Air Quality in Minnesota

Problems and Approaches

Minnesota Pollution Control Agency

January 2001

DNR Photo

Air Quality in Minnesota: Problems and Approaches

This report has three purposes. First, it responds to legislative concerns about air toxics following the Minnesota Pollution Control Agency's release of the *Staff Paper on Air Toxics* in November 1999. Second, it fulfills a requirement (Minn. Stat. § 115D.15 and § 116.925) that the MPCA report biennially to the Legislature on toxic air pollutants. Finally, the report is also a response to a legislative request for information about mobile sources of air pollution following the November 1999 end of the Twin Cities' vehicle inspection program.

This report describes the MPCA's approaches for reducing outdoor air pollutants including particulates and smog-forming pollutants, as well as air toxics. Because the MPCA's authority extends only to the outdoor environment, this report does not address pollutants in indoor air. It is worth noting, however, that studies show that some air toxics are at higher concentrations indoors.

The approaches described in this report were developed with input from other state agencies, local units of government, public interest groups, and citizens.

An extensive set of appendices to this report can be found on the MPCA web site at **www.pca.state.mn.us/hot/legislature/reports**. For a paper copy of the appendices, contact Mary Jean Fenske at (651) 297-5472 or Jeff Buss at (651) 297-8659, or toll-free at (800) 657-3864.

Contents

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What are the problems?

The air may look better, but troubling health impacts remain

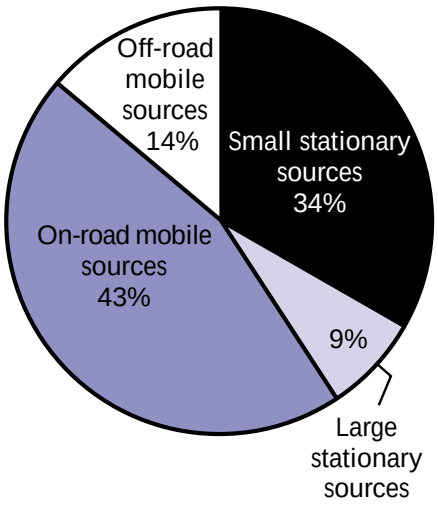
By traditional measures used since the early 1970s, Minnesota's air quality appears good. However, unhealthy air isn't always smoky or yellow or gritty. In contrast to the air pollutants that drove Congress to pass the Clean Air Act — smoke, ash and others hard to miss — today's most troubling pollutants are invisible. In fact, while the air in Minnesota may look fine, in many places it is not.

Health-care and other costs from air pollution emitted by transportation sources alone in the Twin Cities are estimated at one billion dollars per year.[1] The MPCA is concerned about:

Air toxics

Air toxics are substances known to cause or suspected of causing cancer or other serious health problems. In some areas of Minnesota, measured levels of benzene (mostly from gasoline) and certain other air toxics are above health benchmarks.[2] Although benzene is known to cause cancer at high workplace concentrations, current science cannot tell us whether the relatively lower outdoor air levels cause cancer. Diesel exhaust[3] is recognized to cause cancer at high workplace concentrations and may be a concern at ordinary outdoor levels. Other toxics, such as mercury,[4] accumulate in the environment and cause damage to both humans and wildlife.

Where do air toxics come from?



Total air toxics emissions: 56,378 tons (Source: Minnesota Air Toxics Emissions Inventory)

Particulate matter

Airborne particles, especially very small particles from combustion sources such as power plants, vehicles, and woodburning, are creating public health and ecological concerns now, at current outdoor concentrations. Fine particulates, which are less than one-tenth the diameter of a human hair, are estimated to be responsible for at least 70,000 deaths each year in the U.S.[5] Even in the Twin Cities, which does not have as serious an air-pollution problem as some cities, both hospital admissions and deaths from heart and lung disease rise when particles in the air increase. Asthma attacks also go up.

Global climate change

Greenhouse gases such as carbon dioxide may not have direct health effects, but they are changing our climate. While even a few years ago there were still questions about global climate change, the overwhelming scientific consensus today is that the surface of the earth is warming. Fossil-fuel combustion is a primary cause of the warming. The effects are likely to be far-reaching. The anticipated global warming over the next century is roughly the same as the warming of the earth's climate since the last Ice Age. The response of ecosystems to this kind of change will likely include much-reduced biodiversity, declining ecosystem health and stability, and species loss.

1 The Full Cost of Transportation in the Twin Cities Region, August 7, 2000, Center for Transportation Studies, University of Minnesota.

2 The MPCA relies upon state and federal health benchmarks to assess the effects of air toxics. Health benchmarks represent air concentrations (or measures) below which there is little appreciable risk of harmful effects on humans. They are not enforceable regulatory standards. Many chemicals do not have health benchmarks.

3 Diesel exhaust contains air toxics and particulate matter.

4 The MPCA's Mercury Reduction Task Force is charged with developing strategies to reduce mercury emissions and will report on its progress in 2001. Additionally, the EPA announced on December 15, 2000 that it would issue final rules to reduce mercury from coal-fired power plants by 2004.

5 Estimate by Dr. Joel Schwartz, Harvard School of Public Health, September 15, 2000; Air Pollution and Human Health Workshop, sponsored by the American Lung Association of Minnesota and the Isaak Walton League; Minneapolis, Minnesota.

What are the challenges?

MPCA must expand its focus to adequately address new concerns

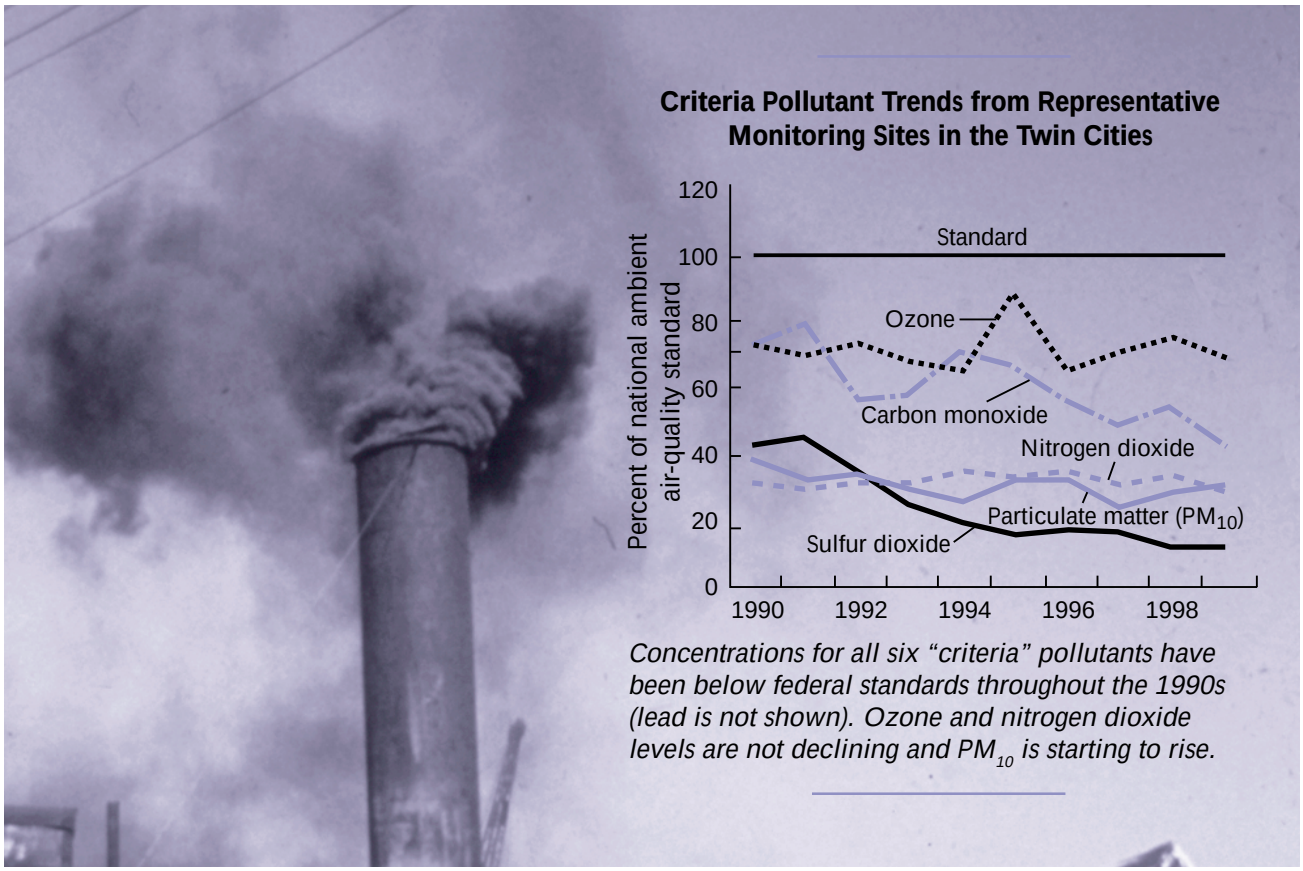
The MPCA currently focuses the majority of its air-quality resources on large stationary sources such as manufacturing facilities. Established programs have successfully lowered emissions from such sources. A strong effort is needed to sustain past improvements and address stationary sources' contribution of new pollutants of concern. It is increasingly apparent, however, that air toxics, particulates and global warming cannot be addressed with these programs alone.

There are no enforceable standards for some chemicals of concern

On average, air quality in Minnesota has improved since 1989 for four of the six "criteria" pollutants, or pollutants with federal standards[6]. Much of this success comes from curbing industrial pollution and improving vehicles and fuels. But control technologies on industrial sources are bringing diminishing returns because they contribute a decreasing share of overall air pollution. More significantly, for hundreds of chemicals, including most air toxics and greenhouse gases such as carbon dioxide, there are no standards for outdoor air.

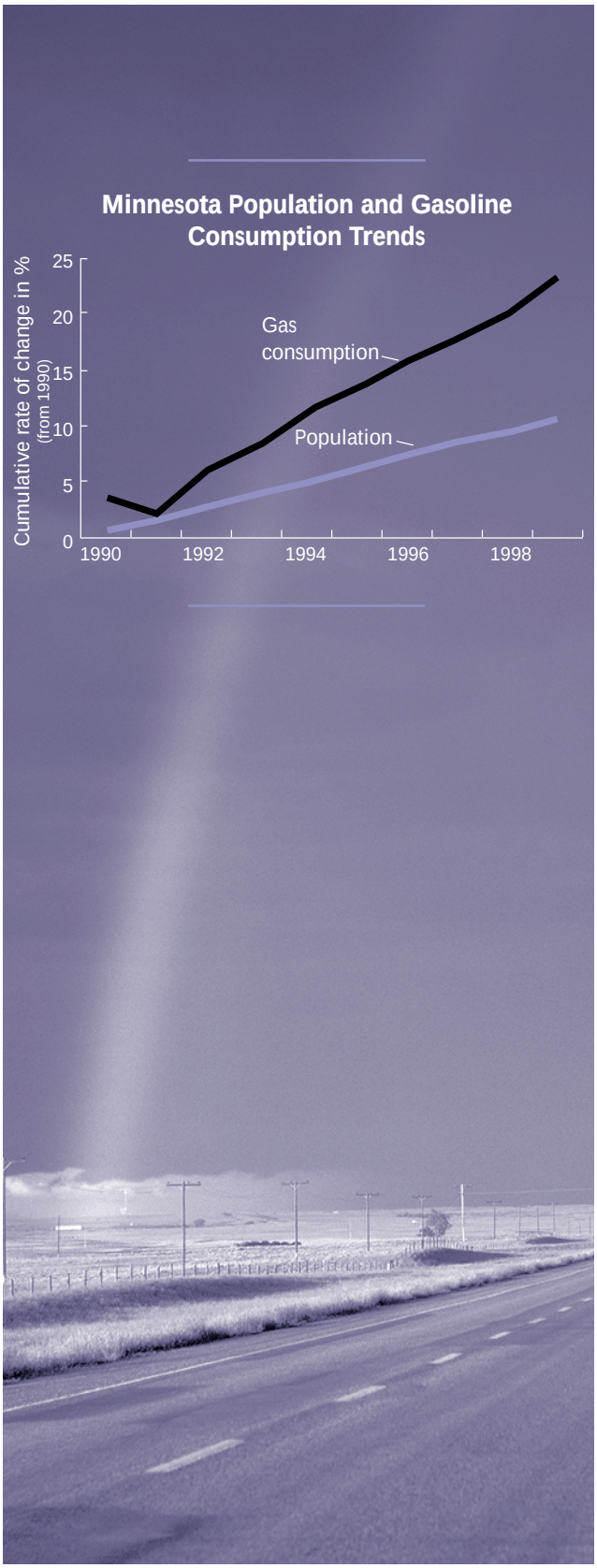
Levels of ozone and fine particles are close to the new federal standards

The U.S. Environmental Protection Agency (EPA) proposed new, stricter standards for ozone and fine particulates less than 2.5 microns in diameter ($PM_{2.5}$). EPA's authority to issue these standards is currently under review by the U.S. Supreme Court. If the new standards are upheld, there may be consequences for Minnesota; episodes of high ozone levels last summer raised concerns that Minnesota may not meet the proposed new



Concentrations for all six "criteria" pollutants have been below federal standards throughout the 1990s (lead is not shown). Ozone and nitrogen dioxide levels are not declining and PM_{10} is starting to rise.

[6] EPA National Air Quality and Trends Report, 1998; criteria pollutants include particles less than 10 microns in diameter (notated as PM_{10}), ozone, nitrogen oxides, sulfur dioxide, carbon monoxide and lead.



standard. For example, during the past two years, ozone levels have approached as high as 97 percent of applicable standards. In the same period, $PM_{2.5}$ levels have reached 90 percent of the proposed standard at the highest measured location. Aside from the damaging health effects of ozone, a violation of federal air-quality standards automatically triggers a variety of federal requirements, at considerable expense to society and business.[7]

Mobile sources are an increasing part of the problem

Mobile sources — cars, trucks, buses, airplanes, trains, off-road vehicles and small engines — are major contributors to air toxics and other air pollution. Although vehicles and fuels are getting cleaner, mobile-source pollution is also affected by factors such as more vehicle trips, longer commutes, more drivers, and decreasing vehicle fuel economy. These factors are all heading in the wrong direction. The MPCA is concerned that the trends in these factors will offset the environmental benefits from cleaner vehicles and fuels. Some of these factors have quality-of-life effects that go beyond air pollution, such as traffic congestion and increased infrastructure costs.

[7] For metropolitan areas experiencing "marginal" non-attainment of federal air pollution standards, the EPA estimates a total regulatory cost of $76.22 per capita. This amount includes both baseline program costs as well as additional costs associated with non-attainment status.

What's currently being done about Minnesota's air quality?

Stationary sources

Under authority delegated from the EPA, the Clean Air Act authorizes the MPCA to address air pollution from large stationary sources such as power plants, factories and incinerators.[8] This authority also includes smaller contributors to air pollution, such as gas stations, dry cleaners, and home woodstoves. Although these sources emit relatively small amounts of pollution individually, their total numbers have a large impact collectively. Beyond their collective impact, smaller stationary sources can have local impacts because they tend to be located in residential areas.

In addition to administering federal programs focused on criteria pollutants, the MPCA also administers the EPA's program to address air toxics from large emitters in specific industries. Beyond its implementation of federal programs, the MPCA is a nationally recognized leader in developing goals and strategies for reducing mercury in the environment. Minnesota has also been a leader in collecting data on air toxics through monitoring. Finally, the Minnesota Office of Environmental Assistance (OEA) provides pollution-prevention assistance to companies with large emissions as reported in the Toxic Release Inventory.

Mobile sources

State efforts

Minnesota addressed carbon monoxide (CO) through its vehicle emissions testing program. The program reduced CO emissions in the Twin Cities to within acceptable limits, and the program was discontinued in November 1999. Minnesota also requires the use of Indirect Source Permits for new facilities that will attract automobile traffic and thus be indirect sources of CO and noise.

Minnesota Planning and the Metropolitan Council also address vehicle pollution through land-use planning. The Metropolitan Council, the Minnesota Department of Transportation (MnDOT), Metro Transit, and other organizations promote alternatives to single-passenger automobile use, including carpools, transit, bicycles and walking. MnDOT has committed to implementing congestion management practices that also improve energy use and air quality, such as ramp metering, high-occupancy vehicle lanes, and better traffic information for drivers. The MPCA, along with the departments of Commerce, Agriculture and Administration, is ensuring that the state's vehicle fleets use fuel-efficient vehicles and alternative fuels.

National efforts

The Clean Air Act gives the EPA authority to regulate pollution from mobile sources. The EPA's requirement for low-sulfur gasoline by 2004 is expected to reduce air pollution, as will the agency's requirement of more stringent pollution-control equipment on new cars and light-duty trucks, including SUVs. According to the EPA, the combination of low-sulfur gasoline and new control equipment will result in vehicles that emit 77 to 95 percent less ozone-forming pollutants.

Beginning in 2004, EPA's new regulations aimed at heavy-duty trucks and buses will require both low-sulfur diesel fuel and more stringent pollution-control equipment.

Finally, as of 2008, the EPA will begin regulating off-road mobile sources, including farm, construction, recreational and lawn equipment, as well as ships and locomotives. In some parts of the country, these sources emit a third of mobile-source contributions to ozone-forming chemicals, and two-thirds of PM_{10}.

The MPCA has begun using alternative-fuel and hybrid gas-electric vehicles, such as this Honda Insight, in its vehicle fleet.

[8] This authority is limited for facilities built before 1970 — most notably, coal-fired power plants.

Is further state action necessary?

These new federal regulations, however, will not be in full effect until 2009. Moreover, virtually all these requirements apply to new vehicles and equipment, not those Minnesotans will use for another 10 or 15 years. These regulations also do not address carbon dioxide, the most significant contributor to global climate change.

In addition, federal air-quality standards may change more quickly than the state's ability to influence the underlying causes of air pollution. A preventive approach gives Minnesota flexibility and time to take air quality into account when making complex, long-term decisions about land use, transportation and energy planning.

It is also vital to go beyond merely meeting federal air-quality standards to meet the real needs of Minnesota's citizens and economy. Even though the state currently meets federal standards, our current levels of air pollution are affecting Minnesotans' health nonetheless.

What more should be done?

The MPCA initially will take steps to make short-term improvements in air quality, while at the same time improve scientific understanding of air-pollution trends in Minnesota. Further, the MPCA will act as advisor to other agencies and local governments responsible for decisions that have long-term consequences for the state's air quality, such as land use, transportation and energy planning. Finally, the MPCA has established long-range goals for improved air quality.

Goals

1. By 2010, reduce emissions of pollutants that contribute to fine particulate and ozone by 20 percent from 2000 levels.
2. By 2010, reduce measured concentrations of air toxics to below health benchmarks.

These goals set a direction for the MPCA to pursue to reduce the effects of fine particles and ozone and take precautionary steps with air toxics, about which less is known in terms of their health effects. In addition, by early 2001, the MPCA will develop goals for reducing Minnesota's contributions to global climate-change gases. To reach these goals, the MPCA will use the following hierarchy of approaches:

- Actions to reduce fuel and energy consumption
- Actions to substitute cleaner fuels for existing ones
- Actions to increase the use of technologies that reduce air pollution

The MPCA believes the most effective way to reach its goals is by addressing the root cause of most air pollution — combustion of fossil fuels. As a result, reducing fuel and energy consumption is the preferred first approach because less consumption results in fewer emissions of all pollutants, including global warming gases. The next-best approach is using cleaner fuels, because it reduces emissions of certain pollutants from all sources that use the fuel. Finally, the third-best approach is to increase use of more effective pollution controls in vehicles, facilities, equipment and engines. These approaches are similar to the pollution-prevention hierarchy used for stationary sources of air pollution.

MPCA action plan

This action plan is organized into four areas: steps already taken or underway, improvements in air quality through long-range planning, further study, and potential action steps for the future.

MPCA's current actions

1. **Reduce benzene emissions at gas stations.** Benzene concentrations at some locations in Minnesota currently exceed the health benchmark for cancer. Using voluntary agreements, the MPCA will work with gas stations so that by July 2003, 85 percent of gasoline sold in urban areas will come from stations operating "stage-one vapor controls." These are vapor-recovery methods that reduce emissions of benzene and ozone-forming pollutants as gas-station fuel tanks are filled. If this target is not met, the MPCA will pursue regulatory strategies to make stage-one controls mandatory.
2. **Lower benzene content in gasoline.** The MPCA will work to secure voluntary agreements with gasoline producers so that 25 percent of gasoline sold in Minnesota will contain less benzene by December 2001. If this target is not met, the MPCA will pursue regulatory strategies to require low-benzene gasoline.
3. **Use toxics evaluation guidance for air emissions permits.** The MPCA will develop a pilot project by February 2001 to evaluate air toxics emissions from permitted stationary sources. This screening quickly identifies chemicals that may exceed health benchmarks and the results can be used to develop a facility's toxics control plan. As part of the pilot project, the MPCA will evaluate whether this would be more efficiently and effectively accomplished through state rules.
4. **Promote the use and distribution of alternative fuels.** The MPCA supports the use of alternative fuels by using E85 (a fuel containing 85 percent ethanol) in all its flexible-fuel vehicles. The MPCA will also continue to test alternative-fuel vehicles, and will encourage other state agencies and the public to use E85, low-sulfur gasoline, propane, compressed natural gas, biodiesel, and other alternatives. The MPCA will consider future requirements if voluntary programs are not successful.

5. **Promote the use of fuel-efficient vehicles and good maintenance practices.** The MPCA will work with partners to encourage the public to purchase cleaner vehicles and adopt driving and maintenance practices that lower emissions. The MPCA will also work with school-bus fleet operators to reduce diesel emissions.
6. **Increase the use of cleaner-burning woodstoves.** Wood smoke contains a variety of toxic chemicals and particulate matter. In February 2001, the MPCA and OEA will join an industry incentive program, modeled after successful programs in other states, whereby manufacturers offer incentives to the public to exchange old stoves for cleaner-burning new models.
7. **Increase availability and use of transit in the metropolitan area.** The MPCA's role here is two-fold: supporting development of more transportation choices and encouraging adoption of those choices. The MPCA will work with MnDOT and the Metropolitan Council to support their efforts to provide multi-modal transportation.

8. **Re-examine goals for indirect source permitting.** The MPCA's indirect source permit program was established to minimize carbon monoxide and noise impacts from large developments and major highway projects. The MPCA will evaluate how this program can help achieve reductions of additional air pollutants.
9. **Join multi-state clean diesel initiative.** Minnesota will join more than a dozen other states to require diesel truck manufacturers to produce cleaner trucks three years earlier than the current EPA schedule.
10. **Shift existing MPCA resources to air-pollution efforts in order to:**
    - Strengthen implementation of federal sector-based standards for air toxics. The MPCA currently addresses air toxics from stationary sources through a federal program that targets the largest toxic emitters as well as certain smaller sources. Strengthening this program would involve more targeted outreach and a stronger field presence to ensure that facilities are complying with standards.
    - Better understand the science behind the likelihood of violating the federal ozone standard. It is critical to learn more about the chemicals that are the biggest factors in forming ground-level ozone in order to clarify what reduction strategies would be most beneficial.
    - Develop and implement a communication plan on air-pollution issues. A proactive communication plan will include partnerships with outside organizations and will target selected pollutants, sources and audiences. The MPCA will work with the OEA and others to increase public outreach.

Improving air quality through long-range planning

1. **Provide environmental analysis of state land-use and transportation planning.** The MPCA will continue to support the efforts of Minnesota Planning, MnDOT and the Metropolitan Council to integrate air-quality issues into land-use and transportation planning.
2. **Provide environmental analysis of state energy/ electricity planning.** Coal combustion to produce electricity is the single biggest source of many pollutants of concern in Minnesota. The Department of Commerce is forecasting a need for 30 to 50 percent more electricity generating capacity in the state within the next five years, and is developing legislation to centralize electricity supply planning. As part of that process, the DOC requested the MPCA to analyze the environmental implications of DOC's energy plan and advocate clean-energy strategies, because the energy decisions we make today will affect air quality for 50 to 70 years.
3. **Provide environmental analysis of transportation fuel consumption and alternative fuels.** Petroleum combustion for transportation is a major contributor to many of the air pollutants of concern in Minnesota. The MPCA will continue to support the Department of Commerce's efforts to reduce petroleum consumption and increase the use and availability of alternative fuels that reduce air pollution through its participation in the Clean Cities Coalition.

DOT Photo

Important areas for further research and study

1. **Identify sources of $PM_{2.5}$.** In 2001, the MPCA will start to learn how much of the fine particles in the atmosphere come from each source category.
2. **Monitor potential "hot spots."** The MPCA will monitor air toxics and $PM_{2.5}$ at a site near the Minneapolis-St. Paul airport beginning in the spring of 2001 and lasting one year. Computer models predict that this area would have higher concentrations of some pollutants. The MPCA will also work with the University of Minnesota's Diesel Technology Center to measure other potential $PM_{2.5}$ hot spots.

Other potential state actions

Many of these potential actions are currently being pursued by other states, often as part of a plan to achieve compliance with federal air-quality standards. The MPCA may propose some of these in the future, depending upon the success of other efforts and the results of research and monitoring.

1. **Implement voluntary greenhouse-gas reduction program.** The MPCA could develop an "early credits" program in collaboration with efforts in other states (New Jersey, New Hampshire, and Wisconsin).
2. **Create a comprehensive inventory of air emissions.** A comprehensive air emissions inventory would help assess the sources and extent of air pollution in Minnesota and support reduction strategies. The MPCA could expand the current inventory to include criteria pollutants from mobile sources and a broader range of stationary sources. The inventory could also include estimated greenhouse-gas emissions and direct emissions of fine particles and their precursors.
3. **Increase turnover of commercial vehicles, including buses.** The Minnesota Trucking Association supported legislation in 1999 similar to that in about 30 other states that would increase the turnover of older diesel trucks to new, less-polluting vehicles. This could be accomplished through incentive programs. A similar effort could be directed to government and private fleets and school buses. Additionally, Minnesota could encourage the retrofitting of older diesel trucks and buses through incentive programs.
4. **Increase turnover of off-road engines.** Minnesota could use incentive programs, as currently done by a number of states that do not meet federal ozone standards, to increase the purchase and use of cleaner off-road engines, such as lawn and garden equipment, recreational vehicles, and outboard motors.
5. **Target grossly polluting vehicles.** A small percentage of vehicles emit a disproportionate amount of all motor-vehicle pollution. Minnesota could create a program similar to that of other states to identify these "gross polluters" and reduce emissions by requiring owners to repair the vehicles or by buying and scrapping the vehicles.
6. **Increase the use of fuel-efficient vehicles.** Minnesota could use incentive programs to increase the purchase and use of fuel-efficient vehicles. This would reduce many pollutants of concern.
7. **Increase use of alternative fuels.** Alternative fuels can have far-reaching effects on air quality because they reduce emissions from the many sources using the fuel. Alternative fuels such as ethanol and biodiesel have the additional value of coming from renewable resources. Minnesota could offer incentives for alternative fuels, based on their environmental benefits, as a means of reducing certain air pollutants.
8. **Create a state science advisory panel.** Minnesota could create a multidisciplinary scientific advisory panel to bring stronger public-health perspectives to pollution-reduction efforts.
9. **Expand monitoring of toxic air pollutants.** The MPCA's existing monitoring network does not measure concentrations of semi-volatile substances such as polycyclic aromatic hydrocarbons, dioxins and pesticides that persist for long periods and are a threat to both health and the environment. Monitoring these substances is much more costly than monitoring the toxic pollutants currently monitored by the MPCA.

Conclusion: What makes a difference?

Through its regulatory programs, the "first wave" of environmental protection, the MPCA has made significant progress in reducing emissions of criteria pollutants from large stationary sources. Despite this progress, the MPCA is concerned about additional pollutants. The MPCA also is concerned about the growing share of emissions from a much larger number of sources, including gas stations, on- and off-road vehicles, gas and diesel engines, and even woodstoves.

The approaches needed to reduce air pollution will depend not only on cleaner fuels, energy and technologies, but also upon the choices that consumers and citizens make each day.

The MPCA is building upon its regulatory efforts with a second wave of environmental protection: encouraging consumers and citizens to make less-polluting choices. To be effective, the MPCA must use new tools and partnerships to make these cleaner choices more available. Additionally, the MPCA must address the new pollutants of concern coming from large stationary sources. Lastly, new and expanded efforts to address other sources will help improve air quality in Minnesota for the future.

“Reducing air pollution will depend not only on cleaner fuels, energy and technologies, but also upon the choices that consumers and citizens make each day.”

Acknowledgements

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Metro Commuter Services
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Minnesota Office of Environmental Assistance
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Lake Street Business Council
White Bear Lake Lions Club
Lavonia Township Lions Club
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Battle Creek/Hillcrest MOMS Club
Metropolitan State University American Government Class (Fall, 2000)

(Although these organizations participated in one or more MPCA events, they do not necessarily endorse the conclusions drawn by the MPCA in the report and appendices.)

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APPENDIX A
DRAFT
Background Information

1.0 Purpose of MPCA's Report on "Air Quality in Minnesota – Problems and Approaches"

The MPCA used scientific data and information gleaned from its stakeholder process to produce this year's report on air pollution. The report describes the air pollutants of concern to the MPCA and the emissions trends for these pollutants. The MPCA also describes in the report what steps are currently being taken to address these pollutants, and what additional steps need to be taken. Lastly, the report outlines the role the MPCA envisions for the citizens of Minnesota and the MPCA to play together to reduce air pollution.

1.1 Respond to legislative concerns raised about air toxics and mobile sources following the MPCA's release of the *Staff Paper on Air Toxics*

The MPCA released the *Staff Paper on Air Toxics* in November 1999. [For paper go to http://www.pca.state.mn.us/air/airtoxics.html.] The paper analyzed outdoor air monitoring data as well as modeling information from EPA. The analysis indicates the health of Minnesotans may be at greater risk than previously thought from toxic air pollutants, and that mobile sources are significant contributors to overall risk.

These findings created a great deal of public interest as well as some concern. Legislators, other state agencies, and environmental groups were also very interested.

One common criticism the MPCA received about the *Staff Paper* was the lack of an action plan to address the problem. This report includes the actions the MPCA is committed to doing to reduce air toxics, as well as other pollutants linked to air toxics. It also includes additional actions that could be proposed in the future depending on the outcome of the actions listed in this report and the results of on-going air pollution research and ambient monitoring. The MPCA's air toxics strategy was developed in 1994. The 1994 strategy is centered on three objectives:

1) Smooth, fair implementation of the Clean Air Act amendments of 1990,
2) Protect public health and the environment, and
3) Collect more information to make better decisions.

In the *1999 Air Toxics Legislative Report* the MPCA reported that ambient air monitoring data strongly indicated that area sources (smaller, largely non-regulated stationary sources, such as wood stoves and gas stations) and mobile sources are contributing substantially to air toxics emissions in Minnesota. The MPCA then evaluated the achievements and shortfalls of the existing strategy's objectives, noting that

implementation has focused primarily on point sources (larger permitted facilities) and that small, unregulated sources are a bigger problem than previously assumed.

Since January 1999, the MPCA has invested effort in reviewing ambient air toxics information and collaborating with other regulatory agencies about what the data might mean. Specifically, the MPCA continued to improve the accuracy of toxic emission inventories, collect and analyze additional ambient air data, and develop new ways to conduct air toxic reviews. While, the MPCA has also reviewed the objectives of the air toxics strategy, and believe that the three objectives themselves are important and timely, the specific steps taken to meet the objectives need to be changed.

1.2 Respond to legislative request for toxic mobile source information following the ending of the Vehicle Inspection Maintenance program

In 1999, the MPCA ended the vehicle inspection and maintenance program. Although the vehicle inspection and maintenance program successfully completed its mission of reducing carbon monoxide emissions in the Twin Cities, the MPCA is still concerned about the emissions of other toxic pollutants from motor vehicles. In response to legislative requests for additional information, the MPCA has developed a report about mobile sources of air pollution in conjunction with the statutorily required Air Toxics report.

The vehicle inspection program began in 1991 because the Twin Cities area failed to meet federal air quality standards for carbon monoxide, an invisible, poisonous gas emitted by motor vehicles. The annual emissions test detected cars that emitted too much carbon monoxide. By having vehicle emissions checked annually and making the necessary repairs, metro residents prevented 500,000 tons of carbon monoxide from entering the air. Another 38,000 tons of hydrocarbons or poorly burned fuel was also kept out of the air as an additional benefit of the vehicle inspection program. Because of the success of this program and the introduction of ethanol-based fuels and improved pollution control devises on new vehicles, the MPCA asked the federal government to reclassify the Twin Cities as an area that meets carbon monoxide standards. The reclassification was announced in October 1999, paving the way to end the vehicle inspection program in January 2000.

Now that the carbon monoxide threat has been successfully addressed, the MPCA has turned its attention to other pollutants that could not be addressed by a simple emissions test. The MPCA is concerned about other air pollutants emitted by motor vehicles (cars, trucks, off-road vehicles) and other gasoline-powered engines (lawnmowers, snowblowers, etc.) These engines emit more than half of some air pollutants in Minnesota, including those that cause smog, or “ground-level ozone.” Smog can damage the lungs, with children and those who exercise outdoors being especially at risk.

Engines also put out toxic air pollutants that can increase our risk of developing cancer. Toxic air pollutants emitted from motor vehicle engines were recently found to be a potential health threat across most of the U.S., particularly in urban areas with large numbers of cars. Americans drive an increasing number of miles every year as urban

sprawl increases and families live farther from work, shopping and recreation. Minnesotans drive more than 123 million miles every day (the distance to the sun and halfway back again!) and the number of miles is increasing every year. As the number of miles driven increases, so does the amount of air pollution released from motor vehicles.

At about the same time that the vehicle inspection program ended, the MPCA released the *Staff Paper on Air Toxics*. However, the report's findings did not influence the decision to end the vehicle inspection program. The vehicle inspection program was only designed to test for carbon monoxide. There are currently no vehicle inspection tests for the nearly 200 different chemicals that are considered "air toxics". In addition, the vehicle inspection program was designed to identify vehicles that were emitting too much pollution because the vehicle was not functioning properly. In terms of air toxics emissions, however, more than 40% of the air toxics are emitted from the exhaust of normally operating vehicles.

During the last legislative session, Governor Ventura sought funding for a special task force to look at options for addressing toxics and ozone-forming pollutants. This funding was denied, but the MPCA chose to reassign several staff to identify ways the MPCA could better address these pollutants within the agency's existing resources. Over the last year, MPCA staff has met with various stakeholders and citizens to continue the dialog about mobile source pollution, its causes and trends, and ways to address the root causes of the problem.

1.3 Fulfill the requirements under Minn. Stat. § 115D.15 and § 116.925

An air toxics report is required biennially under Minn. Stat. § 115D.15 and § 116.925 to the Environment and Natural Resources Committees of the Legislature by January 1. The statute dictates that the report contain:

- An analysis of the achievements, shortfall and resource needs for implementing the MPCA's air toxics strategy;
- An analysis of the data collected from the MPCA's statewide monitoring and inventory program;
- An analysis of reductions in emissions of toxic air contaminants;
- An updated list prioritizing and categorizing facilities emitting toxic air contaminants; and
- The amount of mercury emitted in the generation of electricity.

The first report in 1995 presented the MPCA's long-term air toxics strategy, summarized the MPCA's efforts to implement the Clean Air Act Amendments (CAAA) of 1990, reported the 1993 toxic air emission estimates, and the 1990 emission estimates for mercury. The 1997 report summarized the status of the various air programs in reducing emissions and implementing the CAAA, described improvements in air toxic emissions estimates, and presented available ambient monitoring data. The 1999 report described the MPCA's progress in implementing the air toxics strategy and called for a new strategy based on new data, provided updated information on emissions estimates and monitoring data, and discussed mercury emissions, trends and related activities. The 1999

report identified principal industrial sectors and their contribution to emissions of certain pollutants either on a mass basis or on a toxicity weighted basis. This method of categorizing sources of emissions replaced the list of specific facilities described in the statute (115D.15). The 1999 report may be found at: http://www.pca.state.mn.us/hot/legislature/reports/1999/airtoxics.pdf .

