mercury pollution in Minnesota's waters. With input from stakeholders, the MPCA established a clean-up or restoration plan. The TMDL Implementation Plan was finalized in 2009.

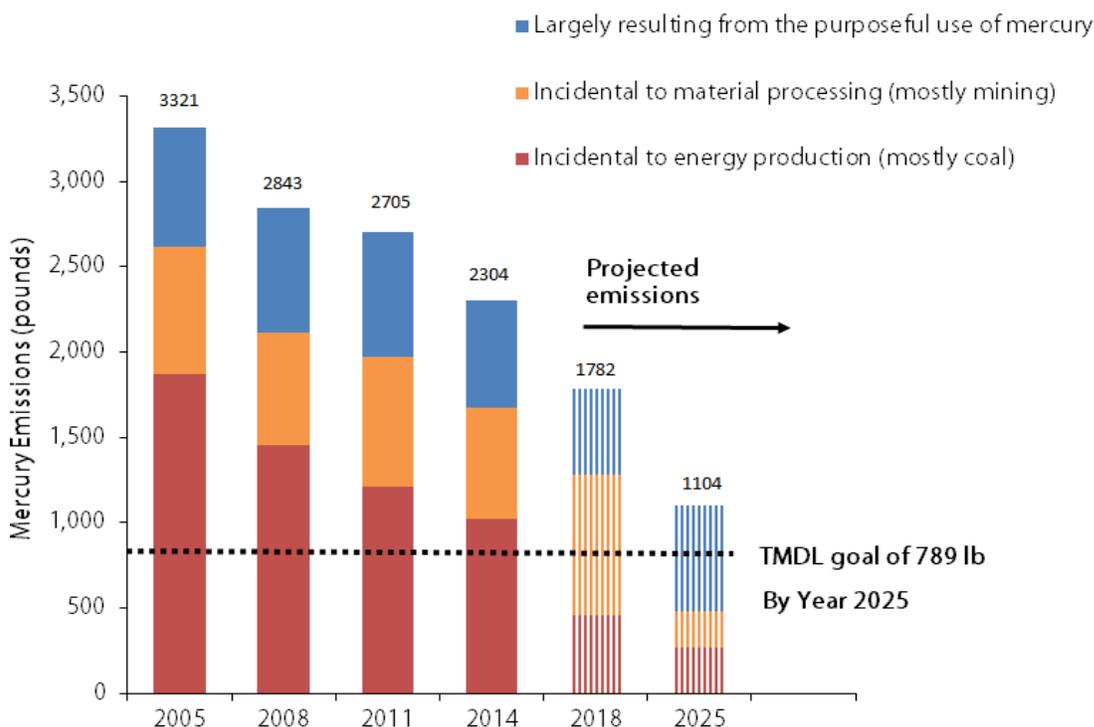
One recommendation of the TMDL Implementation Plan was for the MPCA to promulgate rules to address mercury air emission sources in Minnesota. In September 2014, the MPCA adopted permanent rules to

execute the recommendations of the statewide TMDL. The rules implement the reduction activities called for in the Statewide Mercury TMDL Implementation Plan. The rules:

- § define an actual emission threshold of 3 lb/yr. above which facilities are subject to the rules;
- § codify the mercury emission target of 789 lb/yr. by 2025;
- § carry forward the TMDL implementation plan’s strategy for facilities to prepare reduction plans;
- § institute an annual emission inventory for larger emitters; and
- § adopt federal regulations and compliance language for several sectors where EPA rules include mercury limits among the other pollutants regulated by these standards.

The statewide mercury TMDL established a target of 24 lb/yr. for discharges directly to water. Discharges remain below this level. The MPCA has a permitting strategy for addressing mercury in municipal and industrial wastewater permits to ensure that the goal continues to be met (<http://www.pca.state.mn.us/index.php/view-document.html?gid=1281>)

Progress Toward Meeting the 2025 Statewide Mercury TMDL Goal



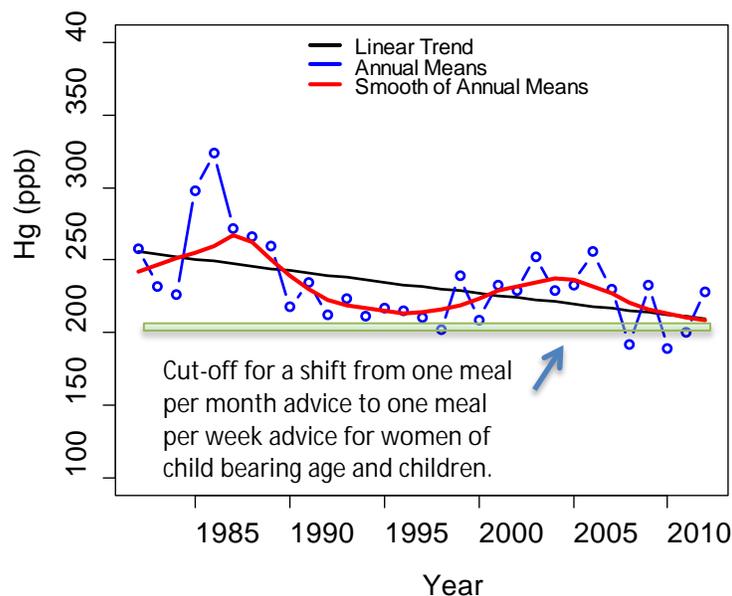
The graphic above shows dramatic mercury emission reductions from the coal-fired electric power generation sector between 2005 and 2018. The reductions account for the Mercury Reduction Act of 2006 including power plant conversions from coal to natural gas. The non-ferrous mining sector’s emissions are expected to increase by 2018 as new facilities come on line and mercury control technology is tested. New controls for mercury emissions at non-ferrous mining facilities are expected to be in place before 2025. Emissions inventory numbers for 2018 and 2025 are based on calculated projections, while the dotted black line represents the emissions goal for 2025. Reductions are needed from the category named “Largely resulting from the purposeful use of mercury” in order to meet the overall goal. This sector includes mercury containing products such as fluorescent lamps, mercury switches, dental amalgam, thermometers, etc. MPCA continues to focus reduction efforts and improve estimates on mercury in products which impact the emissions within this category.

All lakes and rivers within Minnesota will benefit from the reduction in mercury emissions from accomplishing the goals of the statewide TMDL implementation plan. The 2007 Statewide Mercury Total Maximum Daily Load (TMDL) demonstrated that mercury deposition was essentially uniform throughout the state and that deposition represented 99 percent of the mercury source to lakes and rivers in the state. Despite the uniform deposition of mercury, about 10 percent 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 continues through June 2017. MPCA continues to pursue additional funding from other sources for the remainder of the research. This will provide the information that is needed to complete and implement additional mercury TMDL(s) beyond the existing statewide TMDL.

Mercury concentration in Minnesota fish

An analysis of a 25-year record (1982-2006) of mercury in northern pike and walleye from Minnesota lakes found a downward trend until the mid-1990s and then an unexpected rise. After average mercury concentrations declined 37 percent from 1982 to 1992, they increased 15 percent between 1996 and 2006. The trend of mercury in fish was reanalyzed in 2013 with an additional six years of data from the fish contaminant monitoring program. The latest analysis shows another shift in the statewide trend. Over the 31 years (1982-2012), there was a downward trend in the average mercury concentrations. More explanation of the mercury trends in fish is available in the 2016 Clean Water Fund Performance Report <http://www.legacy.leg.mn>

Mercury Concentration Trends in Northern Pike and Walleye from Minnesota Lakes (1982-2012)



References/web links

For more information on mercury, see the following websites:

<https://www.pca.state.mn.us/quick-links/mercury>

<https://www.pca.state.mn.us/air/mercury-air-emission-reduction-and-reporting-amendments>

<https://www.pca.state.mn.us/sites/default/files/wq-iw4-02f6.pdf>

<http://www.epa.gov/mercury/>

Lead

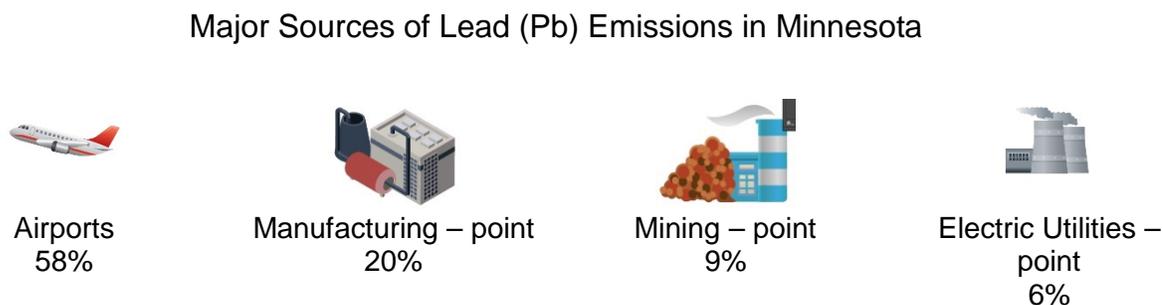
Lead is a metal found naturally in the environment as well as in manufactured products. In the past, the major sources of lead emissions were motor vehicles and industrial sources. Since lead in gasoline was phased out, air emissions and ambient air concentrations have decreased dramatically. Currently, metals processing (lead and other metals smelters) and aircraft using leaded fuel are the primary sources of lead emissions.

Scientific evidence about the health effects of lead has expanded significantly in the last 30 years. Exposures to low levels of lead early in life have been linked to effects on IQ, learning, memory and behavior. There is no known safe level 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. Ecosystems near sources of lead show many adverse effects including losses in biodiversity, changes in community composition, decreased growth and reproductive rates in plants and animals, and neurological effects in animals.

Emissions data and sources

The MPCA estimate for statewide emissions of lead in 2014 is 19 tons. The total mass of lead emitted is much less than the other criteria pollutants. However, it takes only a small amount of lead to cause serious and permanent health problems. Therefore, even relatively low lead emissions are a concern. The table below shows sources of 2014 lead emissions.



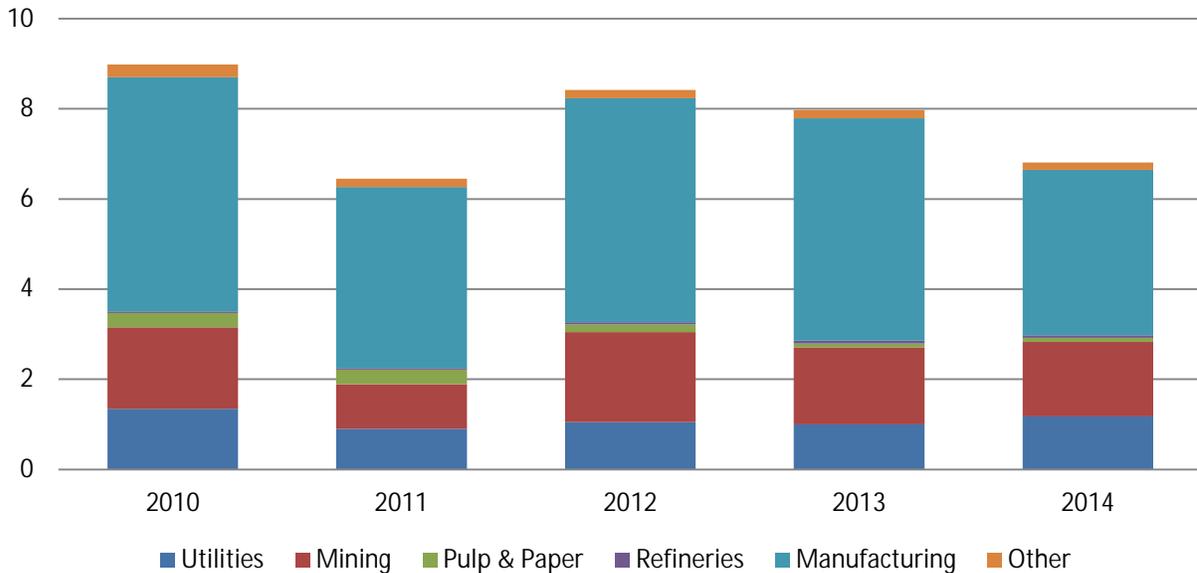
The graphic above shows the approximate percentage of lead from major source categories in Minnesota. Point source data are from 2014 emission inventory, all other data are from the 2011 emission inventory.

Manufacturing facilities contribute 20 percent of Minnesota’s lead emissions. These point sources include metal processing and some combustion of waste and coal. General aviation aircraft emit 58 percent of lead emissions from burning leaded fuel. Taconite mining and electric utilities add an additional nine and six percent respectively of lead to the environment.

Trends

Point sources contribute 35 percent of the state's lead emissions. Increases in lead emissions from manufacturing and taconite mining resulted in increased lead emissions in 2010 from previous years. In 2011, there was a slight decrease in lead emissions due to decrease in manufacturing emissions, taconite mining, and electric utilities. In 2012, lead emissions rebounded to 2010 levels. There was a decrease in lead emissions in 2013 and 2014 due mainly to decreases in manufacturing and mining.

Lead Point-Source Emission Trends by Sector
in Minnesota, 2010-2014



References/web links

For more information on lead, see the following websites:

<http://www3.epa.gov/airquality/lead/>

<http://www3.epa.gov/airtrends/lead.html>

<https://www.pca.state.mn.us/air/lead-homes>

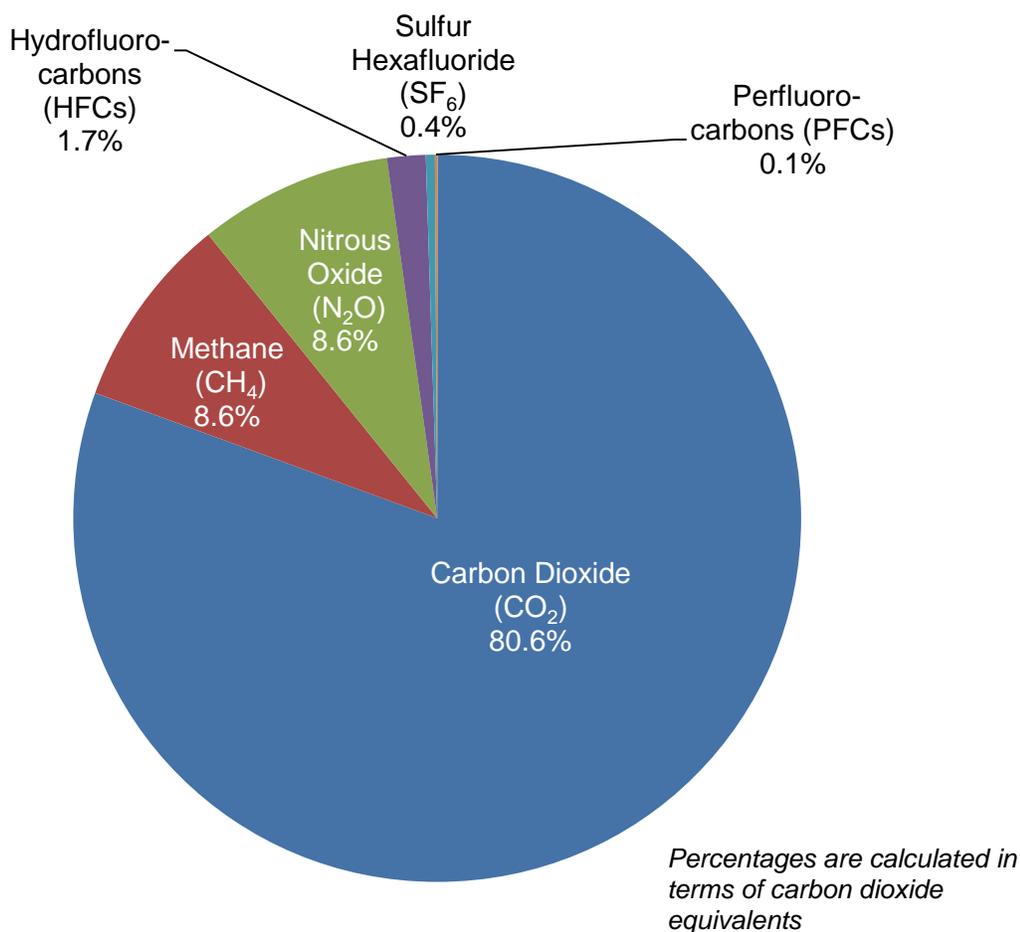
<http://www.health.state.mn.us/divs/eh/lead/index.html>

Greenhouse Gases

Greenhouse gases (GHGs) are gases that, upon release to the atmosphere, 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. The most abundantly emitted greenhouse gas, CO₂, is mainly formed from the combustion of fossil fuels such as oil, natural gas and coal. In 2012, emissions of CO₂ amounted to more than 80 percent of Minnesota greenhouse gas emissions.

Emissions of GHGs are reported in terms of CO₂ equivalents (CO₂-e). CO₂-e compares the global warming potential of emissions of different gases to the impact of the emission of one ton of CO₂. The figure below shows the GHG emissions in Minnesota for 2012 as the percent of emissions from each type of GHG in CO₂-equivalent terms. Methane and nitrous oxide are emitted in smaller quantities than CO₂ but have much higher global warming potentials. The other gases are emitted in very small amounts, but are very potent GHGs. Of the total 2012 emissions in CO₂-equivalent terms, HFCs amount to 1.7 percent, SF₆ amounts to 0.4 percent, and PFCs amount to 0.1 percent.

Greenhouse Gas Emissions (CO₂e) in Minnesota, 2012

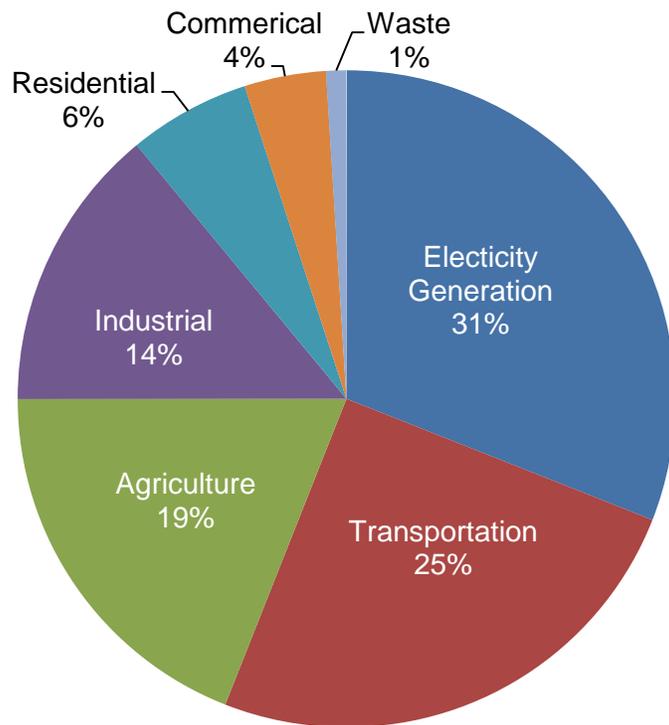


In 2012, Minnesota's GHG emissions were estimated to be 154.5 million CO₂-e tons. Most of Minnesota's GHG emissions are the result of using fossil fuel energy for electricity generation, transportation, heating, and other uses.

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. Agriculture is also a significant contributor to the statewide GHG emissions; major sources of agricultural emissions are crop production and livestock. The figure below shows GHG emissions by economic sector.