The following 2001 report describes the MPCA's strategies for reducing outdoor air pollutants including particulates and smog-forming pollutants, as well as air toxics.

2.0 Description of Process Used to Develop Report

2.1 Air toxics problems in the context of broader air pollution issues

Over thirty years of efforts to reduce air pollution have significantly improved air quality in many parts of the country. However, the majority of these efforts have focused on six pollutants (carbon monoxide, lead, sulfur dioxide, particulate matter, ozone, and nitrogen oxides are the so-called "criteria pollutants"). Beyond the six criteria air pollutants traditionally regulated by the federal government, there are many thousands of other substances that are released into the air as waste products. Some of these chemicals are air toxics, which are less well understood than the criteria pollutants. Many of these are not visible, and efforts to measure a few of them in our air have only begun recently. National air quality standards exist only for the criteria pollutants.

The distinction between air toxics and criteria pollutants is fuzzy with much overlap, and sometimes criteria pollutants must be included with air toxics in describing the impacts. For example, many air toxics are contained in the particulate matter category, while other air toxics contribute to the formation of ozone. If the term air toxics is defined broadly to include all substances in the air in concentrations sufficient to interfere with health, comfort, and safety, or with the full use and enjoyment of an area; then many pollutants are "air toxics". Climate changing gases are sometimes thought of as a separate category, although they fit this broad definition of air toxic. Some discussion of this topic is included because the sources of climate changing gases overlaps considerably with air toxics. Climate change gases are also in a different category than criteria pollutants and most air toxics because of the irreversibility of their effects over typical human time scales.

As scientists learn more about air pollution, they are finding that it causes more harm than previously thought. The available scientific data today suggests that very fine airborne particles have a more significant impact on health than other pollutant categories. These very fine particles in the air can be released directly into the air in their final form or can be formed in the air from emissions of other chemicals.

The air toxics problem is linked to many other environmental problems, and actions taken to address concerns about air toxics will have the added benefit of helping to solve other air quality problems. The most important activity contributing to air toxics (and related problems) is the combustion of fossil fuels. Reducing the combustion of fossil fuels will reduce emissions of air toxics, reduce emissions of ozone-forming (smog-forming)

pollutants, reduce emissions of airborne particles and reduce emissions of climate changing gases. In other words, many environmentally related problems can be addressed simultaneously by adopting measures to reduce the use of fossil fuels.

This report focuses on a subset of air toxics that are of concern because of their concentrations in Minnesota's air. Other toxics (such as mercury and dioxin) are called persistent bioaccumulative toxics. Although sometimes emitted to the air, persistent bioaccumulative toxics are of concern primarily because of their ability to travel long distances, to move into soil and water, and to build up in fish, mammals and/or other organisms. Because they are important environmentally, Persistent Bioaccumulative Toxics are briefly discussed in Appendix F. However, the focus of this report (with the exception of mercury) is on air pollutants that adversely impact humans through inhalation.

In addition, because the MPCA's authority extends only to the outdoor environment, this report does not address pollutants in the indoor air which some studies show are higher than in the outdoor air for many pollutants (Wallace, 1996; Ott, 1998*).*

2.2 Input received from interest groups, other agencies and citizens

Because the MPCA does not have regulatory authority over "mobile sources" in the manner it has over point and area sources; the MPCA is looking at other approaches. For example, the MPCA is working with federal, state and local governments, the legislature, businesses and individuals to come up with solutions to the problem. Working with others to address a complex problem like mobile source pollution requires a number of appropriate and connected steps. These include identifying and quantifying the problem, identifying the causes and their information about the most effective solutions. In preparing this report, the MPCA sought stakeholder input about specific steps the MPCA and others could take to address environmental problems associated with mobile sources of air pollution.

2.2.1 Purpose of the stakeholder input

This report was prepared with input from other state agencies, local units of government, public interest groups and citizens (i.e. "stakeholders"). The processes used to collect stakeholder input involved two-way communication. First, as part of each stakeholder event, the MPCA informed the stakeholders about what the MPCA knew about the issue. Second, the MPCA sought input from stakeholders about the nature of the problem and its causes, potential solutions, and the appropriate role(s) for the MPCA. The stakeholder forums were not designed to build consensus among the stakeholders. Instead the events were designed to inform the MPCA's approach to addressing air toxics and mobile sources of air pollution.

2.2.2 Input about the report itself.

The MPCA staff met with seven legislators[1] from the House and the Senate to discuss their information needs for the report. Based on their input, the MPCA staff decided to prepare a brief report about both air toxics and mobile sources of air pollution. In addition to the report, the MPCA decided to produce a more lengthy set of appendices.

MPCA staff met also with management and staff from a number of state agencies that have influence over state air quality. The purpose of these meetings was to clarify roles and activities, seek their input about the MPCA's five strategies to reduce air pollution form mobile sources, and to gauge their interest in participating in stakeholder events.

2.2.3 What the MPCA learned from the stakeholder events – common themes

- There is a lot of interest in using incentives to induce changes that result in less air pollution.

- Stakeholders want to see the state lead by example in terms of cleaner vehicles and fuels.

- State agency fleet managers are looking for high-level support from cabinet members/Governors office. State agencies should "model the way" in acquiring and using more alternative vehicles and their respective fuels that improve the environmental performance of their fleets and support the domestic economy.

- Stakeholders look to the MPCA as a credible source of environmental information.

- Virtually everyone is focused on stationary sources, especially the permitted facilities.

- Many had questions about what role the state should play given the steps already underway at the federal level.

- Other state agencies have an interest in the "modeling the way" strategy.

- Eighty five percent of the citizen participants view the current quality of the Twin Cities' air as fair to good. Two percent and sixteen percent said the air is poor and excellent respectively. With respect to future air quality 85 % are somewhat to very concerned about air pollution in the future.

- The MPCA found a fair level of support among citizens for strategies to reduce pollution from vehicles: Fifty percent or more of the participants supported or strongly supported five out of the six cleaner air options presented by MPCA staff.

2.2.4 An approach for collecting stakeholder input

[1] In June 2000, MPCA staff met with Senators Steve Murphy, Ellen Anderson, and Jane Krentz as well as Representatives Betty Folliard, Kathy Tingelstad, Dennis Ozment, Jean Wagenius.

The MPCA collected input about air toxics and mobile sources of air pollution as part of its stakeholder input on the MPCA's biennial budget process.[2] One hundred twenty participants from all regions of the state provided input about environmental priorities, resource needs and options to meet resource needs. Mobile sources of air pollution ranked first as an environmental priority among ten choices offered to the metro-area participants. Mobile sources ranked third as an environmental priority among the same ten choices offered to participants from all parts of the state.

The MPCA chose to focus subsequent stakeholder events toward mobile sources of air pollution because off-road and on-road mobile sources constitute nearly 60% of all emissions of air toxics. Mobile sources also produce major shares of certain criteria pollutants as well as global warming gases. The stakeholder input was aimed at developing solutions to reduce air pollution from mobile sources. Consequently, the forums focussed on the sources of the pollution rather than on specific pollutants. In this way, the solutions considered to address air toxics, for example, could be looked at in terms of their ability to reduce other pollutants of concern that are also emitted from mobile sources, such as ozone precursors and global warming gases.

To collect meaningful stakeholder input, the MPCA narrowed the scope of the issues to present to stakeholders to five separate approaches or strategies that could reduce air pollution from mobile sources. These strategies were prepared to create specific starting places for stakeholder discussions.[3] From these starting points, the MPCA intended to develop a shared understanding of the problem and to build support for specific actions to reduce mobile source pollution.

The MPCA's five strategies include short-term approaches, including efforts already proven effective elsewhere, to make immediate improvements in the Twin Cities' air quality. The five strategies also include longer-term approaches to address what the MPCA believed to be the root causes of the mobile sources pollution problem: fossil fuel consumption. The five strategies are:

1. **Land Use Choices:** *Encouraging development that reduces the length and number of car trips needed for commuting to work and getting around.*

2. **Transportation Choices:** *Supporting additional transportation choices so people don't have to resort to a car to get around.*

[2] "Stakeholder Input Meetings on the Biennial Budget Process: Results and Common Themes," Minnesota Pollution Control Agency (August 2000).

[3] The MPCA staff did this in response to feedback from previous stakeholder events. In previous events stakeholder had voiced concerns about time commitments, clarity about the MPCA's views and what the agency wanted to accomplish through stakeholder input. In response to these kinds of comments, the MPCA staff held a series of stakeholder events – each brief in time and specific in its focus and purpose. In this way, stakeholder input was used to best use. *See* "Mercury Contamination Reduction Advisory Council – Summary of Post-Process Participant Interviews and Recommendations," Minnesota Pollution Control Agency (July 1999).

3. **Technical Improvements:** *Encouraging technological improvements in vehicles/fuels beyond federal requirements*

4. **Modeling the Way:** *Demonstrating positive MPCA and other agency examples in purchase of vehicles/fuels, and supporting commuting and other travel choices*

5. **Individual Choices:** *Encouraging less polluting individual behaviors*

2.2.5 Stakeholder forums hosted by the MPCA

The MPCA used a variety of advice-seeking processes to solicit input and exchange ideas about ways to reduce air toxics and to reduce emissions from mobile sources of air pollution. These events were designed as ways for the MPCA to inform various groups about the MPCA's understanding about air toxics and other pollutants, and their trends. Secondly, the MPCA solicited advice from various groups about the scope of the problem, the MPCA's role in addressing the problem, and directions, gaps and areas that needed additional information. The forums hosted by the MPCA were based on specific sub-issues related to air toxics and mobile sources. The forums focussed on the following topics:

- Land use and transportation
- Technical improvements beyond federal requirements; and
- Transportation behavioral change.

In each of these events, the MPCA played both the roles of convenor and participant. For each of these areas, the groups explored the scope of the problem, what could and should be done about it, and what role, if any, the MPCA should play to address the problem. Stakeholder participation was important to enable the MPCA to better inform legislators about the linkages between transportation, land use and air quality.

2.2.5.1 Summary of the Land Use, Transportation and the Environment Event, July 31st through August 2nd, 2000

Purpose of this stakeholder event

Given the close connection between transportation, public health and the environment, the MPCA will in the future be working closely with sister agencies and external stakeholders to ensure clean and reliable transportation. To start the discussion with the MPCA, the following people were invited to a three-day meeting.

Participants

Pat Bursaw, Mn/DOT Metro; Jim Hansen, Mn/DOT; Otto Schmid,
Mn/DOT Metro; Dave Zumeta, Minnesota Department of Natural Resources;
John Wells, Minnesota Environmental Quality Board; Tony Kwilas and Mike Robertson

Minnesota Chamber of Commerce; Dave Weirens and Carol Lovro, Association of Minnesota Counties; Dan Hunt, Builders Association of Minnesota; Remi Stone, League of Minnesota Cities; Barb Thoman, Transit for Livable Communities; J. Drake Hamilton and Dee Long, Minnesotans for an Energy Efficient Economy; Jeanette Brimmer, Minnesota Center for Environmental Advocacy; Bob Works, John Sampson, David Belluck and Bruce Johnson, Minnesota Department of Transportation; Paula Maccabee, Minnesota Sierra Club; Gary Anderson and David Anderson, Center for Transportation Studies; Joe Esker, Paul Schmiechen, Dale Thompson, Ned Brooks and John Hensel, Minnesota Pollution Control Agency.

Facilitator: Jeff Buss, Minnesota Pollution Control Agency

Presenters: Mark Fillipi, Metropolitan Council; Innocent Eyoh, Kari Palmer, Chris Nelson, Greg Pratt, John Seltz, Minnesota Pollution Control Agency.

Process used for this event

- The MPCA shared with the participants what it knows about air pollutants from mobile sources and the trends as best as the agency understands them;

- The MPCA solicited stakeholder perspectives about what the environmental trends mean for their respective organizations and the state;

- The MPCA and stakeholders explored potential solutions to address the concerns raised by the stakeholders;

- The MPCA and stakeholders considered various roles the MPCA could or should play to address the concerns; and

- The MPCA and stakeholders tested potential solutions in terms of the opportunities they present or the barriers that exist to implementing them.

Summary of Stakeholder Input

The stakeholder identified four primary areas for the MPCA to focus upon to address mobile sources of air pollution. Those areas were:

- Transit funding enhancement.
- A common state message about environmental issues related to land use and transportation.
- Supporting community-designed, transit-supported development.
- Efficient pricing of transportation.

What follows are the steps and discussion that led the group to identify these areas.

After the MPCA presentation about the problem, the stakeholders were asked what information or messages surprised them. The stakeholders responded as follows:

- Ozone levels at Lake Mille Lacs
- Ozone is highest outside the metro area
- Future impacts of developing nations on CO2 levels
- Need to reabsorb last 20 years of carbon to "halt" global warming
- Effects of agriculture on global warming
- Air toxics in cars is 8 times higher than outside air
- Concerns about data quality
- Data collection "defines" the problem
- Population as a driving force
- Incremental cancer risks associated with the regulated chemicals
- Consumption as a driving force
- There are other drivers such as housing, education, etc. beyond the scope of environmental regulation – but needs to be part of the message
- Off-road contribution of mobile sources as significant
- One chemical at a time approach is too little too late
- "Command and control" approach – viable or not?
- We're running up against notions of personal freedom . . . to drive and live wherever
- Need information to influence choices (the 100th monkey)
- Pay attention to the credibility of the messenger
- Look at the market externalities
- Understand the system first before implementing a remedy
- Keep in mind the opportunity costs associated with pollution reduction efforts
- Need to offer choices that are easy to take
- Need to market transportation choices as attractive alternatives

What did stakeholders identify as issues warranting attention?

The stakeholders chose the following issues as representative of their brainstorming effort:

- Auto dependent development patterns
- Deteriorating air quality
- Public denial about the problem – lack of information
- Increased travel and consumption rates
- Government integration – one stop shop
- Transportation impacts on air quality
- Global climate change
- Sound scientific support for decision-making
- Land use (noise)
- Air quality problems (ozone, global warming, haze, health)
- Perception that the air quality is good

- Market forces sending the wrong signals
- "To regulate or not to regulate"?

What kinds of solutions did stakeholders offer to address the issues?[4]

- Awareness and Education
- Efficient Pricing of Transportation
- Common Message (from State Agencies)
- Transit Funding Enhancement
- Community designed, transit supported land use
- Over-riding philosophy (the big picture)
- Regulation
- (Government) Procurement
- Incentives for Cars and Fuels
- Non-fossil powered transportation
- Research
- Alternative work sites

What role did stakeholders envision for the MPCA to address the issues?

The group's solutions went beyond the areas of land use and transportation. In terms of clarifying roles, the group focused on the following four from the above clusters:

1. Transit funding enhancement

- Provide environmental messages/information in support of transit
- Advocate for clean buses and transit improvements
- Model behavior – encourage use of multi-modes of transportation
- Advocacy on funding issues
- Multi-modal funding as an air quality issue
- Weigh in on the use and allocation of Transportation Equity Act (TEA-21) funds

2. Common state messages (about environmental issues related to transportation and land use)

- Repository for information about the state of air quality
- Information on innovative practices to reduce air pollution
- Work with the health-care community on issues relating to health and air pollution
- Provide expertise to other agencies, the legislature and communities
- Get the message out about air pollution
- Work with the Environmental Quality Board (EQB) to develop interagency plan to prevent climate change.

[4] There was also a catchall "other" category that included tongue-in-cheek suggestions.

- Work with EQB to convene an environmental congress to create a state strategic plan for addressing land use, transportation and the environment – with **measurable outcomes**
- Be an informed champion with integrity – exhibit leadership for clean air

3. Community-designed, transit-supported development

- Advocate a smart growth state investment strategy
- Propose comprehensive planning by local units of government as part of state aid for water treatment.
- Offer grants to communities for demonstration projects that improve air quality.
- Establish carry-capacity levels for different geographic regions (i.e. airsheds)
- Use cleaned up brownfields for open space or non-industrial development.
- Provide technical assistance on air and water quality
- Provide more environmental information for land use decisions
- Participate on interagency teams to provide technical assistance on environmental issues to local units of government for land use decisions.
- Provide measured outcomes and evaluate progress to ensure accountability.

4. Efficient pricing of transportation

- Address individual vehicles that emit excessive levels of pollution.
- Explore the use of fees, incentives and regulations to reduce pollution from off-road engines.
- Provide expertise about how a carbon emissions trading system would work and evaluate its feasibility.
- Work with state and federal agencies to explore a carbon tax, congestion pricing and other market-based efforts.

2.2.5.2 Summary of the Mobile Sources Stakeholder Meeting About Technical Improvements beyond Federal Requirements, August 29, 2000

Purpose of this stakeholder event

To explore areas where the Minnesota could best advance technical improvements in fuels and engines beyond federal requirements.

Participants

Leo Raudys, John Hensel and Ned Brooks (PCA); Mike Hansel (Koch); Marilyn Jordahl (MNDOT Environmental Services); J. Drake Hamilton (ME3); Gary Barnes (CTS); Todd Iverson (MN Trucking); Tom Sem and Robert Lettin (ThermoKing); LaVaughn Henry (Ford); Tim Gerlach (American Lung of MN); Alan Klink (Marathion Ashland); Ralph Groschen (MN Dept. of Agriculture) and Mike Taylor (MN Dept. of Commerce).

Presenting: Chris Nelson, Kurt Anderson, Rocky Sisk and Mike Mondloch
Facilitator: Jeff Buss

Summary of Stakeholder Input

This stakeholder group identified the following areas to consider making technical improvements to reduce air pollution:

- Research
- Education
- Fuels
- Non-financial incentives
- Incentives

What follows are the steps the group took to address the issues listed above

Do government officials and citizens need to pay attention to mobile source pollution in Minnesota? What are your key concerns?

- Are the Twin Cities VOC or Nox limited? More current information is needed.
- Ozone is a concern – where is it coming from?
- Does Minnesota have sufficient monitoring coverage?
- Air toxics in the Twin Cities (i.e. benzene) are too high
- How does Minnesota compare to other states and metropolitan areas?
- Need a better understanding of on and off road inventory (diesel and gas)
- What role has congestion played?
- Are there seasonal variations in pollutants?
- What are the future trends in terms of growth, traffic, fleets, etc.
- What are the benefits of various reduction options?

- Does early action make sense?
- What are the consequences of non-attainment?
- What are the benefits of being proactive?
- Can Minnesotans afford the new (vehicle) technology on a wide scale?
- Avoid solutions that work at cross purposes (i.e. less diesel emissions and more fuel consumption)
- What are the technology improvement bottlenecks?
- Consumer education
- Market incentives/signals that educate consumers
- Clarify impact by source: standardize them by pollutant
- Sufficient monitoring and analysis to know where to proceed first
- How to balance action with emerging information?
- How is pollution distributed?
- Do EPA's upcoming regulations on fuels and vehicles solve the problem?
- How can we offer incentives to speed up the turnover of the fleets?
- Are there increases in CO and CO2?

Brainstorming question: What technical improvements should be pursued in Minnesota?

More Research

- Improvements in traffic flow to reduce emissions
- Study traffic congestion relief
- Off-road gasoline – identify large sources and address
- Resources for expanded study on technical fixes (e.g. target gross emitters)
- Must have "health/damage hazard factor" on known emissions
- Life-cycle cost-benefit analysis on chosen alternative
- Rate air borne pollution constituency based on long/short term environmental impact

Education

- In-cabin air quality awareness
- Promote telecommuting and alternative work sites (public and private)
- Increase consumer awareness about problems and solutions
- Ad campaign to educate consumers about clean autos

Fuels

- 85% limit fossil content gasoline
- voluntary early low sulfur gasoline
- voluntary low benzene gasoline
- less toxic fuel
- 95% limit fossil content diesel

- opt in to reformulated gasoline (RFG)
- develop alternative EPACT plan
- greater E85 use by general public
- alternative technology/fuel mandates for new bus funding
- consolidate on and off road fuel specs
- voluntary stage 1 vapor reduction
- airport ground vehicle improvements

Non-financial incentives

- Emissions credits for 2 cycle engines (for trade in)
- Traffic preference for alternative fuels (sane lane preference)

Incentives

- Incentives for new technology (Minnesota adopting California approaches)
- Lower sales tax on cleaner vehicles
- Incentives for early action
- Incentives for diesel retrofit – on road
- Incentives to push sales: sale tax exemption and $35/yr license tabs for alternative fuel vehicles (AFVs) and off-road equipment with 40% emission reduction
- Incentives for transit ridership
- Incentives to push sales: fuel tax exemption on 20/80 bio-diesel (make bio-diesel costs the same as regular diesel)
- Increase technology turnover rate
- Incentives for clean air choices
- Increase telecommuting and alternative work areas
- Regulate emissions on government vehicles: city, school bus, plows, construction equipment
- Emissions testing for heavy duty diesel
- Alternative technology tax credits
- Off-road heavy duty diesel retrofit
- Clean fuels/vehicle legislation
- State fleet should all be low emission
- Issue “E”nviro bonds

Follow up question: What technical improvements <u>must</u> be pursued in Minnesota?

- Alternative technology and/or fuel mandates for new bus funding
- Incentives
- Clean fuels/clean vehicles legislation
- Incentives for fuel efficient vehicles
- (CAFÉ) education to the public
- push consumer education on consequences of transportation decisions

- voluntary fuels improvements
- incentives for low emission options
- 95% limit on fossil content diesel fuel
- "fair share" pollution (worst 10%)
- consolidate on & off road fuel specs
- incentives or incentives or even incentives

What role should the MPCA play to pursue these actions that the group brainstormed?

- Promote incentives
- Use regulatory authority if possible
- Research role (jointly with MNDOT for example)
- Encourage a preventative approach
- Work with other governmental entities or private sector to take voluntary actions
- Change the way air penalties are used (now they go to the general fund)
- Target those that emit more than their fair share
- Make complex issues easier to understand
- Targeted information to address public choices
- Work closely with other agencies
- Preach what you practice
- Provide the environmental rationale for decision-makers

How might the MPCA promote incentives without asking for additional funding?

- Lead by example
- Encourage others
- Revenue neutral approaches
- Target areas for best bang for the buck (assuming that everything really has a cost its just a matter of who bears it)
- Focus on the benefits of proposals "what is most worth doing?"
- What options are most likely to succeed?

2.2.5.3 **Summary of the Transportation Behavior Change Stakeholder Event, September 28th, 2000**

Purpose of this event

People's choices about transportation can influence the level of environmental impact to Minnesota's air. More people could make transportation and behavior choices that favor clean air. Such as; how to get around, the type of vehicle purchased, fuel type chosen, driving habits, and location of work, recreation and home. MPCA staff gathered colleagues from state government and non-profit organizations working to encourage behavior change, to share tools and perspectives and to offer the MPCA suggestions on its role in encouraging transportation behavior changes that would result in less deterioration of the environment.

Participants

Jay Jaffee, Minnesota Department of Health; Mary Gliniany, Full Circle Environmental; Betsy Barnum, Great River Earth Institute; Mat Holinshead, Sierra Club; J. Drake Hamilton, Minnesotans for and Energy Efficient Economy; Patty Carlson, Metro Commuter Services; David Van Hattum, Minneapolis Transportation Management Organization; Sue Wiley, Office of Environmental Assistance; Jim Dustrude, MnDOT; and MPCA staff Ned Brooks, Jeff Buss, Ralph Heussner, Becky Helgeson, Sherryl Livingston and John Hensel.

Summary of Stakeholder Input

There is no clear lead on many of these issues - need multi-agency group to address with budget. (and no one has chosen to take the lead)
Explore benefits of reduced road demand = better efficiency of system - not need additional facilities.
Use Minn. Stat. Sec. 116D as authority for leadership.
Study circle with leaders could have tremendous leadership.
MnDOT Agency Mission should be to reduce vehicle miles traveled (VMT).

Results of this event

The first part of the day-long event consisted of presentations by behavior change "practitioners" working in the area of health promotion, transportation and the environment. Several panelists presented their approach to behavior change in their particular field. Following this panel discussion, the group talked about common themes and the role for state government in behavior change. The group listed the following themes and roles:

COMMON THREADS (to behavior change models presented by panel and others)

Easy, fun, popular.

Portray alternative is more attractive.
Audience segment/assessment - different w/different segments.
Selling prevention - benefits down road.
Engage public.
Positioning.
Marketing (not just social marketing).
Common tread - kids know truth how not to get jaded - how to focus?
Needs to start w/self. Where are you at?
Multifaceted approaches.
-kids
-study circles
-mass media
Selling Point-- Pollution in air as motivator, people reacting to time.
Regulations, norms, availability cuts both ways - for all of the above.
Be aware of what's going in the other direction.
Kids emulate adult behavior. Look at adults.
Kids - it's for the kids we change behavior.
No guilt - recognize that.
Norms created by corporate messages.
VW Beatle popularity.
"Neme Machine" book by S. Blackmore -- images replicate.
Has to be an internal shift.
Kids are motivators.

ROLE FOR GOVERNMENT IN BEHAVIOR CHANGE

Define the problems, get word out.
Find ways to support businesses that are moving in the right direction.
Municipalities/ government support and champion non-profit, grass-roots efforts.
Champion efforts.
Multi media - use variety of outreach/education methods.
Protect health, environment, etc., how to be proactive.
Understand community norms.
Partnering with other groups - getting together.
Provide tools. Money, training, hard copies of materials.
Regulation/policy.
Set an example.
Availability of options, services.
Support of making right choice.
Incentives.
Forum for community values, sampling and giving advice.
Galvanize advocates (gov. is people) do the will of the people.
Think outside box with budget.
Research for public good.

Following this discussion, the group was asked to list roles and tools for the MPCA to

encourage one or two of the following behavior changes to improve air quality:

- Reduce driving. Commuting - non-commuting.
- Fuel choice.
- Vehicle choice/use.
- Driving habits.
- Vehicle maintenance.

The group split into two smaller groups, one discussing reducing driving and the other vehicle choice. The groups listed the following tactics and roles:

WHAT SHOULD WE DO TO REDUCE DRIVING? (PCA role – support(s), lead(l), assurance(a))
Car pools (s).
Shuttling to events (s).
Advertising regulations/broadcasters industry (l/a).
State government shall do everything in out power to do the right thing (116D).
Research interior car air quality (s/l).
Tele - shopping, commuting, conferencing. Push the technology (s).
Effective and efficient public transportation (s).
Improve the image of non-driving (l/s).
A tool box of neighborhood ideas for things like "car sharing" (s/l).
Car sharing (s).
License plate breaks for car poolers (s).
Advocate for dedicated funding for transit (l).
Financial incentives for how much you drive - gas tax.
Continue to support commuter services activities. Co-sponsor, charge steering committee at transit issues (s).
Travel diary to track out transportation habits with recognition tied to it (a).
Provide programs that support education financially without needing to work (s).
Buddy system for better behavior (s).
Bike paths, bike routes, campaign to teach drivers/bikers to be aware of each other (s).
Promote benefits of not driving (l/s).
Subsides for bike use (s).
Encourage cities to consider alternative in their city planning / new developments (s).
Allow bus time to be part of your 40 hour work week (s).
Proof of purchase bus system (s).
More buses with bike racks (s).
Address those who just love to drive (s).
Improve perception of the quality of local schools (s).
Sit down and partner with those groups and economic interests that would benefit from people not using autos (l/s).
Research the impact of students performance if they didn't drive school (s).
Look into the CFL requirement for space development for new schools (l).
Revised zoning requirements (s).

Utilize technologies such as study circles (s/l).
Address to non-work driving that happens and why (s).
Provide information about what is available to commuters (s).
Community discussion groups (s/l).
A model with local leaders involved (s).
Is it measurable (l/s).
Cash out / incentives for business that don't take advantage of their deductions (s).
Equal rights for non auto transportation of users (s).

WHAT SHOULD THE MPCA DO TO ENCOURAGE VEHICLE CHOICE?

MPCA provide "good housekeeping" seal of approval (green guide and Vermont) on cars; incentive is low license tab fee and maybe insurance. For businesses, extra bonus money from MPCA if selected. Partners = American Lung Association, dealer associations, others.
MPCA announce all PCA fleet cars most fuel-efficient; sell to entire state fleet management and Governor. (Also flexible-fuel vehicle).
State to lower tax on E85.
Make sure Governor drives fuel efficient car.
Create catchy phrase or theme - get teenagers to come up with it.
Find effective way of getting information to people (they may receive but not read or get).
MPCA must strongly clarify ending emissions testing.
MPCA set up voluntary car maintenance/emissions test with private businesses. Free or sponsored by____?
Tax break for fewer cars per family.
Define and publicize E85 - no one know shat it is.
New cars that meet CA standards sold here get rebate or? from state and lower tabs.
MPCA applaud / publicly award cars that are fuel efficient, etc. Lower tabs.
MPCA be visible leader.
Annual report card (DOT, MPCA, Commerce) on VMT and gas use (graphic) compared to pop, etc. (time commuting) - just information not interpretation.
Make data available. (use on billboards or drive-time radio)
Target car loan sources and car clubs to give simple comparative info.
Show at car auto shows.
Take insights, etc. to Porky's on weekend.
Old clunker buy-back.
Ask for funding (we decide limits/criteria) change in where Air Quality penalties go - so we can use for incentives (as above).
Free E85 for a day - education campaign on E85.
Take Prius and Insight to capitol - rides to legislators.
MPCA re-work ISP for new development to encourage other transportation besides cars.
Preferential parking spaces for certain vehicles (how?) voluntary by businesses/development.
MPCA start study circles of powerful leadership types (fleets, etc.)

In closing, the group discussed insights and advice to state government on encouraging transportation behavior change:

ADVICE TO COMMISSIONER/GOVERNOR/LEGISLATURE REGARDING MPCA'S ROLE (in encouraging transportation behavaior change)

Incentives - main mechanism because it offers most flexibility.
PCA coordinate education program re: clean air behavior. (and needs money)
Cut a deal. Let us run controversial agenda and take the heat, want true public reaction.
Reclaim public awareness - public needs balanced information.
Don't shy away from regulation, especially incentives. Public expects it (more incentive - type). Give people the right signals ($).
Public's choices are a large part of air problem but no funding is generated for program. (tax, fee as incentive vs disincentive)
Lead by example.
Incorporate VMT reduction < employees < agencies.

2.25.4 Citizen Input to Mobile Source Reduction Strategies

In September and October of 2000, MPCA staff sought input from citizens about their perceptions of the air quality in the Twin Cities and to gauge their level of support for a variety of options under consideration to improve the region's air quality. In total, the MPCA received the input of 183 people from around the Twin Cities area representing a variety of viewpoints.

Participants

To make sure that the input represented Minnesotans' views, MPCA staff arranged to participate in regularly scheduled meetings of civic, social, service and other groups that staff believed did not have an inherent bias in favor of or in opposition to strategies to reduce vehicle pollution. Citizens attended the meeting because of their involvement in the group and not because they had a position or opinion about the subject that they wished to express.

Participant Summary

Group	City	Number of Participants	Date
St. Paul Rotary Club	St. Paul	97	9/19/00
Lake Street Business Council	Minneapolis	11	9/21/00
White Bear Lake Lions Club	White Bear Lake	33	9/28/00
Lavonia Township Lions Club	Southern Scherburne Co.	11	10/2/00
Minnesota Quality Conference (public sector employees)	St. Paul	7	10/10/00
Battle Creek/ Hillcrest MOMS Club (stay-at-home mothers' club)	Maplewood	11	10/16/00
Metro State University Political Science Class	St. Paul	24	10/25/00
		183	

Methodology

To seek citizen input, the MPCA utilized a keypad voting system where each participant used a handheld keypad to anonymously indicate their response to a set of questions. Results were then immediately displayed on the screen allowing participants to see the results and then discuss the findings. While this system does not yield a statistically accurate representation of the general population, it does provide a snapshot of each

groups' views. The MPCA believes that enough of a diversity of groups participated in this process to allow for some general conclusions to be drawn about citizens of the region.

Questions

Following a few warm-up questions to acquaint people with the voting system, MPCA staff asked three types of questions:

1. Demographic questions
2. Participants' views and concerns about current and future air quality
3. Level of support for options to address air pollution from cars and trucks.
4. Follow-up questions (following a brief presentation on the MPCA's view of air quality).

Participant Demographic Summary

Question	**Percent of participants**
Where do you live?	
Minneapolis or St. Paul	28
Suburb within I 494/694 beltline	23
Outside I 494/694 beltline	49
How did you get here today?	
Minivan, pick-up, SUV	30
Mid-sized car or station wagon	27
Compact car or station wagon	28
Didn't drive—used bike, bus, etc.	5
How much do you drive?	
20,000 miles per year	25
15,000 miles per year	29
10,000 miles per year	28
5,000 miles per year	18

Key Findings

- Views and Concerns About Current and Future Air Quality

Eighty five percent of the participants in the sessions view the current quality of the Twin Cities' air as fair to good. Two percent and sixteen percent said the air is poor and excellent respectively.

With respect to future air quality 85 % are somewhat to very concerned about air pollution in the future.

This question was asked twice – one at the beginning of the sessions and again at the end as a follow-up after MPCA staff presented information about air pollution in the Twin Cities. It is interesting to note that the same percentage of respondents expressed that they were somewhat to very concerned both times. However, the number of people expressing greater concern increased following the presentation with a corresponding decrease in those stating that the are somewhat concerned.

- Support for strategies

We found a fair level of support for five out of the six cleaner air options; supported or strongly supported by 50% or more of the respondents.

66% supported or strongly supported the older truck clean up option, making this the most strongly supported measure.

Participants expressed the least amount of support for increased transit at the expense of funding for highways and roads supported by only 41% of the respondents. However, this same option, when paid for by an increase in the tax on gasoline was supported by 53% of the respondents.

In general, support for the options slips the farther away from the core cities of Mpls and St. Paul.

Options tied to fuel consumption and cost of fuel slip among higher fuel consumers.

Following the presentation by MPCA staff on current and future air quality, support for the cleaner air strategies as a whole increased.

Summary of Participant Views of Options for Cleaner Air

Option for Cleaner Air	Mean Response (1-5 scale; strongly oppose to strongly support)
Require cleaner burning fuel, reducing pollution by 20% at an added cost of $0.05-0.08 per gallon.	3.5
Provide rebates for the purchase of more fuel efficient vehicles (>35MPG) via a surcharge on less fuel-efficient vehicles (<20MPG).	3.4
Fix or remove high-polluting vehicles using existing motor vehicle taxes.	3.3
Require older commercial trucks to clean up their emissions (leading to slightly higher costs for goods and services)	3.7
Increased or improved transit (bus, rail) at the expense of funding for highways and roads.	3.0
Increased or improved transit funded by an increase in the tax on gasoline by $0.02-0.03 per gallon.	3.4

Conclusions

The MPCA found a fair level of support for strategies to reduce pollution from vehicles: Fifty percent or more of the participants supported or strongly supported five out of the six cleaner air options. Support for certain strategies drops among suburban residents and among higher fuel consumers.

Following a presentation by MPCA staff on current and future air quality, support for the cleaner air strategies as a whole increased. This suggests that a better understanding of the problem can lead to increased support for measures to address current and future concerns.

While more research is needed to validate this notion, participants seem to have a fairly realistic view of current and future air quality concerns. Eighty five percent say current air quality is fair to good, similar to the MPCA's characterization of the region's current air quality. Perhaps more importantly, 85% of respondents are somewhat to very concerned about air pollution in the future. With respect to pollution from vehicles the MPCA too is most concerned about future trends.

This may suggest that future mobile source outreach efforts could focus on building public support for preventive measures to reduce air pollution in the future rather than trying to convince people that we currently have a problem.

For a detailed analysis of the findings contact Ned Brooks at 651-296-8709 or ned.brooks@pca.state.mn.us.

2.25.5 Alternative Fuels Workshop for State Agencies

Summary

On July 27, 2000, the Pollution Control Agency, Department of Administration, Department of Commerce and Office of Environmental Assistance cosponsored a workshop on alternative fueled vehicles and related federal mandates. The workshop attendees consisted of 38 procurement and fleet administrative staff representing 17 State departments.

Through this workshop the sponsors seek to educate state agencies on the Energy Policy Act of 1992 (EPAct) mandate and increase the use of alternative transportation fuels by State vehicles. Specific objectives of the workshop were to:

- Provide an overview of alternative fuels and vehicles and their availability.
- Explain State departments' requirements in acquiring and reporting alternative fueled vehicles under the EPAct.
- Inform department staff of the resources and assistance available from the co-sponsors to aid departments in meeting the requirements of EPAct and using more alternative fuels.

During and following the workshop we received many questions, comments and concerns about the EPAct requirements and use of alternative fuels. Based on large and small group discussions, the following feedback emerged:

- Need top-level support and advocacy for agency fleet administrators in meeting the agencies EPAct requirements and promoting the use of alternative fuels in state vehicles. Alleviate misconceptions on the reliability of the vehicles, fuel and maintenance.
- The cost-effectiveness and performance of alternative fuels must be demonstrated.
- Fuel must be readily available.
- Operator/vehicle awareness of the fuel needs to be raised.
- Improve vehicle choices. Sometimes a less efficient vehicle is selected to fill the EPAct requirement over a higher MPG gasoline-only vehicle.
- Provide education on EPAct and alternative fuels beyond the commissioners and fleet administrators.

Based on the above comments and a discussion of the implications of the above, the workshop cosponsors propose the following action items:

- Seek high-level support from cabinet members/Governors office. State agencies should "model the way" in acquiring and using more alternative vehicles and their respective fuels that improve the environmental performance of their fleets and support the domestic economy.
- Prepare educational materials for procurement and fleet management staff.
- Prepare educational materials for state vehicle users
- Explore ways to meet the EPAct mandate and goals of reducing petroleum use through vehicle efficiency vs. alternative fuel use.

Background: For departments covered by the EPAct requirements, 50% of all new light duty vehicles purchased must be alternative fuel vehicles. This increases to 75% in 2001. With very few exceptions, departments meet this requirement by purchasing flexible fuel vehicles that can operate using E85, an 85% ethanol fuel, straight gasoline or and combination of the two. Over 500 vehicles currently in the state fleet are flexible fuel vehicles although the majority of these operate on gasoline only most of the time. E85 fuel can be purchased at nearly 50 public sites in Minnesota. No other state has as many fueling locations.

2.2.7.1 **Meetings with sister agencies**

Purpose of the meetings.

As part of the development of its stakeholder events, MPCA staff met in May and June of 2000 with staff from other state agencies. The purpose of these meetings was to solicit their views about the scope of the stakeholder events and the kinds of information that should be collected. The meetings were also an opportunity to share some initial ideas with other agencies that make decisions that influence the state's air quality.

Participants.

Christine Smitten, Jim Barton**,** Eli Cooper**,** Connie Koziak **(**Metropolitan Council**);** Patty Carlson (Manager Metro Commuter Services)**;** John Sampson**,** Richard Cady**,** Marilyn Jordahl and Dave Belluck (MnDOT Environmental Services); Tim Henkel, Otto Schmid, Pat Bursaw and Deb Sorensen (MnDOT / Metro Planning); Dave Zumeta and Tom Balcom (Minnesota Department of Natural Resources); Robert Einweck and Hillary Carpenter (Minnesota Department of Health); and John Wells (Minnesota Planning - Minnesota Environmental Quality Board).

Comments and Suggestions

- The MPCA could also look at smaller scale efforts to provide assistance, such as providing technical assistance and developing common guidance and procedures.
- Combine the transportation and land use stakeholder events.
- Interested in exploring incentives to change behaviors, including tax credits, etc.
- Look carefully at studies such as MATES II that indicate that diesel is a primary source contributing to health problems.
- Interested in modeling the way activities.
- Look carefully at the MPCA role in areas outside its traditional jurisdiction – including land use and transportation.
- There are areas of common interest such as managing the growing transportation demand in ways that also result in less air pollution.
- There may be common measures MnDOT and MPCA could use to track mobility and air quality.
- Developing goals for the MPCA's efforts would help clarify what needs to be done.
- There are areas where the Urban GEIS would help inform the MPCA's efforts to reduce emissions from mobile sources.
- Look at using economic signals and incentives as means to make cleaner choices more viable – look for ways to internalize costs, such as health costs associated with pollution, that are not currently reflected in the price of goods that produce air pollution.

References:

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Ott WR, Roberts JW. Everyday exposure to toxic pollutants. Scientific American 278:86-91 (1998).

APPENDIX B
DRAFT
Particulate Matter: Concerns and Trends

Introduction

A large and growing body of literature documents the adverse health effects associated with particulate air pollution. In many instances these effects have been found at U.S. ambient concentrations that are below the federal ambient air quality standards (NAAQS) (EPA, 2000a). Recently, attention has focused on smaller invisible particles, primarily from combustion sources, which are inhaled deeply into the lungs.

Particulate air pollution has been associated with premature death, increased hospital and emergency room admissions, aggravation of respiratory and cardiovascular disease, decreased lung function, increased respiratory symptoms (cough, shortness of breath, wheezing, asthma attacks), chronic obstructive pulmonary disease, and restricted activity due to illness, and altered respiratory defense mechanisms (EPA, 1996). These findings were generated using a range of epidemiological different study designs including population-based cross sectional studies, daily time-series studies of short-term exposure, and prospective cohort studies of long-term exposure.

Many studies demonstrate that sensitive sub-populations are more vulnerable to the effects of the pollution than others. Specifically, the elderly and people with pre-existing medical conditions such as cardiovascular or respiratory disease, pneumonia, and chronic obstructive pulmonary disease, have been shown to be at higher risk of premature mortality and hospital admissions, children have been shown to have increased respiratory symptoms and decreased lung function, and asthmatic children and adults are at higher risk of asthma attacks. The Environmental Protection Agency (EPA) recently summarized specific concerns of ambient particulate matter concentrations on sensitive populations (EPA, 2000a).

Recently, two landmark prospective epidemiology studies provided strong evidence that long-term exposures to ambient levels of fine ($PM_{2.5}$) particulate air pollution are causing increased death rates (mortality) in U.S. cities. The findings of the Six Cities (Dockery et al., 1993) and American Cancer Society (ACS) (Pope et al., 1995a) studies were dramatic. They played a prominent role in EPA's development of the $PM_{2.5}$ standard. After taking differences in personal risk factors into account, the Harvard Six Cities study found 26% higher risk of death between the most fine particulate polluted (Stuebenville, Ohio) vs. the least fine particle polluted (Portage, Wisconsin) city. The ACS study found 17 % higher overall death rates between the most and least polluted cites.

1.0 Definition

Particulate air pollution is a mixture of solid particles and liquid droplets found in air that vary greatly in size, composition and origin. Particulate matter (PM) derives from anthropogenic (human–made) stationary and mobile sources and natural sources. Particulate matter is characterized several ways.

For regulatory purposes, particulate matter air concentrations are described according to the mass of specific size fractions present in a cubic meter of air (ug/m3). Over time, the Environmental Protection Agency (EPA) has focused particulate matter control efforts on smaller sized particles. The original PM National Ambient Air Quality Standard (NAAQS) addressed total suspended particulate matter (TSP) defined by a 40 um aerodynamic diameter size cutoff. In 1987 the PM NAAQS was changed to PM_{10}, to selectively focus on the more hazardous particles smaller particles. PM_{10} is known as inhalable (or thoracic) particulate matter, and includes particulate matter with aerodynamic diameters smaller than or equal to 10 um. In 1997 EPA added a second size class for particle matter with aerodynamic diameters less than or equal 2.5 um, the $PM_{2.5}$ standard (62 FR 38651). PM_{10} particulate matter is therefore composed of 1) particles with diameters between 2.5 um and 10 um, known as the coarse fraction, and 2) particles with diameters less than or equal to 2.5 um, known as fine particulate matter. By definition, the sum of the coarse particulate matter (PM_{10} – PM2.5) plus fine particulate matter (PM2.5) equals PM_{10}. Several of the pollutants studied are subsets of the others. For example, PM2.5 is a subset of PM_{10}, and PM_{10} is a subset of total suspended particles.

Evidence from health impact studies indicates the smaller-sized particles are generally highly associated with adverse health effects. The science points to the fine particulate matter in particular being more strongly associated with serious health effects, such as premature mortality, than coarse particulate matter (EPA, 2000a). One explanation for this is that they penetrate more deeply into the lungs, and have greater retention. Ongoing research is investigating the mechanism by which the smaller particles may have more significant health impacts and also whether other measures of the particles, such as the number of particles, size distribution, or surface area may be more useful characterizations for health impact assessments (Lighty et al., 2000).

2.0 Particulate Matter Sources/ Emissions

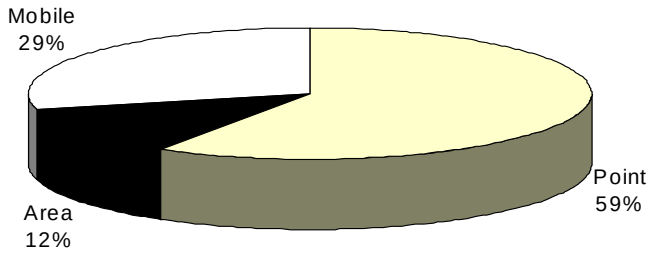
Particles can also be categorized based on their mode of formation. The three general size classes are: ultrafine or nuclei mode (with aerodynamic diameters less than 0.1 um), fine or accumulation mode (with aerodynamic diameters between 0.1 um and 2.5 um), and coarse mode (with dynamic diameters > 2.5 um). The major source of ultrafine and fine mode particles are combustion sources, such as from combustion of fossil fuels in transportation (diesel trucks, buses, and cars), power generation, and manufacturing. Residential wood burning, forest fires, and high temperature industrial processes (e.g., metal smelters, steel mills) may be other significant sources in some areas. Fine particulate matter can be directly emitted or formed secondarily through the condensation

of volatile compounds or by chemical reactions of gases in the atmosphere (e.g., sulfur oxides, nitrogen oxides, volatile organic compounds and other gases). Nuclei mode particles are only found near sources of condensable gases, such as near motor vehicle tailpipe emissions. Over time these nuclei mode particles grow in size through an aggregation process and become fine mode particles. Major components of fine particulates include sulfates, nitrates, ammonia, elemental carbon, organic carbon (such as polycyclic aromatic hydrocarbons), minerals, trace elements (e.g., lead, cadmium, vanadium, nickel, copper, zinc, manganese, and iron), and water. Fine particles may remain in the air for days to weeks and may travel hundreds to thousands of kilometers (Lippmann, 2000). Secondary particulate matter is dominated by sulfate in the eastern U.S. and relatively more nitrate in the western U.S. (EPA, 2000b).

Coarse particles are primarily composed of crustal materials (aluminosilicates), soil, and mineral ash. Most coarse mode particles (>2.5 um) are generated by mechanical processes such as grinding, crushing, or abrasion of surfaces, suspension of dusts, evaporation of sea sprays, and biological sources (bacteria, pollen, and spores). Vehicular traffic, construction, and agricultural activities suspend dust. In summary, the fine and coarse mode particles have distinctly different formation processes and chemical compositions. Coarse mode particles typically remain in the air for minutes to hours after their release and may travel less than one to tens of kilometers (Lippmann, 2000).

Figure 1 shows the sources of estimated PM_{10} emissions in Minnesota in 1997 (EPA, 2000b). In total, 962,200 short tons were emitted. Figure 1 does not include fugitive dust emissions, such as those from agricultural activities, unpaved roads, and construction.

Figure 1. Sources of 1997 PM_{10} Emissions in Minnesota



The extent to which various combustion sources contribute to the ambient $PM_{2.5}$ concentrations, such as diesel engines, passenger vehicles, power plants, manufacturing operations, wood burning, has not been studied in any detail for Minnesota.

For many pollutants, emission inventory databases are routinely used to estimate source allocation of important pollutant sources to the air. Developing a Minnesota-specific source allocation for fine particulate matter would require consideration of the

atmospheric reactions leading to secondary formation of particles from sulfur dioxide, nitrogen oxides, volatile organic compounds (VOCs) and potentially other species.

3.0 Particulate Matter Concentrations and Trends

3.1 Minnesota Data

Background information on airborne particles in Minnesota was presented in *Minnesota Air: Air Quality and Emission Trends* (MPCA, 1997). Since that report, there has been additional PM_{10} monitoring in Minnesota that sheds further light on trends and other aspects of our understanding of PM_{10}. In addition, MPCA $PM_{2.5}$ monitoring began in April 1999 to assess the state's compliance with the proposed federal National Ambient Air Quality Standard (NAAQS) for $PM_{2.5}$. The proposed NAAQS are 15 um/m3 as an annual average and 65 ug/m3 for 24-hour time periods.

The 1997 MPCA air quality and emission trends report indicated that PM_{10} concentrations were decreasing across the state. The more recent monitoring shows that this trend has leveled off. Figure 2 shows the concentrations of PM_{10} measured at the Minneapolis Public Library monitoring site in downtown Minneapolis. The concentrations decreased significantly from the onset of monitoring in 1984 until about 1994. Since about 1994 or 1995, the PM_{10} concentrations at the Minneapolis site have not continued to decrease, but instead have started to increase slightly. A similar turnaround in the trend of PM_{10} concentrations occurred at the St. Louis Park and Minneapolis-Humboldt Avenue monitoring sites. In contrast, PM_{10} concentrations have remained steady over the period from 1985 to the present at the Virginia, MN monitoring site. At the St. Paul Ross Avenue monitoring site, PM_{10} concentrations have continued to trend downwards up to the present, although the change since 1994 is not statistically significant.

More intensive chemical analyses are needed to fully understand the chemical composition of the $PM_{2.5}$. Concentrations of individual elements on PM_{10} filters were measured by X-ray fluorescence (XRF). These XRF measurements of specific elements generally accounted for a small fraction of the total mass collected on the filters (averaging 9% to 13% across all sites). Under the assumption that the sulfur measured by XRF was in the form of sulfate, the fraction of the total PM_{10} mass accounted for by the XRF measured elements averaged 13% to 28% across all sites. Figure 3 shows the fraction of PM_{10} concentration accounted for by elements measured using XRF (under the assumption that all sulfur present is in the form of sulfate).

The XRF analysis is targeted for the more toxic heavy metals and not the total makeup of the PM_{10} sample. The method misses aluminum (the most common metal in the earth's crust and not reported because the PM_{10} sampler is made of aluminum and is subject to erosion in the inlet and subsequent contamination of the sample) and silicon (common as sand particles, SiO_2, and not reported because the PM_{10} filter is made of quartz and would overwhelm any sample contribution). The analysis will also miss low atomic mass elements such as carbon (up to 30-50% of the mass) and oxygen which would most likely

be present in combination with carbon, aluminum, and silicon, contributing additional mass. All of the above could account for most of the missing mass in a typical sample.

Table 1 shows the average $PM_{2.5}$ concentrations at monitoring sites in Minnesota. Based upon these initial monitoring results, none of the sites exceeds the new $PM_{2.5}$ standard (which is currently being reviewed by the Supreme Court), although the Red Rock Road and St. Paul Health Center sites are close to the annual average standard of 15 $\mu g/m^3$.

With less than 2 years of $PM_{2.5}$ sampling it is too early to determine trends. MPCA staff can, however, look at the ratios of $PM_{2.5}$ to PM_{10} and can look at the variation in $PM_{2.5}$ as a function of time of year and as a function of wind direction. Figure 4 shows the $PM_{2.5}$ concentrations at five monitoring sites. Most measurements were in the range of 5 to 20 $\mu g/m^3$, and there appears to be a tendency for higher concentrations in the winter months. The bar graph in Figure 5 illustrates the $PM_{2.5}$ concentrations at five sites, showing the median, 25^{th} and 75^{th} percentile values, and range of values at each site. Figure 6 shows the $PM_{2.5}$ concentrations as a function of month, further illustrating the tendency for higher wintertime values.

Figure 7 shows $PM_{2.5}$ concentrations at 4 monitoring sites as a function of wind direction. Concentrations generally tended to be higher with southerly winds and lower with northerly winds. This finding is in keeping with other work and with the observation that there are more sources of fine particles (i.e., fossil fuel burning) to the south of Minnesota than to the north. Figure 8 shows the ratios of $PM_{2.5}$ to PM_{10} at four sites in Minnesota. In general, the ratios tended to lie between 0.3 and 0.5.

The higher wintertime $PM_{2.5}$ values may seem to be in contradiction to the fact that $PM_{2.5}$ concentrations tend to be higher with southerly winds, since southerly winds occur predominantly in the summertime. To date, only a small amount of data exists to evaluate these findings. $PM_{2.5}$ measurements were begun in Minnesota in April of 1999, and wind direction data were available for this analysis only through December of 1999. Figures 9, 10, and 11 show the patterns of occurrence of $PM_{2.5}$ concentrations as a function of month of the year and wind direction. The figures show that $PM_{2.5}$ concentrations were higher with southerly winds, regardless of the time of year. Similarly, for any given wind direction $PM_{2.5}$ concentrations tended to be higher in wintertime than at other times. These findings will be further evaluated as more data become available.

Table 1. $PM_{2.5}$ concentrations at sites in Minnesota.

Site Name	County	Sampling Start Date	Date of Last Valid Sample	Number of Valid Samples	Average Concen-tration ug/m3	Min Concen-tration ug/m3	Max Concen-tration ug/m3
					Std - 15 $\mu g/m^3$		std – 65 $\mu g/m^3$
Mpls - Phillips Community Center	Hennepin	4/21/99	9/28/00	252	10.9	1.8	50.3
Richfield Intermediate School	Hennepin	4/12/99	9/27/00	109	11.1	0.4	48.5
North Mpls Fire House Site 0907	Hennepin	4/24/99	9/27/00	87	11.2	2.0	35.0
St. Louis Park City Hall	Hennepin	4/24/99	9/27/00	95	11.1	1.5	48.3
St. Paul - Red Rock Road	Ramsey	4/3/99	9/27/00	102	13.4	3.1	44.3
St. Paul Health Center - downtown	Ramsey	3/31/99	9/6/00	107	13.5	2.5	51.0
East St. Paul - Harding High School	Ramsey	4/24/99	9/28/00	170	11.4	1.9	33.7
St. Paul/Highland - Randolph Elem. School	Ramsey	4/12/99	9/27/00	107	11.0	0.4	45.8
St. Michael - St. Michael Elem. School	Wright	11/26/99	9/27/00	44	11.9	1.6	41.8
Hastings - Dakota County Government Center	Dakota	4/24/99	9/27/00	107	10.4	1.7	43.6
Shakopee - Pearson Elementary School	Scott	1/7/00	9/27/00	66	12.4	1.3	37.5
Rochester - Ben Franklin Elem. School	Olmsted	1/7/00	9/24/00	72	11.9	2.4	36.9
St. Cloud - Talahi Community School	Stearns	12/20/99	9/21/00	60	11.6	1.7	39.2
Mille Lacs Tribal Headquarters	Mille Lacs	12/8/99	9/18/00	70	9.4	1.0	27.0
Duluth/Superior Public TV - UMD Campus	St. Louis	5/6/99	9/15/00	91	7.7	0.9	21.6
West Duluth - Lincoln School	St. Louis	1/19/00	9/15/00	59	9.1	1.0	36.3
Virginia City Hall	St. Louis	5/30/99	9/9/00	78	8.2	1.1	25.8
Silver Bay - MN Veterans home	Lake	11/8/99	8/10/00	27	7.9	1.0	21.0
Perham - Prairie Winds Middle School	Ottertail	11/14/99	9/3/00	42	9.6	2.3	27.1
Albert Lea - City Hall Bldg.	Freeborn	11/8/99	6/11/00	33	12.4	2.0	30.6
Hutchinson - City Hall	McLeod	11/2/99	9/21/00	37	12.1	1.9	31.1
West Lakeland - Sanders Property	Washington	11/26/99	9/15/00	43	12.3	2.0	39.6

Table 2 is a matrix of correlation coefficients among PM_{10} and $PM_{2.5}$ concentrations. $PM_{2.5}$ concentrations were highly correlated among sites, including the Virginia, MN site that is distant from the other sites. PM_{10} concentrations were generally highly correlated among sites, except that the Virginia, MN PM_{10} concentrations were not correlated with PM_{10} concentrations from the other sites. PM_{10} and $PM_{2.5}$ concentrations were moderately well correlated with one another across most sites; however, the Virginia, MN PM_{10} concentrations were not well correlated with PM_{10} or $PM_{2.5}$ concentrations from any of the sites (including $PM_{2.5}$

concentrations from the Virginia, MN site itself). The reason for this lack of correlation is not yet known.

Table 2. Correlation coefficients among PM_{10} and PM2.5 concentrations at sites in Minnesota

	Ross Ave	*St Louis Park*	*Vandalia Ave*	*Mpls Library*	*Humboldt Ave, Mpls*	*Virginia MN*	*Phillips Mpls $PM_{2.5}$*	*Red Rock Road $PM_{2.5}$*	*Virginia MN $PM_{2.5}$*	*Harding High $PM_{2.5}$*
Ross Ave St. Paul	1.00									
St Louis Park	0.81	1.00								
Vandalia Ave	0.85	0.86	1.00							
Mpls Library	0.82	0.87	0.90	1.00						
Humboldt Ave, Mpls	0.80	0.82	0.89	0.83	1.00					
Virginia MN	0.44	0.47	0.57	0.42	0.47	1.00				
Phillips, Mpls $PM_{2.5}$	0.62	0.54	0.52	0.49	0.53	0.20	1.00			
Red Rock Road $PM_{2.5}$	0.66	0.55	0.50	0.53	0.49	0.14	0.92	1.00		
Virginia, MN $PM_{2.5}$	0.66	0.65	0.44	0.59	0.52	0.23	0.86	0.85	1.00	
Harding High $PM_{2.5}$	0.71	0.64	0.54	0.60	0.58	0.19	0.95	0.96	0.87	1.00

The first six rows and columns are PM_{10} data, while the last four rows and columns are PM2.5 data. All sites except the Virginia, MN site were located in the Minneapolis-St. Paul metropolitan area.

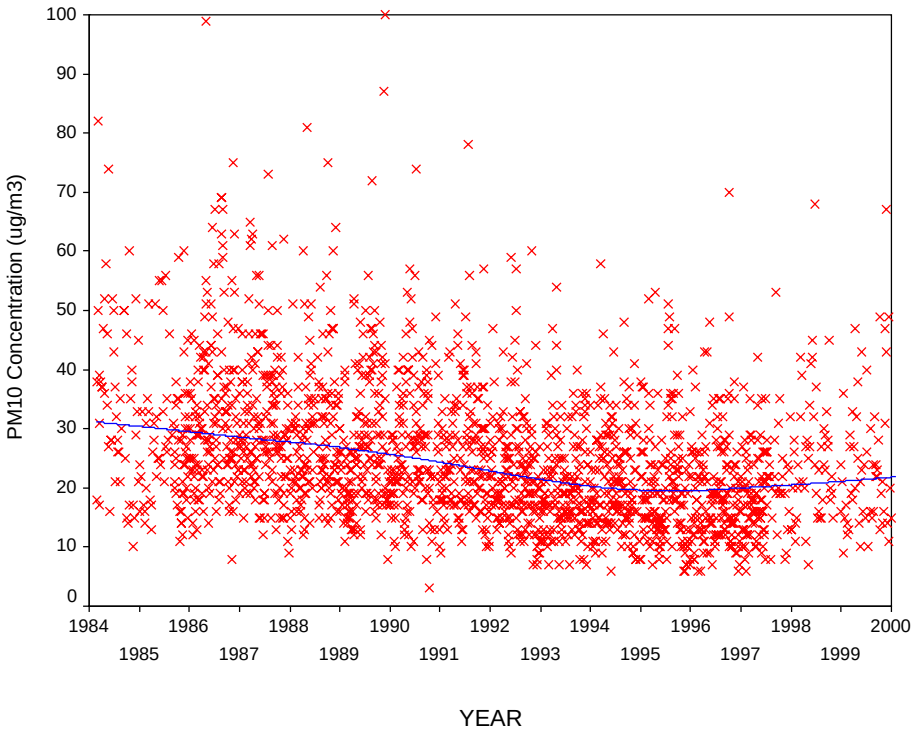


Figure 2. PM_{10} concentrations measured at the Minneapolis Public Library monitoring site.

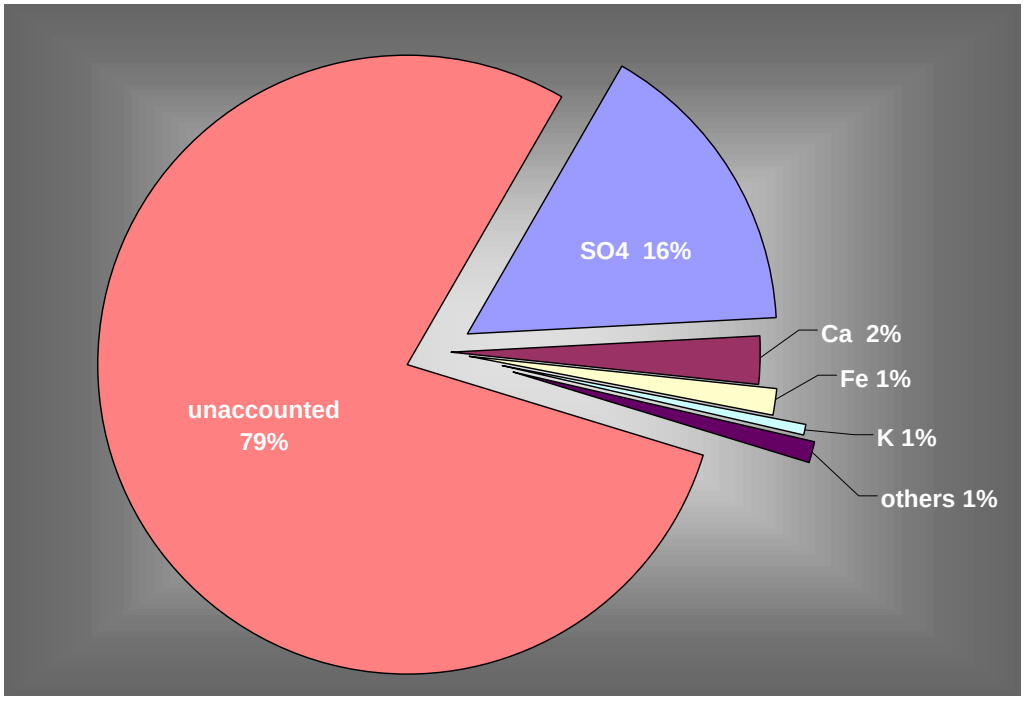


Figure 3. Percentage of PM_{10} mass accounted for by elements measured by X-ray fluorescence. The assumption is made that all the sulfur is in the form of sulfate ($SO_4^{=}$).

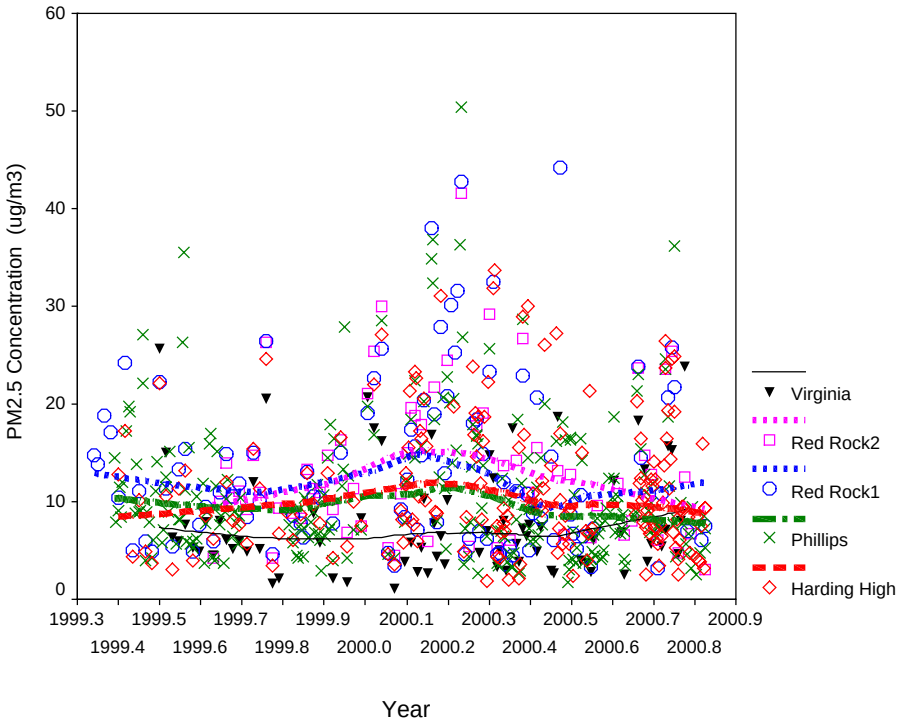


Figure 4. $PM_{2.5}$ concentrations measured at 5 sites in Minnesota.

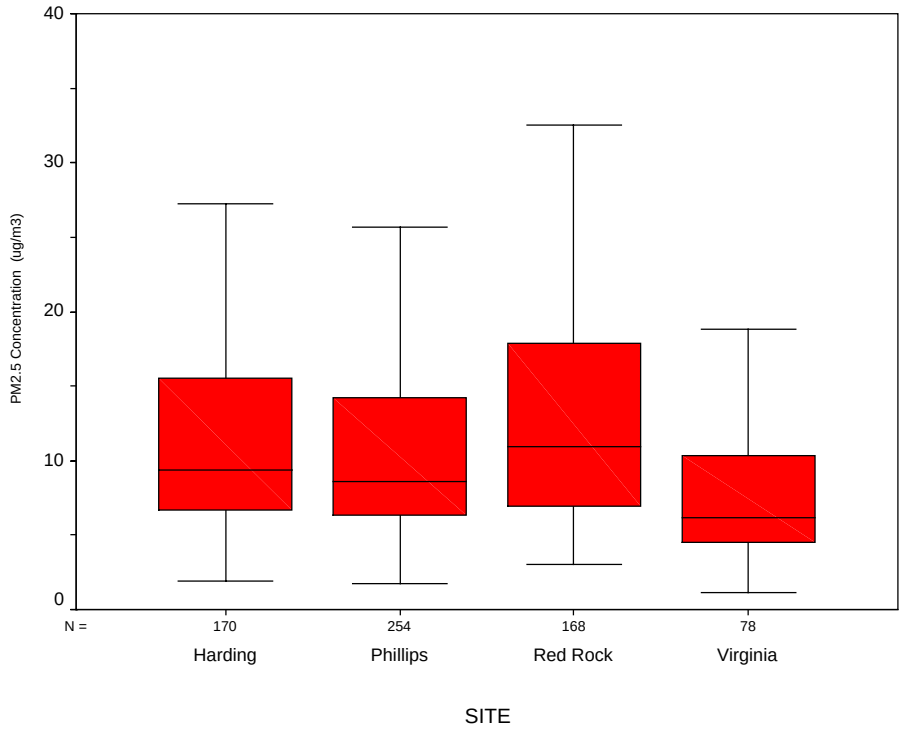


Figure 5. Boxplot of $PM_{2.5}$ concentrations at four sites in Minnesota. The boxes encompass all the measurements between the 25th and 75th percentile values. The midline in each box represents the median concentration at that site, and the brackets extending from the boxes encompass all the values not considered statistical outliers.

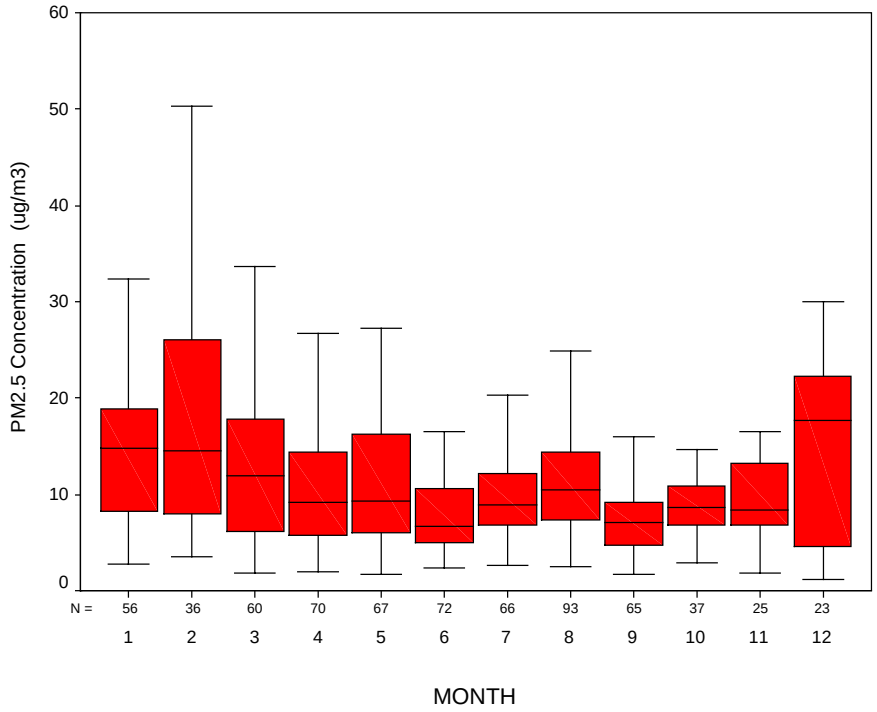


Figure 6. $PM_{2.5}$ concentrations at five sites in Minnesota by month. The boxes encompass the 25th through the 75th percentile values. The midline within the box is at the median, and the brackets encompass all values that are not statistical outliers.

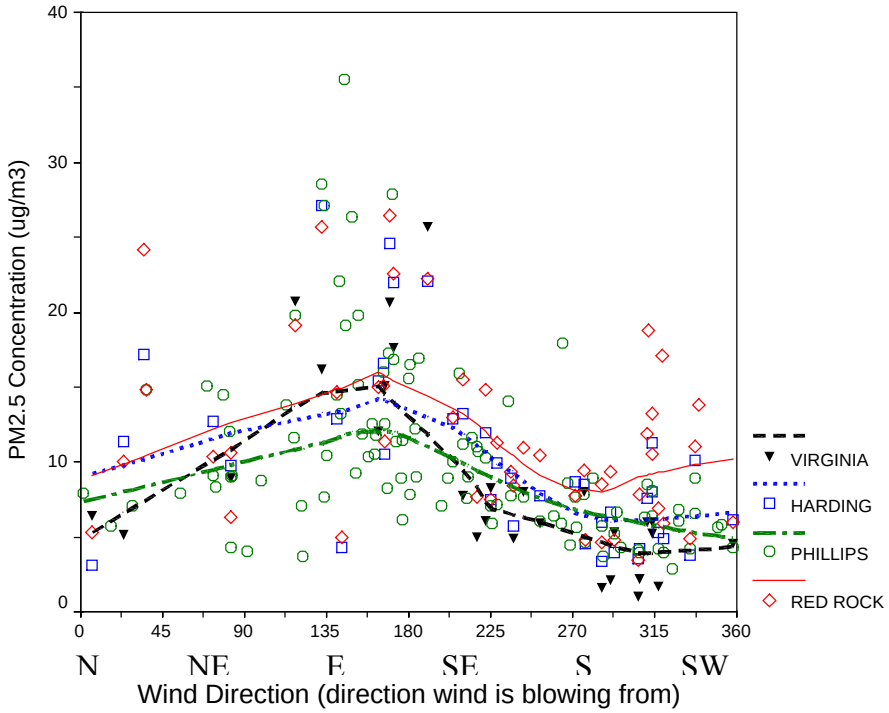


Figure 7. $PM_{2.5}$ concentrations at four sites as a function of wind direction.