Sources of Greenhouse Gas Emissions in Minnesota, 2012
(Estimates include Net Imported Electricity in Minnesota)

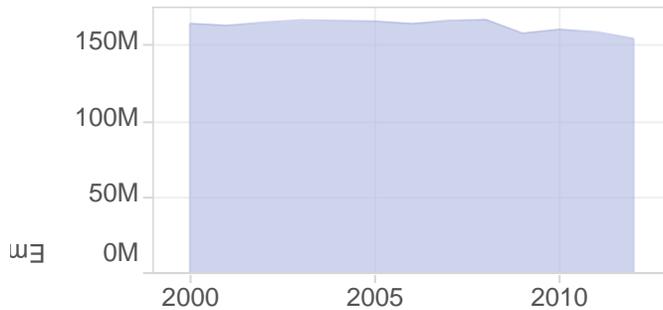


Percentages include carbon dioxide, nitrous oxide, methane, hydrocarbons, perfluorocarbons, and sulfur hexafluoride calculated in terms of CO₂ equivalents

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 2000, Minnesota's total greenhouse gas emissions have declined by about 6 percent. Each economic sector shows a unique trend in emissions.

Trend of total GHG emissions, 2000-2012
(Million CO₂-e tons)

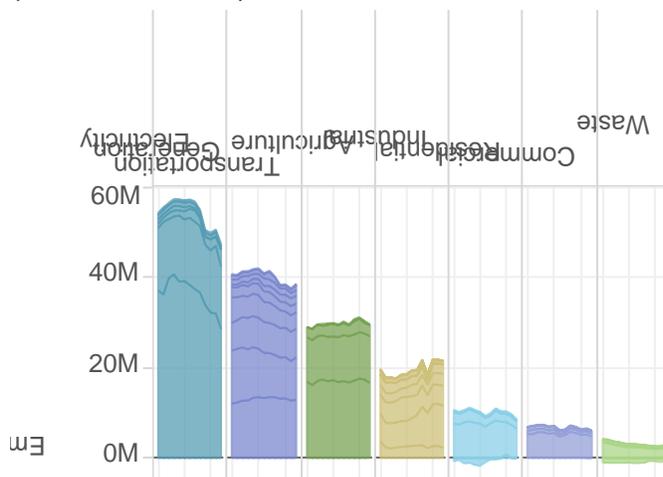


Electricity generation GHG emissions peaked in 2003 and 2004. Since 2000, electricity generation emissions have decreased by 13 percent. This decrease in emissions is attributed to renewable energy, replacement of coal-fired units with natural gas units, and a temporary closure at Xcel's Sherburne County facility.

Transportation GHG emissions peaked in 2005, and have decreased 5 percent since 2000 because new vehicles are more fuel efficient.

Agriculture GHG emissions have increased 2 percent since 2000 because of emissions from raising livestock.

Trend of economic sector GHG emissions, 2000-2012
(Million CO₂-e tons)



The residential and waste sectors each have a source of negative emissions because of carbon sequestered in new housing construction and demolition debris in landfills.

The Next Generation Energy Act of 2007 (Minn. Stat. § 216H.02) established a 2015 GHG emission reduction goal 15 percent below 2005 emissions, and longer term goals for 2025 (30 percent below 2005 emissions), and 2050 (80 percent below 2005 emissions). Between 2005 and 2012, GHG emissions from Minnesota declined by about 7 percent. An updated progress report will be available in January 2017.

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-0>

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. The majority of pollutants with MPCA emission estimates are part of EPA's hazardous air pollutant group. Federal rules require hazardous air pollutant emission inventories be completed every three years. The most recent completed inventory for Minnesota is for 2011. The inventory includes five principal source categories: point, nonpoint, mobile, fire and biogenic sources.

Point Sources: Typically large, stationary sources with relatively high emissions, such as electric power plants and refineries.

Nonpoint Sources: Typically stationary sources, but generally smaller sources of emissions than point sources. Examples include dry cleaners, gasoline service stations and residential wood-burning appliances. Nonpoint sources may also include a diffuse stationary source, such as open burning. These sources do not individually produce sufficient emissions to qualify as point sources. For example, a single gasoline station typically will not qualify as a point source, but collectively the emissions from many gas stations may be significant.

Mobile Sources: Mobile sources are broken up into two categories; onroad vehicles and nonroad sources. Onroad vehicles include vehicles operated on highways, streets and roads. In 2011, EPA used a new MOVES model to estimate onroad emissions. MOVES2014 estimates for 2011 emissions are lower than in 2008. EPA used new and additional source classification codes (SCCs). SCCs were aggregated at the vehicle and fuel level and did not include road class or emissions type. Nonroad sources are off-road vehicles and portable equipment powered by internal combustion engines. Lawn and garden equipment, construction equipment, aircraft and locomotives are examples of nonroad sources.

Fires: Fire emissions are defined as emissions produced by inadvertent or intentional agriculture burning, prescribed burning or forest wild fires. As in 2008, EPA used Satellite Mapping Automated Reanalysis Tool for Fire Incident Reconciliation version 2 (SFv2) to estimate 2011 emissions. SFv2 uses multiple fire information data sources for the development of fire emission inventory data. From 2008 to 2011, small improvements were made to SFv2, most significant being the collection of local activity data such as acres burned and types of fuel used, in order to make the emissions estimates more accurate. Fires vary greatly from year to year so it is difficult to make yearly comparisons.

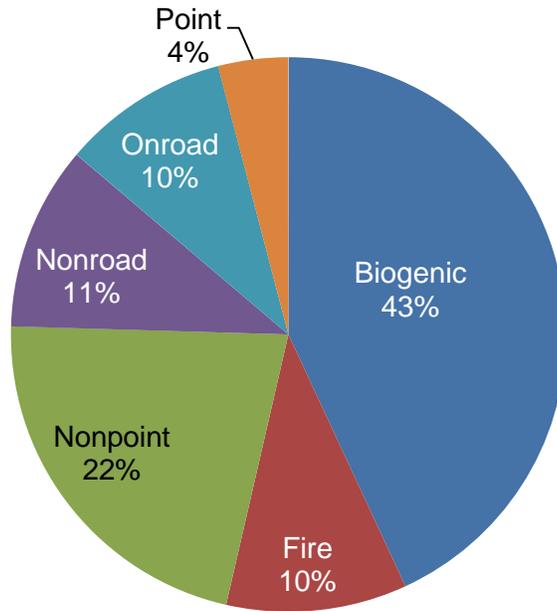
Biogenic: Biogenic emissions come from natural sources such as soils and vegetation. The emissions are widespread and contribute to background air chemistry. They are affected by vegetation, temperature and solar radiation. In 2011, biogenic emissions from air toxics totaled 76,000 tons.

MPCA staff compiled the emissions estimates for point and the majority of nonpoint sources in the 2011 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 estimated by EPA. Although for the 2011 Air Toxics emission inventory EPA includes emissions from biogenic sources in the nonpoint category; this causes a significant increase, and misrepresents nonpoint source emissions. In this report biogenic sources are report as its own separate category. For all nonroad equipment and onroad vehicles, MPCA used estimates from EPA's national inventory.

MPCA is developing an online workbook containing statewide information for both criteria pollutants and air toxics. It will include both 2008 and 2011 statewide emissions separated by source category and pollutants. Users will be able to extract SCC level information to make their own charts, graphs, and trends. The workbook will be placed at the following website. <https://www.pca.state.mn.us/air/air-emissions>

The following chart summarizes directly emitted air toxics pollutant emissions in Minnesota from 2011. It does not include the secondarily formed pollutants. Biogenic emissions contribute 43 percent and nonpoint source account for 22 percent of emissions. Onroad and nonroad mobile sources account for 22 percent of the emissions. Point sources contributed four percent and fires accounted for 10 percent of the total.

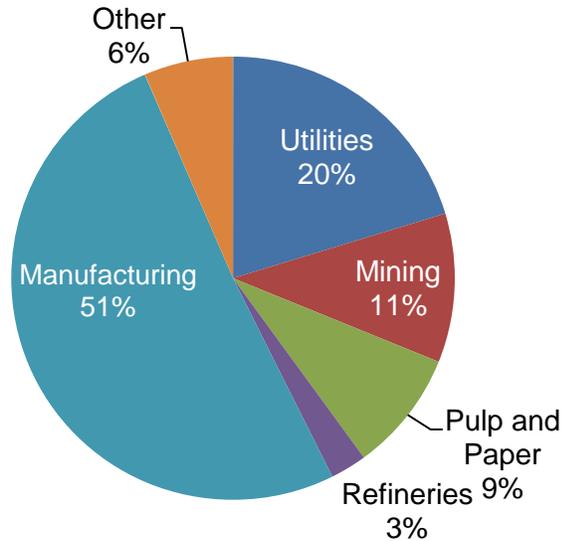
Major Sources of 2011 Air Toxics Emissions in Minnesota



Total air toxics emissions for 2011: 177,000 tons

A more detailed breakdown of emissions for each major source category is shown in the following five pie charts. For point sources, manufacturing dominates the air toxics emissions with 51 percent of the total. Electric utilities account for 20 percent of the point source emissions.

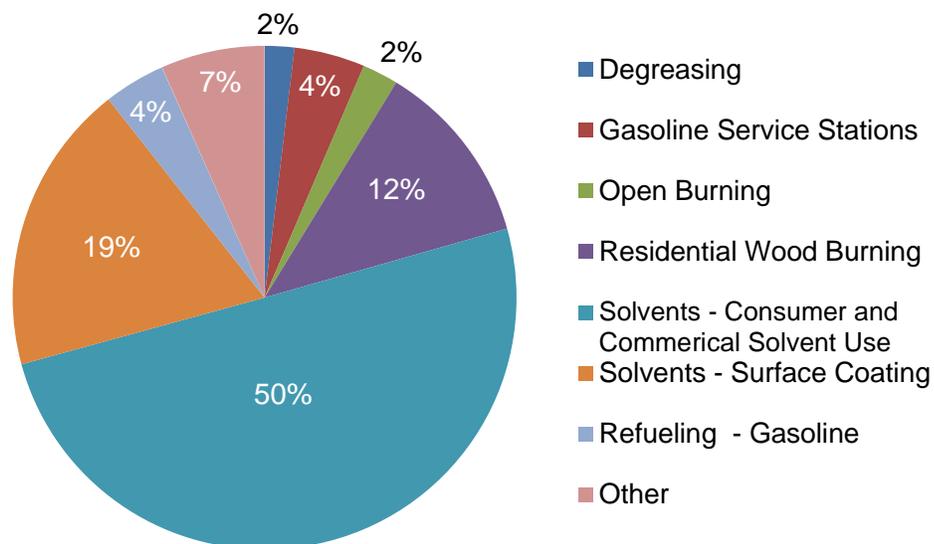
Contribution of Major Categories to 2011 Point Source Air Toxics Emissions in Minnesota



Total air toxics point source emissions in 2011: 8,900 tons

For nonpoint sources, 50 percent of emissions come from consumer and commercial solvent use. Other significant source categories were residential wood burning, and surface coating.

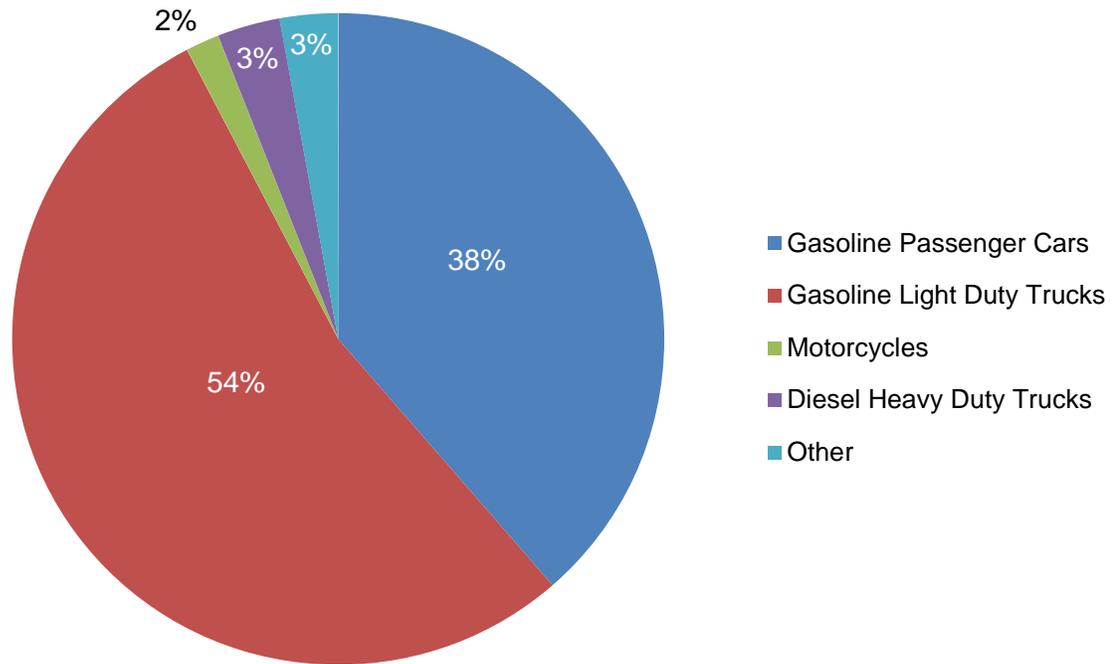
Contribution of Major Categories to 2011 Nonpoint Source Air Toxic Emissions in Minnesota



Total air toxic nonpoint source emissions in 2011: 39,000 tons

For onroad mobile sources, the largest emission contributor is light duty gasoline trucks, which accounts for about 54 percent of the total mobile source emissions in 2011. The second largest contributor of onroad mobile source emissions is light duty gasoline vehicles, which accounts for another 38 percent of mobile source air toxics emissions.

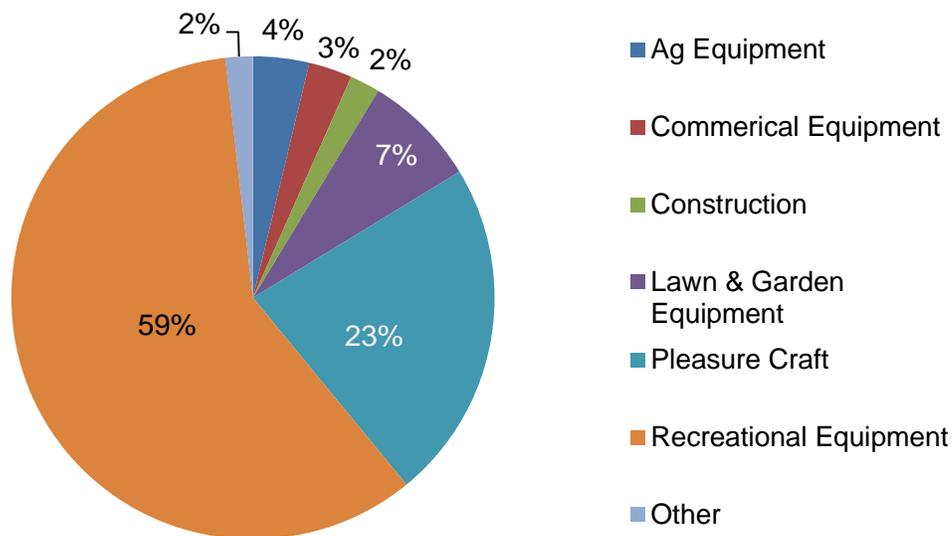
Contribution of Major Categories to 2011 Onroad Mobile Source Air Toxics Emissions in Minnesota



The total onroad mobile source emissions in 2011: 17,000 tons

For nonroad mobile sources, the largest emission contributor is recreational equipment (all-terrain vehicles, snowmobiles, etc.), which accounted for 59 percent of all of the emissions. The second largest contributor is pleasure craft which accounted for another 23 percent of the emissions.

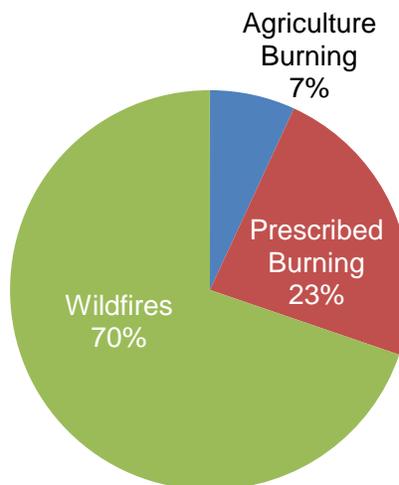
Contribution of Major Categories to 2011 Nonroad Mobile Source Air Toxics Emissions in Minnesota



The total nonroad mobile source emissions in 2011: 19,000 tons

Wild fires accounted for 70 percent of total emissions while 23 percent of emissions can be attributed to prescribed burning, and the rest to agricultural burning. To estimate 2011 emission, EPA relied on the Satellite Mapping Automated Reanalysis Tool for Fire Incident Reconciliation version 2 (SFv2). Fires show greater variability between years which makes year to year comparisons hard to do.

Contribution of Major Categories to 2011 Air Toxics Emissions from Fires in Minnesota



The total fire category emissions in 2011: 18,700 tons

Biogenic emissions come from natural sources such as vegetation. EPA estimates biogenic sources from vegetation and soils, emissions from other natural sources such as volcanos and lightening are not included. Biogenic emissions are estimated using a model which utilized spatial information on land use and vegetation and combines it with temperature and solar rotation. Biogenic emissions are found everywhere in the environment and are contributors to background air chemistry. Because of their widespread presence they need to be accounted for in the photochemical models. In 2011, biogenic emissions from air toxics in Minnesota totaled 76,000 tons.

For more information on air toxics, the Minnesota Air Toxics Emission Inventory and the Great Lakes Air Emissions Inventory, see the following websites:

<https://www.pca.state.mn.us/air/air-toxics-minnesota>

<https://www3.epa.gov/ttnchie1/net/2011inventory.html>

Chapter 2: 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 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 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 stream flow.

Minnesota has been successful in controlling end-of-pipe discharges to our state's waters from wastewater treatment plants and industries. But 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 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 Total Maximum Daily Load (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.

At the state level, the Clean Water, Land and Legacy Amendment to the state constitution increased the state sales tax by three-eighths of a percent beginning July 1, 2009 through 2034. According to the law, 33 percent of the money raised is to be allocated to a Clean Water Fund. Money deposited into the fund may be spent only to protect, enhance and restore water quality in lakes, rivers and streams, and to protect groundwater from degradation. The Legislature appropriated \$182.5 million of Clean Water Funds for water activities during fiscal years 2014-2015 and \$228.3 million for fiscal years 2016-2017.

Minnesota agencies released the most recent Clean Water Fund Performance Report in February 2016 to help Minnesotans make connections between Clean Water Funds invested, actions taken and outcomes achieved in fiscal years 2010-2015. Report measures provide a snapshot of how Clean Water Fund dollars are being spent and what progress has been made. The measures are organized into four types: Environmental and Drinking Water, Partnership and Leverage, Organizing and Performance and Financial Measures. Each measure has detailed status ranking and trend information. For a link to the report and more information on the Clean Water Fund, please see the following web site:

<http://www.legacy.leg.mn/funds/clean-water-fund>

Water Discharge Quality and Trends

This year's report contains surface water discharge data from municipal and industrial wastewater point sources for flow and five measures of water pollution covering the years 2000-2015. Summaries of pollutant loads discharged by 945 facilities—581 domestic wastewater and 364 industrial facilities—are included. Maps on the next two pages show the distribution of municipal wastewater treatment facilities by size and the distribution of various types of industrial facilities found in Minnesota. A map of wastewater flow by major watershed for 2015 is also included.

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 waste stream and facility type characteristics. 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.