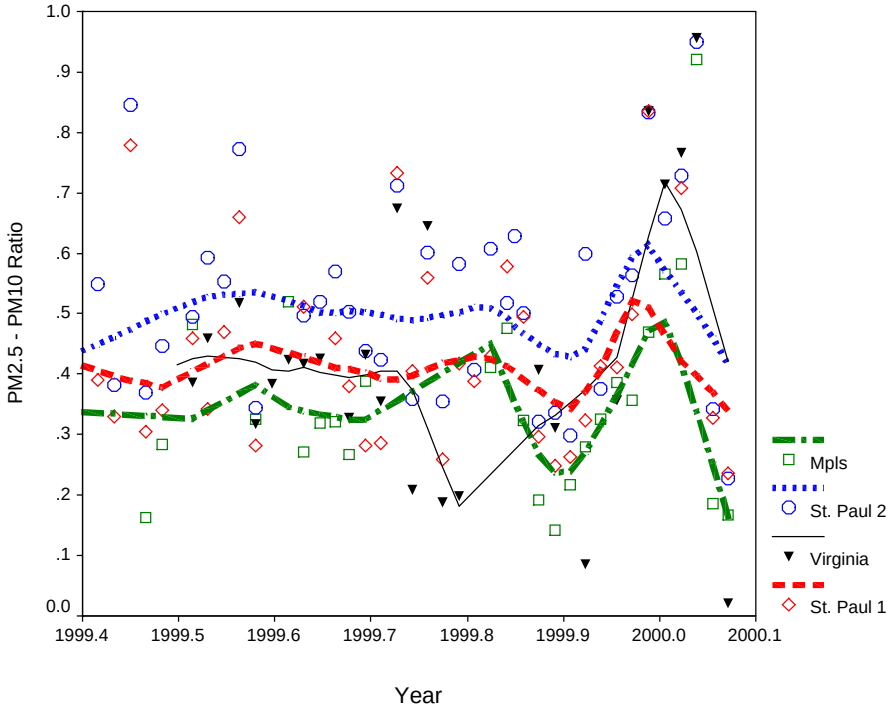


Figure 8. $PM_{2.5}/PM_{10}$ ratios at four sites in Minnesota.

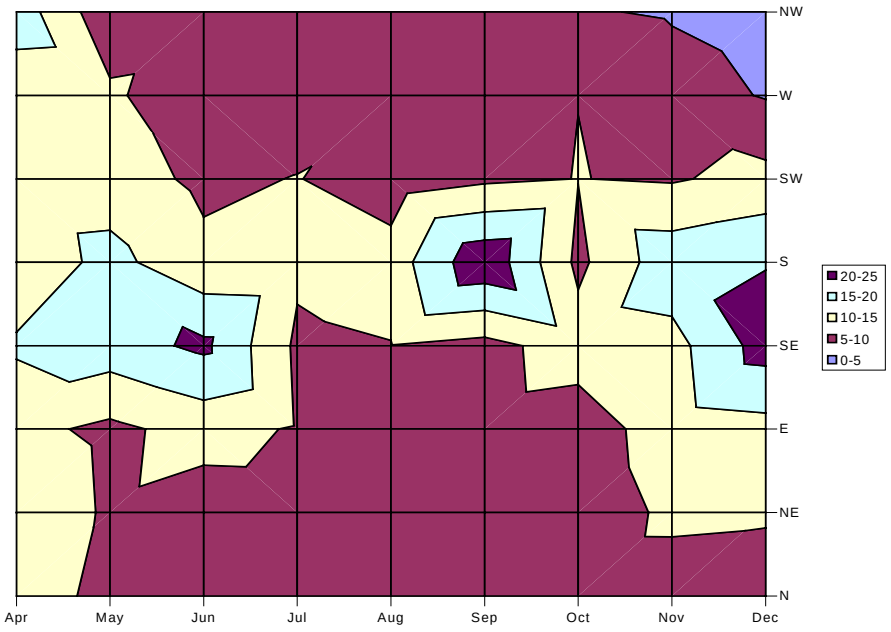


Figure 9. $PM_{2.5}$ concentrations ($\mu g/m^3$) as a function of wind direction and month of the year. The concentrations were averaged over four sites for each month by wind direction combination. Missing values were interpolated.

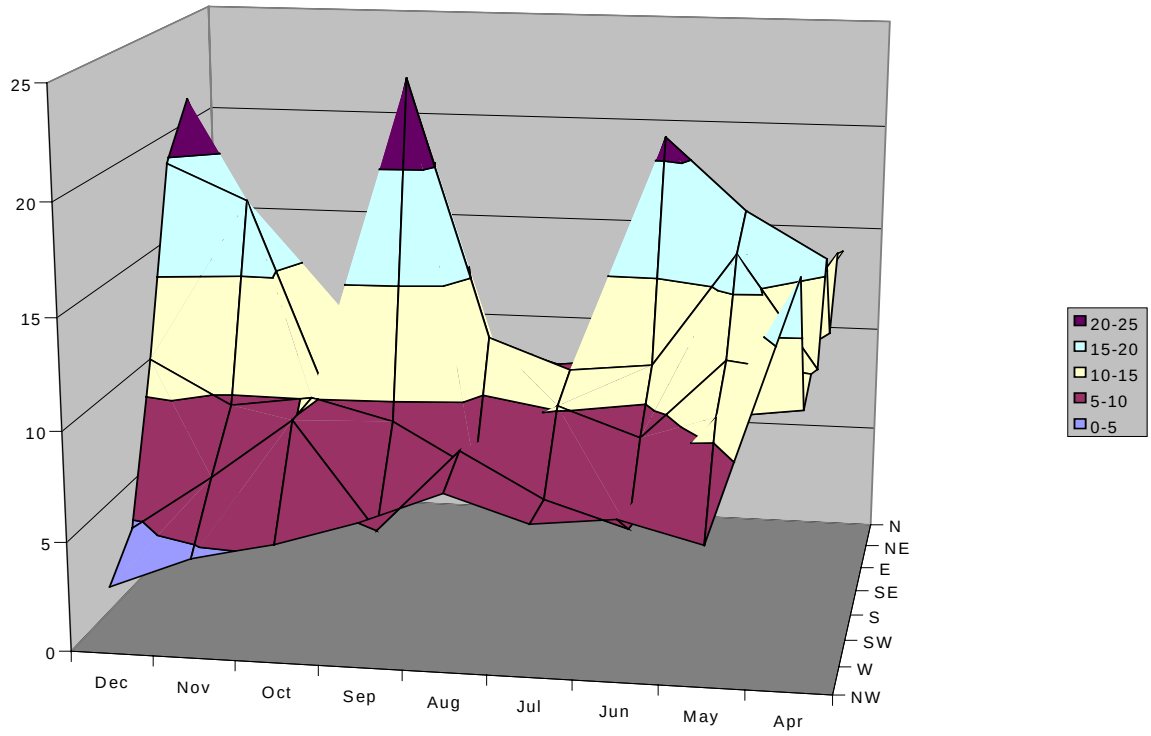


Figure 10. $PM_{2.5}$ concentration ($\mu g/m^3$) as a function of wind direction and month of the year. This figure plots the same data as shown in figure 8, but in a three-dimensional format.

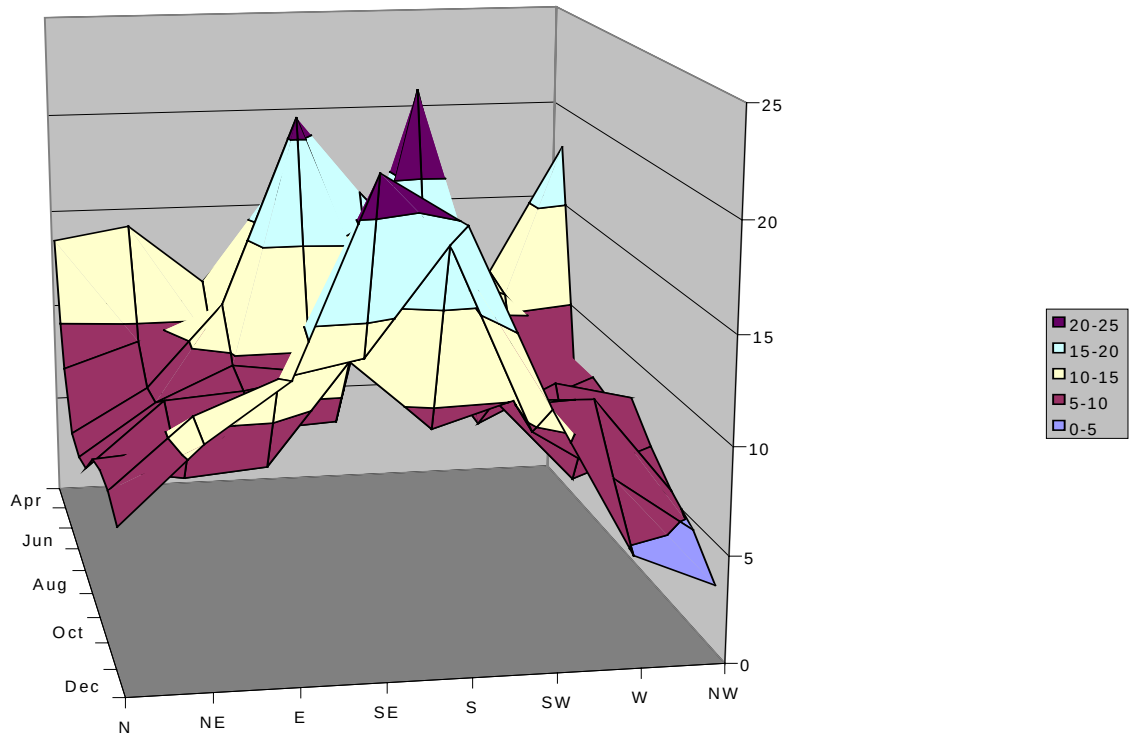


Figure 11. Same as figure 9 but viewed from a different angle.

The EPA/National Park Service Visibility Program, Interagency Monitoring of Protected Visual Environments (IMPROVE), was established to collect visibility related data associated primarily with Class I areas. http://www.epa.gov/ttn/amtic/visdata.html. The IMPROVE program recently estimated general ambient (background) levels of fine particle concentrations in MN to range from about 3.5 ug/m3 to 7 ug/m3 based on ambient Midwest monitors (MALM, 2000). Longer term monitoring results for the IMPROVE visibility program report Boundary Waters annual average PM2.5 concentrations of about 4.5 ug/m3. This is composed of approximately 44% [35% - 70%] sulfate, 8.7% nitrate, 35% organics, 4.5% elemental carbon, and 8% crustal materials (Malm, 2000).

3.2 Comparison of Minnesota Data With Other Areas

Table 3 compares PM_{10} concentrations of the Twin Cities with some other metropolitan areas across the United States. On a national scale, Minnesota's ambient particulate concentrations are lower than the eastern U.S., but higher than many western states. An informal look at this data shows that the PM_{10} concentration of the air in the Twin Cities does not appear to be substantially lower than many other cities.

Table 3. Comparison of PM_{10} Concentrations Among U.S. Metropolitan Statistical Areas, 1998

Metropolitan Statistical Area	Weighted Annual Mean PM_{10} Concentration (ug/m^3)	2nd Maximum PM_{10} Concentration (ug/m^3)	90th Percentile PM_{10} Concentration (ug/m^3)
Las Vegas, NV-AZ	60	188	90
Chicago, IL	33	102	50
Los Angeles/Long Beach, CA	33	78	55
Detroit, MI	29	114	53
Cincinnati, OH-KY-IN	28	57	47
Baton Rouge, LA	27	64	44
Dallas, TX	26	75	41
Jersey City, NJ	26	63	41
Bakersfield, CA	25	131	46
New York, NY	25	114	41
Boston, MA-NH	24	71	41
Cedar Rapids, IA	24	76	37
Orlando, FL	24	63	35
Gary, IN	23	136	36
Minneapolis-St. Paul, MN-WI	22	73	36
Rochester, MN	21	36	31
Denver, CO	21	99	40
Duluth-Superior, MN-WI	20	81	30
Oakland, CA	19	59	30
Portland-Vancouver, OR-WA	19	59	31
Hartford, CT	18	66	31
Grand Forks, ND-MN	15	81	22
Santa Fe, NM	14	28	20

Excerpts from EPA (2000b) National Air Quality and Emissions Trends Report, 1998 (Table A-14 and Table A-13) For comparison with other cities, please go to this source at:
http://www.epa.gov/oar/aqtrnd98/

4.0 Health Impact Information

4.1 General Concerns about Particulate Matter

Recently EPA quantified the following health impacts associated with ambient concentrations of particulate matter: premature mortality, acute and chronic bronchitis, respiratory and cardiovascular hospital admissions, emergency room visits for asthma, asthma attacks, lower and upper respiratory illness, minor restricted activity days and work loss days. Additional health impacts which could not be quantified included infant mortality, low birth weight, changes in lung function, chronic respiratory diseases other than bronchitis, lung structural changes, altered immune defenses, cancer and non-asthma respiratory emergency room visits (EPA, 2000a).

Based on a qualitative assessment of the epidemiological evidence of effects associated with PM for populations that appear to be at greatest risk with respect to particular health endpoints, the MPCA concluded the following with respect to sensitive populations:

1. Individuals with respiratory disease (e.g., chronic obstructive pulmonary disease, acute bronchitis) and cardiovascular disease (e.g., ischemic heart disease) are at greater risk of premature mortality and hospitalization due to exposure to ambient PM.

2. Individuals with infectious respiratory disease (e.g., pneumonia) are at greater risk of premature mortality and morbidity (e.g., hospitalization, aggravation of respiratory symptoms) due to exposure to ambient PM. Also, exposure to PM may increase individuals' susceptibility to respiratory infections.

3. Elderly individuals are also at greater risk of premature mortality and hospitalization for cardiopulmonary problems due to exposure to ambient PM.

4. Children are at greater risk of increased respiratory symptoms and decreased lung function due to exposure to ambient PM.

5. Asthmatic individuals are at risk of exacerbation of symptoms associated with asthma, and increased need for medical attention, due to exposure to PM.

The following section summarizes several recent epidemiological studies identifying particulate matter at ambient outdoor concentrations as an important contributor to morbidity (illness) and mortality (death) in the U.S. Included are the Six Cities and American Cancer Society (ACS) studies and the HEI reanalysis of those findings. A recent large study of short-term impacts from elevated PM_{10} on mortality and morbidity (NMMAPS) (Samet et al., 2000a and Samet et al., 2000b) is also described.

4.2 Prospective Cohort Studies of Long-term Mortality

Prospective cohort epidemiology studies are generally regarded as the best way to measure actual human effects from pollutants. Epidemiology studies can be used to measure adverse health effects where there are sufficient differences in exposure between groups of people or, for a given population, due to changing pollutant concentrations over time. In addition to requiring adequate differences in exposures, to find significant effects, the pollutant must actually cause a measurable increase in the disease incidence to be detected. Typically, with the exception of high occupational exposure situations and criteria air pollutant exposures, impacts of most ambient pollutants have not been detectable using epidemiological methods.

Prospective cohort studies assess long-term effects of exposures to study individuals who are recruited at the beginning of the study and followed for a long time. Over the course of the study, individual-specific information is collected, especially regarding personal behaviors and risk factors for illness and their health status.

Both the Six Cities and American Cancer Society (ACS) prospective cohort epidemiology studies collected extensive information about the study participants over time. This was particularly important because numerous risk factors contribute to disease and premature mortality. For example, because smoking is known to cause a major portion of all lung cancers, and to contribute to heart and lung disease, the additional contribution of air pollution, though not insignificant, may be too small to see especially if personal smoking exposures aren't accurately and precisely known and considered.

Both the Six Cities and ACS studies compare the age-adjusted rates of death across the observed range of pollution levels (most-polluted to least-polluted). Although each study described their findings using different terminology, mortality rate ratios or mortality risk ratios, both are relative risks. A relative risk is the increase in risk of an adverse outcome (eg. death) given the presence of some risk factor (e.g. an air pollutant), across some range of pollutant concentrations, in this case for residents in the most-polluted city relative to residents in the least-polluted city.

In these studies the relative risk is a best available estimate of the true relative risk. It is accompanied by the confidence interval, a range of values, which provides information about the level of certainty that the estimated relative risk is close to the true relative. Specifically, there is a 95% chance that the true relative risk falls within these 95% confidence intervals. Narrow confidence intervals indicate the calculated relative risk is a more precise estimate of the true relative risk. A 95% confidence interval that ranges below 1.0 indicates the results are not statistically significant (at $p<0.05$) and may have resulted from chance alone.

Harvard Six Cities Study

Study Design

In a prospective cohort study beginning in 1974 (Dockery et al., 1993), a random sample of 8111 white adults from six U.S. cities were followed for 14 – 16 years. Their vital status and individual health risk factors including age, sex, body-mass index, smoking history, education level, medical history and occupational history were observed. Of the 1,430 total deaths that occurred during the study, 8.4% were from lung cancer and 53.1% were from cardiopulmonary disease. A Cox proportional hazards model was used to estimate adjusted mortality risk ratios.

Individual Risks

As expected, mortality was most strongly associated with smoking. Overall, current smokers (of 25 pack years) had a 59% higher chance of death by any cause, an 800% higher chance of death from lung cancer, and a 230% higher chance of death from cardiopulmonary disease than nonsmokers. Other individual risk factors for a higher mortality rate included having less than a high school education and being overweight (a higher body-mass index).

Impact of Air Pollution

The six cities were selected to represent the range of U.S. particulate air pollution at that time. Ambient (outdoor) air concentrations of total suspended particulate (TSP), inhalable particulate matter (initially PM_{15}, that is particulate matter with a 15 um aerodynamic diameter cutoff, *and* later PM_{10}), fine particulate matter ($PM_{2.5}$), sulfur dioxide, nitrogen dioxide, ozone, suspended sulfate and aerosol acidity were measured at central locations in each city. The average annual city pollutant concentrations are shown in Table 4. Except for ozone and aerosol acidity, all measured air pollutants were highest in Steubenville, OH. The lowest particulate air pollution was found in Portage Wisconsin. The highest total suspended particulate levels, in Steubenville and St. Louis, declined over the course of the study. For most pollutants, the average pollutant concentrations varied roughly 2- to 3-fold between the least and most polluted cities. Ozone was relatively less variable, and sulfur dioxide was more variable than the other pollutants.

Because the overall populations may have differed, the mortality rates were adjusted for smoking, age, sex, education and body-mass index to permit a fair comparison between the cities. Adjusted mortality rate ratios for deaths by all causes were estimated between each city and the least particulate-polluted city (Portage). Adjusted relative risks between Steubenville and Portage were also calculated separately for three cause of death categories: cardiopulmonary (i.e., cardiovascular and non-malignant respiratory disease), lung cancer, and all other causes (Table 4).

The key findings are summarized below:

- Mortality was found to be strongly associated with $PM_{10,}$ $PM_{2.5}$, and sulfate particles. Recall that sulfate particles are a subset of $PM_{2.5,}$ which is a subset of PM_{10}. The mortality rate ratios are expressed in terms of the range of each pollutant. The relative rate ratios between the most and least particulate matter polluted cities for fine, inhalable, and sulfate particles were nearly equal at 1.27 [95 percent confidence interval, 1.08 to 1.47], 1.26 [95 percent confidence interval, 1.08 to 1.48], and 1.26 [95 percent confidence interval, 1.08 to 1.47], respectively.
- After adjusting for the study participants' individual risk factors, there was a 26% higher mortality rate (risk of death) in the most polluted city, Steubenville, Ohio, than in the least polluted city, Portage, Wisconsin. Comparisons between the other cities and Portage are shown in Table 4.
- Fine particulate matter (PM2.5), PM_{10}, and sulfate particulate air pollution were each associated with cardiopulmonary-related deaths and with lung cancer deaths, but not with deaths from all other causes. Specifically, there was a 37% higher risk of death from cardiopulmonary diseases and a 37% higher risk of death from lung cancer associated with the higher air pollution levels in Steubenville, OH compared to the lower levels in Portage, WI.
- When the mortality rate ratios for subgroups (such as male vs. female or smoker vs. nonsmoker) were compared between the cities, similar differences were found within subgroups as for the general population

Recently, elemental data from the Six Cities Study was analyzed to identify source-specific differences in the effects. A 10 ug/m3 increase in PM2.5 from mobile sources resulted in a 3.4% [95% CI 1.7 – 5.2%] increase in total mortality, compared to a 1.1% [95% CI 0.3 – 2.0%] increase from coal combustion sources. In contrast, crustal-derived PM2.5 was not associated with increased mortality (Landen, et al., 2000). In other words, the researchers found the fine particles from mobile sources were more potent at causing death than equivalent PM2.5 air concentrations from power plants. Fine particulate matter from either mobile sources or power plants was more hazardous than PM from natural sources such as soils.

Table 4. Six Cities Study

	Measured Air Pollution and Adjusted Mortality Rate Ratios [a]					
	Portage, Wis.	Topeka, Kansas	Watertown, Mass.	Harriman, Tenn.	St. Louis, Missouri	Steubenville, Ohio
	Annual Average Concentrations					
Total Suspended Particulate (ug/m^3)	**34.1**	56.6	49.2	49.4	72.5	**89.9**
Inhalable Particulate Matter (PM15 or PM_{10}) (ug/m^3)	**18.2**	26.4	24.2	32.5	31.4	**46.5**
Fine Particulate Matter ($PM_{2.5}$) (ug/m^3)	**11**	12.5	14.9	20.8	19	**29.6**
Sulfate particles (ug/m^3)	5.3	**4.8**	6.5	8.1	8.1	**12.8**
Aerosol Acidity (H+) (nmol/m^3)	10.5	11.6	20.3	36.1	**10.3**	**25.2**
Nitrogen Dioxide (ppb)	**6.1**	10.6	18.1	14.1	19.7	**21.9**
Ozone (ppb)	**28**	27.6	**19.7**	20.7	20.9	22.3
Sulfur Dioxide (ppb)	4.2	**1.6**	9.3	4.8	14.1	**24**
	Adjusted Mortality-Rate Ratios and 95% Confidence Intervals [b]					
Mortality - All causes	1.00	1.01 [0.82-1.24]	1.07 [0.89-1.28]	1.17 [0.97-1.41]	1.14 [0.96-1.36]	1.26 [1.06-1.50]
Mortality – Cardiopulmonary Disease (Heart and Non-cancer Lung)	n.r.	n.r.	n.r.	n.r.	n.r.	1.37 [1.11-1.68]
Mortality – Lung Cancer	n.r.	n.r.	n.r.	n.r.	n.r.	1.37 [0.81-2.31]
Mortality – All Other Causes	n.r.	n.r.	n.r.	n.r.	n.r.	1.01 [0.79-1.30]

n.r. – not reported
Excerpted from Table 2 and Table 5 of Dockery, et al. (1993)
Lowest and Highest Air Concentrations are shown in Bold
ug/m3 – micrograms per cubic meter air
nmole - nanomole

[a] Adjusted mortality rate ratios compare each city's mortality rates with the least polluted city, Portage. For example, the adjusted mortality rate ratio for St. Louis of 1.14 indicates that the death rate, after correcting for differences in the individual risk factors, was 14 % higher in St. Louis than in Portage.
[b] [ ] 95% Confidence Intervals illustrate that there is uncertainty in the estimate. If the study were to be repeated 100 times, statistics predict that 95% of those studies would result in a mortality rate ratio that would fall within the confidence interval range.

Pope et al. 1995a Study (American Cancer Society Cohort)

Population Characterization

The second large landmark prospective cohort study (Pope, et al., 1995a) assessed the relationship between mortality and air pollution for much larger group 552,138 adults living in 154 U.S. metropolitan areas from 1982 through 1989. These individuals were being followed for a major American Cancer Society (ACS) study. Mortality risks were adjusted for individual risk factors, such as smoking history, sex, age, alcohol consumption, race, occupational history, passive cigarette smoke, and education. The total causes of death were sub-categorized as lung cancer, cardiopulmonary (nonmalignant respiratory and cardiovascular) disease, and all other causes.

Individual Risks

With respect to individual risk factors, current smokers (25 pack-years) had a 207% increased risk of mortality from all causes, a 973% increased risk of mortality from lung cancer, and a 228% increased mortality risk from cardiopulmonary disease compared to nonsmokers.

Air Pollution Concentrations

Ambient air concentrations of fine particles and sulfate particles, measured during 1980, were used to estimate exposures to fossil fuel combustion sources. Overall, sulfate concentrations in 151 cities averaged 11 ug/m^3 and ranged, between cities, from 3.6 ug/m^3 to 23.5 ug/m^3 (for a difference of 19.9 ug/m^3). Fine particulate monitoring data, available from 50 metropolitan areas, averaged 18.2 ug/m^3 and ranged from 9.0 ug/m^3 to 33.5 ug/m^3 for a difference of 24.5 ug/m^3. These two air pollution measures (sulfate and fine particulate) were significantly correlated with a correlation coefficient of 0.73.

Impact of Air Pollution

Adjusted mortality risk ratios for specific health outcomes were developed using a Cox proportional hazards model by comparing the most vs. the least polluted metropolitan areas. Mortality from all causes and cardiopulmonary disease were each significantly associated with fine particulate matter. For an increase of 24.5 ug/m^3 fine particles there was a 17% and 31% higher mortality rate from all causes and cardiopulmonary disease, respectively. Mortality from all causes, lung cancer and cardiopulmonary disease were each significantly associated with sulfates. For an increase of 19.9 ug/m^3 sulfate particulates, there was a 15%, 36% and 26% higher mortality rate from all causes, lung

cancer, and cardiopulmonary disease, respectively. Similar pollutant effects were found within population subgroups (smokers vs. never smokers, men vs. women, etc.).

Table 5. Mortality Rations from Pope, et al. Study

	Associations Between Health Effects and Air Pollutants Adjusted Mortality Rate Ratios	
	Fine Particulate ($PM_{2.5}$) (Range of 24.5 ug/m^3)	Sulfate Particulate (Range of 19.9 ug/m^3)
Mortality – All Causes	1.17 [1.09 – 1.26]	1.15 [1.09 – 1.22]
Mortality – Cardiopulmonary	1.31 [1.17 – 1.46]	1.26 [1.16 – 1.37]
Mortality – Lung Cancer	1.03 [0.80-1.33]	1.36 [1.11 – 1.66]
Mortality – Other Causes	1.07 [0.92-1.24]	1.01 [0.92-1.11]

Excerpt from Pope, et al. (1995a) Table 2

Using a simple linear regression of the each city's mortality rate (adjusted for age, sex, and race) versus the annual average air pollutant concentrations there were 8.0 additional deaths/year/100,000 persons per 1 ug/m^3 fine particulate and 10.5 deaths/year/100,000 persons per 1 ug/m^3 sulfate.

Health Effects Institute Reanalysis of the Harvard Six Cities and ACS Studies

Due to the importance of the findings from these two prospective studies, their validity and their implication of a cause and effect relationship between fine particle concentrations and mortality were intensely scrutinized. A number of questions were raised. Some of the major concerns with the findings included:

- The differences in mortality rate may be explained by other (confounding) factors such as weather, other pollutants, or personal risk factors that were not used for the analysis (confounding means that the observed association may have resulted from a risk factor that both correlated with the exposures and with mortality).
- Lacking long-term exposure data, the results were questionable.
- Increased mortality rates reflected people's lives being shortened by trivial amounts of time (euphemistically referred to as mortality displacement).
- Lacking a clear scientific explanation for how the particles caused death, (i.e., a biological mechanism), the epidemiologic evidence wasn't convincing.
- Different statistical models may produce substantially different results.
- The data analysis may be flawed.

A number of interested parties wanted to independently review the raw data. Because of the extensive set of confidential information about the individual study participants, the data was not released to interested stakeholders for reanalysis. Instead, the Health Effects Institute (HEI) commissioned a data reanalysis of both landmark studies. HEI is an independent, nonprofit corporation with joint support from the U.S. Environmental Protection Agency (EPA) and industry. Their stated mission is to provide high-quality, impartial, and relevant science on the health effects of pollutants from motor vehicles and other environment contaminants.

The reanalysis team was selected based on epidemiology and biostatistics expertise and to minimize potential conflicts of interest. The reanalysis team conducted a detailed in depth analysis to validate the original results and to test the sensitivity of the results using alternate models and risk factors. The reanalysis effort, lead by Dr. Daniel Krewski of the University of Ottawa, was published in July 2000 (Krouski et al., 2000).

General Findings

The reanalysis validated the data as accurate, repeated and extended the statistical analyses and found, with a few minor exceptions, the results to be very reproducible and robust to alternate analytical approaches and additional risk factors. Overall, based on the audit of the data and reanalysis, all significant effects reported in the original papers were reconfirmed, and the relative risks for mortality generally increased by one or two percent. Selected findings are summarized:

- Overall, the effects of fine particulate matter and sulfate particles showed similar results between sub-groups, except the less educated group had higher mortality rates with increasing fine particulate matter concentrations.
- The reanalysis assessed changes of both annual average pollutant concentrations and individual risk factors during the course of the study and found somewhat lower, but still significant, adjusted mortality rate ratios.
- An association was also identified between sulfur dioxide and mortality. This pollutant explained some, but not all, of the between city differences in response to fine and sulfate particulate matter.
- A better method to adjust for smoking history was used leading to less uncertainty in the impacts on smokers (a narrower confidence interval entirely greater than zero).
- The sensitivity of the data was tested using alternate statistical models. They found the choice of the model didn't substantially change the conclusions.
- To rule out questions about personal risk factors not originally included, the reanalysis considered approximately 30 additional personal risk factors. Overall, these didn't change the results. One exception was some evidence that some of the lung cancer mortality, originally associated with sulfate, may have been confounded to some degree by occupational exposures.
- The reanalysis assessed mortality from other specific disease types (cardiovascular, respiratory, other forms of cancer, etc.). The highest risks were for cardiovascular mortality. No association was found between air pollution and mortality from non-malignant respiratory deaths. The Six Cities data showed increased risks for individuals with pre-existing heart and lung disease and low lung function.

The U.S. spatial distribution of fine particles, sulfate and sulfur dioxide were modeled and presented on maps along with an overlay of the relative risks of mortality across the U.S. These maps may be viewed on pages 192-194 of the Investigators Report Part II: Sensitivity Analysis available (in Krewski et al., 2000) from http://www.healtheffects.org/news.htm#Krewski.

The reanalysis identified several topics for additional research:

- The concentration response relationship was assessed for linearity. Mixed results were found and the reanalysis concluded that this would require further evaluation.
- With respect to the precise cause of health impacts, the reanalysis concluded that "mortality may be attributed to more than one component of the complex mixture of air pollutants in urban areas".
- Reanalysis of the ACS data identified that the pollutants and mortality were spatially correlated and that this reduced the regression coefficients somewhat. Differences in impacts among different regions was an area identified for further research.

4.3 Short Term Time Series Studies: National Morbidity, Mortality, and Air Pollution Study (NMMAPS)

4.3.1 Purpose

The National Morbidity, Mortality, and Air Pollution Study (NMMAPS) (Samet et al., 2000a and Samet et al., 2000b) assessed acute (immediate) health effects of air pollution on mortality (death) and morbidity (illness). Daily mortality was studied in 20 and 90 of the largest U.S. cities and daily hospital admissions of the elderly were studied in 14 U.S. cities. The wide range of cities across the U.S. included cities with a diverse array of sources and concentrations of particulate matter and other air pollutants. Minneapolis/St. Paul (specifically Hennepin and Ramsey Counties combined) was included in all 3 analyses.

Other study purposes included methods development and the following specific issues:

- Methods to combine information from many cities.
- Methods to better predict actual personal air pollution exposures (rather than simply using centrally located ambient monitoring stations).
- Methods to incorporate trends in mortality caused by other factors such as seasons, influenza, behaviors, demographic shifts.
- Some have suggested that the increased mortality rates were a measure of air pollution risk to frail people who would have died within a few days absent the air pollution (referred to as mortality displacement). One objective was to assess the degree to which the air pollution decreases years of life.
- Attempt to characterize the effects of PM_{10} and other pollutants both individually and as mixtures.
- Explore factors that may account for differences between cities in the response.

4.3.2 Methodology

For each city, a multivariate regression analysis was conducted using PM_{10} and the other pollutants. The results were then combined across all cities.

Individual Risks

Daily mortality counts were obtained from the National Center for Health statistics for the entire population. Although there are many possible measures of illness, the Medicare records of hospital admissions for the elderly were used because they were a readily available and comprehensive database.

Unlike the long-term prospective cohort studies, where each person's individual risk factors were measured, in these daily time series studies each person served as their own control. The statistics assess the degree to which short-term changes in air pollution levels impact people. The design assumes that generally, an individual's personal risk factors change little from one day to the next. Therefore, population changes in death or illness rates are assumed to reflect factors occurring to the population at large, such as air pollution changes, weather changes, or influenza epidemics.

Air Pollution

NMMAPS assessed the association of PM_{10} alone and in combination with gaseous air pollutants in many cities with different characteristics of air pollution from various sources (Ozone, nitrogen dioxide, sulfur dioxide, and carbon monoxide), to see if the previously reported associations between particles and morbidity and mortality were consistent. They used currently available air pollution monitoring data from EPA's Aerometric Information Retrieval System database.

Average daily PM_{10} across all cities ranged from 20 ug/m^3 to 50 ug/m^3. Specifically, the 1987 –1994 average daily PM_{10} in Mpls/St. Paul was 26.9 ug/m^3. For comparison, the annual average concentrations for the same MN sites now averages 22 ug/m^3 (EPA, 2000b). Recent Minneapolis/St Paul trends for particulate matter are discussed in section 3.1.

4.3.3 Results

Mortality Findings

The study found that the total number of deaths correlated with PM_{10}. Across all cities, there was an average 0.5% increase in the overall population death rates for every 10 ug/m^3 increase in PM_{10} measured one day before death. The risk of death from heart and lung disease were slightly higher than for all causes. The results did not appear to be affected by other pollutants.

The regression coefficients for the effect of PM_{10} on total mortality and cardiopulmonary mortality for Minneapolis/St. Paul (Hennepin and Ramsey counties) were very close to the national average at 0.48% [95% CI –0.07 to 1.03] and 0.48% [95% CI -0.26 to 1.23], respectively. In these counties, with a combined population of 1,518,195, the average daily non-injury related death rates were 26.3 deaths per day (of which 13.9 were from cardiovascular and non-malignant respiratory disease).

Across the country individual cities showed somewhat different results. The overall findings combine all cities. The cities in the northeast U.S. showed the greatest effect from PM_{10}. The reasons for these differences are unknown at this time. Developing a better understanding of the differences in effects in different regions, which might be due to differences in PM_{10} composition or other characteristics, was identified as an area needing additional research.

Findings of Morbidity (Illness)

The elderly populations (greater than or equal to 65 years) in 14 cities were studied for hospitalization admissions. The study found a 1% increase in cardiovascular disease hospitalizations and a 2% increase in both pneumonia and chronic obstructive pulmonary disease (COPD) admissions for each 10 ug/m^3 increase of $PM_{10.}$

Findings of Methodology

The relationship between particulate matter and mortality and morbidity did not appear to depend on the presence of the other pollutants, as their inclusion or exclusion didn't significantly alter the results.