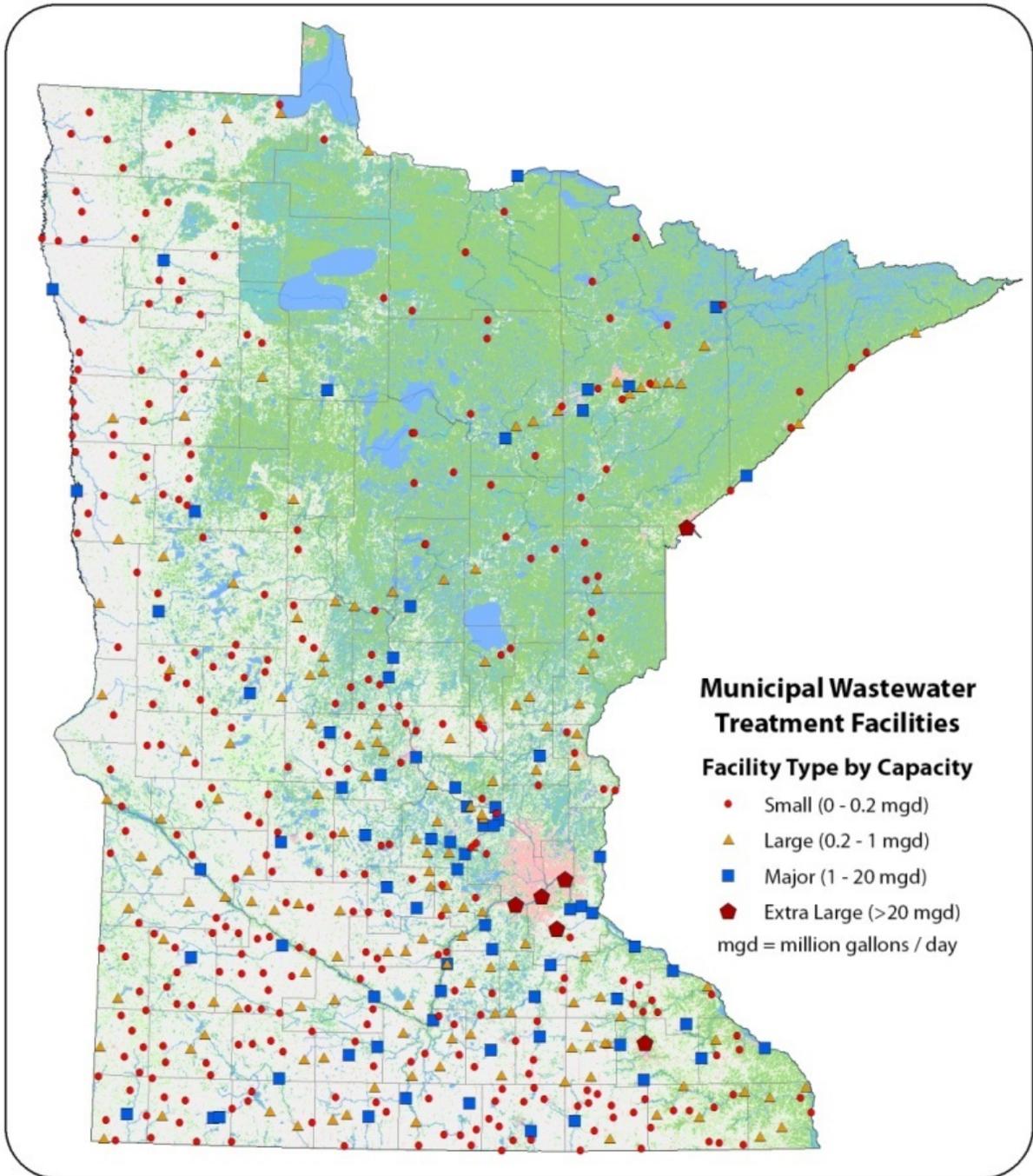
2015 effluent flow and pollutant loading estimates for NPDES permitted facilities exclude once through non-contact cooling water data from power generation facilities. Extremely large volumes of (primarily) river water are used by the power industry for cooling purposes. These once through non-contact cooling waters are discharged with the addition of heat, but 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.

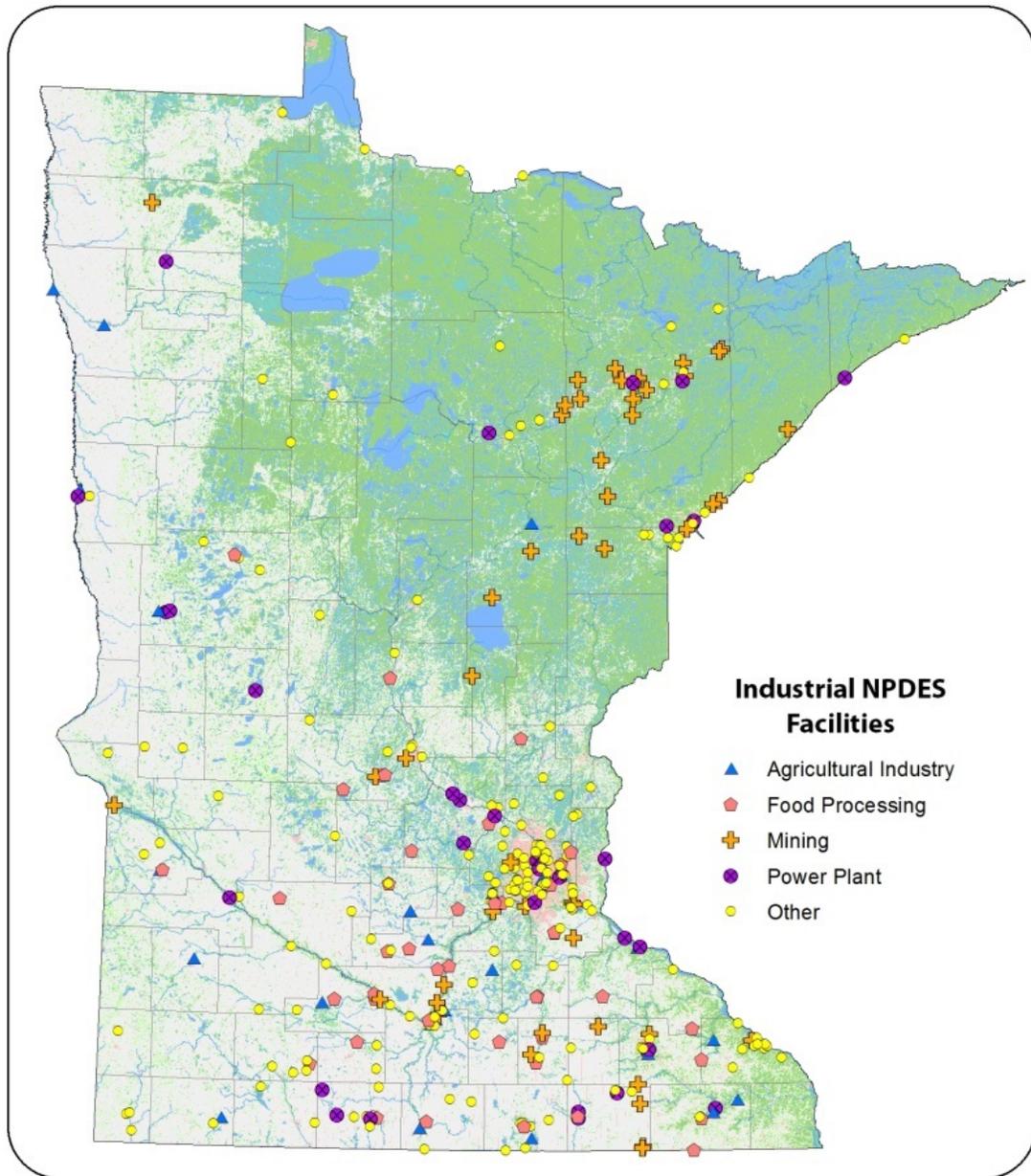
Prior to 2014, the wastewater sections of MPCA's Pollution Reports to the Legislature were based on data reported by approximately 99 major wastewater dischargers. These are facilities permitted to discharge at least 1 million gallons per day and account for approximately 85 percent of the volume of 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.

Five common chemical parameters found in wastewater treatment plant effluent are highlighted in this report, including: total suspended solids (TSS), biochemical oxygen demand (BOD), total phosphorus (TP), total nitrogen (TN) and mercury (Hg). Effluent flow volumes are also included in this report and are discussed in the Introduction and Summary section on pages 4-9 of this report. Long-term trends for the five chemical parameters are measured as a percent change from a 2000-2001 baseline.

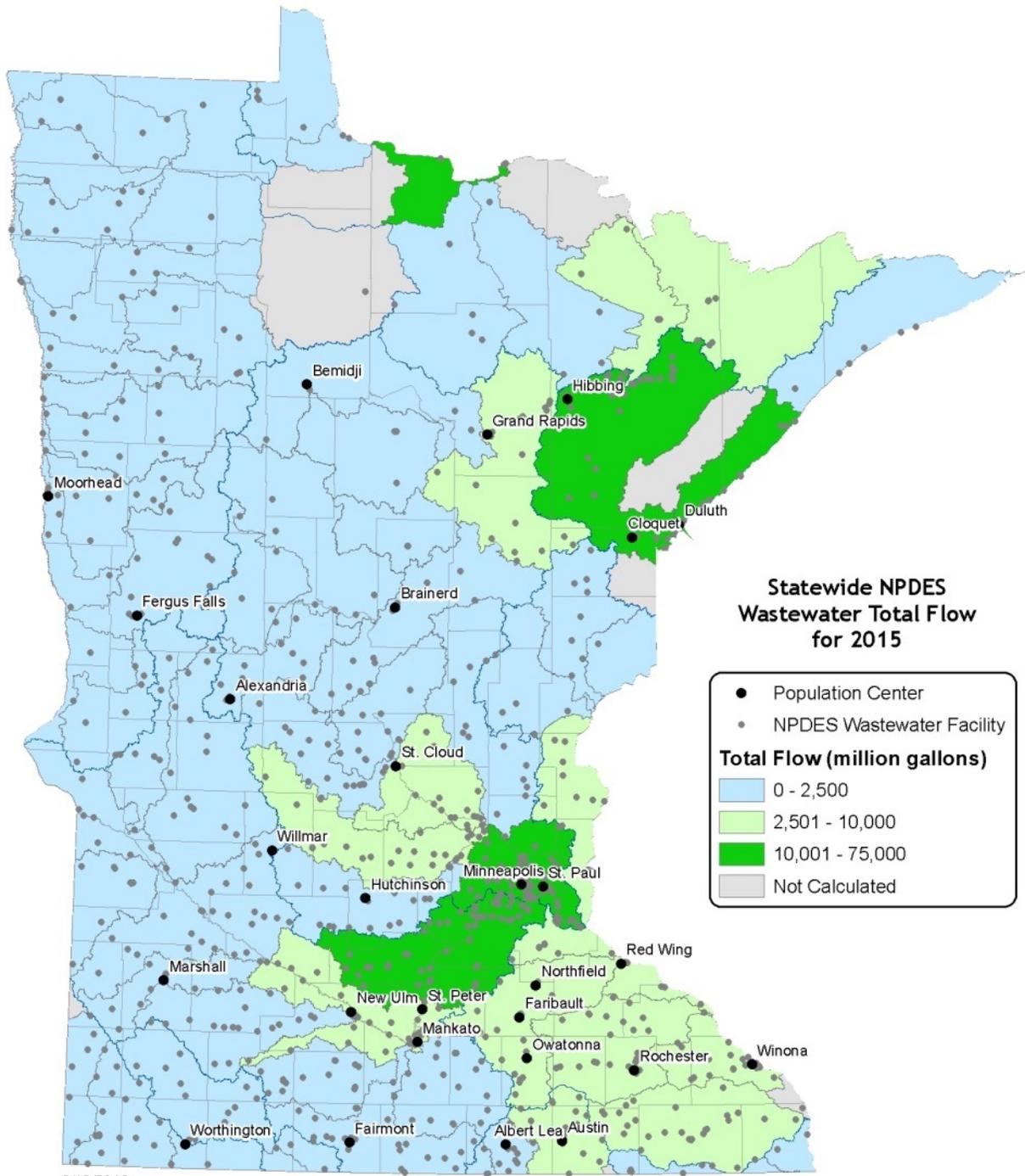
Distribution of Municipal Wastewater Facilities by Size



Distribution of Industrial Wastewater Dischargers by Type



Wastewater Flow by Major Watershed for 2015

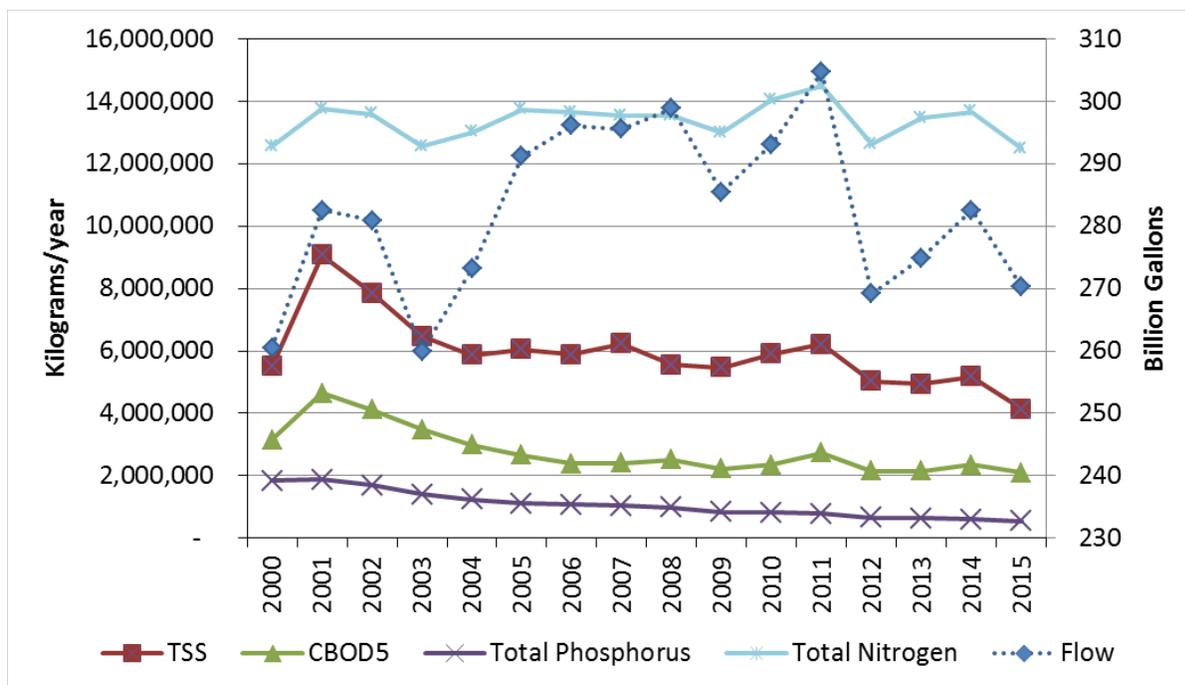


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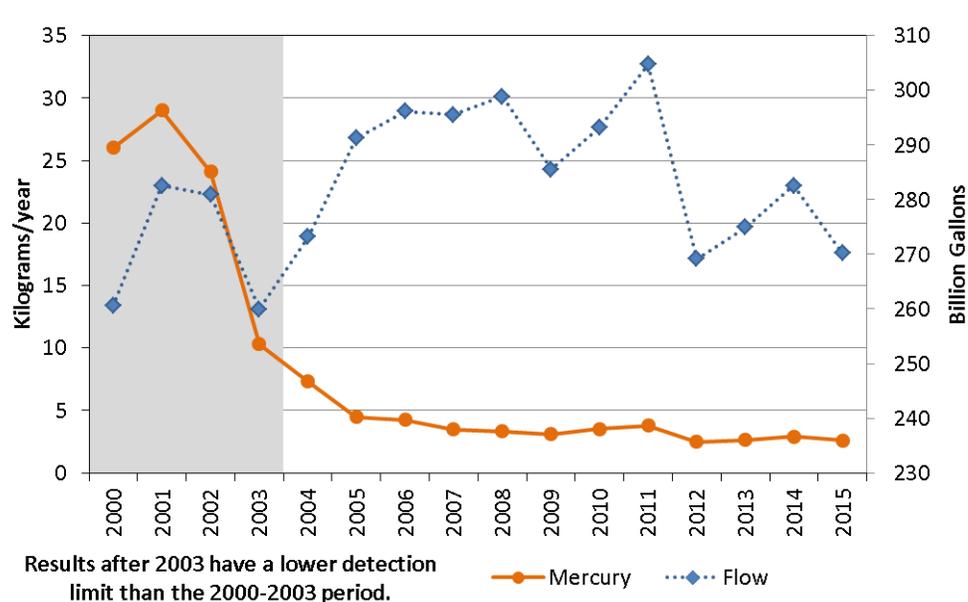
Pollutant Loading Trends

Flow and pollutant loading trends are shown in the following figures with pollutant loading shown as kilograms and flow in billion gallons.

Pollutant Loading Trends from NPDES Wastewater Facilities, 2000-2015



Mercury Loading Trends From NPDES Wastewater Facilities 2000 – 2015



Total Suspended Solids

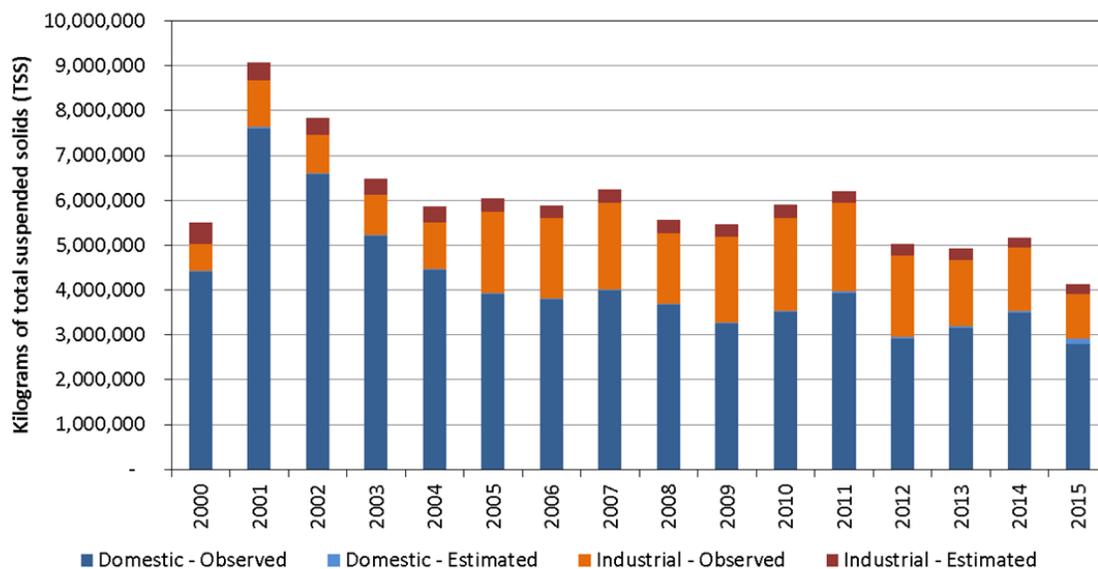
Total suspended solids (TSS) is a measure of the material suspended in water or wastewater. TSS cause interference with light penetration, buildup of sediment and potential degradation of aquatic habitat. Suspended solids also carry nutrients that cause algal blooms that are harmful to fish and other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

The TSS load for 2015 was 4,140 metric tons, a 20 percent decrease from the 2013-14 average. On average the data show an annual 5 percent reduction in TSS loads from a 7,265 metric ton per year baseline in 2000/2001.