The Health Effects Institute review team concluded that this study provided fairly convincing data that the reported mortality rates did not just reflect a slight life-shortening in frail individuals, but rather reflected meaningful differences in life expectancy. They also recommended further research on this issue.

4.4 Additional Evidence for Health Effects

In addition to the evidence of mortality associated with particulate matter, there is extensive literature describing other categories of adverse effects. EPA summarized the available information in the most recent final criteria document (EPA, 1996).

Many more studies of health effects of the particulate matter are now available and will be summarized in the newer criteria document. EPA expects a revised draft of the new Particulate Matter Criteria Document to be available shortly. Table 6 provides a recent summary of illness occurring in association with ambient particulate matter concentrations.

Table 6. Summary of Acute Morbidity Studies

Health Indicator	Reference	Brief Summary of Findings
Hospital admissions (respiratory illness)	Pope (1989, 1991) Lipfert and Hammerstrom (1992) Thurston et al. (1992, 1993) Burnett et al. (1994) Schwartz (1994b, 1994c)	Respiratory admissions, including asthma, were associated with particulate air pollution; the estimated percent increase in admissions associated with a 10 $\mu g/m^3$ increase in PM-10 studies typically ranged from 0.8 to 3.4%
Emergency visits (respiratory illness)	Samet et. al (1981) Sunyer et al. (1993) Schwartz et al. (1993)	Respiratory emergency department visits were associated with particulate pollution; the estimated percent increase associated with a 10 $\mu g/m^3$ increase in PM-10 ranged from 0.5 to 3.4%
Exacerbation of asthma	Whittemore and Korn (1980) Bates et al. (1990) Ostro et al. (1991) Pope et al. (1991) Roemer et al. (1993)	Exacerbation of asthma, as measured by attacks, bronchodilator use, emergency visits, and hospital admission, was associated with particulate pollution; the estimated percent increase associated with a 10 $\mu g/m^3$ increase in PM-10 was typically around 2 or 3 % but ranged from 1.1 to 12.0%
Respiratory symptoms	Pope et al. (1991) Pope and Dockery (1992) Braun-Fahrlander et al. (1992) Neas et al. (1992) Schwartz et al. (1991) Hoek and Brunekreef (1993, 1994) Ostro et al. (1993) Roemer et al. (1993)	Respiratory symptoms have been associated with particulate pollution; the estimated percent increase in lower respiratory symptoms and cough associated with a 10 $\mu g/m^3$ increase in PM-10 was typically around 1-3% but had a wide range from 0 to 28%
Lung function	Dockery et al. (1982) Pope et al. (1991) Neas et al. (1992) Pope and Dockery (1992) Hoek and Brunekreef (1993, 1994) Pope and Kanner (1993) Roemer et al. (1993) Koening et al. (1993)	Small, but statistically significant declines in lung function have been associated with elevated particulate air pollution; the estimated percent decline associated with a 10 $\mu g/m^3$ increase in PM-10 was typically less than 0.5%

Excerpt from Pope, et al. (1995b)

Table VII-18 of a recent EPA summary of particulate matter health effects (EPA, 2000a) specifically summarizes measured effects of ambient particulate matter concentrations on asthma symptoms. This table is available from www.epa.gov/otaq/diesel.htm#documents in Chapter II of the Regulatory Impact Analysis.

4.5 Specific Questions Regarding Particulate Matter Health Effects

4.5.1 What are the biological mechanisms for PM causing health impacts?

One important question about fine particulate matter is what biological mechanism(s) explain why exposures to fine particulate matter cause these adverse effects. This is still an area of active research. Although the mechanisms are not specifically understood, there is general agreement that the cardio-respiratory system is the major target of particulate matter effects (EPA, 2000a). One recent article summarized the strength of evidence supporting cardiovascular effects associated with ambient particulate matter (Gordon and Reibman, 2000) and is illustrated in table 7. Other references describing this issue can be found at www.healtheffects.org.

Table 7. Experimental Evidence for the Biologic Plausibility of the Cardiovascular Effects Associated with Ambient PM Exposure

Factor	Strength of Evidence[a]	
	Human Studies	Animal Studies
Coagulation pathways	Weak	Weak
Neural		
Heart rate variability	Moderate	Moderate
Heart rate change	Moderate	Weak
Airway irritation	None	None
Arrhythmia	Weak	Moderate
Biological agents[b]	Weak	Moderate
Susceptible individuals	Strong	Moderate
Inflammatory mediators	None	Weak

Excepts from Gordon, T. and Reibman, J, 2000

[a] The strength of evidence is based upon empirical evidence from human or animal studies in which inhaled ambient PM or relevant concentrations of surrogate particles were used.

[b] Moderate *in vitro* evidence.

4.5.2 Is there a safe threshold for fine particulate matter?

An important issue with respect to estimating health impacts from particulate air pollution is whether there are thresholds for effects, and if so, at what concentrations. A threshold is an air pollution exposure concentration or dose below which it is assumed there are no associated effects. Whether there is a threshold at any particulate matter concentration is an important issue. The lower the threshold, the higher the health impact.

Epidemiology studies strongly suggest a causal association between fine particulate matter and premature mortality at average annual concentrations at least as low as, if not lower than, 15 ug/m3. In 1997, EPA lacked adequate evidence to demonstrate the lack of, or presence of a very low, threshold (62 FR 38651). In 1997 EPA selected 15 ug/m3 to be the average annual PM2.5 NAAQS, in part because solid evidence of a threshold

lower than this, if one exists at all, did not exist. At that time EPA concluded that the inherent scientific uncertainties were too great to support standards at the lowest concentrations measured in the studies. In selecting the 15 ug/m3 average annual PM2.5 NAAQS, EPA placed greater weight on the effects measured at the higher concentrations rather than the full range of concentrations for which the epidemiology studies reported effects. This is not surprising considering the data was used to set enforceable standards. The proposed PM2.5 standard of 15 ug/m3 for an annual average was selected based on the studies demonstrating significant associations between fine PM and daily mortality and respiratory effects in cities with average annual PM2.5 concentrations of 16 ug/m3 to 21 ug/m3 (62 FR 38651). EPA also reported data showing measurable health effects from long term exposures at an average PM2.5 concentration of 18ug/m3. It should be noted that representatives from the medical community recommended setting the PM2.5 standards to lower levels (62 FR 38651). EPA clearly stated that the required margin of safety did not mean that no health effects would occur to anyone at concentrations below the standard, or even that the new standard would eliminate all deaths from PM2.5. EPA estimated that the standard, when enforced, would lead to about 15,000 fewer deaths.

The Science Advisory Board advises that there is currently no scientific basis for selecting a threshold of 15 $\mu g/m^3$ or any other specific threshold for particulate matter-related health effects described in this appendix (EPA–SAB-Council-ADV-99-005, 1999). Human impact estimates will vary significantly in relation to the assumed threshold. Whether a threshold exists, and at what concentration, is under active scientific consideration. Recent articles suggest that there is no threshold, at least not above natural background levels. A recent editorial by Ward (2000) in the New England Journal of Medicine summarizes the particulate matter regulatory dilemma and concludes the association between fine-particle concentrations and mortality is linear across the range of current ambient concentrations, i.e., that there is no threshold within the current range of current concentrations. Schwartz and Zanobetti (2000) provided evidence there is no threshold at least down to 5 ug/m3 based on evidence from 10 cities, including Minneapolis and St. Paul.

4.5.3 Source-specific Differences in Particulate Matter Potency

The degree to which particulate matter from different sources, and different chemical composition and size distribution is under active research.

Recently elemental data from the Six Cities Study was analyzed to identify source-specific differences in the effects. A 10 ug/m3 increase in PM2.5 from mobile sources resulted in a 3.4% [95% CI 1.7 – 5.2%] increase in total mortality, compared to a 1.1% [95% CI 0.3 – 2.0%] increase from coal combustion sources. In contrast, crustal-derived PM2.5 was not associated with increased mortality (Landen, et al., 2000). In other words, the researchers found the fine particles from mobile sources were more potent at causing death than equivalent PM2.5 air concentrations from power plants. Fine particulate matter from each of these sources was more hazardous than from soils.

4.6 Estimated Human Health Impacts from Ambient Particulate Concentrations (Nationwide and Specific to Minnesota)

Recent epidemiology studies strongly suggest that particulate air pollution is currently causing a substantial health impact in the nation. The most comprehensive studies have focused on the premature mortality (death) outcome. An extensive literature also shows that less severe effects are impacting a broader segment of the population. Particulate-related health impacts from ambient air concentrations have been described in terms of the number of adverse human effect cases (asthma attacks, hospital admissions, deaths, etc.) and in terms of health-based costs. This section summarizes particulate-related health impact descriptions for the U.S. and for Minnesota.

With respect to premature mortality, the epidemiology research consistently finds measurable increased death rates closely following day to day fluctuations (increases) in ambient U.S. fine particulate concentrations. Consistent associations of average fine particulate matter concentrations with higher mortality rates are also reported in long term studies. Overall, the mortality estimates from the short-term studies result in lower nationwide mortality estimates than those obtained from the long-term studies.

Although short-term studies focus on the acute effects associated with daily peak exposures they generally underestimate the concentration-response relationship because they don't account for the cumulative mortality effects of long-term exposures. EPA concluded that the use of concentration response relationships derived from long-term studies provide a more complete assessment of the effect of air pollution on mortality risk (EPA-SAB-Council-ADV-99-005, 1999).

4.6.1 National Health Impact Estimates

Wilson and Spengler (1996) conclude that the most obvious interpretation of the epidemiology data is that roughly 4% of the U.S. deaths can be attributed to air pollution. Many studies indicate the largest contributor to the mortality is particulate matter. Spengler and Wilson point out that if this is true, then the impact of particulate air pollution is more than 100 times the sum of all other pollutants EPA regulates. Lipfert and Wyzga (1999) describe the average excess risk attributable to air pollution to be approximately 5% for all cause mortality.

At a recent conference in Minneapolis, Dr. Joel Schwartz roughly estimated that 70,000 annual deaths are occurring nationwide from ambient fine particulate matter concentrations. This estimate was developed based on findings from short-term daily death rates measured in time series studies. He later indicated that a nationwide estimate of premature mortality, using data from the long-term chronic epidemiological studies, would result in considerably higher mortality estimates (Schwartz, personal communication, 2000).

A number of organizations have applied recent epidemiology findings to develop nationwide estimates of the human health impacts associated with specific sources and

expected reductions associated with regulatory programs affecting ambient particulate levels, or to assess the change in impacts resulting from particulate matter reduction strategies (EPA, 2000a, EPA, 1999, ABT Associates Inc., 2000, Schwartz and Zanobetti, 2000, McCubbin and Delucchi, 1996). These estimates are obtained by summing impact estimates across smaller areas within the U.S. A higher level of confidence is associated with the aggregated nationwide estimates than an estimate from any specific area.

Most recent health impact estimates of mortality from long term exposures to particulate matter rely on the ACS study results (Pope et al., 1995a) or the Krewski et al. (2000) reanalysis of that study (Table 8). As discussed in Section 4.2, the Pope et al. (1995a) ACS study assessed a large population across many cities, encompassing a wide range of weather conditions, emission sources, and relative concentrations of the major pollutants. Prior to the availability of the Krewski reanalysis, the EPA (EPA-SAB-Council-ADV-99-005, 1999) recommended the use of the long-term Pope et al. (1995a) ACS study to estimate particulate matter-related mortality.

Table 8. Summary of Recent Concentration-Response Relationships for Premature Mortality Estimates

Health Effect	Pop-ulation	Concentration Range	Relative Risk (and β)	Study	Used for which impact assessments
Cardio-pulmonary Mortality	30+ years	$PM_{2.5}$ from 50 cities 9.0 – 33.5 ug/m^3 $PM_{2.5}$ (for a 24.5change in annual median concentration)	1.31 (0.011022)	ACS (Pope et al., 1995a)	McCubb and Delucchi in (1996)
Total Mortality	30+ years	$PM_{2.5}$ from 50 cities 9.0 – 33.5 ug/m^3 $PM_{2.5}$ (for a 24.5 change in annual median concentration)	1.17 (0.006408)	ACS (Pope et al., 1995a)	CAAA 812 Prospective Study (EPA, 1999)
Total Mortality	30+ years	$PM_{2.5}$ from 63 cities $PM_{2.5}$ (for a 24.5change in annual mean concentration)	1.12 (0.0046257)	ACS Reanalysis (Krewski et al., 2000)	ABT Assoc., (2000) MPCA calculation

EPA's Regulatory Impact Analyses for the Revised Ozone and PM National Ambient Air Quality Rule (NAAQS) and Proposed Regional Haze Rule (EPA, 1997) estimated year 2010 benefits for the full attainment of the annual average PM2.5 standard of 15 ug/m3. EPA estimated the plausible range of avoided mortality (lives saved) to be 3,700 to 16,600 based on short term (acute) and long term (chronic) effects, respectively. The

monetary value was estimated at $20 billion to $110 billion per year, though this was considered an underestimate. The possibility of added benefits below the standard were not estimated because they were considered less certain than those above the standard.

Section 812 of the Clean Air Act Amendments of 1990 required EPA to assess the effect of the 1990 Clean Air Act Amendments on public health, the economy and the environment. The first prospective report to Congress "The Benefits and Costs of the Clean Air Act 1990 to 2010" was published in November 1999 www.epa.gov/oar/sect812. This broad overview of the Clean Air Act Amendments found the majority of the monetarized benefits were attributed to reductions in particulate matter and most of those benefits were associated with reductions in premature mortality. As shown in table 8 this analysis relied on a total mortality relative risk of 1.17 for 24.5 ug/m3 median concentration difference. Recently, EPA quantified the avoided nationwide incidence of health impacts associated with the Heavy Duty Engine/Diesel Fuel Rule (EPA, 2000a). A brief overview of the results is provided below.

Table 9 provides a summary of the expected number of cases and associated costs expected to be primarily avoided by a relatively small reduction in $PM_{2.5}$. These estimates were derived based on a 0.27 $\mu g/m^3$ decreases in the national average annual mean $PM_{2.5}$ concentration which is equivalent to a 0.65 $\mu g/m^3$ population – weighted average mean concentration reduction. Refer to EPA, 2000a for modeling and calculation specifics.

Benefits from reductions in the following impacts were not estimated: infant mortality, low birth weight, changes in lung function, chronic respiratory diseases other than bronchitis, lung structural changes, altered immune defenses, cancer and non-asthma respiratory emergency room visits.

Table 9. Primary Estimate of Annual Health Benefits Associated With Particulate Matter Changes Resulting from HD Engine/Diesel Fuel Rule in 2030.

Endpoint	Avoided Incidence[A] (case/year)	Monetary Benefits[B] (millions 1999$, not adjusted for growth in real income)	Monetary Benefits[B] (millions 1999$, adjusted for growth in real income)
PM-related Endpoints[C]			
Premature mortality[D] (adults, 30 and over)	8,300	$48,250	$62,580
Chronic bronchitis (adults 26 and over)	5,500	$1,810	$2,430
Hospital Admissions – Pneumonia (adults, over 64)	1,100	$20	$20
Hospital Admissions – COPD (adults, 64 and over)	900	$10	$10
Hospital Admissions – Asthma (65 and younger)	900	$10	$10
Hospital Admissions – Cardiovascular (adults, over 64)	2,700	$50	$50
Emergency Room Visits for Asthma (65 and younger)	2,100	<$5	<$5
Asthma Attacks (asthmatics, all ages)	175,000	not monetized	not monetized
Acute bronchitis (children, 8-12)	17,600	<$5	<$5
Lower respiratory symptoms (children, 7-14)	192,900	<$5	<$5
Upper respiratory symptoms (asthmatic children, 9-11)	193,400	$10	$10
Work loss days (adults, 18-65)	1,539,400	$160	$160
Minor restricted activity days (adults, age 18-65)	7,990,400	$390	$430

[A]Incidences are rounded to the nearest 100.

[B]Dollar values are rounded to the nearest 10 million.
[C]PM-related benefits are based on the assumption that Eastern U.S. nitrate reductions are equal to one-fifth the nitrate reductions predicted by REMSAD (Regulatory Model System for Aerosols and Deposition).
[D]Premature mortality associated with ozone is not separately included in this analysis (also note that the estimated value for PM-related premature mortality assumes the 5 year distributed lag structure described in Section D-3 of EPA, 2000a.
Excerpt from Table VII-19 of EPA, 2000a.

4.6.2 Minnesota Health Impact Estimates

The MPCA does not currently have a precise measure of the number of premature deaths or other adverse effects Minnesotans currently experience from particulate matter. This section attempts to summarize currently available Minnesota-specific information and to put the Minnesota problem in context.

4.6.2.1 Minnesota's ambient concentrations in relation to the U.S.

Minnesota's fine particulate problem deserves serious attention, but it is clear Minnesota ambient fine particulate concentrations are lower than the more highly polluted eastern U.S. cities such as Steubenville and Philadelphia. Minnesota has higher concentrations than many areas to the west. This is graphically illustrated by modeled results provided in the Krewski et al. (2000) reanalysis Sensitivity Analysis (Figure 31) (http://www.healtheffects.org). The available Minnesota ambient monitoring data was presented in Section 3.1.

Note that planned controls will have their greatest reduction effects in the eastern U.S. where burning high sulfur coal is a major contributor to the fine particulate concentrations. In contrast, in urbanized areas throughout the country, it is the burning of fossil fuels in automobiles and diesel engines that contributes a significant amount of the fine particulate burden to the air. Releases of ammonia to the air may also be contributing to ambient fine particulate levels. A Minnesota-specific source allocation to determine the emission sources contributing to the fine particulate levels has not yet been done.

4.6.2.2 Minnesota Estimates of Premature Mortality from Long-Term Exposure

ABT Associates Inc. (2000) estimated the annual number of deaths from fine particulate matter in Minnesota that would be avoided by implementing a 75% reduction of coal-fired power plant emissions. The RAMSAD air quality model, containing a fairly comprehensive emissions inventory and fate and transport algorithms, was used to model air quality. It was run in a manner consistent with EPA's use of this model for the Tier 2 automotive standards (personal communication with Deck, 2000). ABT Associates relied on the Krewski et al. (2000) reanalysis, using the recalculated relative risk of 1.12 for all causes of death based on city means rather than median data. Krewski personally

recommended using this with 24.5 ug/m3 PM for the difference in means (Deck, 2000). Using this approach, and recognizing that the estimates for smaller regions are less precise than at the national scale, they estimated 153 annual Minnesota deaths that would be avoided by a 75% reduction in power plant-derived particulate matter. These would be in addition to those reductions that are already resulting from the 1990 Clean Air Act Amendments. Other significant contributors to ambient fine particulate matter, particularly diesel engines, automobiles, and other combustion sources were not assessed within the RAMSAD modeling exercise. (Deck, Leland, 2000. ABT Associates, Inc.)

4.6.2.3 Local Estimates of Mortality from Short-term Daily Fluctuations of Particulate Matter

As previously discussed, NMMAPS is a time series study of the short-term effects of air pollutants including PM_{10}. The regression coefficients for the effect of PM_{10} on total mortality and cardiorespiratory mortality for Minneapolis/St. Paul (Hennepin and Ramsey counties) were 0.48% [95% CI –0.07% to 1.03%] and 0.48% [95% CI -0.26% to 1.23%], respectively. In other words, there was about a half- percent increase in daily deaths associated with each 10 ug/m3 increase daily PM10. The overall assessment for all 10 cities also showed approximately a 0.5% statistically significant increase. Finding statistical significance in the epidemiology studies depends on the statistical power can only be available for the analysis. Because the ambient air pollution studies are assessing a small fraction of all causes of death, adequate statistical power is obtained by using large data sets. Thus, the best estimate of the Minnesota effect was 0.48% increase, but this was found with less than a 95% significance level. The actual significance level wasn't reported.

Schwartz (2000) conducted a meta-analysis for 10 U.S. cities including Minneapolis/St. Paul to estimate the association between a short-term 10 ug/m3 PM_{10} elevation and increased mortality rates. Specific data for these 10 cities are summarized in Table 10. Using all cities, the analysis reported a 0.67% (95% CI 0.52% to 0.81%) increase in mortality for a 10 ug/m3 increase in PM10. When the analysis excluded days with the highest PM_{10} ($\geq$ 50 ug/m3), a greater (0.87 %)(CI 0.62% to 1.12%) mortality increase was reported for a 10 ug/m3 PM_{10} increase. The results were essentially unaffected when other pollutant concentrations (sulfur dioxide, carbon monoxide and ozone) were also considered. The location of death, whether it occurred in or out of the hospital, was also examined. Schwartz reported a 0.49 % (CI 0.31% to 0.68%) particulate associated increase in deaths occurring in hospitals and a 0.89 % (CI 0.67% to 1.10%) increase in deaths occurred out of the hospital. The higher impact on individuals not hospitalized was interpreted as evidence that these deaths were in individuals not initially near to death, further suggesting that these deaths didn't simply reflect a minor life- shortening effect. The results also showed that relatively higher health benefits were derived from 10 ug/m3 PM_{10} reductions below lower ambient concentrations than the same amount of reductions below higher concentration levels.

Table 10. City Specific Data used in Meta-Analysis of Daily PM_{10} in Relation to Daily Deaths

City	PM_{10} (ug/m3)	1990 Population	Mean Daily Deaths
Minneapolis/St. Paul	27.5	1,518,196	32.3
New Haven	28.6	804,219	20.4
Birmingham	34.8	651,525	19.1
Pittsburgh	36.4	1,336,449	63.3
Detroit	36.9	2,111,687	59.7
Canton	29.31	367,585	9.9
Chicago	36.5	5,105,067	133.4
Colorado Springs	27.1	397,014	6
Spokane	40.6	361,364	8.7
Seattle	32.5	1,507,319	29.3

Excerpt from Schwartz (2000)

Schwartz (1994) analyzed PM_{10} in relation to Minneapolis-St. Paul hospital admissions of the elderly for pneumonia and chronic obstructive pulmonary disease (COPD). Hospitalization, daily air pollution concentrations and weather data were obtained for 1986 through 1989. The relative risks for a 100 ug/m3 increase in daily PM_{10} were significant for pneumonia admissions and COPD admissions. The relative risk for pneumonia was 1.17 [95% CI 1.02 – 1.33] and for COPD it was 1.57 [95% CI 1.20 – 2.06]. In other words, hospital admissions in the elderly went up 17% for pneumonia and 57% for COPD in relation to a 100 ug/m3 PM_{10} increase. During that period, daily PM_{10} concentrations were distributed as follows. The 10th, 25th, 50^{th}, 75^{th} and 90^{th} percentiles were 18 ug/m3, 23 ug/m3, 32 ug/m3, 44 ug/m3, and 58 ug/m3, respectively and the mean was 36 ug/m3 PM_{10}.

4.6.2.4 Minnesota-specific Information Regarding Non-Lethal Effects

Schwartz (1999) studied the relationship between hospital admissions for cardiovascular (heart) disease in the elderly in 8 U.S. counties including Hennepin and Ramsey. These cities were chosen, in part, because they spanned a range of weather conditions, had relatively varying pollutant concentrations derived diverse sources, and in contrast to the eastern U.S., had lower ambient concentrations with a relatively smaller percent sulfate than many cities to the east. Overall, hospital admissions for heart disease in the elderly (>65 years of age) were found to increase 2.48% (CI 1.82% to 3.15%) for each 25 ug/m3 higher daily PM_{10} concentrations. Carbon monoxide concentration changes were also related to heart disease admissions. The city-specific PM_{10} data is shown in Table 11.

This information illustrates that the best estimates regarding the degree to which Minneapolis and St. Paul heart disease admissions increase as PM_{10} increases 25 ug/m3 are about 2% and 4% respectively. It is noted that although the average effects reported across all cities was approximately 2% or greater, when this type of data is reported for individual cities, the statistical power to consistently find significant differences for each city is diminished.

Table 11. City-specific Daily PM_{10} Concentrations and Increase in Heart Disease Admissions

City	Daily PM_{10} (ug/m3) Distribution (as Percentiles)			Effect of a 25 ug/m3 Daily PM_{10} Difference – (% Increase in Heart Disease Hospital Admissions Among the Elderly)
	25th	50th	75th	% (95th CI)
Minneapolis	20	28	35	2.03 (-1.87 to 6.09)
St. Paul	24	34	37	4.19 (1.44 to 7.00)
Chicago	26	35	49	2.31 (1.31 to 3.33)
Spokane	24	37	57	3.28 (0.43 to 6.21)
Tacoma	20	37	47	2.63 (0.47 to 2.63)
Seattle	21	29	41	1.77 (-0.07 to 3.64)
Colorado Springs	17	23	31	2.76 (-3.2 to 9.09)
New Haven	26	37	51	2.87 (1.04 to 4.73)

Excerpt from Schwartz (1999)

Moolgavkar et al. (1997) found significant associations between PM_{10} and other pollutants and hospital admissions for COPD and pneumonia among the elderly in Minneapolis/St. Paul between 1986 to 1991.

4.6.2.5 Equations for Estimating Particulate Matter Health Impacts from Long-term Exposures

A log-linear equation is typically used to describe the relationship between premature mortality and fine particulate matter. EPA used the following general equations to estimate the benefits of the Clean Air Act Amendment (EPA, 1999). In the epidemiological literature this is often referred to as the "Poisson regression" equation (EPA, 1999):

$$y = \mathrm{B}\, e^{\beta \times PM} \qquad \text{Equation 1}$$

Equation 1 can also be expressed as:

$$\ln(y) = \alpha + (\beta \times PM) \qquad \text{Equation 2}$$

Where:

y = incidence of an adverse health effect (e.g., number of premature deaths)
PM = particulate matter concentration (ug/m3)
B = incidence of the adverse health effect without PM
β = the coefficient of PM (change in incidence per change in concentration)
$\alpha = \ln(B)$
ln(y) = the natural logarithm of y

The coefficient β can be directly calculated from the relative risk associated with a given difference in PM concentrations:

$$\beta = \frac{\ln(RR)}{\Delta PM} \qquad \text{Equation 3}$$

Where:

RR = relative risk associated with a ΔPM difference in annual average fine particulate concentration
ΔPM = a difference in annual mean fine particulate concentration (in ug/m3)

The following equation is used to estimate a change in the incidence of a health effect (i.e., the number of cases) for a given change in ambient PM concentration:

$$\Delta y = -y_o \times (e^{-\beta \times \Delta PM} - 1) \qquad \text{Equation 4}$$

y = initial incidence of mortality (annual number of deaths in the defined population given the initial particulate concentration)
ΔPM = a difference in PM concentration in ug/m3 (e.g., resulting from a potential concentration reduction)
Δy = change in the incidence of death (e.g., number of lives saved)

4.6.2.6 Estimate(s) of Current Health Impacts (Mortality) in the Twin Cities

A number of national estimates have been done to illustrate the magnitude of the particulate matter problem. As with all scientific research of this nature, there is uncertainty in characterizing the health effects attributable to exposure to ambient particulate matter. A greater proportion of the national deaths are expected to occur in the more polluted cities, and there may be some differences in health impacts based on differences in the particulate composition and size distribution. Whether there is a threshold at any ambient air concentration is an unresolved question (Section 4.3.2). .

In order to provide an approximate frame of reference for the Minnesota problem, MPCA applied the equations described above with Minnesota-specific information. This section estimates a plausible range of fine particulate matter-related health deaths occurring in

Hennepin and Ramsey Counties. These estimates do not describe the additional health impacts also expected to occur including a range of less than lethal effects associated with particulate matter and any increased mortality in the younger (less than 30 year old) population.

Because the question of threshold is not fully resolved in the scientific literature, estimates were developed based on various possible effect thresholds.
MPCA estimated a range of potential premature deaths attributable to current Twin Cities fine particulate matter concentrations.

The Twin Cities estimate was developed with the following information. Minnesota Department of Health provided the vital statistics for 1998. The combined incidence of death in Hennepin and Ramsey counties, for people aged 30 and older, was 11,750.

The current average annual ambient PM2.5 concentration for Hennepin and Ramsey counties, based on the 4th quarter of 1998 and the first 3 quarters of 1999, was calculated by averaging the average concentrations from the 8 monitors in those two counties. The overall average was 12.3 ug/m3 PM2.5. For reference, the individual monitor averages from the eight individual monitoring stations are provided in Table 12. Note that these averages differ from those provided in Section 3.1 because these are the most recently available 12 month averages, while the data previously presented was all available data.

Table 12. Recent Average PM2.5 Concentrations Measured in Hennepin and Ramsey Counties

Site Name	County	Number of Valid Samples	Average Concentration (ug/m3)	Minimum Concentration (ug/m3)	Maximum Concentration (ug/m3)
Phillips Community Center	Hennepin	185	11.0	1.8	50.3
Richfield Intermediate School	Hennepin	84	12.0	1.5	48.5
North Mpls Fire House Site 0907	Hennepin	61	12.3	2.0	35.0
St. Louis Park City Hall	Hennepin	71	11.9	1.5	48.3
Red Rock Road	Ramsey	76	13.9	3.1	44.3
St. Paul Health Center	Ramsey	77	14.4	2.5	51.0
Harding High School	Ramsey	145	11.7	1.9	33.7
Randolph Elementary School	Ramsey	81	11.5	2.1	45.8

Overall Mean of the Average Concentrations for 8 Twin City Monitors = 12.3 ug/m3
Results were collected from October 3, 1999 through September 30, 2000

The concentration – response relationship for long-term mortality from PM2.5 was obtained from the Krewski et al. (2000) reanalysis of the Pope et al. (1995a) ACS study. The Krewski reanalysis (Table 31, for dichotomous samplers in 63 cities) reported a 1.12 relative risk for all causes of death in the population aged 30 years and older for a 24.5 ug/m3 difference in annual mean PM2.5 concentrations. The resulting PM2.5 coefficient (β) was 0.0046257. This concentration-response function was also recently used by EPA

for a nationwide estimate of the benefits of the Heavy-duty Engine and Vehicle Standards and Highway Diesel Fuel Sulfur Control Requirements Rule (EPA, 2000a). This concentration-response function provides relatively lower estimates of premature mortality than similar estimates from the Six Cities Study (Dockery et al., 1993) or original ACS Study (Pope et al., 1995).

The number of premature deaths currently occurring in Minnesota due to current PM2.5 concentrations can be estimated assuming a range of possible thresholds. Using equation 4, the estimated number of additional deaths in the Ramsey and Hennepin counties are listed in Table 13. The importance of the threshold assumption is illustrated in Figure 14.

Table 13. Plausible Range of Premature Deaths Avoided in Hennepin and Ramsey Counties as a Function of Possible Thresholds

Estimated Number of Particulate Associated Deaths Per Year Avoided by Reducing PM2.5	PM2.5 Reduction from 12.3 ug/m3 to Potential Threshold	Assumed PM 2.5 Threshold in ug/m3
0	0.0	12.3
16	0.3	12
70	1.3	11
124	2.3	10
178	3.3	9
231	4.3	8
285	5.3	7
337	6.3	6
390	7.3	5

This analysis assumes there is a threshold at 5 ug/m3 or above. If the threshold were actually lower, a higher annual number of deaths would be estimated.

Although the percent increase in mortality and other health effects associated with fine particulate matter is relatively small, due to the large number of individuals exposed to ambient air, as well as the seriousness of the adverse health outcomes, the evidence strongly indicates that this pollutant is currently causing health impacts in Minnesota. A more thorough assessment would be needed to estimate the overall Minnesota health impacts of particulate matter pollution.

Comparison to Cancer Risk Estimates

It should be noted that these estimates are designed to be like actuarial estimates; they are based on actual measured death rates measured in epidemiological studies. This approach should be distinguished from risk estimates where the level of uncertainty is much greater. The latter situation is often the case when doing environmental cancer

risk assessments. The environmental cancer risk assessments typically rely on conservative upper bound estimates generally extrapolated from effects measured at significantly higher concentrations, often from animal data. The recent particulate matter epidemiology studies are measurements of human effects occurring at actual ambient concentrations in populated areas. The long-term study estimates describe the numbers of deaths expected per year. This epidemiological evidence is thus considered more certain with respect to the estimation of effects. The cancer risk assessments are designed to provide protection, but are not expected to provide exact numbers of cancer cases that will occur. Standard EPA risk assessment methods typically result in upper bound cancer cases or risks expected over a 70-year lifetime.

4.6.2.7 CTS Study – Basis for Health Effects Cost Estimates

The University of Minnesota Center for Transportation Studies (CTS) estimated the 1998 air pollution costs of motor vehicle use in the 19 county Twin Cities Region to range from $ 385 million to nearly $5 billion, with a best estimate of $1 billion (Anderson and McCullough, 2000). They found most measurable air pollution costs resulted from adverse human health effects.

The $1 billion dollar estimate was based 73 % on direct health impacts, 18 % on other environmental effects and 10% on global climate change. Financial valuations were done using a damage value approach.

Direct health impacts including premature death, chronic illness, asthma attacks and cancer were quantified. The authors were unable to include all types of health impacts due to a lack of health surveillance information for other effects. Environmental effects included were damage to crops, forests, wildlife, materials, and visibility. The global climate change costs were based on costs per ton of carbon..

The following discussion focuses on the analysis of air pollution-related direct health impacts for the CTS study. To assess the health impacts from motor vehicle-related air pollution, the authors relied on a nationwide study of U.S. urban areas, including the Twin Cities region (McCubbin and Delucchi, 1996).

McCubbin and Delucchi developed lower and upper bound estimates of adverse health effects and associated costs. These bounding estimates were calculated using a range of assumptions regarding natural background pollutant concentrations, direct health impact estimates from epidemiology studies, monetary valuations of health effects, pollutant emission factors, and the effects of particulate matter size and composition.

McCubbin and Delucchi (1996) estimated direct health impacts and their associated costs for three general emission sources:

- direct vehicle emissions (including secondary particulate formation),
- road dust emissions, and

- upstream emissions (e.g., from refineries, auto production and servicing, road construction).

The following pollutants were evaluated in the study: particulate matter (PM), nitrogen oxides, sulfur oxides, carbon monoxide, ozone, benzene, formaldehyde, 1,3-butadiene, acetaldehyde, diesel particulates, and gasoline particulates.

McCubbin and Delucchi relied on the 1990 EPA ambient air monitoring network for criteria pollutant concentrations. The average annual Twin Cities PM_{10} concentration used was 26.9 ug/m^3. For comparison, EPA reported the Minneapolis/St. Paul 1998 weighted annual mean of PM_{10} to be 22 ug/m^3 (EPA, 2000b). Recent monitoring indicates that PM_{10} concentrations decreased until about 1994 when they stabilized or slightly increased (see section 3.1).

McCubbin and Delucchi estimated exposures to selected air toxics, such as benzene, formaldehyde, acetaldehyde, 1,3-butadiene, and diesel and gasoline particulates, using the EPA HAPPEN-MS model in conjunction with available monitoring data. The relative contribution of ambient air concentrations and associated health impacts from gasoline vs. diesel vehicles was estimated based on emissions estimates from vehicles and other sources, dispersion models, and ambient air concentration measurements.

McCubbin and Delucchi (1996) described a range of available epidemiology studies, and those selected to quantify direct health impacts for particulate matter, ozone, carbon monoxide, nitrogen dioxide and sulfur dioxide. They used EPA risk assessment methods and unit risk estimates to estimate potential health impacts (specifically cancer) for the "toxic air pollutants." Overall, they found mortality associated with particulate matter to be the most costly direct health impact of motor vehicle-related air pollution.