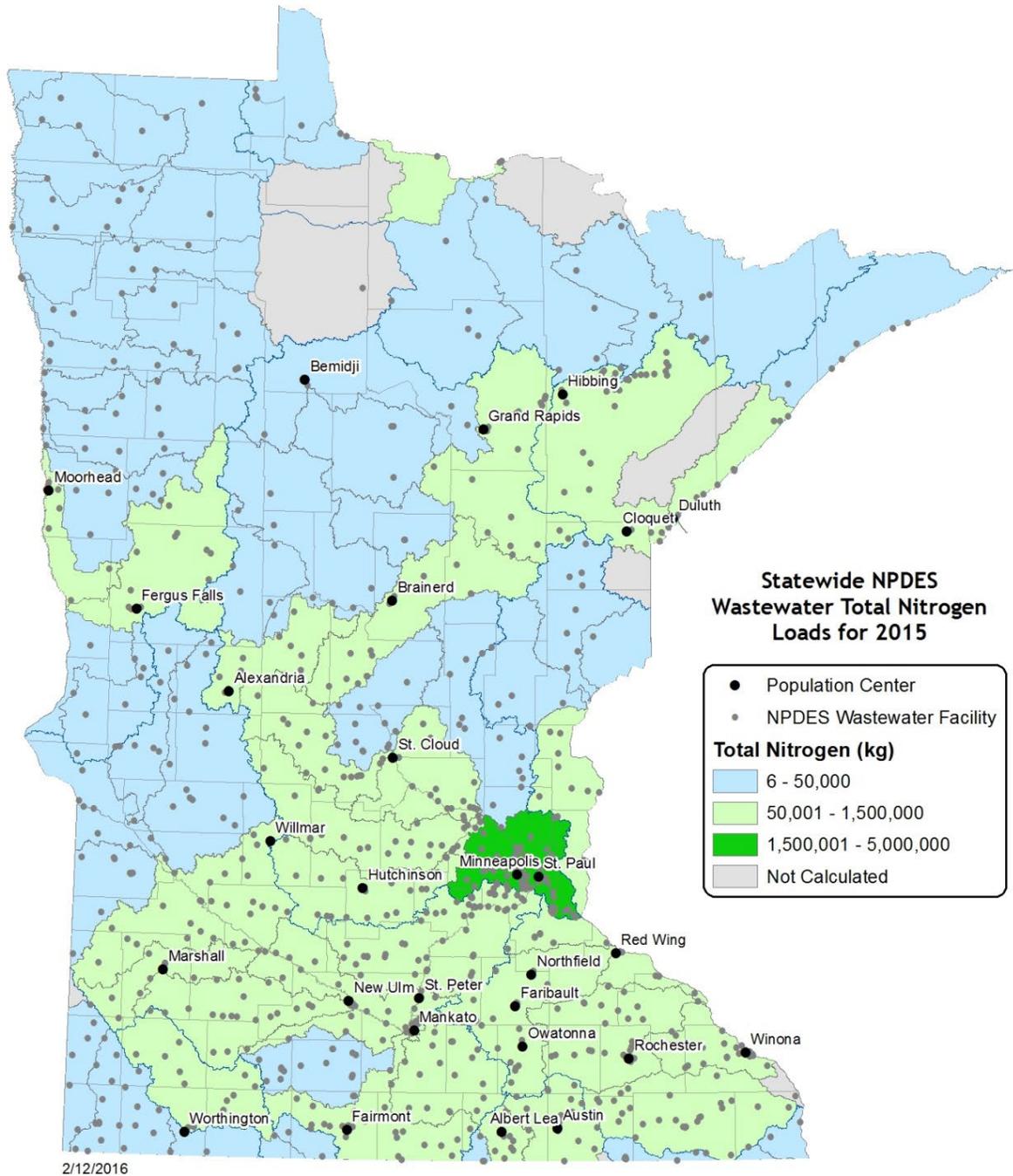
Wastewater TSS data are considered reliable, with 95 percent of loads resulting from observed data points. On average, 82 percent of wastewater TSS loads are discharged by major facilities although the proportion of TSS loads discharged by major facilities has declined from an average of 86 percent from 2000 through 2003 to an average of 80 percent from 2004 through 2015. On average, municipal wastewater dischargers accounted for 82 percent of wastewater TSS loads from 2000 through 2003 while their proportion of wastewater TSS loading declined to an average of 65 percent from 2004 through 2015. Overall, wastewater TSS loads have declined from an average of 7,202 metric tons per year in the 2000 through 2003 period to an average of 5,465 metric tons per year from 2006 through 2015.

TSS is one of the most frequently monitored pollutants in wastewater. Most facilities contain technology based effluent limits (TBELS) which, for most waterbodies, are more restrictive than TSS water quality standards. As a result, most facilities are discharging below a concentration level of concern, wastewater TSS reductions are not generally necessary and long-term average TSS wastewater loading has remained relatively stable during the past decade. 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.

Annual Loading Values from Wastewater Treatment Facilities
for Total Suspended Solids (TSS), 2000-2015



Total Suspended Solids Loads from Wastewater Treatment Facilities by Major Watershed, 2015



Carbonaceous Biochemical Oxygen Demand (CBOD)

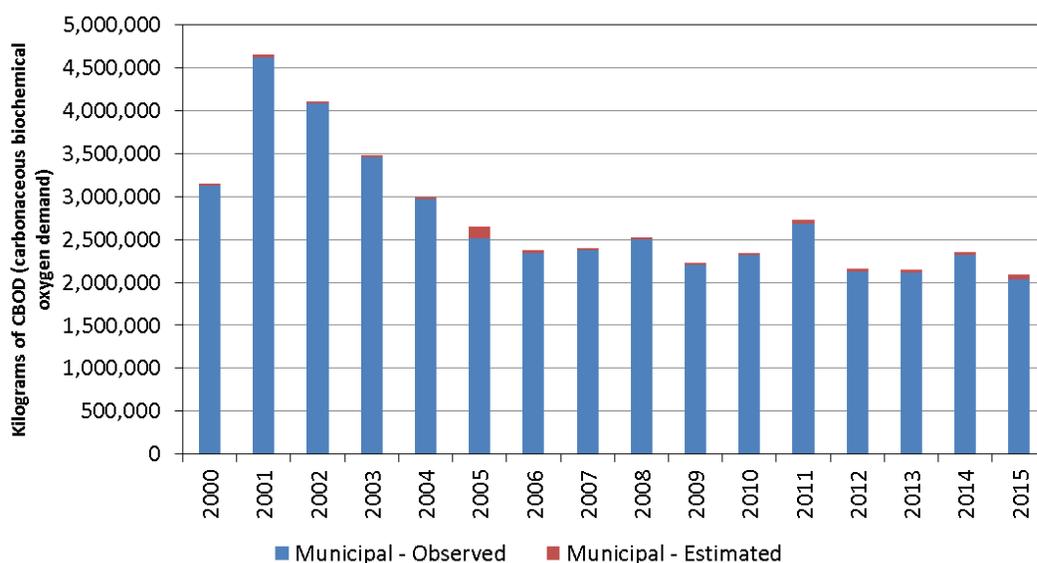
When organic wastes are introduced into water, they require oxygen to break down. High concentrations of organic materials characterize untreated domestic wastes and many industrial wastes. The amount of oxygen required for decomposition of organic wastes by microorganisms is known as the biochemical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

Municipal wastewater treatment facility limitations and reporting requirements are expressed as CBOD. Industrial dischargers most frequently report BOD which reflects the industry-specific requirements within federal regulations. For purposes of this report, CBOD 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 load could be significantly higher than the currently reported values because industrial flow accounts for nearly half of the flow within the state.

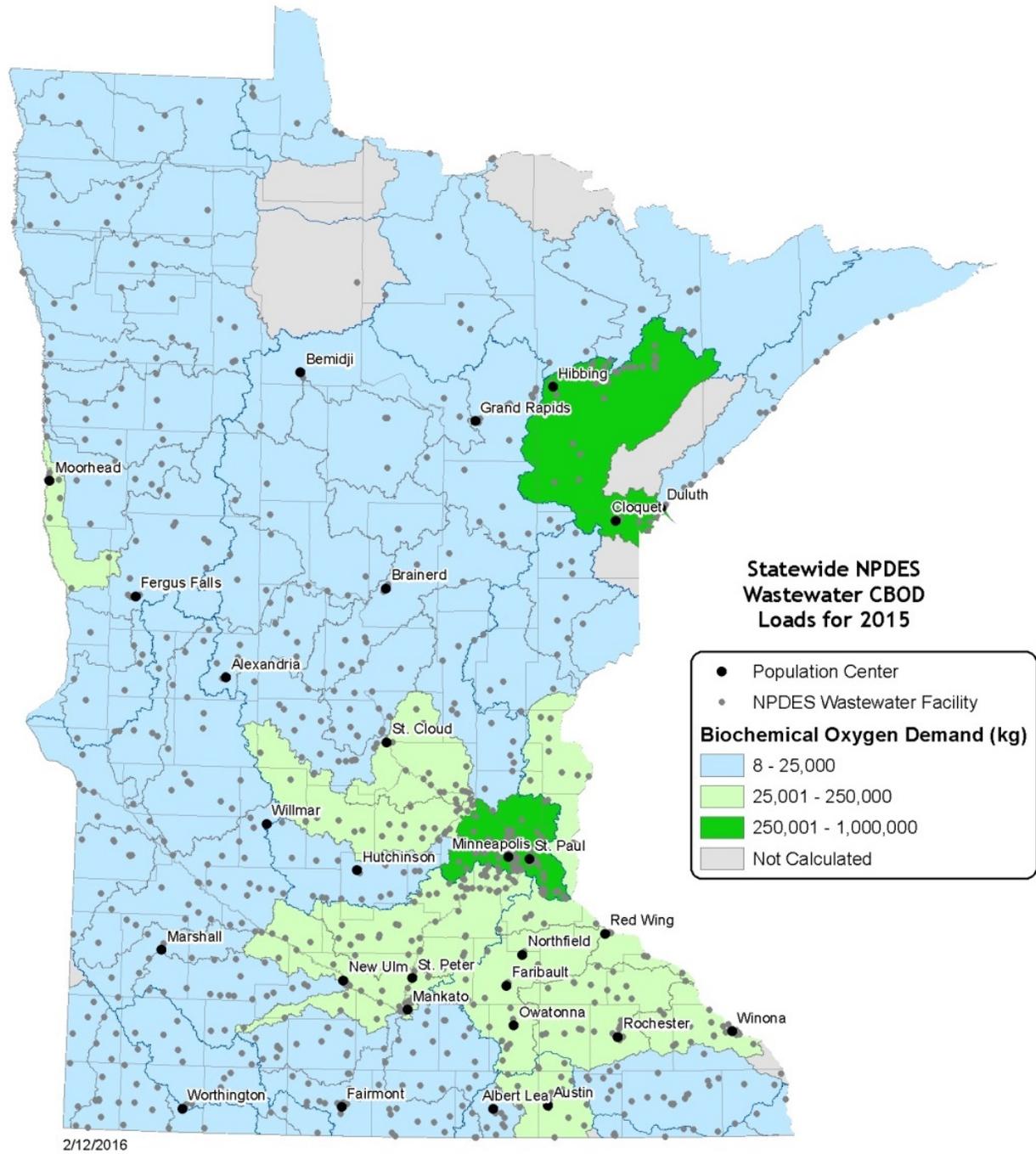
The total municipal CBOD load for 2015 was 2,087 metric tons, an 8 percent decrease from the 2013-14 average. On average the data show a 46 percent reduction in CBOD loads from a 3,146 metric ton per year baseline in 2000/2001.

Municipal wastewater CBOD data are considered reliable, with 99 percent of values resulting from observed data points. On average, 85 percent of wastewater CBOD loads are discharged by major facilities although the proportion of CBOD loads discharged by major facilities has declined from an average of 89 percent from 2000 through 2003 to an average of 83 percent from 2004 through 2015. Overall, wastewater CBOD loads have declined from an average of 3,838 metric tons per year in the 2000 through 2003 period to an average of 2,333 metric tons per year from 2006 through 2015.

Annual Loading Values for Carbonaceous Biochemical Oxygen Demand (CBOD) from Wastewater Treatment Facilities, 2000-2015



Carbonaceous Biochemical Oxygen Demand Loads from Wastewater Treatment Facilities by Major Watershed, 2015



Total Phosphorus

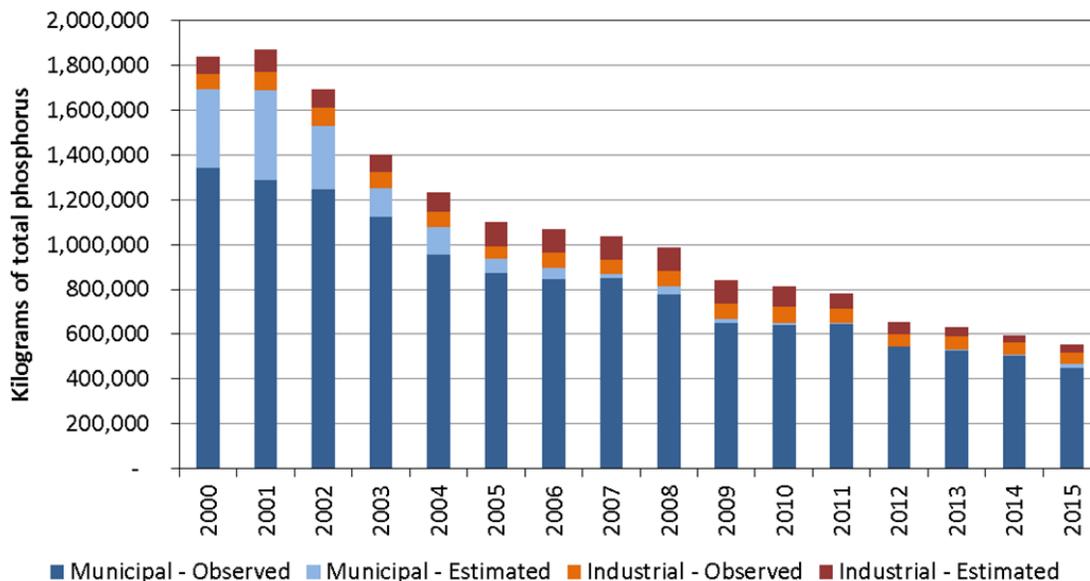
Total phosphorus (TP) is the primary pollutant associated with increased algae growth in Minnesota’s lakes and streams. Excess phosphorus from human activities causes algae blooms and reduced water transparency, making water unsuitable for swimming and other activities. Phosphorus is released from both point and nonpoint sources of pollution. Minnesota has had point source effluent limitations for phosphorus since the early 1970s.

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 Citizens Board adopted a strategy for addressing phosphorus in NPDES permits in 2000. Phosphorus loads were reduced by 50 percent from 2000-09 and have continued to decline since 2009. Overall, these efforts have resulted in a steady decline of phosphorus pollution.

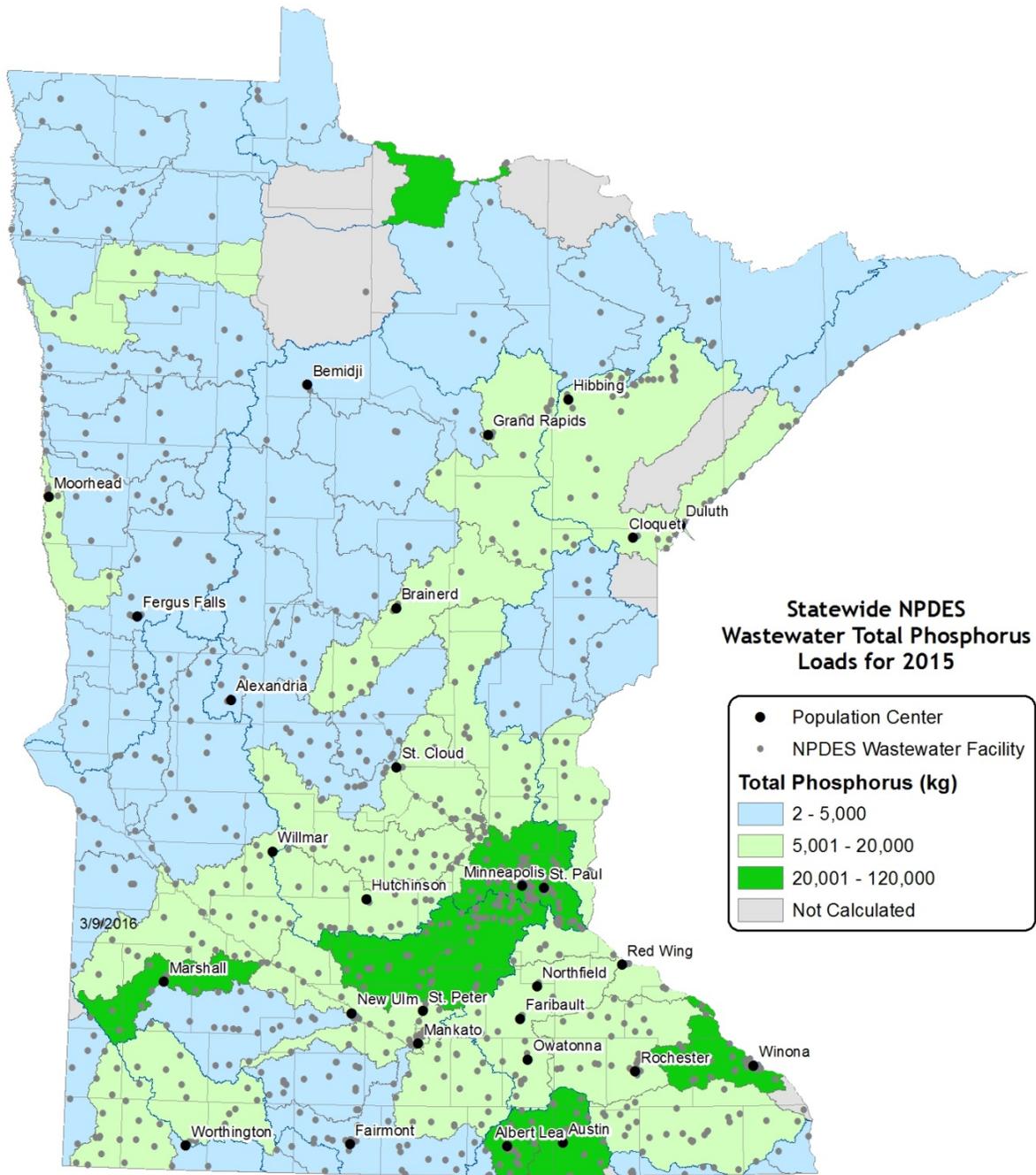
The 2015 total phosphorus load for the state was 544 metric tons, down 8 percent from the 2013-14 average of 615 metric tons. A 71 percent reduction in total phosphorus loads has been accomplished from a 1,855 metric ton per year baseline in 2000/2001.

Total phosphorus wastewater data are considered reliable, with 86 percent of loads resulting from observed data points. On average, 85 percent of wastewater total phosphorus loads are discharged by major facilities although the proportion discharged by major facilities has declined from an average of 88 percent from 2000 through 2003 to an average of 83 percent from 2004 through 2015. Municipal wastewater dischargers accounted for 90 percent of total phosphorus loads from 2000 through 2003 with their proportion of the loading declining to an average of 83 percent from 2004 through 2015. Overall, wastewater total phosphorus loads have declined from an average of 1,802 metric tons per year in the 2000 through 2003 period to an average of 1,086 metric tons per year from 2004 through 2008 and further to an average load of 670 metric tons per year from 2010 through 2015.

Annual Loading Values for Total Phosphorus from Wastewater Treatment Facilities, 2000-2015



Total Phosphorus Loads from Wastewater Treatment Facilities by Major Watershed, 2015



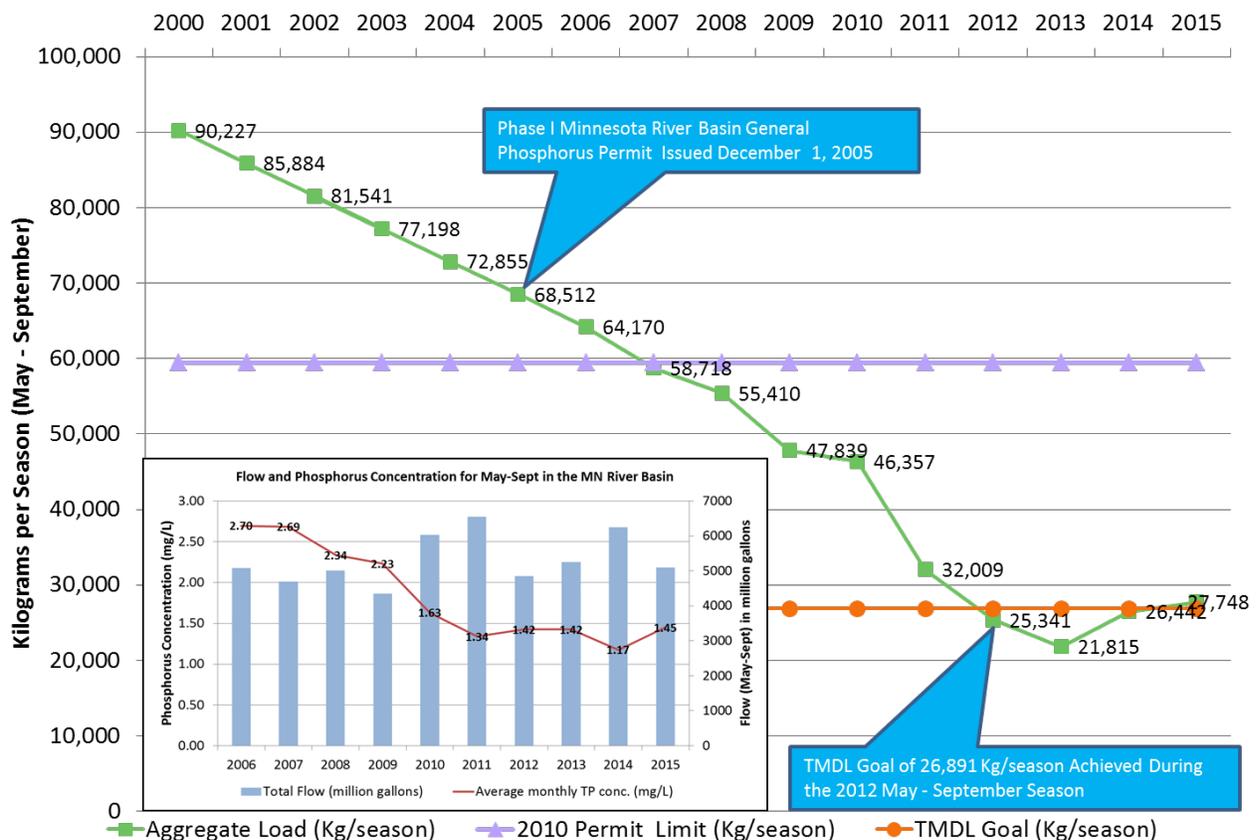
[Minnesota's 2014 Nutrient Reduction Strategy](#) identifies relative nutrient (phosphorous and nitrogen) source contributions to surface waters. The strategy also establishes nutrient reduction goals for both point and nonpoint sources. The phosphorous reduction goal in the Nutrient Reduction Strategy is:

- § Mississippi River: 45 percent reduction by 2025
- § Red River: 10 percent reduction by 2025
- § Lake Superior: no net increase

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 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 apply for coverage and receive a five-month (May-Sep) mass phosphorus limit. The permit required incremental reductions over time. The TMDL's phosphorous reduction goal was met by 2012. The figure below shows the phosphorus reductions required and achieved as a result of the Minnesota River Basin General Phosphorus Permit.

Minnesota River Basin General Permit Phosphorus Permit Reductions Required and Achieved

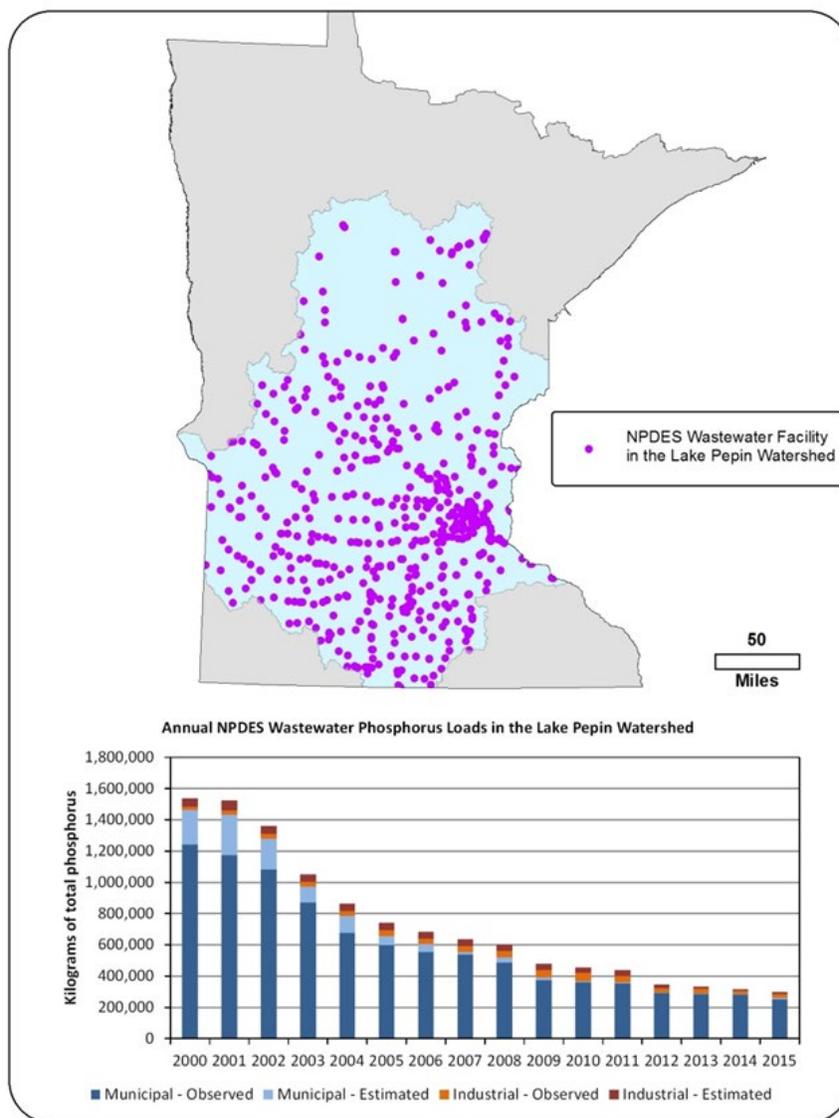


Lake Pepin Phosphorus Watershed Reductions

The Lake Pepin watershed covers a significant portion of the state and contains 82 percent of Minnesota residents. Lake Pepin is impaired due to excess nutrients and, although a Total Maximum Daily Load (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 the Phosphorus Rule in 2008 and eutrophication standards in 2008 and 2015. 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 issuing permit limits to ensure that the load will remain consistent with watershed goals in the future.

Annual Phosphorus Loads from Wastewater Treatment Facilities within the Lake Pepin Watershed, 2000-2015



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 suspended algae in rivers and streams. RES are used in conjunction with lake eutrophication standards (LES), which were approved in 2008.

In addition to effluent phosphorus limits required for new or expanding discharges and for facilities whose discharges affect lakes (Minn. R. 7053.0255), limits are increasingly being established to meet specific water quality targets defined in state numeric eutrophication standards (Minn. R. 7050.0222). Facilities discharging upstream of a waterbody that exceeds river eutrophication standards have greater potential to receive a more restrictive limit upon reissuance. However, some limits associated with downstream lakes are acceptable for rivers flowing through them. Limit determinations for individual facilities are made on a case-by-case basis.

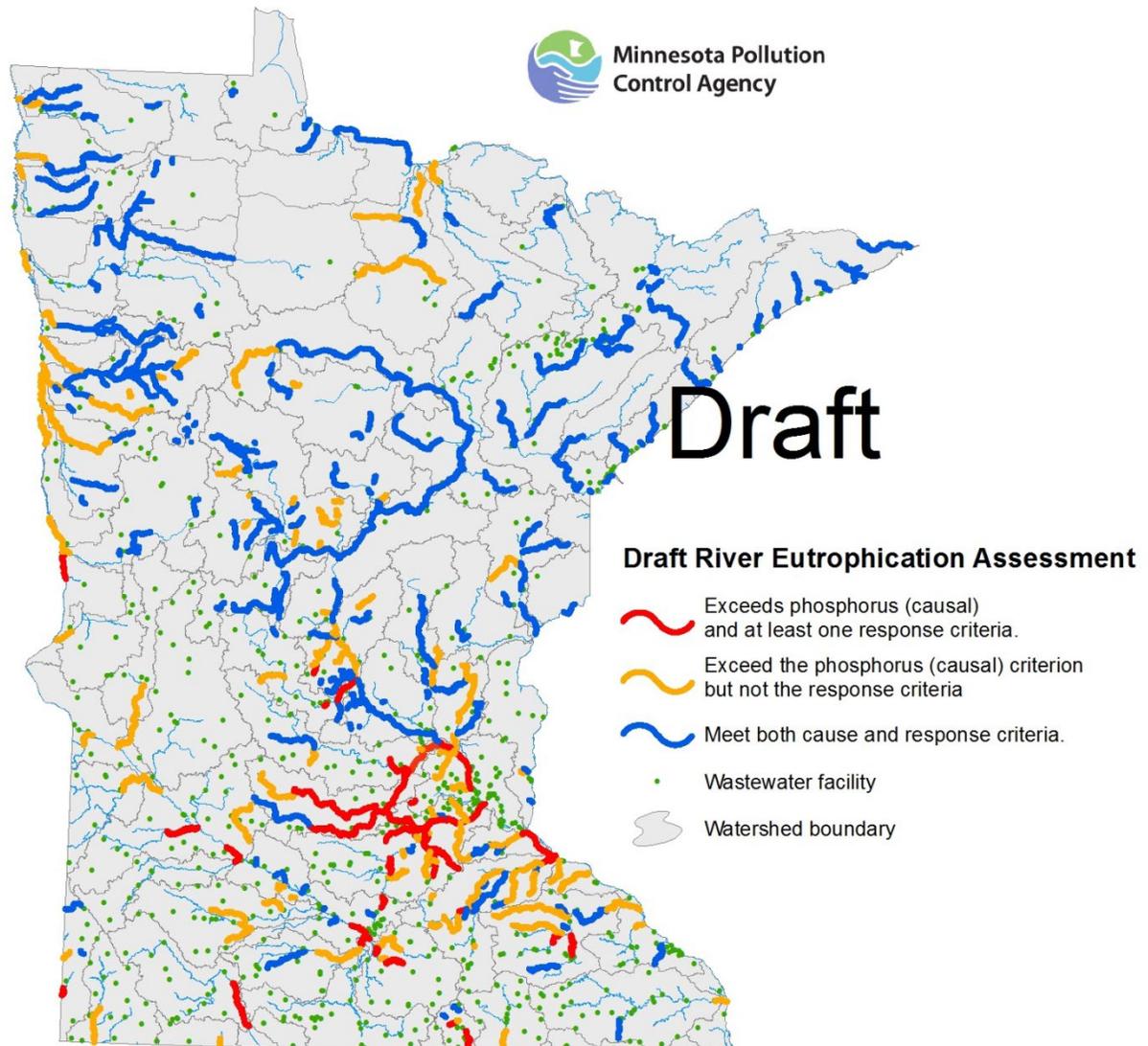
While limits for many pollutants are based on conditions of the immediate receiving water, eutrophication limits must consider water quality in a number of downstream waters. The MPCA outlines the analysis and calculations used to establish necessary phosphorus effluent limits in the following procedure.

<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 will be 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 map on the next page shows the waters identified in the draft river eutrophication assessment. The MPCA will provide a public comment opportunity before the draft assessment is finalized and sent to EPA for approval.

Waters Identified in the Draft River Eutrophication Assessment



This map shows the first draft statewide assessment for river eutrophication standards (RES), commonly considered nutrient or phosphorus standards. Rivers in red exceed both phosphorus and algae levels and will be listed as impaired. Facilities discharging upstream of these locations have a greater likelihood of receiving a more restrictive phosphorus limit following permit renewal. Water quality conditions are carefully examined and limits are determined on a case-by-case basis. Effluent concentrations necessary to meet potential limits may vary widely depending on the specific needs of a waterbody.

Total Nitrogen

Nitrogen in wastewater generally occurs as either nitrate or ammonia. Nitrogen as ammonia can be toxic to aquatic life and nitrogen in the form of nitrate can be a significant problem in drinking water supplies, and can also be toxic to aquatic life. Currently, permits require 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 (a measure of all forms of nitrogen including nitrate, nitrite, ammonia, and organic nitrogen) loads from point source discharges.

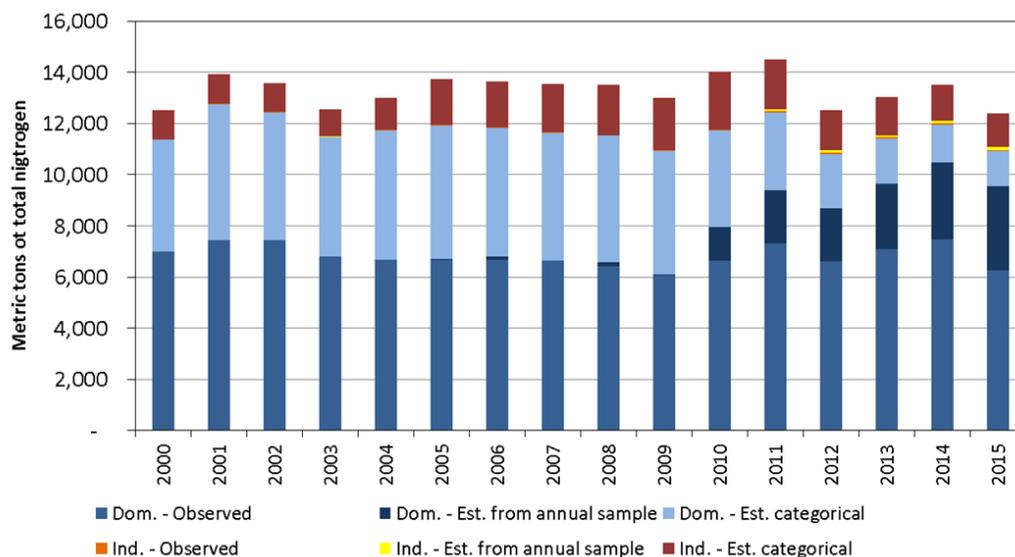
[Minnesota's Nutrient Reduction Strategy](#) defines a total nitrogen load reduction goal of 20 percent from discharges to the Mississippi River and 13 percent from dischargers to the Red River by 2025. As a first step in reaching this goal, additional monitoring for the nitrogen parameters will be added 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 2015 wastewater load for total nitrogen was 12,488 metric tons, a 7 percent decrease from the 2013-14 average.

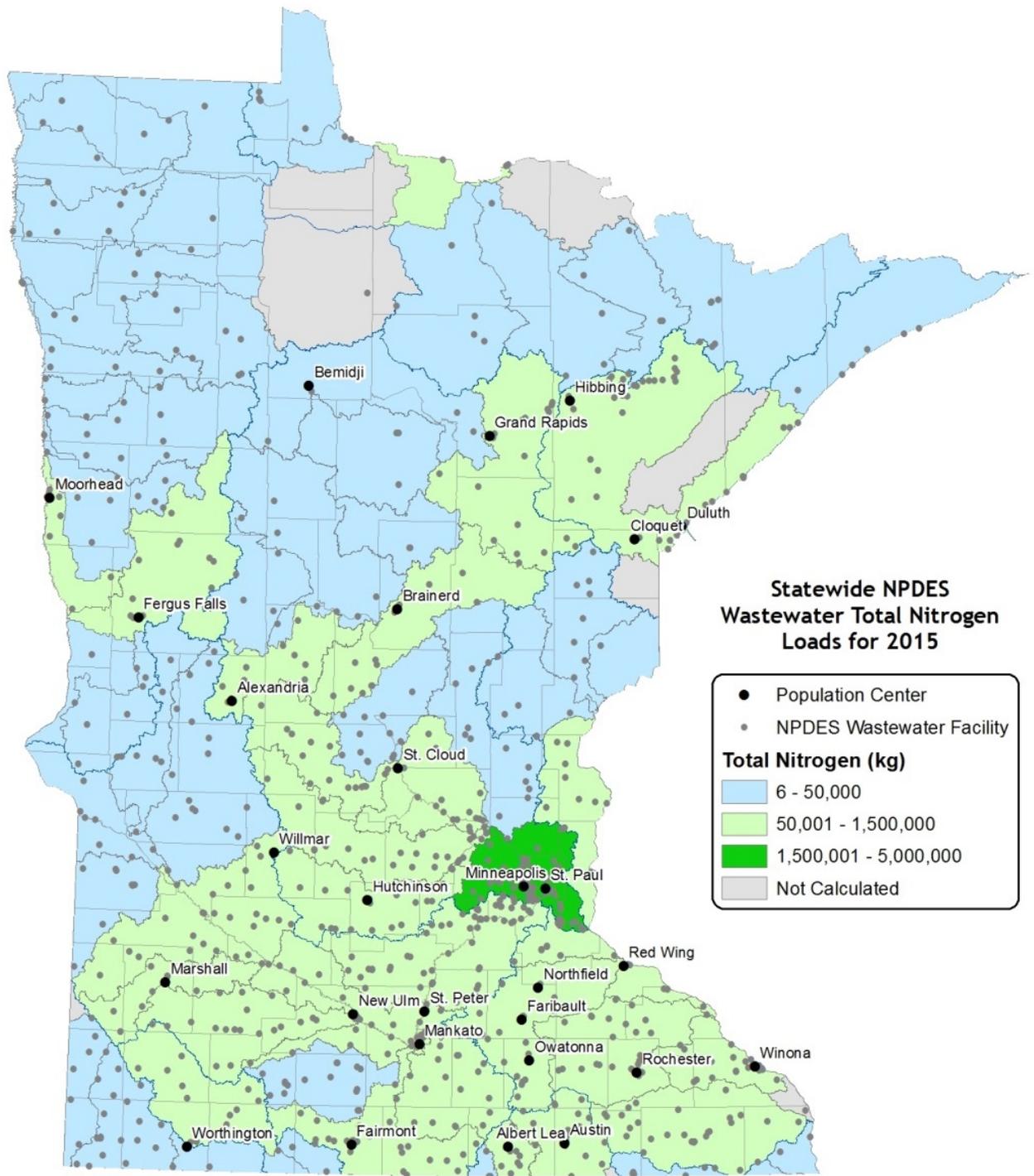
Total nitrogen wastewater data are not considered reliable, with only 51 percent of loads resulting from observed data points. On average, 92 percent of wastewater total nitrogen loads are estimated to be discharged by major facilities. Municipal wastewater dischargers account for 87 percent of total nitrogen. Overall, wastewater total nitrogen loads are estimated to have remained fairly stable at an average annual loading of 13,214 metric tons per year.