The epidemiological studies used to estimate mortality from particulate matter were: Pope et al. (1992) for PM_{10} acute mortality; Ozkaynak and Thurston (1987) for the lower bound estimate of chronic $PM_{2.5}$ mortality; and Pope et al. (1995b) for the upper bound $PM_{2.5}$ chronic mortality. The authors took precautions to avoid double counting mortality from short and long term exposures. For the lower bound estimate $PM_{2.5}$ was assumed to be twice as toxic as PM_{10}. For the upper bound $PM_{2.5}$ was assumed to be 10 times more hazardous than PM_{10}. McCubbin and Delucchi reported being somewhat uncomfortable with the high mortality risk estimates derived from the Pope study. Since then the Pope et al. (1995a) ACS study has been intensely scrutinized and generally accepted. The reanalysis, published by Krewinski in July 2000, provided a strong support for the ACS study. The Health and Ecological Effects Subcommittee (HEES) of the Advisory Council on Clean Air Compliance Analysis of the Science Advisory Board also recommended the use of the ACS data (Pope et al., 1995a) study as the basis for fine particulate matter cost estimates for the Clean Air Act Section 812 analysis (EPA, 1999).

Additional health impact estimates were based on concentration response functions of measured human effects from particulate matter observed in the following studies: Whittemore and Korn (1980) for asthma, Ostro and Rothschild (1989) for respiratory-

related restricted activity day (RRAD), and Abbey et al. (1995) for airway obstructive disease.

Table 14 presents the McCubbin and Delucchi estimates of direct health impacts, in terms of numbers of health effects and associated costs, from manmade sources of U.S. air pollution. McCubbin and Delucchi only present data describing the number of estimated cases of health effects at the national level, not the Minnesota-specific information. Although this is not specific to motor vehicle-associated air pollution, it provides a general sense of the types of effects and associated costs. Numerically there were many more of the less severe health effects, such as asthma, illness, new cancer cases, etc., but most of the health costs resulted from a smaller number of particulate-associated deaths.

Table 14. Summary of U.S. Adverse Health Effects and Costs Caused by all Anthropogenic Air Pollution in 1990

Emission	Ambient Pollutant	Health Effect	1990 Thousands of Cases		Cost of 1990 cases (in $1991 billion)	
			low	high	low	High
CO	CO	headache	170,385	202,416	0.5	2.6
		hospitalizatio	8	23	0.1	0.2
		n	0.5	1.5	0.5	5.8
		mortality	--	--	1.1	8.6
NO_x	NO_x	sore throat	265,577	269,583	0.6	3.0
		excess	121,800	123,700	0.4	1.7
		phlegm	109,618	111,303	0.3	1.5
		eye irritation	--	--	1.3	6.3
VOC + NO_x	O_3	asthma	3,652	11,482	0.04	0.5
		attacks	33,852	37,383	0.1	0.5
		eye irritation	48,584	81,089	0.1	1.1
		lower respiratory illness	14,782	24,672	0.04	0.3
		upper respiratory illness	0 --	276,144 --	0.0 0.3	3.3 5.8
		ARD2	0	276,144	0	3.3
PM_{10}, SO_2, NO_x, VOC	PM_{10}[(a)]	asthma	3,003	3,172	0.03	0.2
		attacks	88,673	120,133	1.8	8.4
		RRAD	39	93	10.1	177.1
		chronic	80	137[b]	40.9	489.0[b]
		illness	--	--	52.8	674.7[b]
		mortality				
All	*All*	*All*	--	--	55.5	695.4

Excerpts from Tables 11.7-3B and 11.7-4B (McCubbin and Delucchi, 1996).
ARD2 = Any symptom or condition
RRAD =Respiratory-Related Restricted Activity Days
Note that toxics were not included on this table.

[a] Includes particulate sulfates, particulate nitrates, and organic particulates, as well as direct or primary particulate emissions.

[b] In McCubbin and Delucchi (1996) p. 212, an alternative upper bound for 1990 was calculated, using the lower-bound estimate of long term deaths from PM (i.e., using Ozkaynak and Thurston, 1987 rather than Pope et al., 1995), with all other original upper-bound assumptions. The alternative upper-bound estimate is approximately half of the upper-bound shown here.

McCubbin and Delucchi reported 95% of the total nationwide costs associated with direct vehicle emissions occurred in urban areas. Table 15 summarizes the range in estimated health costs associated with motor vehicle air pollution in U.S. urban areas. Direct

vehicle emissions account for a majority of health costs, followed by road dust emissions, and a relatively minor contribution from the upstream emission sources. For both the lower and upper bound cost estimates, at least 90% of the health-related costs resulted from the adverse effects of particulate matter. A majority of the health costs result from combustion emissions of particulate matter and its gaseous precursors; nitrogen dioxide, sulfur dioxide and volatile organic carbon.

Table 15. Cost of Motor-Vehicle Air Pollution in U.S. Urban Areas based on a 100% Reduction of Motor Vehicle Emissions in 1990 (Millions of $1991)

	Motor Vehicles		Motor Vehicles + Upstream[1]		Motor Vehicles + Upstream + Road Dust[2]	
	Lower	Upper	Lower	Upper	Lower	Upper
PM_{10}[3]	15,954	253,126	18,059	265,228	20,599	401,037
Ozone	196	1,730	209	1,771	209	1,771
NOx	955	5,072	964	5,093	964	5,093
CO	829	7,089	831	7,094	831	7,094
Toxics[4]	76	1,411	n.e.	n.e.	n.e.	n.e.
Total	18,010	268,428	20,139	280,599	22,679	416,408

Excerpt from Table 11.7-9 McCubbin and Delucchi (1996)
[1] Refineries, auto production and servicing, road construction
[2] Paved and unpaved roads
[3] Includes particulate sulfates, particulate nitrates, and organic particulates
[4] Includes maximum likelihood cancer risk estimate for benzene and upper bound cancer risk estimates for formaldehyde, 1,3-butadiene, acetaldehyde, diesel particulates, and gasoline particulates
n.e. – not estimated due to a lack of ambient air modeling data for the upstream pollution sources

The Center for Transportation Studies (CTS) study summarizes the Twin Cities region health costs from motor vehicle air pollution. Based on the McCubbin and Delucchi lower and upper bound costs for a 10% reduction in motor vehicle use (Tables 11-A.19 and 11-A.20), the authors of the CTS study calculated the geometric mean of the lower bound value and half of the upper bound value to develop their midrange best estimate of the direct health costs. This was the midrange value used to estimate $725 million in total motor vehicle-related air pollution health costs.

Using their midrange values, direct vehicle emissions accounted for 62.6%, upstream emissions for 10.1%, and road dust emissions for 27.3% of the health costs (Anderson and McCullough, 2000, Table 6.9). Specifically for the direct vehicle emissions, diesel emissions accounted for approximately 31% of both the particulate-associated and the total health costs. Gasoline emissions accounted for 69%. Their estimated contributions of pollutants and types of adverse health effects to Twin Cities motor vehicle-related air pollution costs are summarized in Tables 16 and 17, respectively.

Table 16. % Twin Cities Region Health Costs by Pollutant (in 1990) for Direct Vehicle Emissions

	Gasoline Vehicles	Diesel Vehicles	All Vehicles
Particulate Matter	37.8	17.9	57.3
Ozone	0.1	0.0	0.1
Nitrous Oxides	2.3	0.1	2.4
Carbon Monoxide	2.6	0.0	2.6
Total	44.6	19.7	62.6

Excerpt from Anderson and McCullough (2000) Table 6.9

Table 17. % Twin Cities Region Health Costs by Health Impact (in 1990) for Direct Vehicle Emissions

	Gasoline Vehicles	Diesel Vehicles	All Vehicles
Mortality	30.0	13.6	45.2
Cancer	3.5	0.1	0.2
Chronic Morbidity	4.7	4.1	12.2
Acute Morbidity	4.7	0.3	6.7
Total	44.6	19.7	62.6

Excerpt from Anderson and McCullough (2000) Table 6.9

5.0 Other impacts - Impaired Visibility and Acidic Deposition

5.1 Background

The health effects discussed above are most likely to be experienced in populated areas where both higher particulate matter levels and greater populations coexist. However, in more remote areas, where many of our most cherished natural resources are located, fine particles contribute to visibility degradation (regional haze) and acidification of lakes

Visibility is usually defined as the distance that an object can be seen against the horizon. When far distant landscape features are seen clearly, the quality of the air is perceived as good. Visibility degradation is generally perceived as haze in areas with long vistas such mountains or across large water bodies. In addition to the quality of the atmosphere, the nature of the light, the type of object being viewed and even characteristics of the observer all contribute to perceived level of visibility.

Both particles and gases in the air can absorb or scatter light. Both effects reduces visibility. It is the fine or very small particles, those less than about 2.5 microns in diameter, that affect visibility the most. This is the same particle size range for which the PM2.5 ambient air standard was established.

5.2 Composition of Fine Particles

Fine particles in the air can be man-made or natural and are either released directly into the air in their final form (primary particles) or are formed in the air through chemical reactions secondary particles).

Primary particles in the air include:

- carbon from fires and diesel engines,
- wind blown dust, and
- ash from coal burning.

Secondary particles in the air include:

- sulfates from oxidation and reaction of sulfur dioxide from coal and oil combustion,
- nitrates from oxidation and reaction of nitrogen oxides emitted form fossil fuel combustion, and
- organics from photochemical reactions involving volatile organic chemicals emitted from natural and man-made sources.

Visibility impairment is due to absorption and scattering of light by the particles. Nitrates and sulfates are hygroscopic and tend to absorb water. Under high humidity levels, visibility degradation is therefore enhanced.

Nitrates and sulfates in air eventually are removed by deposition of the particles to land and water surfaces, and can be washed out of the air by rainfall. Both effects can lead to acidification of lakes in areas of the state that do not have the chemical buffering capacity to neutralize these acidic inputs.

5.2 Regulatory Context (Visibility)

Section 169A of the federal Clean Air Act (CAA) sets forth a national goal for visibility which is the ‘‘prevention of any future, and the remedying of any existing, impairment of visibility in Class I areas which impairment results from manmade air pollution.’’ There are 156 Class I areas in the country including most national parks and wilderness areas. In Minnesota, the Boundary Waters Canoe Area and Voyageurs Park are Class I areas. EPA promulgated rules to protect the Class I areas from visible smoke plums in 1980. After assurances from the National Academy of Sciences in 1993 that the state of knowledge was adequate to develop a regulatory program for regional haze, EPA promulgated rules to improve overall levels of visibility in Class I areas in July 1999.

The rules call for states to develop plans to maintain the visibility on the best visibility days and improve visibility on the worst visibility days on a schedule that would reach background visibility levels in 60 years. The rule also contains a requirement for certain industries built before 1977 (when anti-degradation regulations -Prevention of Significant Deterioration- were adopted) and after 1962 to install the equivalent of Best Available Retrofit Technology.

The MPCA envisions that implementation of the visibility regulations will occur over an extended period of time through a combination of national regulations such as automobile tailpipe standards and requirements developed by individual states and states acting in regional planning organizations. The regional planning concept is appropriate for pollutants such as fine particulates that travel great distances. Minnesota has elected to join the eight states to the south of Minnesota in a regional planning organization formed by the Central States Air Resource Administrators (CenSARA). Minnesota elected to join these states because it is likely that the states to the south contribute more than states to visibility impairment in our Class I areas. The deadline for submission of state plans to improve visibility is coincident with the deadline for state plans to bring PM2.5 areas into attainment with the federal PM2.5 standard. States participating in regional planning organizations must submit control strategy plans by 2008.

5.3 Regulatory Context (Acid deposition)

In the early 1980's, the MPCA recognized the need to protect areas of Minnesota with lakes that were sensitive to acidic deposition. Through research and policy development activities, acid deposition standards and control requirements were written into state rules in 1986 (Minn. Rules 7021). In 1990, amendments to the federal Clean Air Act were passed. Title IV of these amendments contained national provisions for a two phase program to reduce sulfur dioxide and nitrogen oxide emissions from power plants through a combination of standards to establish a baseline and an allowance trading program to implement the standards in the most cost effective manner. The deadline for the second phase of reductions was January 1, 2000.

5.4 Indicators

As discussed earlier, the MPCA established a monitoring network for PM2.5 in populated areas of the state. The goal of this network is judge compliance with health based standards. Similar monitors are used to judge visibility through measurement of PM2.5. Visibility monitors, however are located in the Class I areas in remote parts of the state. The MPCA, in conjunction with Minnesota tribal authorities and CenSARA, hopes to establish additional visibility monitors in rural areas upwind of Class I areas to help isolate the effects of transport into the state. Both PM2.5 and visibility monitoring sites will also look at the chemical composition of the particles to help determine the source of the particles and possibly the toxicity of the particles. EPA has funded most of these monitoring efforts. Both networks are in their startup phase. Trends in visibility across the country can be deduced from airport visual data for the period before the national visibility monitoring program began in Class I areas in the early 1990's. Visibility in the eastern United States degraded from 1970 to 1980, and then improved from 1980 to 1990 following the trend in sulfur dioxide emissions. Measurements from the Class I areas showed very modest overall improvements in the east from 1990 to 1998. Visibility trends in the west by contrast have improved steadily since 1970. Data from the only visibility monitor in Minnesota is presented below. Only five years worth of data are available. Although variable, the trend appears to be toward improvements in visual range.

Minnesota's lakes are not currently in danger of acidification (although acidified lakes in eastern US and Canada have yet to recover). However, scientists are investigating the possibility that acid rain has increased mercury in fish in some Minnesota lakes, through mechanisms other than acidification. If true, it may be desirable to reduce sulfur emissions even more than is planned under the federal Clean Air Act. Minnesota acid deposition and pH data are available at the National Atmospheric Deposition Program web site referenced below. The maps clearly show that measured levels are under the state 11 kg/hectare sulfate deposition standard and the 4.7 rainfall pH target.

Sulfate deposition trends in the eastern United States show a clear downward trend over the past ten years. This trend is due to implementation of the federal acid deposition program. Minnesota sulfate deposition trends also show a clear downward trend from 1980 to the present. Data from the NADP site near the Boundary Waters Canoe Area is presented below. It should be noted that sulfate deposition appears to have increased in 1998 and 1999 due possibly to increased coal burned at electric utilities. It should also be noted that there is no clear trend for nitrate and ammonium ion deposition, other components of rainfall, which can acidify rainfall and also can act as a nutrient in lakes and soils. Nitrate and ammonia result from combustion and agricultural operations respectively.

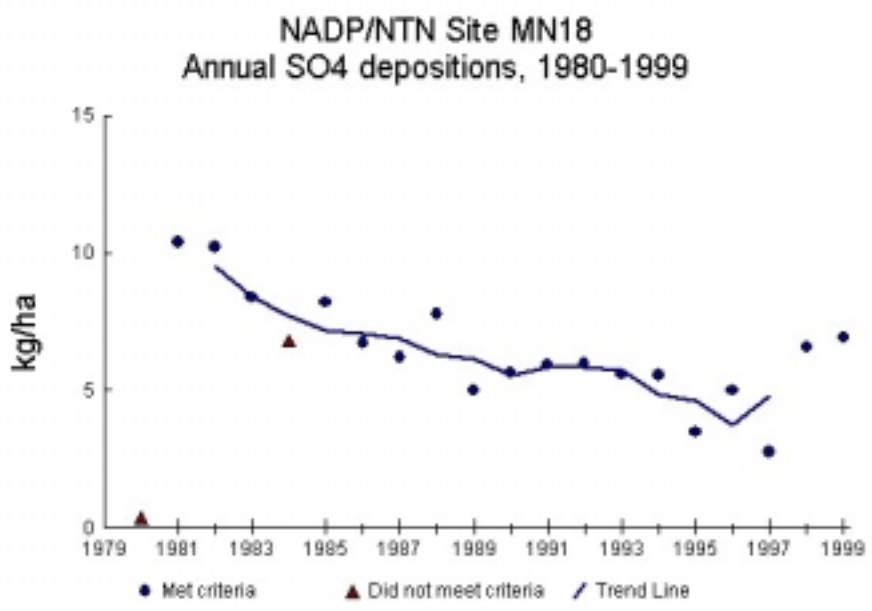


Figure 12. Annual SO4 Depositions

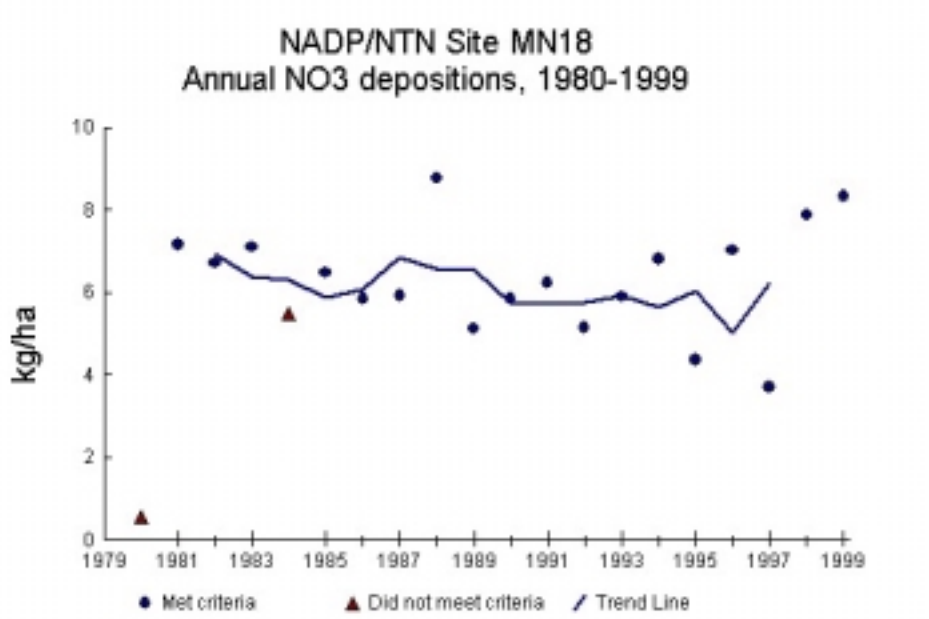


Figure 13. Annual NO3 Depositions

5.5 Links to more information about visibility and acid deposition

Introduction to Visibility, Cooperative Institute for Research in the Atmosphere (CIRA), Colorado State University, 1999.
http://www2.nature.nps.gov/ard/vis/intro_to_visibility.pdf

EPA fact sheet on the regional haze regulations, June 1999.
http://www.epa.gov/air/vis/facts.pdf

Complete final regional haze regulations, Federal Register, July 1, 1999.
http://www.epa.gov/ttn/oarpg/t1/fr_notices/rhfedreg.pdf

Implementation milestones for regional haze regulations.
http://www.epa.gov/ttn/oarpg/t1/fr_notices/implemnt.pdf

EPA's visibility web site.
http://www.epa.gov/air/vis/

The Central States Air Resource Administrators (CenSARA) web site.
http://www.censara.org/

Data and maps of acidic deposition and deposition of other ions. National Atmospheric Deposition Program.
http://nadp.sws.uiuc.edu

1999 Minnesota acid deposition data from the National Atmospheric Deposition Program.

http://nadp.sws.uiuc.edu/isopleths/maps1999/phlab.gif and
http://nadp.sws.uiuc.edu/isopleths/maps1999/so4dep.gif

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APPENDIX C
DRAFT
Criteria Pollutants

Introduction

The Clean Air Act, which was last amended in 1990, requires EPA to set National Ambient Air Quality Standards for pollutants considered harmful to public health and the environment. The Clean Air Act established two types of national air quality standards. Primary standards set limits to protect public health, including the health of "sensitive" populations such as asthmatics, children, and the elderly. Secondary standards set limits to protect public welfare, including protection against decreased visibility, damage to animals, crops, vegetation, and buildings. The EPA set National Ambient Air Quality Standards for six principal pollutants, which are called "criteria" pollutants. Minnesota has, in some cases, established standards that are more stringent than EPA standards. EPA and Minnesota standards are listed in Table 1. The Clean Air Act also requires EPA to periodically review the state of the science for criteria pollutants and revise the standards if warranted. The ozone and PM2.5 standards were revised most recently and are currently under review by the US Supreme Court. Hydrogen sulfide (hydrogen sulfide) is not a criteria pollutant, but Minnesota does have an ambient standard for the chemical, so it will be discussed.

Table 1. Ambient Air Quality Standards

POLLUTANT	STANDARD VALUE *		STANDARD TYPE
Carbon Monoxide (CO)			
8-hour Average	9 ppm	(10 mg/m^3)	Primary
1-hour Average	35 ppm 30 ppm***	(40 mg/m^3) (35 mg/m^3)	Primary
Nitrogen Dioxide (NO_2)			
Annual Arithmetic Mean	0.053 ppm	(100 $\mu g/m^3$)	Primary & Secondary
Ozone (O_3)			
1-hour Average	0.12 ppm	(235 ug/m^3)	Primary & Secondary
8-hour Average **	0.08 ppm	(157 ug/m^3)	Primary & Secondary
Lead (Pb)			

Quarterly Average	1.5 ug/m^3		Primary & Secondary
Total Particulate *All sizes*			
Annual Geometric Mean	75 ug/m^3 60 ug/m^3		Primary Secondary
24- hour Average	260 ug/m^3 150 ug/m^3		Primary Secondary
Particulate (PM 10) *Particles with diameters of 10 micrometers or less*			
Annual Arithmetic Mean	50 ug/m^3		Primary & Secondary
24-hour Average	150 ug/m^3		Primary & Secondary
Particulate (PM 2.5) *Particles with diameters of 2.5 micrometers or less*			
Annual Arithmetic Mean **	15 ug/m^3		Primary & Secondary
24-hour Average **	65 ug/m^3		Primary & Secondary
Sulfur Dioxide (SO_2)			
Annual Arithmetic Mean	0.03 ppm 0.02 ppm***	(80 ug/m^3) (60 ug/m^3)	Primary Secondary
24-hour Average	0.14 ppm	(365 ug/m^3)	Primary
3-hour Average	0.50 ppm 0.35 ppm***	(1300 ug/m^3) (915 ug/m^3)	Secondary
1-hour Average	0.50 ppm***	(1300 ug/m^3)	Primary
Hydrogen Sulfide (H_2S)			
½ hour Average, 2 times per year	0.05 ppm***	(70 ug/m^3)	Primary
½ hour Average, 2 times in 5 days	0.03 ppm***	(42 ug/m^3)	Primary

Units of measure for the standards are parts per million (ppm) by volume, milligrams per cubic meter of air (mg/m^3), and micrograms per cubic meter of air (µg/m^3).
* Parenthetical value is an approximately equivalent concentration.
** A 1999 federal court ruling blocked EPA from implementation of these standards, which were proposed in 1997. EPA has asked the U.S. Supreme Court to reconsider that decision. Minnesota has already adopted the new 8-hour ozone standard and PM2.5 standards and has deleted the 1 hour ozone standard.
*** These are Minnesota standards. There are no corresponding EPA standards. The 3-hour SO_2 standard applies to certain areas in northern Minnesota.

Particulate matter is discussed specifically in the particulate matter appendix and will not be covered in detail in this appendix. The remainder of this appendix provides a brief discussion of each of the other criteria pollutants. Potential health and environmental (secondary) effects, sources, emission trends, and trends in ambient air levels of each pollutant will be discussed. Source categories listed are point (large industrial facilities such as refineries), area (smaller,

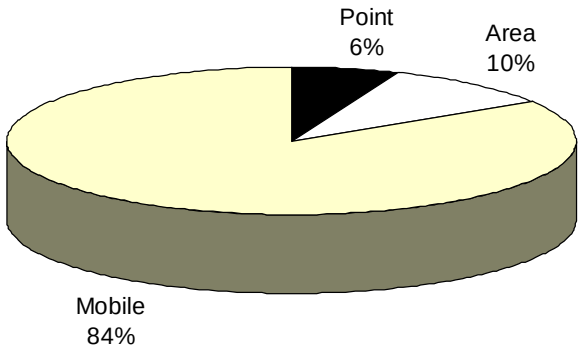
ubiquitous sources such as gas stations and dry cleaners), and mobile sources (cars, trucks, construction equipment, lawn mowers). Point sources are referred to in the *Air Quality in Minnesota* report as "large stationary" sources; area sources as "small stationary."

1.0 Carbon Monoxide (CO)

1.1 Nature and Sources of CO

Carbon monoxide (CO) is a colorless, odorless and at high levels, a poisonous gas, formed when carbon in fuel is not burned completely. It is a component of motor vehicle exhaust, which contributes about 60 percent of all CO emissions nationwide. High concentrations of CO generally occur in areas with heavy traffic congestion. In cities, as much as 95 percent of all CO emissions may come from automobile exhaust. Other sources of CO emissions include refineries and industrial processes, non-transportation fuel combustion, and natural sources such as wildfires. Peak CO concentrations typically occur during the colder months of the year when CO automotive emissions are greater and nighttime inversion conditions (where air pollutants are trapped near the ground beneath a layer of warm air) are more frequent. Figure 1 shows the source contributions to CO emissions in Minnesota in 1997. Emissions totaled 1.45 million tons.

Figure 1. Sources of 1997 Minnesota Carbon Monoxide Emissions.



1.2 Health and Environmental Effects

Carbon monoxide enters the bloodstream through the lungs and reduces oxygen delivery to the body's organs and tissues. The health threat from lower levels of CO is most serious for those who suffer from cardiovascular disease, such as angina pectoris. At much higher levels of exposure, CO can be poisonous and even healthy individuals may be affected. Visual impairment, reduced work capacity, reduced manual dexterity, poor learning ability, and difficulty in performing complex tasks are all associated with exposure to elevated CO levels.

1.3 Trends in CO Levels and Regulatory Implications

Despite significant growth in vehicle miles traveled, monitored CO levels have dropped significantly across the country. This is due to incorporation of vehicles meeting newer more

stringent emission standards. Emissions in Minnesota appear to have decreased more steeply than national emissions. Minnesota's vehicle inspection program, which was active from 1991 to 1999, may have been partially responsible for this difference.

Minnesota air currently meets both state and federal standards for carbon monoxide. Minnesota's last violation was in 1991. While trends in emissions and cleaner vehicles would seem to ensure continued attainment of this standard, it is possible that increased vehicle traffic and may eventually overcome improvements in vehicle technology. This is less likely to occur for carbon monoxide since violations occur as result of traffic near the monitor rather than the total regional emissions of the gas. However, the local character of the CO problem and the uncertainties associated with weather conditions that favor CO violations cause a concern for possible violation of this standard in the future. Table 2 shows CO emissions and monitoring trends.

Table 2: CO Trends

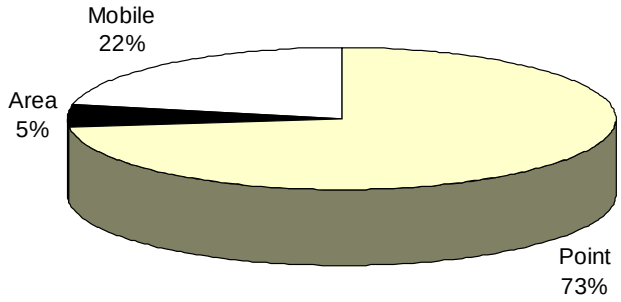
Emissions		
Nationwide	1990-1999	Down 7%
Minnesota	1990-1997	Down 20%
Monitored levels		
Nationwide	1990-1999	Down 36%
Minnesota	1990-1998	Down 25%
Risk of violating standard		
Minnesota	Intermediate	

2.0 Sulfur Dioxide (SO_2)

2.1 Nature and Sources of SO_2

Sulfur dioxide belongs to the family of sulfur oxide gases. These gases are formed when fuel containing sulfur (mainly, coal and oil) is burned and during metal smelting and other industrial processes. Most SO_2 monitoring stations are located in urban areas. The highest monitored concentrations of SO_2 are recorded in the vicinity of large industrial facilities. Figure 2 shows the source apportionment for SO_2 emissions in Minnesota in 1997. 168,000 tons of SO_2 were emitted.

Figure 2. Sources of 1997 Sulfur Dioxide Emissions



2.2 Health and Environmental Effects

High concentrations of SO_2 can result in temporary breathing impairment for asthmatic children and adults who are active outdoors. Short-term exposures of asthmatic individuals to elevated SO_2 levels while at moderate exertion may result in reduced lung function that may be accompanied by such symptoms as wheezing, chest tightness, or shortness of breath. Other effects that have been associated with longer-term exposures to high concentrations of SO_2, in conjunction with high levels of particulate matter (PM), include respiratory illness, alterations in the lungs' defenses, and aggravation of existing cardiovascular disease. The subgroups of the population that may be affected under these conditions include individuals with cardiovascular disease or chronic lung disease, as well as children and the elderly.

SO_2 and NOx are the major precursors to acidic deposition (acid rain), which is associated with the acidification of soils, lakes, and streams, accelerated corrosion of buildings and monuments, and reduced visibility. Sulfur dioxide also is a major precursor to particulate matter smaller than 2.5 microns (PM2.5), which is a significant health concern as well as a main pollutant that impairs visibility.

2.3 Trends in SO_2 Levels and Regulatory Implications

Emissions of SO_2 in Minnesota decreased until the middle 1990's when increased coal consumption by electric utilities caused overall emission levels to increase. Nationally, emissions have continued to decrease due to implementation of the federal acid rain program in a utility sector that is relatively dirty compared with Minnesota electric utilities. Although emissions have increased, monitored levels have decreased most likely because the increases have been at relatively remote power plants with high stacks that disperse emissions effectively. Monitors are located in populated areas. Monitored levels remain comfortably below standards with little future risk of violating standards unless sulfur emissions from coal combustion increase dramatically. Increased sulfur emissions also inhibits efforts to improve visibility in the BWCA

and Voyageurs Park and may hasten acidification of lakes. Table 3 shows trends in SO_2 emissions and ambient concentrations.

Table 3. SO_2 Trends

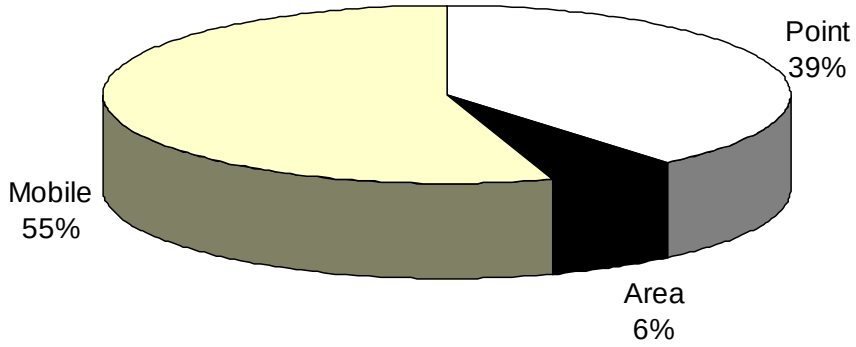
Emissions		
Nationwide	1990-1999	Down 21%
Minnesota	1990-1997	Up 22%
Monitored levels		
Nationwide	1990-1999	Down 36%
Minnesota	1990-1998	Down 50%
Risk of violating standard		
Minnesota	Low	

3.0 Nitrogen Dioxide (NO_2)

3.1 Nature and Sources of NOx

Nitrogen dioxide (NO_2) is a reddish brown, highly reactive gas that is formed in the ambient air through the oxidation of nitric oxide (NO). Nitrogen oxides (NOx), the term used to describe the sum of NO, NO_2 and other oxides of nitrogen, play a major role in the formation of ozone. The major sources of man-made NOx emissions are high-temperature combustion processes, such as those occurring in automobiles and power plants. Home heaters and gas stoves also produce substantial amounts of NO_2 in indoor settings. Figure 3 shows the sources contributing to NOx emissions in Minnesota in 1997. Emissions totaled 463,000 tons.

Figure 3. Sources of 1997 Minnesota Nitrogen Oxides Emissions



3.2 Health and Environmental Effects

Short-term exposures (e.g., less than 3 hours) to current nitrogen dioxide (NO_2) concentrations may lead to changes in airway responsiveness and lung function in individuals with pre-existing respiratory illnesses and increases in respiratory illnesses in children (5-12 years old). Long-term exposures to NO_2 may lead to increased susceptibility to respiratory infection and may cause alterations in the lung. Atmospheric transformation of NOx can lead to the formation of ozone and nitrogen-bearing which are both associated with adverse health effects.

Nitrogen oxides also contribute to the formation of acid rain. Nitrogen oxides contribute to a wide range of environmental effects, including potential changes in the composition and competition of some species of vegetation in wetland and terrestrial systems, visibility impairment, acidification of freshwater bodies and increases in levels of toxins harmful to fish and other aquatic life. Acidification and visibility effects are discussed in the particulate matter appendix.

3.3 Trends in NO_2 Levels and Regulatory Implications

Monitored NO_2 levels are currently about one third of the annual NO_2 standard. Although NOx emissions have increased and may increase further due to increased vehicle travel increased fuel combustion, it is unlikely that these increases will pose a threat to the annual NO_2 standard. A greater threat from increased NOx emissions will more likely be a violation of the one or eight hour ozone standard. Table 4 shows trends in NOx emissions and ambient concentrations.

Table 4. NOx Trends

Emissions		
Nationwide (NOx)	1990-1999	Up 2%
Minnesota(NOx)	1990-1997	Up 8.5%
Monitored levels		
Nationwide	1990-1999	Up 10%
Minnesota	1990-1998	Up 6%
Risk of violating standard		
Minnesota	Low	

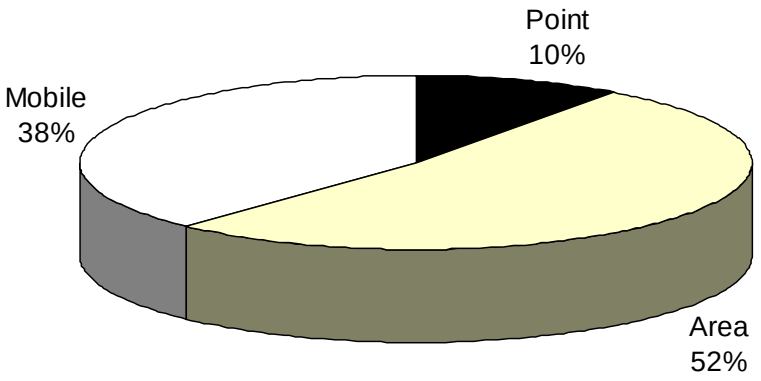
4.0 Ozone

4.1 Nature and Sources of Ozone

Ground-level ozone (the primary constituent of smog) continues to be a pervasive pollution problem throughout many areas of the United States. Ozone is not emitted directly into the air but is formed by the reaction of volatile organic compounds (VOCs) and NOx in the presence of heat and sunlight. Ground-level ozone forms readily in the atmosphere, usually during hot summer weather. VOCs are emitted from a variety of sources, including motor vehicles, chemical plants, refineries, factories, consumer and commercial products, and other industrial

sources. Figure 4 shows the sources contributing to VOC emissions in Minnesota in 1997. Total VOC emissions were 398,000 tons. Nitrogen oxides are emitted from motor vehicles, power plants, and other sources of combustion. Changing weather patterns contribute to yearly differences in ozone concentrations from city to city. Ozone and the precursor pollutants that cause ozone also can be transported into an area from pollution sources found hundreds of miles upwind. In contrast to ground-level ozone, stratospheric ozone occurs naturally and provides a protective layer against ultraviolet radiation high above the Earth.

Figure 4. Sources of 1997 Minnesota Volatile Organic Compounds



4.2 Health and Environmental Effects

Short-term (1-3 hours) and prolonged (6-8 hours) exposures to ambient ozone have been linked to a number of health effects. For example, increased hospital admissions and emergency room visits for respiratory causes have been associated with ambient ozone exposures. Repeated exposures to ozone can make people more susceptible to respiratory infection, result in lung inflammation, and aggravate pre-existing respiratory diseases such as asthma. Other health effects attributed to ozone exposures include significant decreases in lung function and increased respiratory symptoms such as chest pain and cough. These effects generally occur while individuals are engaged in moderate or heavy exertion. Children active outdoors during the summer when ozone levels are highest are most at risk of experiencing such effects. Other at-risk groups include adults who are active outdoors (e.g., outdoor workers), and individuals with pre-existing respiratory disease such as asthma and chronic obstructive lung disease. In addition, longer-term exposures to moderate levels of ozone present the possibility of irreversible changes in the lungs that could lead to premature aging of the lungs and/or chronic respiratory illnesses.