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 Service facilities. Increased monitoring by smaller facilities will reduce the amount of estimation in load calculations and provide a more accurate calculation of nitrogen loads in the future.

Annual Total Nitrogen Loads from Wastewater Treatment Facilities, 2000-2015



Total Nitrogen Load Estimates by Watershed for 2015



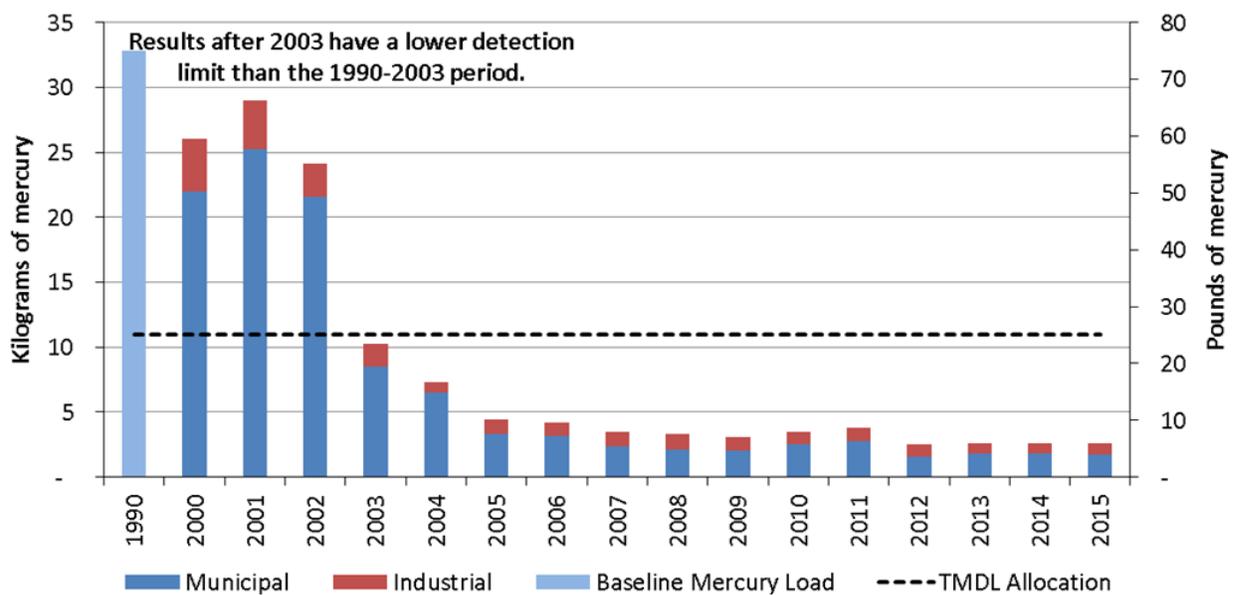
Total Mercury

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 2015 was 2.7 kg, a 0.3 percent increase from the 2013-14 average of 2.6 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 90 percent reduction in mercury loads from a 28 kilogram per year baseline in 2000/2001.

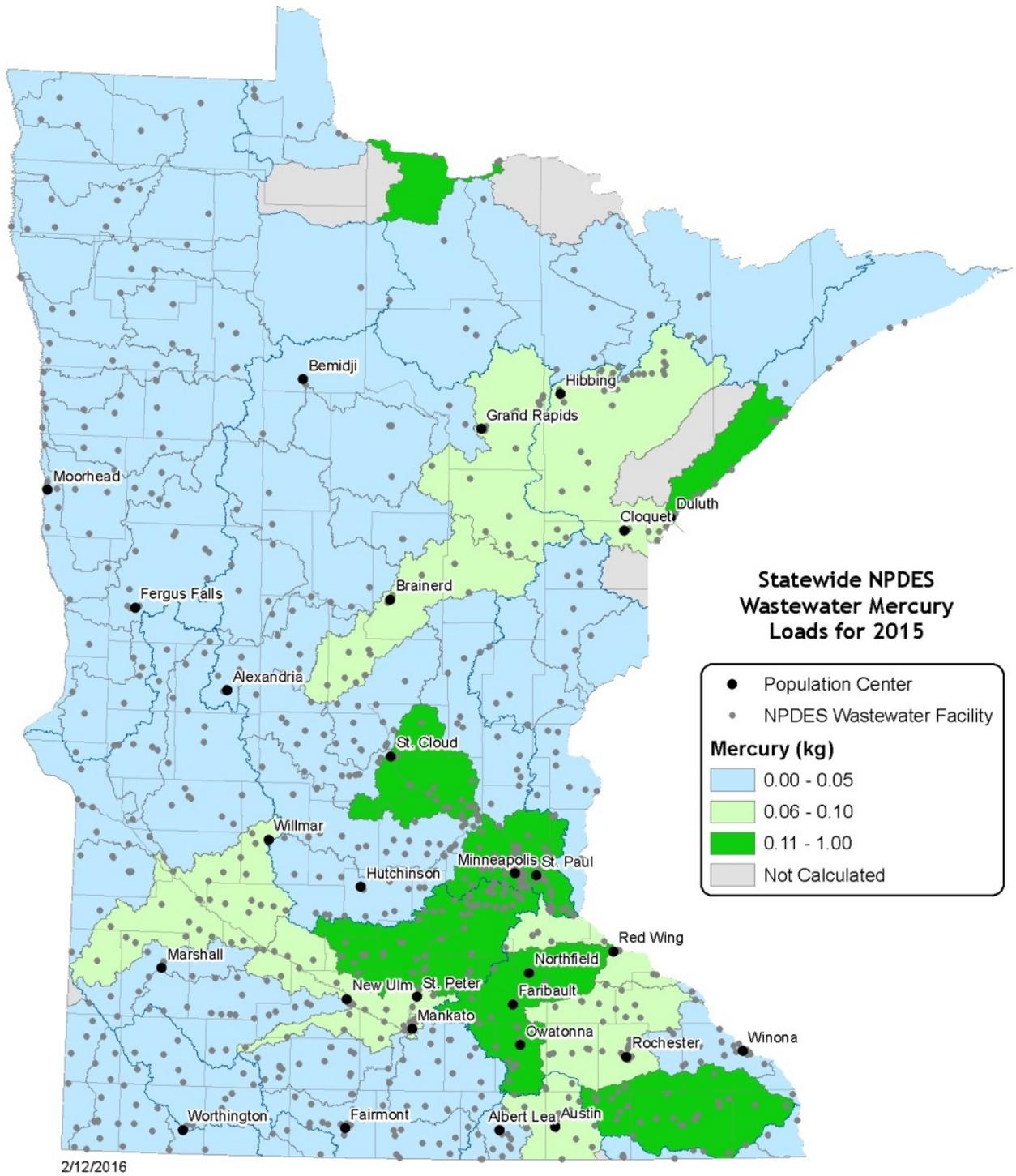
Total mercury wastewater data are considered moderately reliable with 82 percent of values resulting from observed data points. However, early mercury load estimates are considered unreliable due to the use of analytical methods with limited detection capabilities. Analytical laboratories started to provide more precise mercury detection methods since the 2003 or so. Low level mercury data reported since 2005 is considered to be more reliable.

On average, major wastewater dischargers have accounted for 87 percent of total mercury loads since 2005. Municipal wastewater dischargers are estimated to account for 40 percent since 2005. Overall, wastewater total mercury loads are estimated to have declined from an of 4.5 kilograms per year in 2005 to 2.7 kilograms per year in 2015.

Total Mercury Loads by Major Watershed since 1990



Total Mercury Load Estimates by Watershed for 2015



Nonpoint Source Pollution

As previously discussed, 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 pollution from rainfall or snowmelt moving over or through the ground carrying natural and human-made pollutants into lakes, rivers, wetlands and groundwater that now pose the greater challenge for prevention and cleanup. Both point and nonpoint sources of pollution must be controlled to reach the Clean Water Act and state goals of protecting human health and the environment. Despite significant improvements in recent years, too much phosphorus and nitrogen continue to reach many of our waters, carried in soil erosion and runoff from roads, yards, farms and septic systems.

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 pollution can be diffuse and 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 (BMPs). As described below, the Board of Water and Soil Resources (BWSR) reports the amount of nonpoint source pollutants (nitrogen, phosphorus and sediment) avoided by use of BMPs.

Many of the stresses from nonpoint sources of pollution that affect Minnesota's surface and groundwater resources are the result of choices that individuals make every day such as lawn care practices, watercraft operation and waste disposal. The daily decisions that homeowners, developers, farmers and businesses make regarding land use are crucial to protecting water resources from the effects of nonpoint source pollution. Once a water resource declines in quality, recovery is costly and can take many years. Clearly, prevention is the key when it comes to nonpoint source pollution. What happens to Minnesota's water resources in the next 10 years will help determine the quality of those resources for the next 100 years.

Focus on Sources of Nutrient Pollution

Multiple agencies and stakeholders in Minnesota are working together to address excessive levels of nutrients—primarily phosphorus and nitrogen—in Minnesota waters. Reductions in levels of nutrients are designed to protect both Minnesota and downstream waters, including both Lake Winnipeg and the Gulf of Mexico.

The MPCA, working in collaboration with the University of Minnesota and USGS, completed a study in 2013 to characterize total nitrogen loading to Minnesota's surface waters. The Minnesota Legislature provided funding for the study, which used more than 50,000 water samples collected at 700 streams sites, 35 years worth of monitoring data, and findings from 300 published studies. The resulting report, titled *Nitrogen in Minnesota Surface Waters – conditions, trends, sources and reductions*, provides a scientific foundation of information for developing and evaluating nitrogen reduction strategies.

The MPCA study showed elevated nitrate levels, particularly in the southern third of Minnesota. Elevated nitrate levels can be harmful to fish and aquatic life. Because much of the nitrate moves into rivers and streams from groundwater, it may also pollute drinking water wells. Also, nitrate loads leaving Minnesota via the Mississippi River contribute to the oxygen-depleted “dead zone” in the Gulf of Mexico. The dead zone cannot support aquatic life, affecting commercial and recreational fishing and the overall health of the Gulf.

Study results showed that more than 70 percent of the nitrate is coming from cropland with the rest coming from sources such as wastewater treatment plants, septic and urban runoff, forests and the atmosphere. Nitrate concentrations have steadily increased in the Mississippi since the mid-1970s.

Phosphorus is the primary pollutant associated with algae growth in Minnesota's lakes and streams. Excess phosphorus from human activities increase algae blooms and reduce water transparency, making waters unsuitable for swimming and changing the types of fish and other aquatic life.

In 2003 concerns about the phosphorus content of automatic dishwashing detergents prompted the passage of legislation requiring a comprehensive study of all of the sources and amounts of phosphorus entering publicly owned treatment works and, ultimately, Minnesota surface waters. The assessment conducted for the MPCA by Barr Engineering, with assistance from the University of Minnesota and others, estimated how much phosphorus enters Minnesota's lakes, wetlands, rivers and streams, and where it comes from in each of the state's 10 major watersheds (basins). The 2004 report can be found at:

<http://www.pca.state.mn.us/index.php/water/water-monitoring-and-reporting/water-qualityand-pollutants/phosphorus/detailed-assessments-of-phosphorus-sources-to-minnesota-watersheds.html>

This detailed source assessment has been updated twice since 2004.

Using results from the statewide nitrogen study, the phosphorus study and water conditions in the state, 10 Minnesota agencies and local partners developed a Nutrient Reduction Strategy to help guide state programs in achieving additional reductions in nutrients within Minnesota's waters. The strategy establishes nutrient reduction goals for both point and nonpoint sources of pollution. The strategy describes the changes needed to meet milestones and final goals for both nitrogen and phosphorus going into the Mississippi River, Red River and Lake Superior. Year 2025 nitrogen reduction milestones are 20 percent for the Mississippi River and 13 percent for the Red River. Preliminary analysis of data show that Minnesota is positioned to reduce its fair share of the phosphorus heading toward the Gulf of Mexico by 2025, but it will take longer to reach in-state goals for Minnesota's lakes and rivers.

More information on the statewide study of nitrogen in surface waters can be found at the following link:

<http://www.pca.state.mn.us/d9r86k9>. Please see www.pca.state.mn.us/nutrientreduction for additional information on phosphorus and Minnesota's Nutrient Reduction Strategy.

Minnesota Watershed Pollutant Load Monitoring Network

The passage of the Clean Water Land and Legacy Amendment and subsequent appropriations by the Legislature from the Clean Water Fund is enhancing monitoring of Minnesota waters, and our understanding of the relative contributions of pollutants from various sources and waters. One example of this is the MPCA's Watershed Pollutant Load Monitoring Network (WPLMN), 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. Monitoring sites span three ranges of scale:

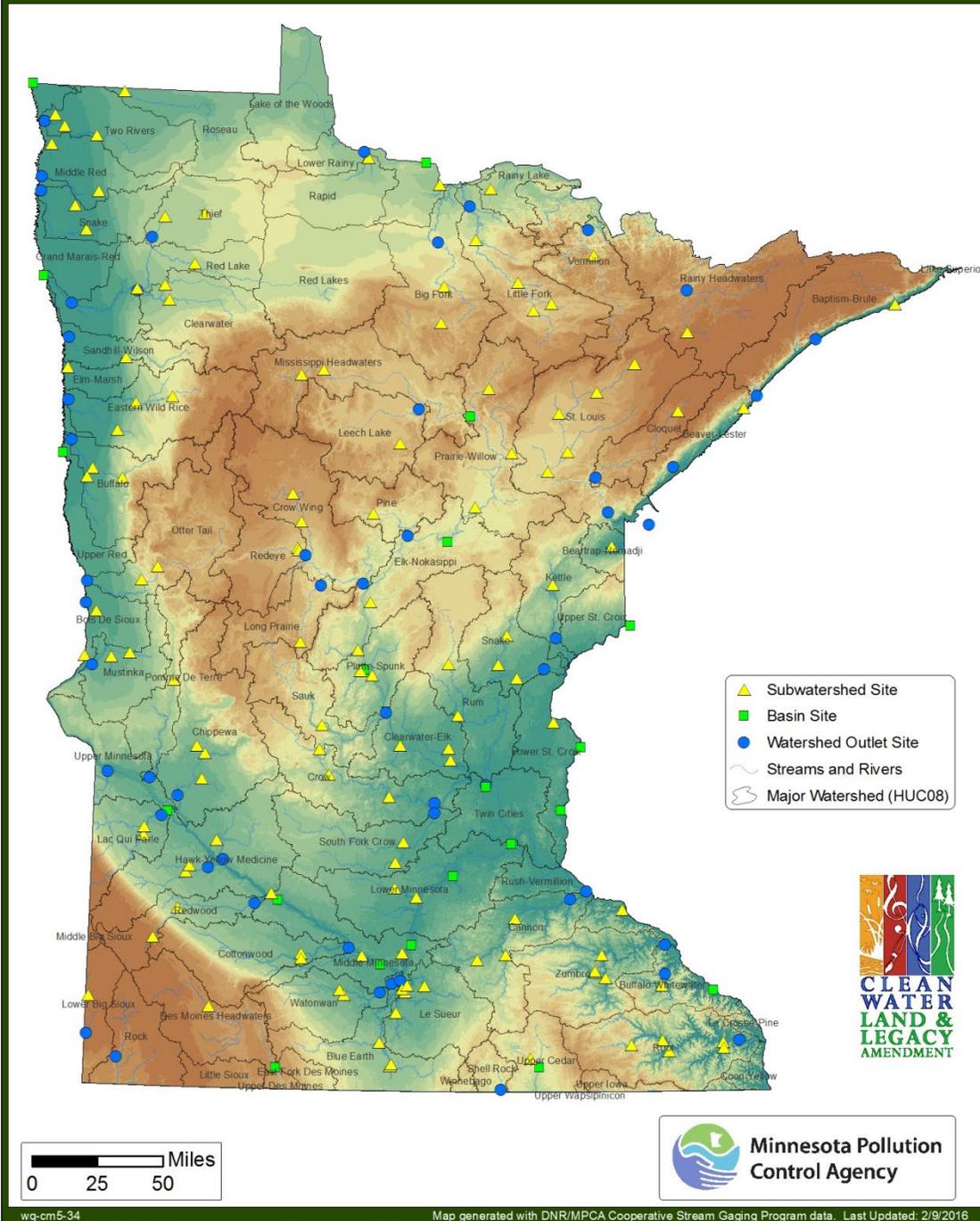
Basin – major river main stem sites along the Mississippi, Minnesota, Rainy, Red, and St Croix rivers

Major Watershed – tributaries draining to major rivers with an average drainage area of 1,350 square miles

Subwatershed – major branches or nodes within major watersheds with average drainage areas of approximately 300-500 mi²

Establishment of basin and major watershed sites within the network began in 2007 with all sites in operation by 2010. Determination and establishment of subwatershed sites began in 2011; all sites were established and in operation by 2015. There are currently 21 major river main stem sites, 53 major watershed sites, and 125 subwatershed sites within the network (see figure on next page).

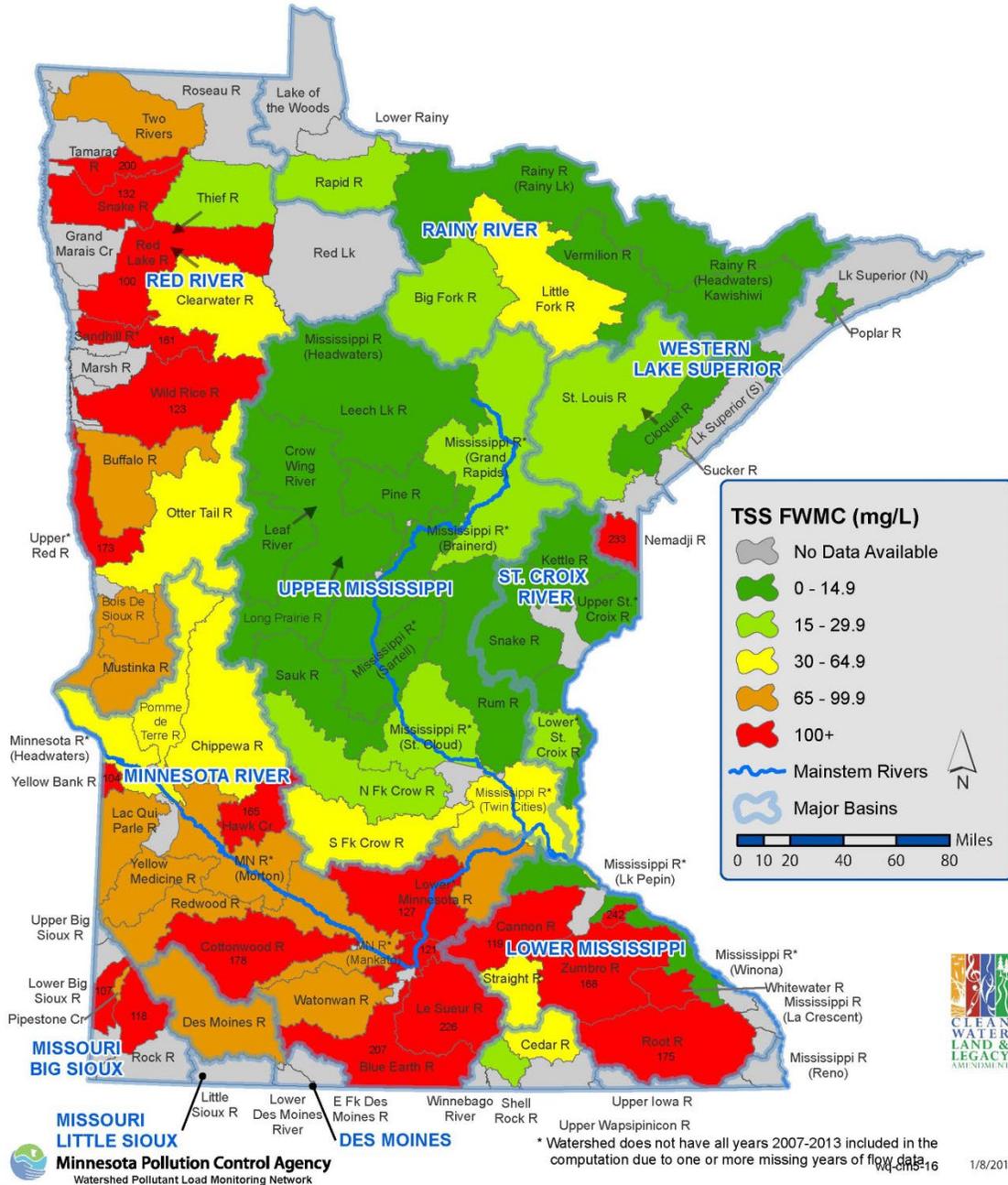
Watershed Pollutant Load Monitoring Network



Site-specific stream flow data are computed at all sites by MDNR or the USGS. Water quality data are collected by the MPCA, local units of government, state colleges and universities, nonprofit organizations, or Metropolitan Council Environmental Services. Intensive water quality sampling occurs at all WPLMN sites. Approximately 35 water quality samples are collected annually at basin and major watershed sites and 25 samples collected seasonally at subwatershed sites. Water quality samples are analyzed for common nutrients and sediment and coupled with site-related discharge data to compute annual or seasonal pollutant loads. The figure below shows the type of information now available. In addition to providing statewide

river water quality and trend information, data are also used to develop watershed protection and restorations plans, total maximum daily load reports, and assist with modeling efforts.

Watershed Pollutant Load Monitoring Network Total Suspended Solids Flow Weighted Mean Concentration (FWMC) by Monitoring Site Watershed Average: 2007-2013



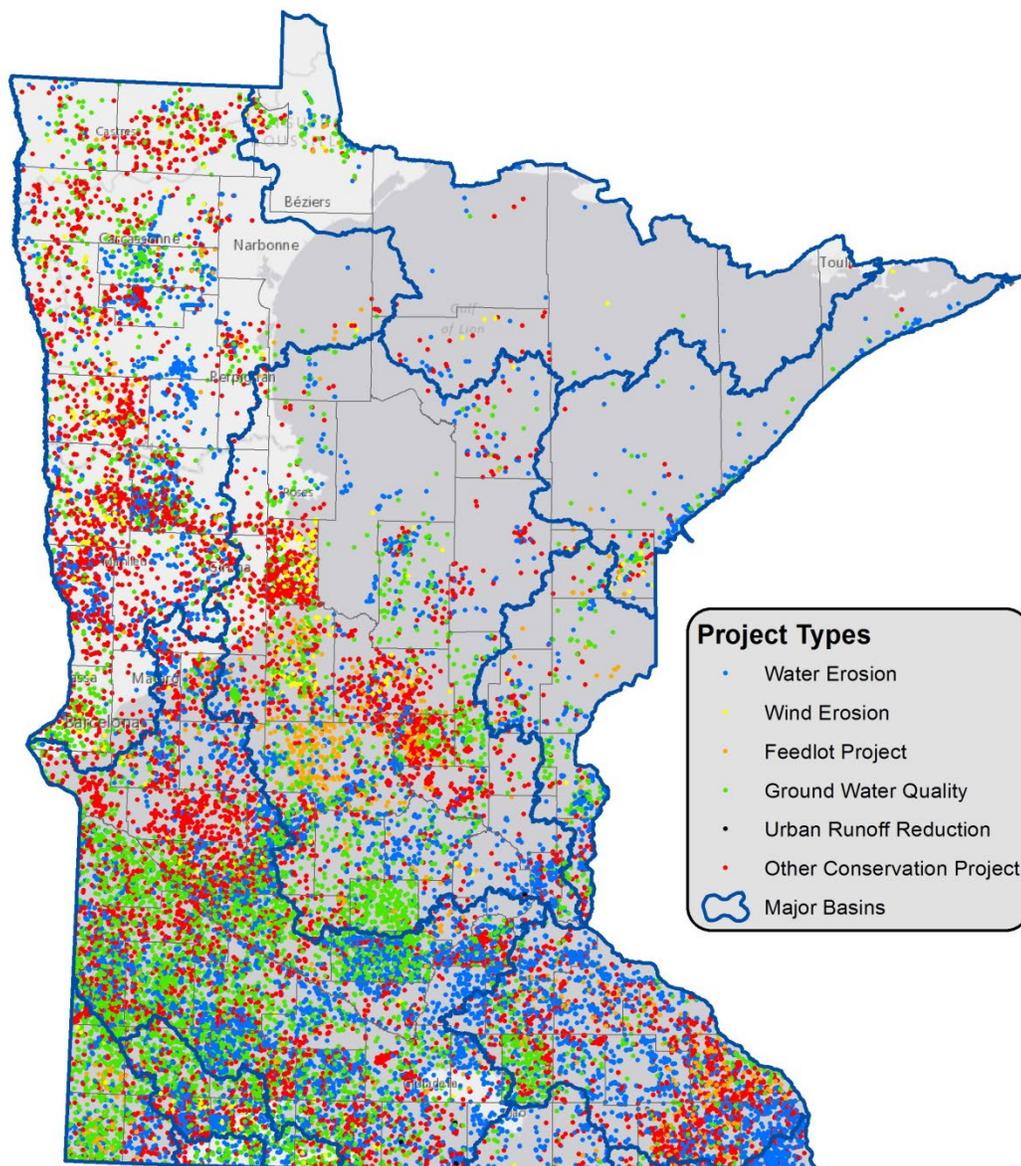
For more information about the MPCA's Watershed Pollutant Load Monitoring Network, see <http://www.pca.state.mn.us/pyrieeb>

Soil Loss Reduction in Minnesota

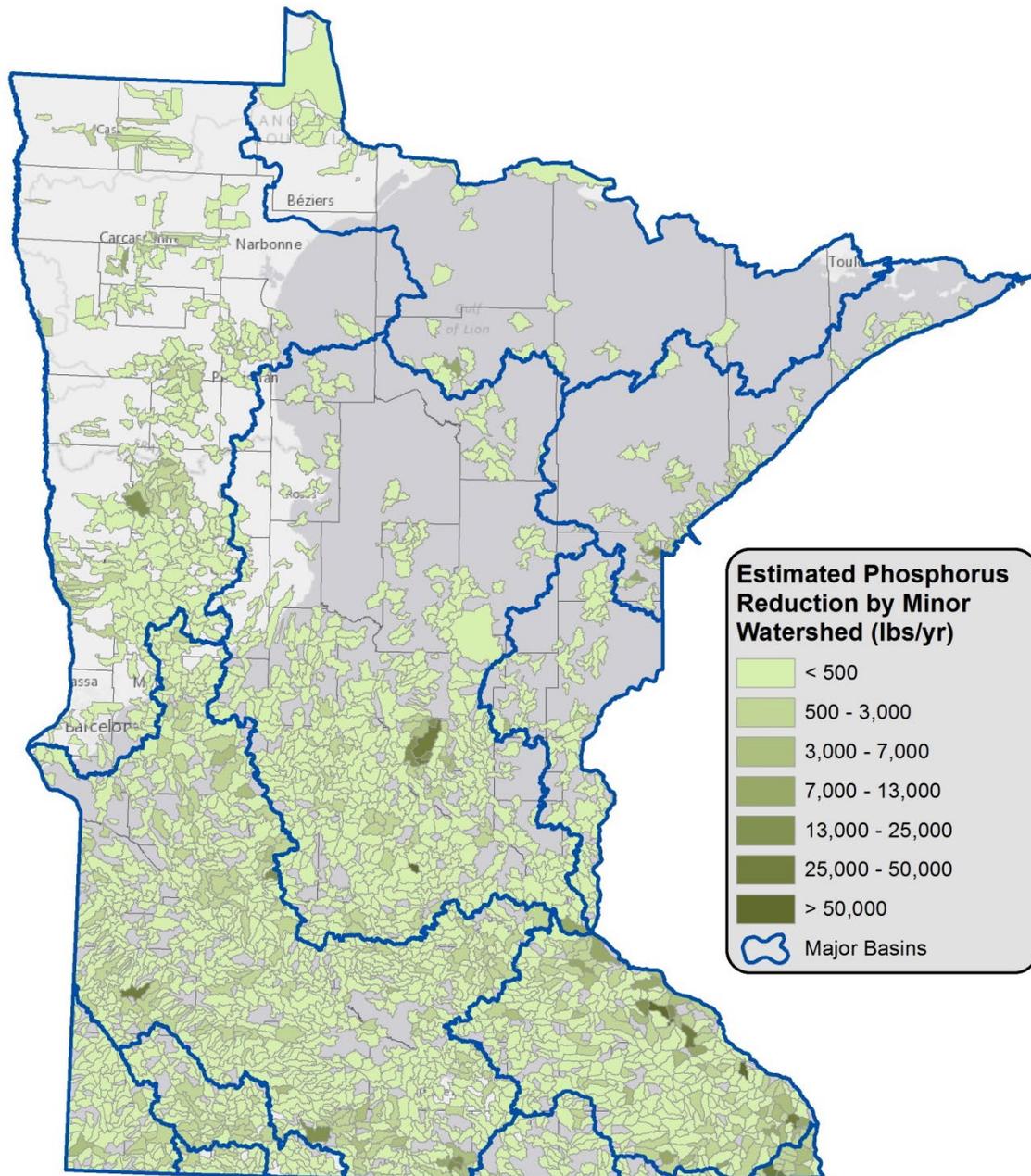
Many conservation projects and best management practices prevent thousands of tons of soil, sediment and other pollutants from leaving fields and becoming airborne or flowing into rivers and lakes. Soil erosion means not only the loss of valuable topsoil, decreases in land productivity and higher fertilizer requirements, It also damages surface water in the form of silt that chokes off rivers, lakes and wetlands, and can contaminate groundwater from over-application of fertilizer.

BWSR tracks soil loss and BMPs to reduce pollution from soil loss and sedimentation using the eLINK database (<http://www.bwsr.state.mn.us/outreach/eLINK/>). The figure below shows the locations of projects tracked by eLINK as reported by county soil conservation offices and local officials for the period 2003-2015.

Location of Conservation and Best Management Projects Reported by eLINK (2003-2015)



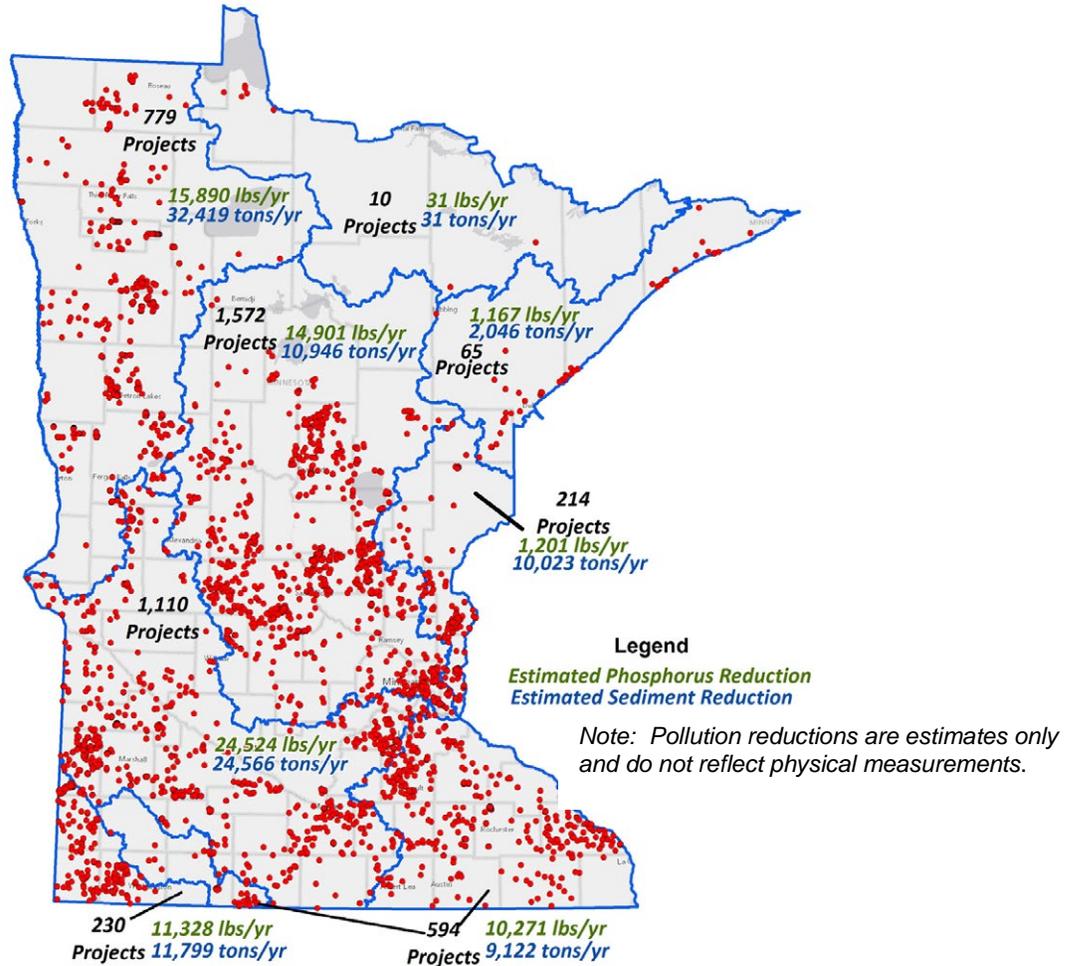
Not only can sediment cause silting problems, but it also can carry chemicals attached to it into the water. One of these chemicals is phosphorus, a common element of fertilizer, which can create problems in surface water such as algae blooms. The proliferation of algae and other aquatic vegetation takes oxygen from the water, suffocating fish, discouraging wildlife and making lakes and waterways unsuitable for recreational use. From 2003-2015, phosphorus reductions statewide in pounds per year by minor watershed are shown below.



Nonpoint Source BMPs Implemented with Clean Water Funding

With funding from the Clean Water, Land and Legacy Amendment, the implementation of practices to improve and protect Minnesota’s water resources has accelerated as has the completion of TMDLs and WRAPs assessments that outline water quality needs. From 2010 to 2015 Clean Water Funds have contributed to the installation of more than 4600 best management and conservation practices, resulting in a reduction of about 79,000 pounds of phosphorus and 120,000 tons of sediment across the state. The map below shows Clean Water Fund Projects and estimated pollution reductions by major basin.

Clean Water Fund Projects 2010-2015



This map includes only features that were mapped in eLINK. Projects that were reported but not mapped are not reflected. An additional 4,913 lbs/yr phosphorus reduction and 3,727 tons/year sediment reduction were reported for non-mapped projects in eLINK. This map includes project data from Clean Water Funds.

The term “emerging issue” refers to newly recognized environmental contaminants and other issues that are not fully understood, have the potential to cause adverse effects on human health or the environment, and are not currently incorporated into environmental protection activities in Minnesota. The MPCA strives to stay abreast of emerging issues in order to help lawmakers, regulators, the public and industry determine when and how to address these issues through agency protection programs. The following pages provide an overview of recent MPCA activities and developments related to emerging issues of concern.

Contaminants of Emerging Concern (CECs)

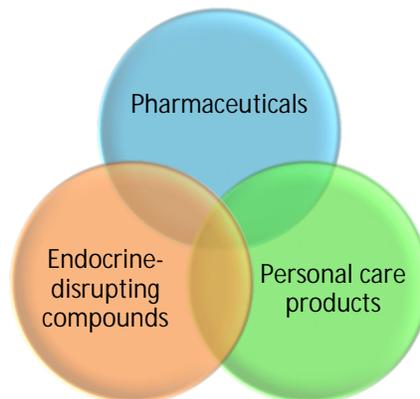
Since 2007, the MPCA has monitored the presence of pharmaceuticals, personal care products, and other wastewater-associated chemicals in Minnesota's groundwater, lakes, and streams. Most of these contaminants of emerging concern (CECs) have not undergone full toxicity evaluations, and, unlike conventional pollutants, lack guidance by which to assess their impact on human health or aquatic life. In addition, some CECs have endocrine-active characteristics, mimicking hormones that have the potential to adversely affect reproduction, behavior, or physiology in wildlife, aquatic organisms, and possibly humans.

The MPCA's monitoring shows that prescription and non-prescription drugs, steroidal hormones, insect repellents, detergents and detergent degradates, and plasticizers are widespread at low concentrations in Minnesota's rivers, lakes, and streams. While these CECs are commonly found downstream of sources such as wastewater treatment plants, they are also present in more remote surface waters where sources of these chemicals are not clear.

As part of its monitoring and assessment work, the MPCA has collaborated with scientists from the U.S. Geological Survey (USGS), St. Cloud State University (SCSU), the University of Minnesota, and the University of St. Thomas to investigate the endocrine activity of these CECs on fish, using both field and laboratory investigations.

The MPCA prepared a legislative report about endocrine-active compounds (EACs) in 2008 (<https://www.pca.state.mn.us/sites/default/files/lrp-ei-1sy08.pdf>). The results of many of the MPCA studies involving CECs can be found at <https://www.pca.state.mn.us/water/endocrine-active-compounds>

Contaminants of Emerging Concern



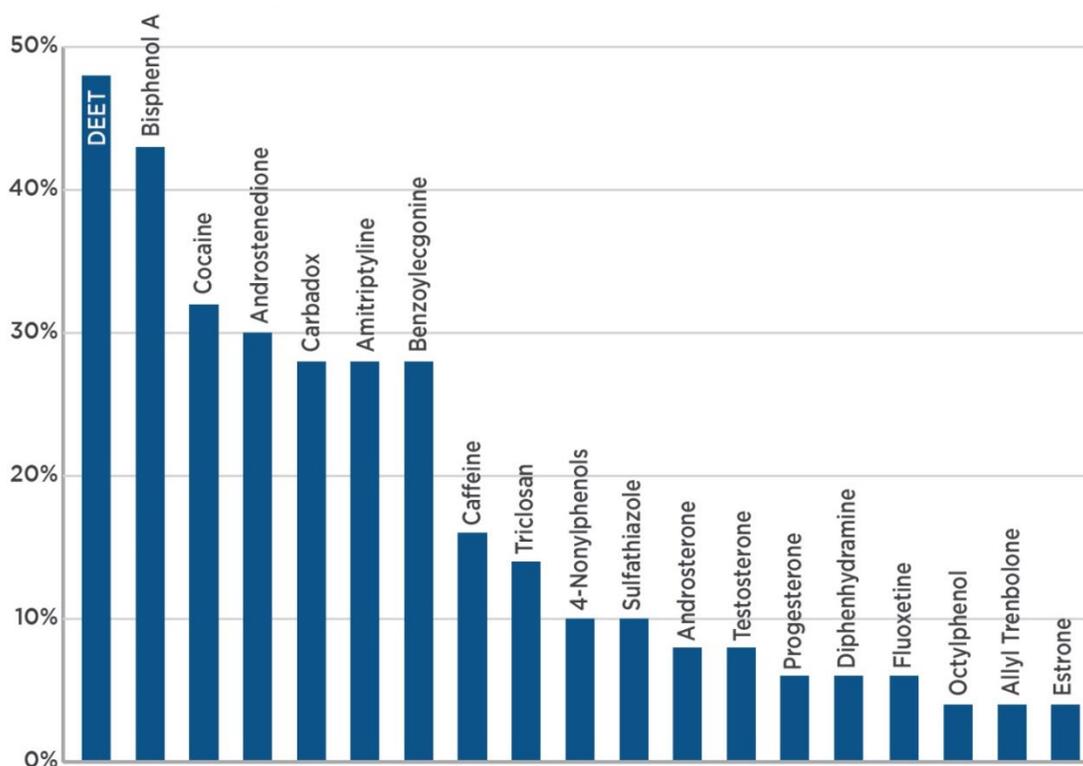
The term *Contaminants of Emerging Concern* typically refers to these overlapping categories of contaminants

Current monitoring efforts

The MPCA's current monitoring efforts are designed to provide long-term presence and concentration data for CECs in surface water and groundwater. These data are analyzed for any trends that may help scientists evaluate the effects of CECs on aquatic plants and animals.