Ozone also affects vegetation and ecosystems, leading to reductions in agricultural and commercial forest yields, reduced growth and survivability of tree seedlings, and increased plant susceptibility to disease, pests, and other environmental stresses (e.g., harsh weather). In long-lived species, these effects may become evident only after several years or even decades, thus

having the potential for long-term effects on forest ecosystems. Ground-level ozone damage to the foliage of trees and other plants also can decrease the aesthetic value of ornamental species as well as the natural beauty of our national parks and recreation areas.

4.3 Revised Ozone Standards

Ozone standards were first promulgated in 1971 and last revised in 1979. Since that time over 3,000 new studies on ozone were published. Many of these studies have shown that ozone can cause adverse health effects at levels below the current standard. In 1997, EPA revised the national ambient air quality standards for ozone by replacing the 1-hour ozone 0.12 parts per million (ppm) standard with a new 8-hour 0.08 ppm standard. The new ozone standard would help protect people who spend a significant amount of time working or playing outdoors which includes children, a group that is particularly vulnerable to the effects of ozone. EPA estimated that the new ozone and particulate standards will combine to prevent 15,000 premature deaths, 350,000 cases of aggravated asthma, and 1 million cases of impaired lung function annually.

On May 14, 1999, the U.S. Court of Appeals for the District of Columbia Circuit issued an opinion regarding the final national ambient air quality standards for ozone and particulate matter that EPA issued in July 1997. The Court of appeals blocked implementation of the new standard. The Department of Justice appealed this decision to the U S Supreme Court. A decision by the Supreme Court is expected in spring 2001.

Two significant issues are involved in the case before the Supreme Court, and the Court's decision will affect US EPA's ability to set regulations in the future. One issue is the EPA's ability to set standards for pollutant effects without a threshold, or a level below which no health impacts are observed. The industry groups that filed the lawsuit claim that only Congress can set standards for effects without a threshold and that EPA's standards are essentially arbitrary. The second issue in the lawsuit seeks to force EPA to consider economic costs when it sets standards. Prior court rulings allow EPA to establish protective standards based solely on environmental and health impacts.

4.4 Trends in Ozone Levels and Regulatory Implications

Monitored levels of ozone in Minnesota are close to both the one-hour and eight-hour ozone standards. Table 5 presents a quick look at the past three years of ambient monitoring data.

Table 5. Ozone Monitoring Data in Minnesota

	1998	1999	2000
Max 1 hr.	.102 ppm	.112 ppm	.093 ppm
4^{th} highest 8 hr.	.073 ppm	.078 ppm	.070 ppm

The values presented are the highest of readings for each averaging time from the seven sites operated by the MPCA and cooperating organizations in the state. The corresponding standards are 0.12 ppm for the one-hour averaging time and .08 for the eight-hour averaging time.

Although judging compliance with the standard involves multiyear averaging and additional statistical projections, this table shows that levels near the standard have recently been recorded in the state. The table also demonstrates that year to year variations make predication of trends difficult. Table 6 shows the emissions and ambient concentrations trends for the chemicals that form ground-level ozone in the atmosphere.

Table 6. Ozone Precursor Trends

Emissions		
Nationwide (NOx)	1990-1999	Up 2%
Minnesota(NOx)	1990-1997	Up 8.5%
Nationwide (VOC)	1990-1999	Down 15%
Minnesota (VOC)	1990-1997	Down 8%
Monitored levels		
Nationwide	1990-1999	Down 4%
Minnesota	1990-2000	No trend
Risk of violating standard		
Minnesota	High	

Computer modeling performed by the Metropolitan Council and the MPCA predicts decreasing emissions of ozone-precursor chemicals until around 2005 and increasing emissions thereafter. The modeling is based on historical data and EPA's Mobile5a emissions model, which is currently under revision. A new version of the Mobile model will be released in 2001 and will allow emissions modeling accounting for recent federal regulations. The MPCA is also collecting current vehicle data for the state so future modeling can account for the trend toward larger, less fuel-efficient vehicles. Ambient monitoring, combined with emissions and dispersion modeling, will help the MPCA track compliance with the federal ozone standard.

The economic costs of achieving non-attainment status under the Clean Air Act requirements were estimated by EPA. The estimates focus on direct costs and rely on survey information collected by the Department of Commerce and are intended to provide a broad view of relative cost between non-attainment class and region. Economies of scale, site specific differences in regional economics, land development, and industrial patterns are reflected in the estimates. Total non-attainment costs for a metropolitan area can involve significant resources that can greatly vary between metropolitan areas and cost assignment (e.g., Regulated facilities may pay a disproportionate cost compared to non-regulated mobile sources). Table 7 compares costs of ozone non-attainment designation for several classes and regions. Differences in per capita costs between non-attainment classes are explained by economies of size and the lower average cost associated with higher populations (EPA, 1997).

Table 7. Costs of Ozone Non-Attainment

Non-Attainment Class and Region	Average Per Capita Cost	% of Per Capita Income
Marginal (Atlanta, Knoxville, Reno, Seattle)	$76.22	0.24%
Moderate (Atlantic City, Cincinnati, Grand Rapids, Hartford, Huntington, Nashville, Portland, St. Louis)	$85.42	0.29%
Serious (Baton Rouge, Dallas, Phoenix, Providence, San Diego, Santa Barbara)	$26.21	0.09%
Severe (Baltimore-Washington D.C., Chicago, Houston, Los Angeles, New York, Philadelphia, Sacramento)	$28.09	0.09%

5.0 Lead (Pb)

5.1 Nature and Sources of Lead

In the past, automobiles were the major contributor of lead emissions to the atmosphere. As a result of EPA's regulatory efforts to reduce the content of lead in gasoline, the contribution from the transportation sector has declined over the past decade. Today, metals processing is the major source of lead emissions to the atmosphere. The highest air concentrations of lead are found in the vicinity of nonferrous and ferrous smelters, and battery manufacturers. The biggest remaining threat of lead exposure is through ingestion of lead paint flakes and particles. This exposure can occur both inside older homes and through ingestion of soil contaminated by flaking paint and poor paint removal operations. Children are particularly susceptible to lead poisoning through exposure to lead paint.

5.2 Health and Environmental Effects

Exposure to lead occurs mainly through inhalation of air and ingestion of lead in food, water, soil, or dust. It accumulates in the blood, bones, and soft tissues. Lead can adversely affect the kidneys, liver, nervous system, and other organs. Excessive exposure to lead may cause neurological impairments, such as seizures, mental retardation, and behavioral disorders. Even at low doses, lead exposure is associated with damage to the nervous systems of fetuses and young children, resulting in learning deficits and lowered IQ. Recent studies also show that lead may be a factor in high blood pressure and subsequent heart disease. Lead can also be deposited on the leaves of plants, presenting a hazard to grazing animals.

5.3 Trends in Lead Levels

Levels of lead in the air dropped dramatically after lead was phased out of gasoline beginning in 1978. Secondary lead smelters in Minnesota have either closed down or installed effective control measures. Except for localized exposure from lead paint removal operations, lead in the

air is no longer a problem in Minnesota. Table 8 shows trends in lead emissions and ambient concentrations.

Table 8. Lead Trends

Emissions		
Nationwide	1990-1999	Down 23%
Minnesota	1990-1997	Unknown
Monitored levels		
Nationwide	1990-1999	Down 60%
Minnesota	1990-1998	Down 92%
Risk of violating standard		
Minnesota	Low	

6.0 Hydrogen Sulfide (H_2S)

6.1 Nature and Sources of Hydrogen Sulfide

Hydrogen sulfide is a colorless gas with a strong smell of rotten eggs at low concentrations. However, at high concentrations the compound has no detectable smell due to olfactory fatigue potentially leading to insidious exposures and serious toxicity. Hydrogen sulfide is produced as a by-product of anaerobic degradation of protein and is most commonly encountered in sewage treatment facilities, petrochemical and natural gas processing plants, volcanic gases, coal mines, natural hot springs. Livestock waste storage and handling systems are also a source of hydrogen sulfide emissions. In Minnesota, the most important sources include sugar beat processing lagoons, feedlots, and paper manufacturing.

6.2 Health and Environmental Effects

The annoyance threshold for hydrogen sulfide corresponds to various human health responses including nausea, vomiting, depression, and diarrhea and serves as a first-line warning system for potentially hazardous concentrations of hydrogen sulfide. At concentrations above the odor threshold, hydrogen sulfide causes irritation of the eyes and upper respiratory tract, which if prolonged can result in acute pulmonary edema. With higher concentrations the central nervous system effects predominate producing headache, dizziness, excitement and staggering gait leading to convulsions, respiratory failure and coma.

6.3 Trends in Hydrogen Sulfide Levels and Regulatory Implications

The state ambient air quality standards for hydrogen sulfide along with other state ambient air quality standards were promulgated in 1969 based on a review and interpretation of data on air pollution exposures and appropriate Federal air quality criteria. A number of other states have hydrogen sulfide or total reduced sulfur standards that are similar to Minnesota's.

Hydrogen sulfide is not a large-scale problem across the state. However, exceedences of the standard have been monitored near several facilities. For this reason, there is no ongoing state ambient monitoring network for hydrogen sulfide and no routine statewide emission inventory is conducted for hydrogen sulfide. Because there is no ambient monitoring network or emission inventory, it is not possible to discuss trends.

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APPENDIX D
DRAFT
Air Toxics

Introduction

In November 1999, the MPCA Staff Paper on Air Toxics cited 11 pollutants of concern because levels in Minnesota exceeded health benchmarks (levels below which health impacts are not expected) based on monitoring and/or modeling in some areas of Minnesota. After further analysis, here is the status of the four chemicals for which the MPCA recommended action:

- Benzene remains a pollutant of concern in the outdoor air despite the fact that levels are declining slightly. Other Minnesota studies show even higher levels of benzene indoors than outdoors.
- Formaldehyde levels remain above the current cancer health benchmark at most sites and are a concern, but the benchmark may increase based on improved toxicity information.
- Carbon tetrachloride levels have dropped below the health benchmark at all sites monitored since 1998 (the substance was banned from production in 1996).
- Chloroform exceeded the health benchmark at one monitoring site in International Falls, probably due to nearby paper mill emissions. The U.S. paper mill has been required to further reduce chloroform-forming chemicals. The Minnesota Department of Health reviewed the health and information and recommended a revised health benchmark. Chloroform does not exceed this revised benchmark at any sites, including Intentional Falls.

Diesel exhaust is a concern

Diesel exhaust was recommended for further study and the MPCA believes there is enough data to warrant preventative steps to reduce diesel exhaust emissions (see Diesel Exhaust Appendix) and to recommend additional research to better understand the problem in Minnesota. The MPCA is still improving its capacity to monitor the other six pollutants of concern recommended for further study.

Noncancer effects may be more important

For Minnesotans as a whole, mobile sources and area sources (small stationary sources) are estimated to be much bigger contributors to increased cancer risk from breathing outdoor air toxics compared with point sources (large stationary sources). While the MPCA continues to be concerned with the cancer risk associated with breathing air toxics, including diesel exhaust, the non-cancer effects may be even more important (partly because of the conservatism in the method used to derive the cancer health benchmarks). In addition, point source industrial facilities and numerous smaller sources may be responsible for elevated air pollution levels for people living nearby.

Scientific uncertainty calls for a precautionary approach

Scientific knowledge of the health and ecological effects caused by particular pollutants is improving, but the MPCA only monitors and models a fraction of the anthropogenic (human-

caused) pollutants emitted into the air each day. These pollutants may have cumulative effects, but there is little research available on risk to public health from exposure to multiple pollutants. The health benchmarks are set for exposure to individual pollutants. Depending on the use of the health benchmarks, such as for environmental reviews of major point source emissions, risks may be described as the sum of the estimated risks from individual pollutants. In this report, MPCA is making individual comparisons of health benchmarks with ambient concentrations.

Regulatory approaches cannot keep up with scientific understanding; therefore a precautionary approach to reduce air toxics is appropriate. The action steps the MPCA is taking are described in the Action Steps-Mobile Sources and Action Steps -Stationary Sources Appendices.

1.0 Definitions

1.1 Pollutant and Source Definitions

Basic Air Toxic Definition

Toxic air pollutants, or air toxics, include a wide variety of different chemicals released to air that are known or suspected to cause serious harm to individuals exposed to high enough amounts.

Which Chemicals are Air Toxics?

While there is no single complete list of toxic air pollutants, several partial lists have been compiled to identify those of relatively greater concern. These lists were developed based on available, but often limited, information about their toxic effects, the amounts released to the air, and their measured ambient air concentrations. Considering that over ten thousand chemicals are listed for use in the U.S., clearly many chemicals have not been evaluated.

- Prior to the 1990 Clean Air Act Amendments Congress defined "hazardous air pollutants" (HAP) as air pollutants which EPA believed cause, or contribute to, air pollution which may reasonably be anticipated to result in an increase in mortality or an increase in serious irreversible, or incapacitating reversible, illness. The 1990 Clean Air Act Amendments redefined HAPs to be 188 specific chemicals. The list is provided on EPA's web site at http://www.epa.gov/ttn/uatw/pollsour.html.
- As required by Section 112(k) of the 1990 Clean Air Act Amendments, the U.S. Environmental Protection Agency assessed the amounts of chemicals released to urban air and developed a list of 33 Priority Air Toxics for the Integrated Urban Air Strategy. They are listed on EPA's web site at http://www.epa.gov/ttn/uatw/urban/list33.html. After this list was developed, EPA added diesel exhaust particulate matter as another pollutant of significant concern.
- The MPCA Staff paper on Air Toxics (MPCA, 1999) identified chemicals in Minnesota's air that were found, either through direct measurement or modeling efforts, to be present at concentrations greater than health-based benchmarks. An update on the MPCA Staff Paper on Air Toxics is provided in section 3.

These are not exhaustive lists. Additional chemicals may also be considered toxic air pollutants or "air toxics". For example, hydrogen sulfide can clearly be toxic, even lethal, at high enough concentrations in air, yet it does not appear on any of the lists described above. The criteria air pollutants may also cause serious health effects and so may also be considered toxic air pollutants.

Several factors limit scientists' ability to identify all toxic air pollutants of concern.

- For most chemicals scientists lack comprehensive toxicity information and exposure data. Health-benchmarks for inhalation exposure are only available for a fraction of the chemicals released to air.
- Health-benchmarks are developed to be air concentrations likely to be without appreciable risk of harmful effects on humans. However, depending upon the chemical, the level that could cause harm may be slightly higher than or far above the health benchmark. Lower benchmarks indicate that the chemical is either relatively more dangerous or that it is a chemical for which little information is available.
- Current scientific methods have been unable to measure adverse health effects from exposures in the range of ambient outdoor air concentrations. It is uncertain whether this is because information is lacking and the epidemiology methods are insensitive or because health effects are not occurring even at levels above the benchmarks.
- People are exposed to mixtures of chemicals in the air they breathe, not individual chemicals. Information on the toxicity of these mixtures is lacking.
- With respect to a number of volatile organic compounds found in outdoor ambient air, an individual's personal exposures, from their daily activities such as pumping gas, using consumer products and spending time indoors, often lead to higher exposures to these chemicals than breathing the outdoor air.
- Recent efforts to identify priority toxic air pollutants have assessed risks of breathing these chemicals in air. The environmental and human health impacts of air toxics that persist and accumulate in the environment and the food chain, such as mercury, dioxin, and certain pesticides, have not been included in these assessments.

Crossover between air toxics and criteria pollutants

Although Congress defined the Hazardous Air Pollutants to increase their assessment and promote reduction efforts of chemicals not already regulated as criteria pollutants, there is crossover between these two regulatory definitions. For example, the criteria pollutant particulate matter (PM) is a complex and variable mixture. Depending on its emission source, it may include toxic metals such as mercury, cadmium, vanadium, polycyclic aromatic hydrocarbons (PAHs), dioxins, furans, etc. Furthermore, lead is both a criteria pollutant and HAP.

Sources

Toxic air pollutants are released to the air by manufacturing operations, cars, trucks, power plants, businesses, consumer products, and other combustion processes such as woodburning, burning trash, etc. Natural sources of toxic air pollutants include plants, volcanos, forest fires and microbes. When discussing emissions sources, sources are usually labeled as 'point,' 'area,'

or 'mobile' sources. Point sources are usually large, permitted facilities. In the *Air Quality in Minnesota* report, point sources are referred to as "large stationary sources." Area sources are smaller, ubiquitous sources such as gas stations and residential wood burning. In the *Air Quality in Minnesota* report, area sources are referred to as "small stationary sources." Mobile sources are cars, trucks, construction equipment, aircraft, and other small non-point sources.

1.2 Health Information Definitions

Effects

In general, high enough exposures to various toxic chemicals can lead to a range of serious health effects. Examples of serious health effects include: harm to a developing fetus or child, interference with successful reproduction, cancer, harm to specific organs, such as the liver, kidney, bones, heart, skin, etc., or to systems, such as the blood-forming, respiratory, and immune systems. The minimum chemical exposure that will result in a specific effect depends on the chemical and the particular effects. Some effects are very apparent, while others, such as behavioral changes or slight changes in blood chemistry, are more subtle and difficult to measure. Hazards of high level exposures to a number of urban air toxics were described in the MPCA Staff Paper (MPCA, 1999). EPA also summarizes hazards associated with toxic air pollutants can be found at the following web site: http://www.epa.gov/ttn/uatw/hapindex.html.

Dose Response Concept in Toxicology

Chemicals differ in their abilities to harm people. This is why some chemicals are considered to be "poisonous" and other chemicals to be "safe". In fact, essentially all chemicals, at high enough exposure levels, can cause harm. People who study poisons often describe this by the phrase "the dose makes the poison." For some chemicals there are small exposure levels that most scientists believe cause no harm. These chemicals are considered to have a threshold. A threshold is an exposure level that causes no harm. For example, when diluted enough, an acid may be safe to touch. For other chemicals, including many that cause cancer, regulatory scientists assume that even the smallest amounts of exposure can slightly increase a person's chance of getting cancer. Higher exposures increase their chance of getting cancer even more. This non-threshold phenomenon may also apply to some effects of other chemicals.

Properties and Exposures

Because the definition of toxic air pollutants is so broad, it includes chemicals from many classes of chemicals encompassing a broad range of physical chemical properties. Air toxics include both organic and inorganic chemicals, volatile and semi-volatile organic compounds, and metals. Once released to the environment, toxic air pollutants may occur as gases, vapors, or as liquid droplets or solid particles (aerosols). Some "persistent" chemicals remain in the environment for long periods of time, while others undergo chemical reactions and change to different, more or less hazardous, chemicals. Some occur singly while others occur as complex mixtures. Depending on their chemical physical properties and fate in the environment, some such as the volatile organic compounds remain primarily in the air. Some, which readily dissolve in water, may be found in rainwater, lakes and rivers. Others, such as semi-volatile organic compounds (chlorinated pesticides and dioxins) and some metals (mercury) tend to remain in the

environment for long periods of time and can accumulate in the food chain. Thus, although air toxics are, by definition, initially released to the air, people can contact these chemicals different ways, through different routes of exposure, such as by breathing the air, drinking water, or eating food. More information on these chemicals is included in the PBT Appendix.

What are Health Benchmarks?

A health benchmark is a concentration of an individual chemical in the air that, based on available information, is considered essentially safe for the public to breathe. The health benchmarks are extrapolated from higher concentrations that have been shown in animals or humans to cause adverse effects. Exposures to air concentrations somewhat higher than the health benchmarks may also be safe, but there is not enough information to know how much higher, if any, would be safe. Health benchmarks do not indicate at what higher concentrations actual health impacts would likely occur. More information on health benchmarks and their development is available in section 4.0.

How do Benchmarks and National Ambient Air Quality Standards (NAAQS) Differ?

Fundamentally different approaches are used in setting health benchmarks, also known as health risk values (HRVs) in Minnesota (see section 4.1 for more information of HRVs), and the NAAQS. Health benchmarks and NAAQS are not derived by the same methods or applied in the same manner, nor are not designed to provide equivalent levels of protection. The HRVs were not developed with a specific intended application, while the NAAQS are chemical concentrations associated with monitoring requirements, specific averaging times, and enforcement consequences. Because the NAAQS are enforceable standards, setting them requires a much higher burden of proof to demonstrate health effects at levels of potential environmental concentrations than is needed for setting the HRVs.

U.S. EPA attempts to set the NAAQS at concentrations with a margin of safety below clearly defined human health effects. Because there are clear economic consequences for exceeding an enforceable NAAQS, there is clear pressure not to set them farther below the human effect levels than necessary. In contrast, the HRVs are derived as protective levels that the Minnesota Department of Health (MDH) is confident are without appreciable harm. The HRV development process uses best available toxicity and epidemiology data, but where greater uncertainties exist, the resulting HRV concentrations are set lower in a health-protective manner.

EPA selected the 15 ug/m3 annual average PM2.5 NAAQS because it was slightly lower than the lowest level that was most likely to cause serious effects (e.g., death, asthma attacks, bronchitis). EPA used epidemiological studies that measured human health impacts including mortality and less severe effects to set the PM2.5 annual standard, and reported clear evidence of short-term PM2.5 health effects most evident at concentrations of 16 ug/m3 and higher. EPA also reported data showing measurable health effects from long term exposures at an average PM2.5 concentration of 18ug/m3. EPA concluded that 15 ug/m3 would provide a "margin of safety" and set the PM2.5 NAAQS at that concentration. EPA clearly stated that the required margin of safety did not mean that no health effects would occur to anyone at concentrations

below the standard, or even that the new standard would eliminate all deaths from PM2.5. EPA estimated that the standard, when enforced, would lead to about 15,000 fewer deaths in the U.S.

Members of the medical community petitioned EPA to adopt standards significantly lower than the current proposed fine particulate matter (PM2.5) standards to protect the more vulnerable residents (62 FR 38651). EPA did not select a lower level because of the greater uncertainty in measuring adverse effects at the lower concentrations. The PM2.5 standard is currently under Supreme Court review.

2.0 Sources and Emissions

2.1 Chemicals Highlighted in MPCA's Staff Paper

A summary of emission contributions by principal source category (point, area, and mobile) to pollutants highlighted in the MPCA Staff Paper is shown in Table 1. In the *Air Quality in Minnesota report* point and area sources are referred to as "large stationary" and "small stationary" sources, respectively. Background contributions are also shown in this table as a percent of the modeled mean concentration. Background concentrations are made up of chemicals arriving in our air via long-range transport and emitted from natural and unidentified sources. The analysis is based on data from the US EPA Cumulative Exposure Project (CEP) study (Woodruff et al, 1998; Caldwell et al, 1998; Rosenbaum et al, 1999; SAI, 1999) for Minnesota.

Table 1. Emissions by Principal Source Category (Data from EPA CEP study)

Pollutant	Total Emissions (ton/day)	Point Source Contribution (%)	Area Source Contribution (%)	Mobile Source Contribution (%)	Background Concentration as Percent of Modeled Mean Concentration (%)
Acrolein*	2.13		**64**	36	0
Arsenic	0.09	**94**	4	2	0
Benzene	25.76	5	28	**67**	32
Butadiene	3.89	2	32	**66**	0
Carbon Tetrachloride	0.04	42	**58**		100
Chloroform	0.34	**83**	17		94
Chromium	0.07	**83**	12	5	0
Ethylene Dibromide	0.00				100
Formaldehyde*	15.40	9	33	**58**	26
Nickel	0.18	**77**	19	4	0

* The emissions for these pollutants are for direct emissions only. Secondary formation of acrolein was not studied in the CEP study. But the nationwide source contribution for the secondary formed formaldehyde is similar as the Minnesota source contribution for direct formaldehyde emissions.

Overall, point sources are the primary emission sources for metals and chloroform, contributing about 80% or more of the emissions. Point sources also contribute 42% of carbon tetrachloride emissions. However, their contributions to other volatile organic compounds (VOC), such as

formaldehyde, benzene, 1,3-butadiene, and acrolein, are either insignificant or negligible. This is an overall result for the entire state but not necessarily for the ambient air concentrations next to a particular facility where the facility may contribute significantly.

In contrast with point sources, mobile sources have insignificant or negligible contributions to emissions of metals, chloroform, and carbon tetrachloride, but dominate the emissions of benzene, formaldehyde, and 1,3-butadiene. Mobile sources also contribute significantly to acrolein emissions; the contribution is 36%.

Area sources are responsible for emissions of almost all pollutants listed in Table 1. Their contributions are more than 12% for each pollutant (except for arsenic and ethylene dibromide). Area sources also are the primary emission sources for acrolein and carbon tetrachloride.

Formaldehyde is present in the atmosphere due to two processes: direct emissions and secondary formation. The secondary formation, or creation of chemicals by atmospheric chemical reactions, of formaldehyde could account for as much as 88 percent of formaldehyde concentrations in air. Table 1 lists direct emissions of formaldehyde in Minnesota. EPA's Cumulative Exposure Project (CEP) study does not provide information on the secondarily formaldehyde emissions for Minnesota. However, it shows that the nationwide source contribution for the secondary formed formaldehyde is similar to the Minnesota source contribution for direct formaldehyde emissions. That means mobile sources are the major contributors to both direct and secondary formaldehyde emissions.

Estimated emissions of carbon tetrachloride were about 0.04 ton/day in Minnesota in 1990. Although the production of carbon tetrachloride was gradually reduced by the phase-out in the end of 1995, chemical-manufacturing processes, waste-water-treatment processes, waste incineration, landfill waste disposal and petroleum-refining processes emitted the chemical in 1990. However, a significant part of measured ambient concentrations for carbon tetrachloride is attributed to accumulated background concentrations due to its long atmospheric lifetime. There are no emissions estimated for ethylene dibromide estimated by the CEP study.

It should be noted that information is limited for air toxics emissions in Minnesota. The EPA CEP study used 1990 data and an estimation method that was not recommended by the EPA Office of Air Quality Planning and Standards, Emission Factor and Methodologies Section. Large uncertainties were associated with the study results. The MPCA staff completed a comprehensive emission inventory for point, area, and mobile sources for calendar year 1996. Further analysis of source contributions is presented in Section 2.2.

2.2 MPCA's Emission Inventory and EPA's National Toxics Inventory

Environmental agencies use emissions inventories to determine pollutant sources, model chemical concentrations, and other regulatory work. Each inventory may use unique source category definitions or include different pollutants. It is important to understand these differences when comparing inventory and modeling data.

After the EPA CEP study (Woodruff et al, 1998; Caldwell et al, 1998; Rosenbaum et al, 1999; SAI, 1999), MPCA staff developed a comprehensive statewide air toxics emission inventory (MNEI) (MPCA, 2000) for point, area, and mobile sources for calendar year 1996. The U.S. EPA, also, compiled a 1996 National Toxics Inventory (NTI) (U.S. EPA, 2000) with emission data submitted from the MPCA for certain point and area sources. The definitions of point and area sources, as well as pollutants estimated, vary from one emission inventory to another. Summarized comparisons are shown in Tables 2 and 3. Final NTI data may differ slightly from that presented in following sections due to ongoing quality assurance.

Table 2. Comparison of definitions and coverage of point sources in three inventories

Inventory	Point	Number of Facilities	Number of Counties

CEP	• Facilities reporting to the Toxic Release Inventory (TRI)
	  • Processing > 12.5 tons, or
	  • Using > 5 tons of a Hazardous Air Pollutant (HAP)
	And
	• Point sources from the National Interim Volatile Organic Compound (VOC) or Particulate Matter less than 10 microns (PM_{10}) Inventories
	  • Emitting > 100 tons for VOC, Carbon Monoxide (CO), Nitrogen Oxides (NO_x), Sulfur Dioxide (SO_2), or PM
		493	66

96MNEI	• Facilities required to submit their annual inventories of criteria pollutants with potential to emit
	  • $\geq$ 100 tons of VOC, CO, NO_x, or PM,
	  • $\geq$ 50 tons of SO_2,
	  • $\geq$ 25 tons of PM10
	  • $\geq$ 0.5 tons of lead,
	  • $\geq$ 10 tons of one HAP, or
	  • $\geq$ 25 tons of any combination of HAPs
	and
	• Facilities reporting to the Toxic Release Inventory (TRI)
	  • Processing > 12.5 tons, or
	  • Using > 5 tons for a MNEI pollutant
		827	82

96NTI	• Major sources defined in the CAA with potential to emit
	  • $\geq$ 10 tons of one HAP, or
	  • $\geq$ 25 tons of any combination of HAPs
	and
	• Facilities with source-specific emissions from 96MNEI
		210	54

The area source definition is dependent on the point source definition. An area source is defined as any stationary source of targeted pollutants, which does not qualify as a point source. Therefore, one source classified as an area source in one emission inventory may be covered as a point source in another emission inventory.

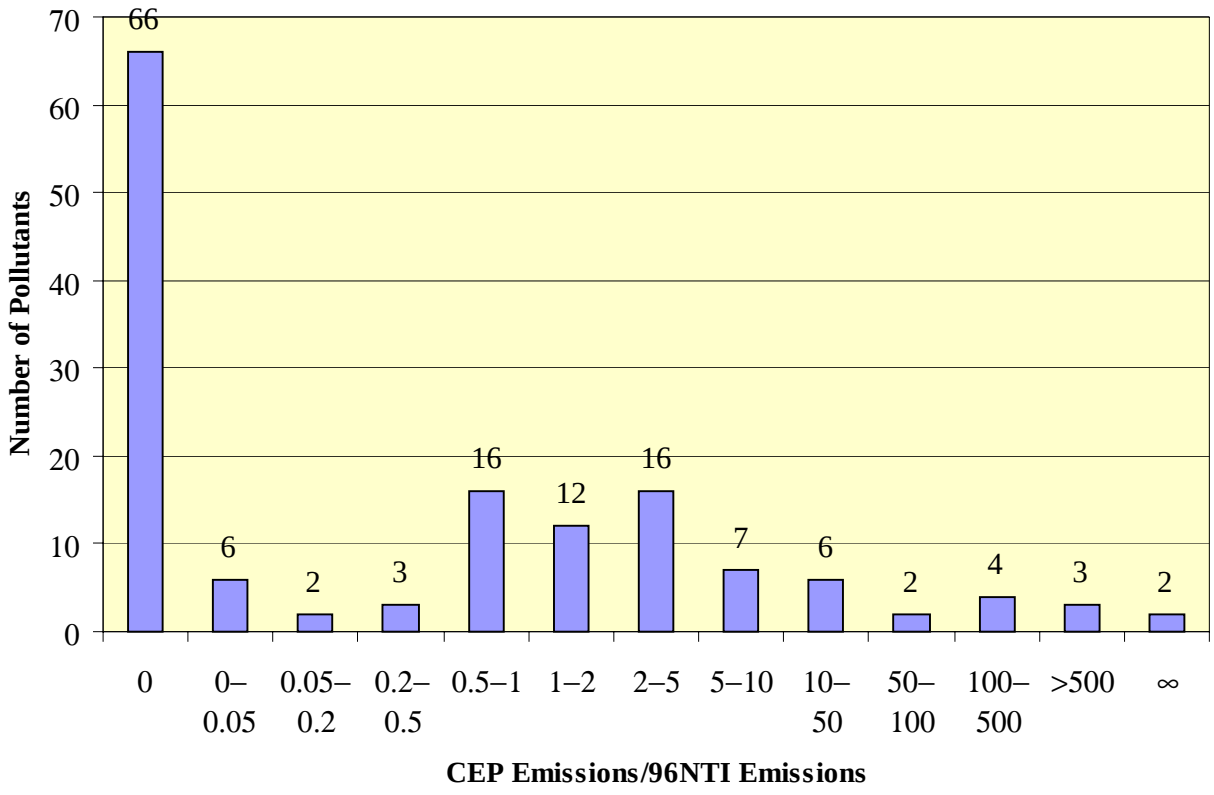
The definition of mobile sources, sometimes referred to as non-stationary sources, is consistent in all three emissions inventories. Mobile sources include on-road vehicles and non-road sources, such as aircraft, locomotives, construction equipment, lawn mowers, and recreational vehicles.

Table 3. Comparison of pollutant coverage in three inventories

Inventory	Year	Targeted Pollutants	Estimated Pollutants
CEP	1990	188 HAPs	79
96MNEI	1996	109 MN Pollutants	86
96NTI	1996	188 HAPs	143

Although both the CEP and the 96NTI focused on the 188 HAPs, only 77 pollutants were common in these two inventories. A comparison of CEP emissions and 96NTI emissions is shown in Figure 1. Emissions for 66 pollutants were estimated in the 96NTI but not in the CEP (CEP emissions/96NTI emissions equals 0). Two pollutants were estimated with emissions in the CEP but not in the 96NTI (CEP emissions/96NTI emissions equals ∞). Estimated emissions for 28 pollutants were within a factor of 2 range for these two emission inventories (0.5 < CEP emissions/96NTI emissions < 2).

Figure 1. Comparison of emission estimates from the CEP and the 96NTI



A comparison of 96MNEI emissions and 96NTI emissions is shown in Figure 2. There are 52 common pollutants in these two emission inventories. However, emissions for 91 pollutants were estimated in the 96NTI but not in the 96MNEI (96MNEI emissions/96NTI emissions equals 0), 34 pollutants in the 96MNEI but not in the 96NTIP (96MNEI emissions/96NTI emissions equals ∞). Estimated emissions for 37 pollutants were within a factor of 2 range for these two emission inventories (0.5 < 96MNEI emissions/96NTI emissions < 2).

Figure 2. Comparison of emission estimates from the 96MNEI and the 96NTI

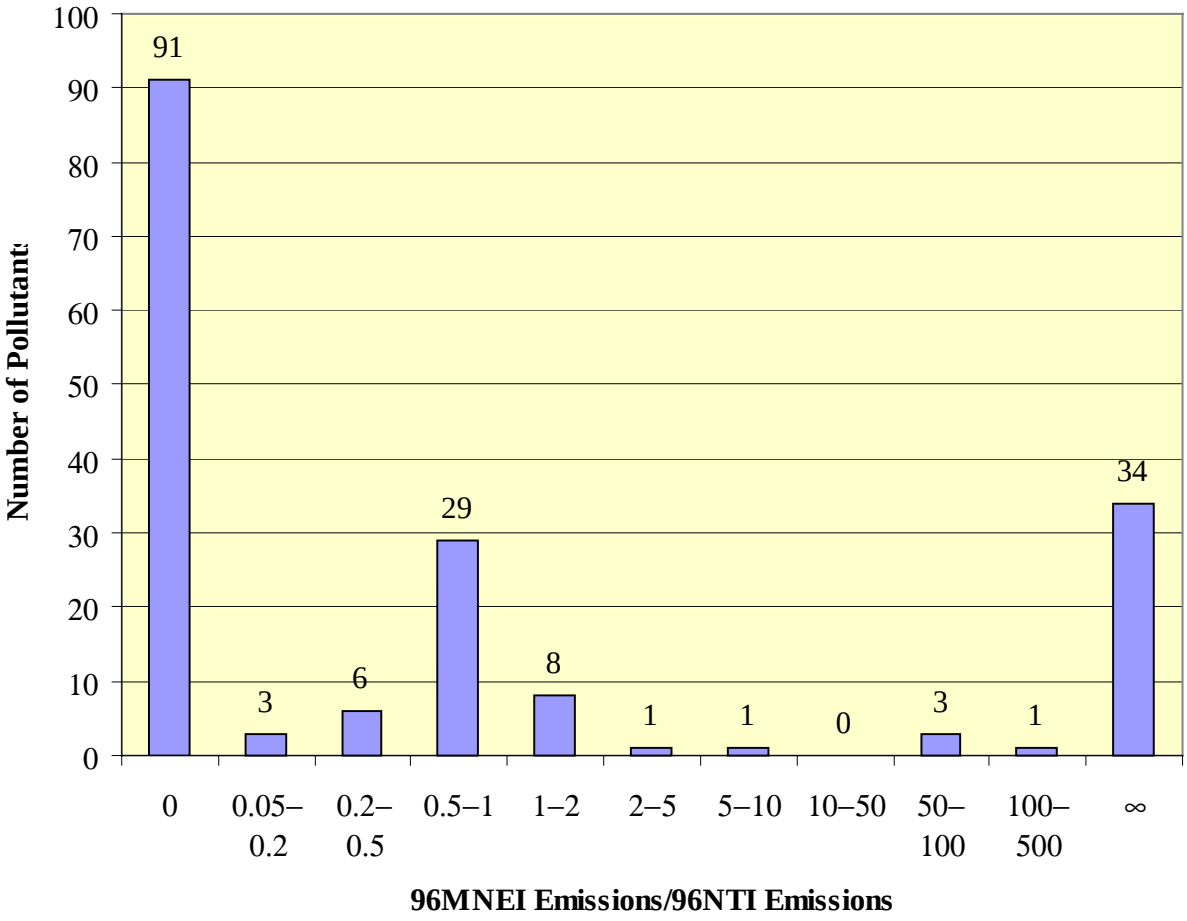


Table 4 shows a comparison of source contributions for the 10 of the 11 pollutants of concern in the MPCA Staff Paper (no data for diesel particles/polycyclic organic matter). Overall, the CEP and 96NTI emissions are within a factor of two for acrolein, benzene, formaldehyde, and chromium. However, CEP emissions are 2.5 to 5.5 times of 96NTI emissions for carbon tetrachloride, chloroform, arsenic, and nickel. On the other hand, CEP estimated about 45% of 96NTI emissions for 1,3-butadiene and zero emissions for ethylene dibromide. In contrast with CEP results, the 96MNEI and 96NTI emissions are within a factor of two for all pollutants except acrolein for which 96MNEI estimated about 18% of 96NTI values. The comparison of emissions from individual principal source categories shows a larger range than comparison of

total emissions. This is mainly due to different source definitions, source coverage, and emission estimation methods.