Since 2010, the MPCA has monitored CECs in lakes and streams in conjunction with statewide probabilistic surveys of a random selection of surface water locations. These surveys provide large data sets that allow statistically valid estimate of the occurrence of CECs in Minnesota's surface waters. The surveys are conducted every five years in cooperation with EPA's National Aquatic Resource Surveys. Monitoring surveys of CECs in rivers and streams were conducted in 2010 and 2014; in lakes, the first survey was conducted in 2012, with the next scheduled for 2017. The figure below shows the most frequently detected CECs in 50 randomly selected Minnesota lakes sampled during the 2012 Statewide Probabilistic Lakes Survey (<http://www.pca.state.mn.us/index.php/view-document.html?gid=19427>)

Percentage of Lakes with Detections of Contaminants of Emerging Concern (2012)



The MPCA began monitoring for the presence of CECs in groundwater beginning in 2009, using the monitoring wells in the MPCA's ambient groundwater monitoring network. Each year, about 40 of the approximately 250 wells in the network are sampled for analysis of CECs. As of 2016, most of the network wells have been sampled for CECs. These data provide a good indication of the presence of CECs in Minnesota's ambient, surficial groundwater in non-agricultural areas of the state.

Assessment of CEC sources and effects

Recent MPCA investigations are focusing on potential sources of CECs to surface and groundwater, and evaluating the effects of CECs on aquatic life. The latter studies are conducted in collaboration with university and federal agency research scientists who are developing techniques to understand how CECs and EACs affect aquatic life.

The MPCA's legislatively directed studies (2007 and 2009) targeted CECs and EACs in surface water in the vicinity of wastewater treatment plants, and assessment of the observable effects of EACs on wild and caged laboratory-raised fish. Subsequently, the MPCA conducted a focused lake study from 2009 to 2011 that also included assessment of EACs in the lake on caged and wild fish. In this study, fish exposed to water from the lake that contained EACs showed some evidence of endocrine disruption. The sources of EACs to the lake included groundwater contaminated by septic drainage fields and stormwater runoff.

Studies currently underway include:

- § **Assessment of CECs at wastewater land application sites:** A three-year study conducted in collaboration with the USGS that focuses on evaluating if CECs are being released into the environment via rapid infiltration basins, large drainfields, or land-applied septage. The project goal is to evaluate the best management practices of MPCA programs relative to how they may impact groundwater, to inform future prevention or mitigation efforts. All field work for this study has been completed and data analysis and report preparation are underway.
- § **Developing a risk-based approach to prioritize CECs:** Currently, there is no established means to compare the risk a specific CEC poses to fish and other aquatic life relative to other contaminants. This absence makes it difficult to get past the most basic interpretations of CEC monitoring data and to develop prioritized, appropriately focused follow-up work. To address this, in 2014 the MPCA assigned a staff team to develop risk-based screening values to assess the potential impact of CECs on aquatic life. The team completed method development for deriving Aquatic Life Screening Values (ALSVs) in January 2015 (<https://www.pca.state.mn.us/sites/default/files/wq-cec2-01.pdf>), and developed draft ALSVs for 10 CECs by July 2015. Based on insights gained during this process, the agency modified its approach to a less time-intensive and more informative way of evaluating the risk posed by CECs to aquatic life. The new approach provides a "profile" of information about specific CECs that can be used in a semi-quantitative manner to compare risk, and in this way, focus on those CECs that may pose the greatest risk to aquatic life. By early summer 2016, the team expects to have Aquatic Toxicity Profiles (ATPs) for ten or so CECs that are most frequently detected in Minnesota's lakes and streams. This work will complement work done by MDH's drinking water CEC program, which is focused on human exposure to CECs.
- § **Assessment of CECs in stormwater and stormwater best management practices:** In collaboration with local watershed districts, MPCA staff will collect samples from several locations to assess the contribution of CECs in stormwater to the aquatic environment. The studies also include detailed analysis of how CECs are affecting aquatic organisms (in partnership with state universities), and an evaluation of how BMPs already in place to address contaminants in stormwater may affect the release of CECs to the environment.

Perfluorinated chemicals (PFCs)

Perfluorinated chemicals (PFCs) such as perfluorooctanesulfonic acid (PFOS), perfluorooctanic acid, (PFOA), perfluorobutyric acid (PFBA) and others, are manmade chemicals used to manufacture products that are heat and stain resistant and repel water. PFCs are used in emulsifier and surfactant applications, and to make fluoropolymers. PFCs are found in fabric, carpet and paper coatings, floor polish, personal care products, non-stick surfaces, fire-fighting foam and certain insecticides. PFCs are widespread and persistent

in the environment and they have been found in animals and people all over the globe. At least 3,000 fluorinated compounds of concern to scientists are now in commercial use worldwide.

In Minnesota, 3M manufactured PFOS and PFOA from approximately 1950 until they were phased out in 2002. During that time, large volumes of PFCs were released into the Mississippi River in effluent from the 3M Cottage Grove wastewater treatment plant. Four sites in Washington County were identified where 3M disposed of PFC wastes prior to the advent of modern solid and hazardous waste laws and regulations aimed at protecting groundwater. City and private wells affected were identified, and residents provided safe drinking water. As of early 2012, all major waste excavation work was complete at these sites. Additional long-term work remains to contain, pump and treat a large remaining plume of PFC-contaminated ground water and to monitor remedy effectiveness over time.

More information on MPCA and MDH activities related to PFCs can be found at these links:

<https://www.pca.state.mn.us/waste/perfluorochemicals-pfcs>

<http://www.health.state.mn.us/divs/eh/hazardous/topics/pfcs/pihgs.html>

MPCA investigations also detected PFOS at elevated concentrations in fish taken from Pool 2 of the Mississippi River and downstream, as well as in 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 79 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.

MPCA will continue to evaluate conditions in PFOS-affected waters to determine if further remedial, regulatory or prevention activity is needed to assure that these waters fully support their beneficial uses.

In addition to fish tissue, PFCs have been found in some shallow groundwater wells, in the influent, effluent and sludge of wastewater treatment plants, in ambient air, in blood of bald eagles, in tree swallows, in household dust, and 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.

There is some good news, in that blood levels in humans and wildlife of PFOS and PFOA have dropped in the past 10 years, likely in response to actions to phase out use and avoid exposure to PFOS, PFOA. See results of a recent MDH Biomonitoring study at this link:

<http://www.health.state.mn.us/divs/hpcd/tracking/biomonitoring/projects/emetro-landing.html>

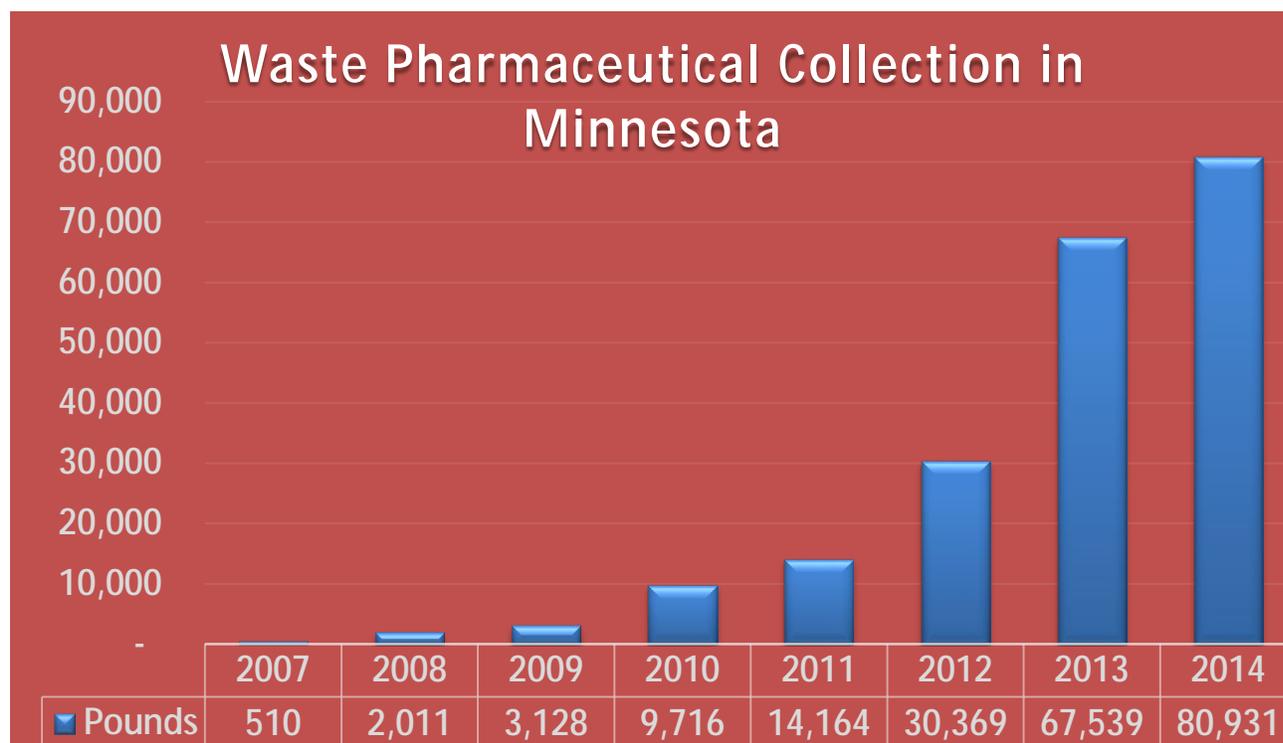
The MPCA and the MDH continue to examine potential sources of PFC exposure, and track advances in PFC toxicology and environmental fate. Dozens of peer-reviewed scientific studies on fluorinated chemicals are published each month by researchers worldwide, including Europe, China and North America. A court-commissioned [C8 Science Panel](#) identified probable links of PFOA exposure to high cholesterol, ulcerative colitis, pregnancy-induced hypertension, thyroid disease, testicular cancer, and kidney cancer in a West Virginia case. The U.S. EPA is currently re-examining the basis for its PFOS drinking water exposure guidance, and is considered tightening the benchmark.

A July 2015 international symposium, *Fluoros 2015*, gathered science and policy experts from industry, academia and governments from Europe, Asia and the Americas to examine the "state of the science" and discuss outstanding questions and challenges related to PFCs and other fluorinated chemicals.

Related activities and developments

Outreach and assistance

- § The MPCA’s Household Hazardous Waste Collection program helps county governments get the word out about proper disposal of un-needed or out-of-date pharmaceuticals. The MPCA website provides the materials needed to launch a public campaign for pharmaceuticals collection that counties can reference when they get inquiries about this issue, or use to publish their own county-specific materials. Pharmaceutical collection is based at law enforcement facilities in compliance with current Drug Enforcement Agency (DEA) regulations. In addition, DEA has funded the disposal costs for about 25 percent of the pharmaceuticals collected. A total of more than 200,000 pounds of pharmaceuticals have been collected since 2007. There are now over 200 collection sites available to Minnesotans. The communication materials ensure that a common message is delivered by local units of government, and eliminates the need for individual counties or governments to develop their own materials. The Medication Disposal Toolkit is available here: <http://www.pca.state.mn.us/sbiz10e6>
- § The Western Lake Superior Sanitary District, in partnership with the MDH and the MPCA, produced an advertising project aimed at reducing the release of toxics, including pharmaceuticals. It is located here: <https://www.pca.state.mn.us/waste/handle-care>
- § MPCA’s website also includes information for households to help locate the nearest collection site so they can properly handle their leftover pharmaceuticals, and links to reports describing the presence of pharmaceuticals in Minnesota waters.



- § In 2015, the MPCA collaborated with the Metropolitan Council to design, fund and build a new interactive exhibit at the State Fair that focuses on household contributions of CECs to wastewater and wastewater treatment. The exhibit includes a children’s slide that “goes down the drain” of a giant bathroom sink, and (eventually) discharges sliders into a simulated river. Designed to entertain

children and their families, the exhibit surrounds fairgoers with information about how CECs get into the environment, the challenges CECs present to wastewater treatment plants, and actions people can take to reduce their contribution of CECs to the environment.

Reducing toxic chemicals in products

In addition to the pharmaceuticals, personal care products, and other wastewater-associated chemicals the MPCA monitors in Minnesota's surface water and groundwater, numerous other chemicals used in consumer and other products are being found in the environment. Examples of this broader category of chemicals of concern include the plasticizers used to soften plastic products (bisphenol A and phthalates), flame retardants in electronics, furniture and building materials (a broad category of many chemistries), surfactants used in paint, detergents, and pesticides (alkylphenol ethoxylates), and metals used in inks, dyes, paints, toys, and other products (cadmium, lead). Besides getting into the environment, these chemicals can enter people's bodies. Preventing this exposure and release was the goal of the federal Toxic Substances Control Act (TSCA), passed in 1976, but the law is universally viewed as ineffective.

The Minnesota Legislature passed a ban starting in 2017 on the retail sale of cleaning products containing triclosan used directly by consumers, except for those with FDA approval. The Legislature also directed the MPCA to report on the presence of microbeads in Minnesota's waters and the potential impact of the beads on aquatic ecosystems and human health. Microbeads are small plastic pellets used in personal care products such as hand soap, exfoliating scrubs and toothpaste. When these products are used by consumers and are washed down the drains of sinks and showers, the microbeads end up in wastewater treatment systems. The MPCA consulted with the University of Minnesota on the report, which was completed in December 2014 and is available here: <https://www.pca.state.mn.us/sites/default/files/lrwq-s1sy14.pdf>

In the absence of a strong federal statute, Minnesota and other states have taken steps to enact chemicals policy to protect their citizens from chemicals in consumer products. Minnesota's Legislature passed the Toxic Free Kids Act (TFKA) in the 2009-10 biennial budget (Minn. Stat. 116.9403), directing the MPCA and MDH to develop recommendations for reducing and phasing-out priority chemicals in children's products and promoting consumer product design that uses green chemistry principles. The MPCA and MDH recommendations were published in a December 2010 report: "[*Options to Reduce and Phase-out Priority Chemicals in Children's Products and Promote Green Chemistry.*](#)" The TFKA also called for establishment of Minnesota's lists of Priority Chemicals and Chemicals of High Concern however, there are currently no manufacturer requirements related to the chemicals that appear on these lists.

The MPCA helps MDH maintain and update these lists and is in regular dialogue with stakeholders and legislators interesting in advancing Minnesota's approaches. Since MDH released the list of Priority Chemicals in February 2011, the MPCA has made these chemicals a focus of its pollution prevention activities (see below). For more information about the Toxic Free Kids Act and the MDH priority chemicals lists, see the following web pages:

<http://www.pca.state.mn.us/index.php/view-document.html?gid=15319>

<http://www.health.state.mn.us/divs/eh/hazardous/topics/toxfreekids/priority.html>

<http://www.health.state.mn.us/divs/eh/hazardous/topics/toxfreekids/highconcern.html>

The United States Senate Committee on Environment and Public Works began work to develop a reform proposal for TSCA in 2010, and this work has been on-going since then, including much dialogue with and testimony from stakeholders (US EPA, chemical manufacturers, product manufacturers and retailers, trade organizations, state environmental agencies, public health agencies, and environmental and other advocacy organizations). On June 23, 2015 the U.S. House adopted the TSCA Modernization Act of 2015; subsequently, on December 18, 2015, the U. S. Senate adopted the Frank R. Lautenberg Chemical Safety for the 21st Century Act. Before TSCA reform can occur, members of Congress must work together to draft a

compromise bill that both chambers of Congress will approve and that the President will sign; it remains to be seen how arduous a task this will be.

Pollution Prevention and Green Chemistry

Most of the MPCA's regulatory activities focus on the treatment, storage and disposal of wastes and wastewaters. Pollution prevention is focused on reducing, eliminating, or preventing *pollution* at its source, before pollution is generated, which is why it is also known as "source reduction." Green chemistry goes beyond pollution prevention to the design of less toxic, more sustainable, less energy-consuming chemicals that can replace problematic chemicals. Pollution prevention and green chemistry are non-regulatory in nature and rely on the stewardship of industry and manufacturers for implementation. See the link below for a fuller description of green chemistry:

<http://www.acs.org/content/acs/en/greenchemistry/what-is-green-chemistry/principles.html>

The entry point for this work is often product design. During all stages of the life-cycle of a consumer or other product (i.e. during its manufacture, use and final disposal), there is a potential for release of chemicals from the product to people and to the environment. If problematic chemicals can be reduced or eliminated from the manufacturing cycle, or replaced with less toxic, more benign chemicals, the potential for pollution and exposure can be reduced or even eliminated. The MPCA's Pollution Prevention program has been promoting green chemistry and engineering since 2009.

Using grant money obtained from U.S. EPA, the MPCA has funded three major projects focusing on products involving chemicals that have been named as Priority Chemicals or Chemicals of High Concern by MDH under Minnesota's Toxic Free Kids Act. These include:

- § reducing retailers' use of thermal receipt papers, many of which contain the Minnesota Priority Chemical Bisphenol A (BPA) or Bisphenol S (BPS), a common alternative now showing endocrine activity similar to that of BPA. The final report of the BPA/BPS thermal receipt paper project is posted on <https://www.pca.state.mn.us/sites/default/files/p-p2s10-14.pdf>
- § providing detail about paper test results, but more pointedly, estimates about the quantity of BPA/BPS that can be source reduced from specific operational changes that businesses can take with their point-of-sale procedures.
- § surveying the use in Minnesota of formaldehyde and hexabromocyclododecane (HBCD), a flame retardant, in building products, and
- § surveying the use of nonylphenol (NP) and nonylphenol ethoxylate (NPE) in industrial/institutional detergents.

(BPA, formaldehyde and HBCD are all listed as Priority Chemicals by MDH while NPE is listed as a Chemical of High Concern.)

The MPCA has also awarded curriculum development grants to several Minnesota post-secondary institutions to defray the cost of re-vamping college chemistry curricula to incorporate green chemistry principles into teaching the newest generations of chemists. More details on these and other pollution prevention efforts can be found in the MPCA's December 2013 Toxics and Pollution Prevention Evaluation Report: <http://www.pca.state.mn.us/index.php/view-document.html?gid=20575>

Increasingly, the MPCA's Pollution Prevention program is collaborating with programs inside the MPCA, with Minnesota state agencies such as MDH and the Department of Commerce, with environmental agencies in other states that have enacted chemicals policy, and with state and national organizations such the Minnesota Green Chemistry Forum, the Minnesota Technical Assistance Program (MnTAP), Interstate Chemicals Clearinghouse (IC2) and the Green Chemistry Council GC3 to collaborate to better understand

the use of toxic chemicals in products, and to identify and pursue opportunities to advance knowledge of and use of green chemistry.

Find more on MPCA's Pollution Prevention program at <https://www.pca.state.mn.us/quick-links/pollution-prevention>