Table 4. Comparison of source contributions for the 10 pollutants of concern

	CEP/96NTI (%)				96MNEI/ 96NTI (%)			
Pollutant Name	**Area**	**Mobile**	**Point**	**Total**	**Area**	**Mobile**	**Point**	**Total**
Acrolein	90.64	105.79	34.47	94.53	0.00	38.43	337.29	18.36
Benzene	81.36	64.24	979.06	72.10	57.08	49.00	129.78	51.34
1,3-Butadiene	19.77	104.43	619.89	44.68	78.45	62.81	40.24	73.94
Carbon Tetrachloride	156.40		1604.51	253.92	85.11		100.00	86.11
Chloroform	196.40		485.69	390.51	99.53		100.00	99.85
Ethylene Dibromide	0.00		0.00	0.00	98.44		106.27	98.44
Formaldehyde	58.18	92.28	144.63	79.24	1.76	85.36	193.71	52.45
Arsenic	383.25	1324.69	553.55	550.80	22.02	3.21	96.27	90.60
Chromium	33.87	125.85	254.24	139.10	73.02	61.14	121.79	94.51
Nickel	139.38	85.47	319.51	238.05	52.45	15.41	102.10	77.47

Every emission inventory has its limitations and uncertainties. MPCA staff developed the 96MNEI with a full understanding of the uncertainties and limitations for this inventory. The U.S. EPA compiled the CEP and 96NTI. MPCA staff could not access every detail of these inventories. Therefore, the ability of MPCA staff to evaluate the data from EPA's CEP and 96NTI is limited, so the MPCA decided to use the 96MNEI in the development of air toxics control strategies. Table 5 shows a summary results of the 96MNEI, including pollutant names, estimated emissions, and contributions from each principal source category.

Table 5. Summary results of the 96MNEI

		Total Emissions	Contribution to Total (%)		
Pollutant Name	**Cas No.**	**(lb)**	**Area**	**Point**	**Mobile**
Polycyclic Aromatic Hydrocarbons (PAHs)					
Acenaphthene	83329	14,403	99.96	0.04	0.00
Acenaphthylene	208968	305,294	99.98	0.02	0.00
Anthracene	120127	20,253	99.53	0.38	0.09
Benz(a)anthracene	56553	29,190	98.72	0.52	0.76
Benzo(a)pyrene	50328	10,016	57.50	41.03	1.47
Benzo(b)fluoranthene	205992	8,808	98.08	0.12	1.80
Benzo(ghi)perylene	191242	6,207	92.78	0.01	7.22
Benzo(k)fluoranthene	207089	3,023	95.24	0.00	4.76
Chrysene	218019	18,097	95.47	0.11	4.42
Dibenz(a,h)anthracene	53703	5,783	99.59	0.01	0.40
Fluoranthene	206440	29,052	99.12	0.26	0.61
Fluorene	86737	34,573	99.95	0.05	0.00
Indeno(1,2,3-cd)pyrene	193395	28,823	99.91	0.00	0.09
Naphthalene	91203	1,042,418	97.16	2.78	0.06
Phenanthrene	85018	112,421	99.90	0.02	0.08

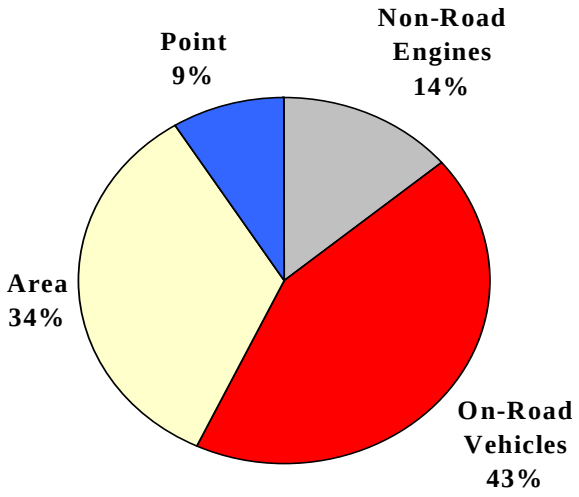
Pollutant Name	Cas No.	Total Emissions (lb)	Contribution to Total (%) Area	Point	Mobile
Pyrene	129000	34,720	99.52	0.01	0.46
Non-Metal Compounds (Excluding PAHs)					
Acetaldehyde	75070	2,818,299	0.00	2.20	97.80
Acetone	67641	2,373,610	70.29	2.07	27.64
Acrolein	107028	302,588	0.00	32.48	67.52
Acrylonitrile	107131	8,369	98.97	1.03	0.00
Atrazine	1912249	679,139	100.00	0.00	0.00
Benzaldehyde	100527	251,702	2.72	0.01	97.27
Benzene	71432	13,389,480	27.77	0.99	71.24
1,3-Butadiene	106990	4,694,301	75.67	0.07	24.27
Butyraldehyde	123728	111,582	0.00	0.00	100.00
Carbon tetrachloride	56235	10,304	92.18	7.82	0.00
Chlorobenzene	108907	336,981	99.96	0.04	0.00
Chloroform	67663	63,604	32.80	67.20	0.00
Crotonaldehyde	123739	165,315	0.00	0.00	100.00
1,2-Dichlorobenzene(o)	95501	42,557	100.00	0.00	0.00
1,3-Dichlorobenzene(m)	541731	2,723	100.00	0.00	0.00
1,4-Dichlorobenzene(para)	106467	389,140	100.00	0.00	0.00
Di-n-butyl phthalate	84742	1,038	85.69	14.31	0.00
Diethylhexyl phthalate (DEHP)	117817	2,689	0.00	100.00	0.00
Ethylbenzene	100414	4,273,668	15.44	4.94	79.62
Ethylene dibromide (Dibromoethane)	106934	7,127	100.00	0.00	0.00
Ethylene dichloride (1,2-Dichloroethane)	107062	9,544	99.68	0.32	0.00
Ethylene oxide	75218	831,850	99.99	0.01	0.00
Ethylidene dichloride (1,1-Dichloroethane)	75343	2,017	100.00	0.00	0.00
Formaldehyde	50000	7,439,264	1.53	17.30	81.17
Glycol ethers	0	1,059,986	20.05	79.95	0.00
Hexachlorobenzene	118741	1	14.77	85.23	0.00
Methyl bromide (Bromomethane)	74839	1,079,019	96.34	3.66	0.00
Methyl chloride	74873	119,886	30.13	69.87	0.00
Methyl chloroform (1,1,1-Trichloroethane)	71556	1,951,754	94.00	6.00	0.00
Methylene chloride (Dichloromethane)	75092	1,013,311	62.23	37.77	0.00
Methylene diphenyl diisocyanate (MDI)	101688	1,530	0.00	100.00	0.00
Phenol	108952	236,236	0.61	96.90	2.49
Propionaldehyde	123386	357,488	0.00	1.26	98.74
Propylene dichloride (1,2-Dichloropropane)	78875	397	99.94	0.06	0.00
Styrene	100425	2,933,760	0.09	39.11	60.80
1,1,2,2-Tetrachloroethane	79345	2,322	95.69	4.31	0.00
2,3,7,8-tetrachlorodibenzo-furan (TCDF)	51207319	2	33.14	66.86	0.00
2,3,7,8-tetrachlorodibenzo-p-dioxin (TCDD)	1746016	0.013	81.05	18.95	0.00
Tetrachloroethylene (Perchloroethylene)	127184	852,254	81.13	18.87	0.00
2,4-Toluene diisocyanate	584849	4	0.00	100.00	0.00
Toluene	108883	35,530,797	35.20	8.15	56.65
Total polychlorinated biphenyls (PCBs)	1336363	5	1.60	98.40	0.00
Total polychlorinated dibenzodioxins (PCDDs)	0	4	92.64	7.36	0.00
Total polychlorinated dibenzofurans (PCDFs)	0	27	83.78	16.22	0.00

Pollutant Name	Cas No.	Total Emissions (lb)	Contribution to Total (%) Area	Point	Mobile
1,1,2-Trichloroethane	79005	453	60.85	39.15	0.00
Trichloroethylene	79016	581,361	32.60	67.40	0.00
Trichlorofluoromethane (CFC-11)	75694	450,954	100.00	0.00	0.00
Trifluralin	1582098	42,490	100.00	0.00	0.00
1,2,4-Trimethylbenzene	95636	3,051,818	0.00	3.55	96.45
1,3,5-Trimethylbenzene	108678	1,027,865	0.00	0.33	99.67
Trimethylbenzene	2551137	260,369	93.98	6.02	0.00
Vinyl chloride	75014	30,092	99.09	0.91	0.00
Vinylidene chloride (1,1-Dichloroethylene)	75354	5,254	99.99	0.01	0.00
Xylenes (Isomers and mixture)	1330207	21,824,066	30.25	8.66	61.10
m-Xylenes	108383	5,051,469	3.79	0.01	96.21
m/p-Xylenes	0	55,126	86.94	0.21	12.86
o-Xylenes	95476	3,467,951	16.41	5.01	78.57
p-Xylenes	106423	109,303	100.00	0.00	0.00
Metal Compounds					
Antimony	7440360	1,415	0.00	100.00	0.00
Arsenic	7440382	11,168	1.54	98.43	0.04
Beryllium	7440417	253	18.70	81.30	0.00
Cadmium	7440439	2,376	10.30	89.70	0.00
Chromium	7440473	33,133	37.86	58.54	3.60
Chromium (6)	18540299	3,020	65.48	34.52	0.00
Cobalt	7440484	36,564	90.78	9.22	0.00
Copper	7440508	49,803	2.67	36.39	60.94
Lead	7439921	158,652	0.86	94.62	4.52
Manganese	7439965	87,974	2.26	96.45	1.29
Mercury	7439976	3,269	7.29	83.06	9.65
Nickel	7440020	43,915	22.00	76.05	1.95

Polycyclic aromatic hydrocarbon (PAH) emissions were dominated by area sources, which contributed more than 92.8% of total emissions for 15 PAHs and 57.5% for benzo(a)pyrene. Emissions of metal compounds were mainly from point sources, which were responsible for nearly 60% or more of total emissions for 9 out of 12 metal compounds. Area and mobile sources were responsible for more than 60% of emissions of chromium (6), cobalt, and copper. For non-metal compounds (excluding PAHs), each principal source category accounted for more than two thirds of total emissions of individual pollutants: area sources for 29 pollutants, point sources for 11 pollutants, and mobile sources for 13 pollutants.

The total mass of emissions can be summed to determine sources of air toxics emitted in Minnesota. The total mass of air toxics emissions emitted in Minnesota in 1996 was estimated to be 56,378 short tons. Figure 3 shows the breakdown of total air toxics emissions in Minnesota in 1996. It is important to note that a large mass of emissions is not necessarily indicative of high human health or ecological risk, as discussed in section 1.0.

Figure 3: 1996 Minnesota Air Toxics Emissions by Principal Source Category



The inventory results represent emissions for calendar year 1996 only. The pollutants in the inventory were limited to a subset of 109 air toxics that have emission information. Area source categories covered in the 96MNEI are not comprehensive. Many other area sources need to be explored in the future.

There were a number of uncertainties associated with the methodology used to compile the 96MNEI. The most significant uncertainties resulted from a lack of source-specific emission information, the use of default activity data for non-road mobile sources, and the use of generic emission factors. These uncertainties caused an underestimation for a whole subcategory of non-road mobile sources and inaccurate results for some pollutants from certain source categories. The examples are an overestimation of 1,3-butadiene emissions from Gasoline Marketing and inappropriate ethylene oxide emissions from Industrial Surface Coating. A detailed discussion of uncertainties can be found at MPCA web site: http://www.pca.state.mn.us/air/toxics.html#3.5.

Further work is needed to improve the reliability of the Minnesota air toxics emissions inventory to support regulatory activities in the MPCA, the Great Lakes region, and the EPA, but the 96MNEI inventory represents an important milestone towards the development of a comprehensive and reliable emission inventory in Minnesota.

3.0 Air Toxics - Concentrations and Trends

In 1999, the MPCA compared EPA's Cumulative Exposure Project (CEP) modeling with ambient monitoring from Minnesota. Since that time, the MPCA collected more monitoring information and EPA released its National Air Toxics Assessment modeling, based on more recent data than the CEP. This section looks at the MPCA's updated monitoring and EPA's newer modeling data and compares it to earlier data and conclusions.

3.1 Summary of MPCA Staff Paper Modeling and Monitoring

In November 1999, the MPCA completed the *MPCA Staff Paper on Air Toxics* (MPCA, 1999). The MPCA Staff Paper compared ambient air concentration modeling from the U.S. Environmental Protection Agency's Cumulative Exposure Project (CEP) and ambient air monitoring from MPCA's monitoring networks to health benchmarks. MPCA listed eleven chemicals as pollutants of concern because (1) the CEP model-predicted concentration exceeded the health benchmark in at least one census tract or (2) the monitored annual average concentration at one or more monitoring sites exceeded the health benchmark. These substances are listed in Table 6.

Table 6. Pollutants of Concern from the MPCA Staff Paper

POLLUTANT	**Exceeded Health Benchmark Based on CEP Modeling**	**Exceeded Health Benchmark Based on Monitoring**
Formaldehyde	**X**	**X**
Benzene	**X**	**X**
Carbon tetrachloride	**X**	**X**
Chloroform		**X**
Ethylene dibromide		**X**
1,3-butadiene	**X**	*No monitoring data*
Acrolein	**X**	*No monitoring data*
Arsenic	**X**	**X***
Nickel	**X**	
Chromium	**X**	**X***
Diesel Particles / Polycyclic Organic Matter (POM)	**X****	

*Data for arsenic and chromium are mostly below the minimum quantifiable level, but there is an indication that concentrations may exceed health benchmarks at some sites.
** The health benchmark for POM was assumed to be that of benzo(a)pyrene.

The MPCA determined that ambient air concentrations of four of these chemicals: formaldehyde, benzene, carbon tetrachloride, and chloroform warranted action. The remaining pollutants were highlighted for further study.

Further details regarding the information in the MPCA Staff Paper were published in Environmental Health Perspectives in September 2000 (Pratt et al, 2000).

In preparation for this legislative report, MPCA updated the analysis of the air toxics monitoring data. In the MPCA Staff Paper, monitoring data from 1991 to mid-1998 was analyzed. In this update, the monitoring data has been analyzed up to the end of 1999. This update is necessary in order to continue tracking concentration trends for the primary pollutants of concern and to help determine for which pollutants MPCA action is warranted.

3.2 Summary of MPCA Air Toxics Monitoring Efforts

Siting of Monitors

The MPCA operates a set of statewide toxic air pollution monitoring sites that developed over several years to address multiple concerns. Some sites were established to measure concentrations in the vicinity of specific point sources. Other sites were established to collect baseline data on air toxics concentrations in the Minneapolis-St. Paul metropolitan area (metro area) and in Duluth. A third group of sites was established as part of a legislatively mandated statewide air toxics monitoring network (SATMN). Throughout this appendix, references to 'SATMN' sites refer only to this subset of monitoring locations, and not the entire monitoring effort of the MPCA. The objective of the SATMN study was to collect one-year snapshots of concentrations at sites throughout the state. These sites were randomly selected with weighting for geographic coverage and population density. Sites were typically located at rooftop level and away from immediate pollution sources following guidance provided by EPA (EPA, 1994). All rooftops are made of either pitch and gravel or rubber membrane. The only sites located at ground level were Holloway and Sandstone.

The MPCA air toxics monitoring network is one of the most extensive of its kind in the U.S. The siting of individual monitors was done by professionals with more than 20 years of experience in siting air pollution monitors. One of the important considerations in monitor siting is to represent the air quality of the general location of the monitor while avoiding the influence of microenvironmental sources such as rooftop vents and stacks, idling vehicles, paint or solvent use and storage, construction activity, etc. These considerations are described in the EPA monitoring guidance document.

The SATMN sites were selected using a peer review process in which three professors from the University of Minnesota provided advice and extensive comments on versions of the network protocol. After several iterations the network design was finalized. The network was designed to characterize typical ambient air concentrations that residents are potentially exposed to in a city, town, or township. The intent is not to target specific industries, and monitoring equipment has not been and will not be placed at the fence line of any industry.

The potential "pool" of sampling sites included all minor civil divisions (MCDs) in the state. (A minor civil division is defined as any community that is a city or a township.) A weighting score that incorporated emissions and population was calculated for each MCD. The MCDs were separated into six geographic regions to ensure geographic coverage of the state. Within each region, the MCDs were ranked by the population and emissions weighting score. The ranked scores were divided into five tiers. Tier one contained the top 20 percent of the scores, tier 2 contained the next 20 percent, tier 3 the next 20 percent, tier 4 the next 20 percent, and tier 5

contained the lower 20 percent. In general, tiers 1 to 3 contained most of the highly populated areas of each region, while tiers 4 and 5 contained MCDs with small populations.

One sampling location (MCD) was selected at random from each tier for sampling. The order in which the five sites in each region were to be monitored was also chosen at random. Within each MCD selected for sampling, a location was chosen that represented the MCD as well as possible given the need for power and security for the monitors. Under this protocol, each MCD within a given tier and a given region had an equal probability of being selected. This procedure means that the monitoring results can be considered representative of the state since the results from each randomly selected site can be related back to the population of sites from which it was drawn.

Results

For the purposes of this update, the MPCA focused on the SATMN sites for mean ambient air concentration data. This was done so that a similar time frame would be compared between sites (all the SATMN sites have one year of data). In addition, the SATMN sites are located away from immediate pollution sources, so bias from near-by point sources was removed. Finally, the SATMN sites are organized under a single study and allow for comparisons with fewer caveats. This focus on the SATMN sites allowed the MPCA to update some of the conclusions originally found in the MPCA Staff Paper.

A listing and characterization of the SATMN monitoring sites is given in Table 7. Note that some of the designations can be deceptive. For example, the Duluth 7550 site is located on a hilltop away from both the town center and most of the industry and traffic. As a result, many of the chemical concentrations seem to correlate better with a small town than an urban area. It is also important to consider the exact location of the monitor.

Table 7: The Statewide Air Toxics Monitoring Network

Site Name	Site I.D.	Monitoring Year	Region	Tier	Population of MCD*	Site Type**
Alexandria	2010	1996-97	3	3	8,251	SATMN-S
Bemidji	2302	1998-99	Added		11,494	SATMN-S
Duluth 7550	7550	1998-99	1	1	85,746	SATMN-U
Elk River	3050	1997-98	2	2	12,811	SATMN-S
Fergus Falls	2005	1997-98	3	2	12,596	SATMN-S
Granite Falls	4003	1997-98	4	4	3,049	SATMN-S
Harding High	871	1998-99	6	2	271,660	SATMN-U
Hibbing	7014	1997-98	1	3	17,964	SATMN-S
Holloway	4500	1998-99	4	5	120	SATMN-R
International Falls 1241	1241	1996-97	Added		7,811	SATMN-S
Little Falls	3049	1996-97	2	3	7,595	SATMN-S
Minnehaha Academy	958	1997-98	6	1	366,480	SATMN-U
Moorhead	2103	1998-99	3	1	33,618	SATMN-U

Pipestone	4002	1996-97	4	3	4,559	SATMN-S
Plymouth	260	1996-97	6	3	57,391	SATMN-U
Rochester	5008	1997-98	5	1	76,865	SATMN-U
Sandstone	1400	1996-97	1	5	280	SATMN-R
St. Cloud	3052	1998-99	2	1	50,143	SATMN-U
Warroad	2401	1997-98	Added		1,815	SATMN-S
Winona	5210	1998-99	5	2	25,805	SATMN-U
Zumbrota	5356	1996-97	5	5	946	SATMN-R

*1994 population data taken from the Statewide Air Toxics Monitoring Study: Background Information and Project Plan, 1996 (MPCA, 1996).
**Abbreviations: SATMN, Statewide Air Toxics Monitoring Network; -R, rural site; -S, small town site; -U, urban site.

For trend analysis, MPCA has relied primarily on monitoring data in urban areas such as the Twin Cities and Duluth and, in some cases, sites near point sources. These monitoring sites have concentrations dating back to 1991 and were the only locations that allowed for long-term trend analysis. The data were analyzed through 1999. The five sites in table 8 were analyzed for trends.

Table 8: Air Toxics Monitoring Sites Used for Trends Analysis

Site Name	Site I.D.	Monitoring Year	Site Type*
Duluth	7549	1994-active	Urban
Holman Field	816	1991-active	Urban
Koch420	420	1991-active	Industrial
Minneapolis Library	945	1991-active	Urban
St. Paul Park	436	1993-active	Industrial

*Abbreviations: Urban - site located to characterize the urban area; Industrial - site located near an industrial facility.

Analytical Techniques

Three types of samples are collected for MPCA air toxics monitoring: volatile organic compounds (VOCs), carbonyls, and particulate matter ≤ 10 μm in aerodynamic diameter (PM_{10}). All sample types are collected for 24 hours every sixth day. VOCs are collected using stainless steel canisters and samples are analyzed using a gas chromatograph/mass spectrometer as prescribed in the U.S. federal reference method TO-14A (EPA, 1999a). Carbonyls are analyzed according to U.S. federal reference method TO-11A (EPA, 1999b). The PM10 samples are analyzed for metals using energy dispersive X-ray flourescence (XRF).

Lower Detection Limits (LDLs)

MPCA reports lower detection limits (LDLs) that are determined as described below.

VOCs and carbonyls: The LDL is determined by the following procedure. A standard is prepared one to five times the estimated LDL. A minimum of seven samples of this standard

are processed through the entire analytical method. The resulting concentration data are input to the following equation:

$$LDL = t \times (SD), \text{ where}$$

t = the t-value appropriate for a 99% confidence level for the standard deviation with *n*-1 degrees of freedom, and
SD = the standard deviation of replicate analyses.

Metals (XRF): Using the XRF instrument, an element's peak is detected above background with 99% confidence if the peak counts are greater than three times the square root of the background counts:

$$LDL = (3 \times (Ib)^{1/2}) / Ip * 1/(T^{1/2}) * \text{concentration, where:}$$

Ib = background (cps, or counts per second),
Ip = peak (cps), and
T = time.

Protocol for treating values below detection

Although some measurements are below the level of reliable quantification, the information contained in the reading is valuable and should not be discarded. Likewise, it would represent a loss in information to assign some arbitrary value, such as one-half the detection limit. Therefore, all valid data, including values below detection, zeroes and negative values, are retained in the database used for statistical analysis.

In the case of several metals, a large fraction of the measurements are below the lower detection limit (LDL). In addition, since the reading from a blank filter is subtracted from each measurement, there are some negative values in the data. These negative values could be censored in some way, such as converting them to zero (or one-half the LDL). However this censoring would alter the frequency distribution. The best method for treating such data is a matter of debate in the scientific literature. The MPCA chose to retain all the raw values in the data for the statistical analyses reported here.

A blank subtraction is also done with the carbonyl data. With VOCs, there is presently no blank subtraction; however, was some blank subtraction was done early on, resulting in a few negative values. There are also several VOCs and carbonyls that are often below the LDL.

Five of the chemicals from the MPCA Staff Paper (1,3-butadiene, arsenic, chromium, ethylene dibromide and nickel) could only be briefly summarized because the majority of the monitored values from the SATMN data were below the LDL. The quality of the data, therefore, made it unfeasible to do more than a cursory analysis. Table 9 gives the percent of samples for each chemical above the LDL for all the SATMN sites combined from 1996-1999. The sites were

also screened to ensure that certain sites did not have significantly higher percentages above the LDL.

Table 9: LDLs for Pollutants from the MPCA Staff Paper

Chemical Name	CAS Number	Percent Above the Lower Detection Limit	Number of Valid Samples
1,3-Butadiene	106-99-0	1%	160
Arsenic	7440-38-2	3%	687
Benzene	71-43-2	99%	1135
Carbon Tetrachloride	56-23-5	99%	1136
Chloroform	67-66-3	37%	1134
Chromium	7440-47-3	18%	873
Ethylene dibromide	106-93-4	1%	1134
Formaldehyde	50-00-0	99%	1193
Nickel	7440-02-2	2%	1137

Statistical Software

All statistical analyses were done using either SPSS version 8.0 or Microsoft Excel 97.

Data Gaps in Monitoring Analysis

During analysis of MPCA's ambient air toxics monitoring data, several gaps in the monitoring data have been determined. These gaps include: concern with the lower detection limits of some compounds, the lack of monitoring data for persistent and bioaccumulative chemicals, and the lack of trend data for non-urban locations.

Lower Detection Limits of Compounds

The MPCA found several low detection limits to be of concern during the analysis of the Minnesota ambient air monitoring data. Of over 40 chemicals analyzed that have available health benchmarks, five of these chemicals have lower detection limits that are higher than the lowest health benchmark, as shown in Table 10.

Table 10: LDLs Compared with Health Benchmarks

Chemical Name	CAS Number	Lowest Health Benchmark (ug/m3)	Average LDLs (ug/m3) *updated through 1999	LDL Comparison to Health Benchmarks
1,3-butadiene	106-99-0	0.04	0.187	**Benchmark<LDL**
Arsenic	7440-38-2	0.002	0.005	**Benchmark<LDL**
Cadmium	7440-43-9	0.01	0.016	**Benchmark<LDL**
Chromium VI	7440-47-3	0.0008	0.002	**Benchmark<LDL**
Ethylene dibromide	106-93-4	0.05	0.271	**Benchmark<LDL**

In the case of 1,3-butadiene, arsenic, and chromium, this causes a particular concern because modeling concentrations from the CEP study indicate that these chemicals may require further analysis. This analysis cannot be done when the majority of the data is below the LDL.

In the case of the metal compounds, part of the problem with the LDLs stems from the energy dispersive X-ray flourescence (XRF) equipment used for analysis. This screening technique is capable of determining the concentration of 33 elements, however, since it is a screening technique, the LDLs can be relatively high. More refined (and expensive) techniques could be used for analysis of individual metals that might allow analysis down to the level of the health benchmarks.

Lack of Information on Semi-Volatile Chemicals

A second significant data gap is the limitations on the compounds for which MPCA monitors. Currently, MPCA has ambient air monitoring data for seven carbonyl compounds, 37 volatile organic compounds (VOCs), and 33 metal elements. The MPCA does not have ambient air monitoring data for any semi-volatile organic compounds. These semi-volatile compounds are more likely to persist and bioaccumulate in the environment than VOCs or carbonyl compounds.

From a long-term perspective, these persistent and bioacccumulating toxics (PBTs) may pose a greater risk to human health and the environment than the VOCs. PBTs include compounds such as polycyclic aromatic hydrocarbons (PAHs), dioxins, furans, pesticides, polychlorinated biphenyls (PCBs), polybrominated biphenyls (PBBs), and pollutants of emerging concern (e.g., endocrine disruptors). More information on these chemicals is available in the PBT Appendix.

The PBTs are much more complex and expensive to monitor and analyze than the chemicals which MPCA currently monitors. The MPCA has been unable thus far to monitor these chemicals due to budget and staffing considerations.

Lack of Non-Urban Trend Data

The MPCA has up to ten years of trend data for air toxics at select monitoring locations. However, all of this trend data is located in either urban areas or near specific facilities with large emissions. These sites were located in consideration of MPCA's limited monitoring budget. The monitoring took place in areas that were likely to have the highest ambient air concentrations and potential impacts on nearby residents.

However, this strategy has left a gap in trend data for rural and small town areas of the state. Without trend data for rural areas of the state, it is difficult to know which compounds may be a concern statewide and which are exclusively urban or industry-specific concerns. Since nearly half of Minnesota's population lives in rural or small-town areas, this lack of trend data makes it difficult to judge their continuing exposure to air toxics.

3.3 Updated Monitoring Data for Pollutants from MPCA Staff Paper

The chemicals identified as pollutants of concern in the MPCA Staff Paper on Air Toxics were examined more closely through evaluation of the first three years of monitoring data from the statewide air toxics monitoring network (SATMN). The chemicals basically fell into three categories:

- Chemicals which could be evaluated in more depth (benzene, carbon tetrachloride, chloroform, and formaldehyde).
- Chemicals which could not be evaluated in depth due to detection limitations (ethylene dibromide, 1,3-butadiene, arsenic, nickel, chromium).
- Chemicals which are not monitored at MPCA (acrolein, polycylic organic matter (POM)).

Five of the chemicals could only be briefly summarized because the majority of the monitored values were below the lower detection limit (LDL). The quality of the data, therefore, made it unfeasible to do more than a cursory analysis. Only compounds with a significant amount of data above the LDL was analyzed in depth.

MPCA focused on the Statewide Air Toxics Monitoring Network (SATMN) sites, a subset of all sites, for mean ambient air concentration data for the benzene, carbon tetrachloride, chloroform, and formaldehyde updates. This was done so that a similar time frame would be compared between sites (all the SATMN sites have one year of data). In addition, the SATMN sites are located away from immediate pollution sources, so bias from near-by point sources was removed. Finally, the SATMN sites are organized under a single study and allow for comparisons with fewer caveats. The SATMN data analyzed in this update were collected from 1996 to 1999.

Benzene Update

Conclusions from MPCA Staff Paper

Monitoring data and modeling studies showed that benzene concentrations in Minnesota were elevated above the lower bound of the health benchmark (1.3 $\mu g/m^3$) in the Twin Cities metropolitan area and in other smaller population centers in the state (*e.g.*, Duluth, St. Cloud, Rochester, Mankato). Since 1991, it appeared that benzene concentrations in the metropolitan area had decreased slightly. The reason for the decrease was unclear. Given the magnitude of the measured concentrations, especially in the metropolitan area and other smaller population centers, the MPCA Staff Paper concluded that benzene in the air presented potential health problems in Minnesota.
0

Update on benzene ambient concentrations

Mean benzene concentrations ranged from 1.70-0.47 ug/m^3 between sites. Median benzene concentrations ranged from 1.38-0.41 ug/m^3. The health benchmark for benzene is based on the

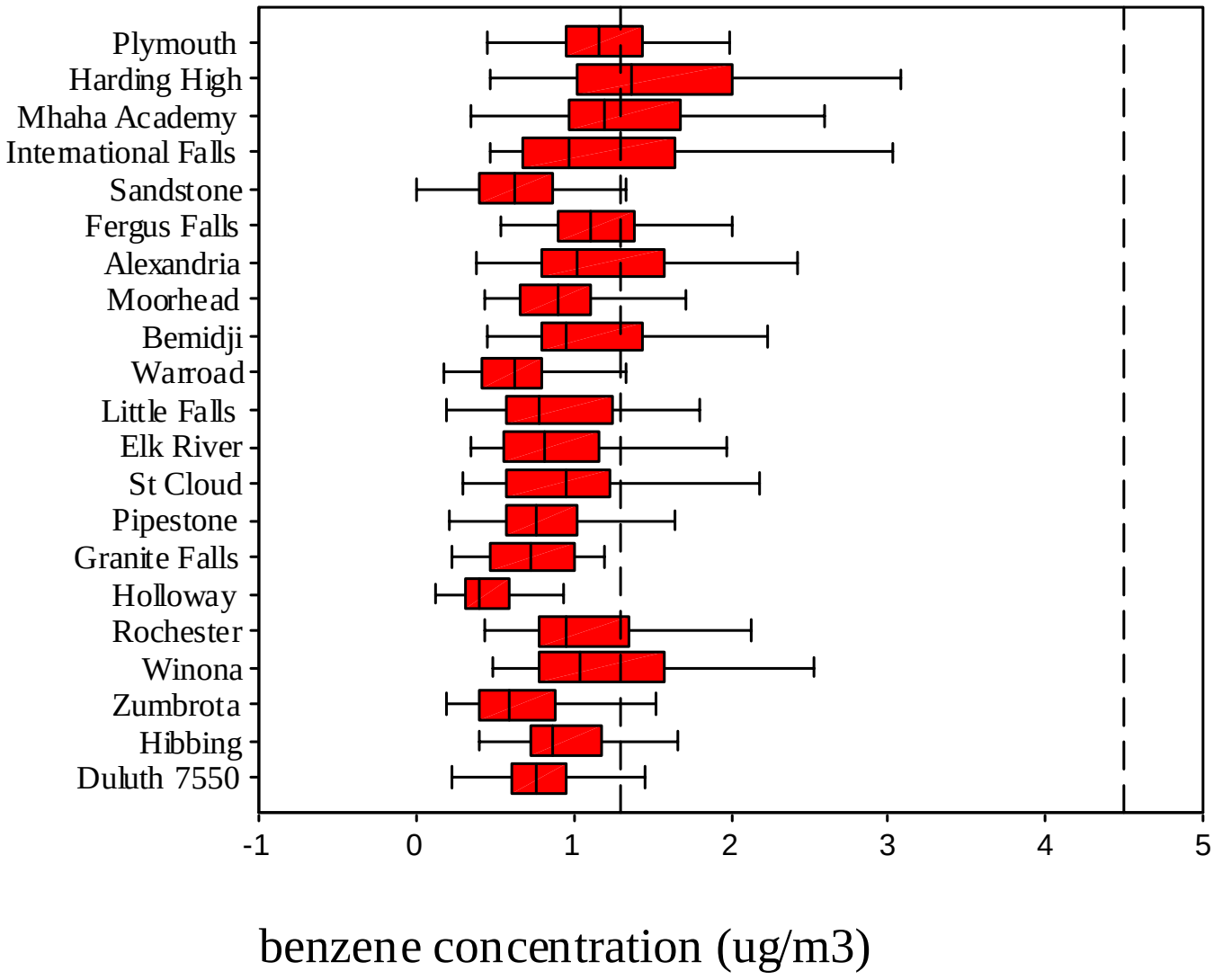
MDH's proposed health risk value (HRV) and which is a range from 1.3-4.5 ug/m^3. The mean values at several urban sites exceeded the lower range of the cancer health benchmark (1.3 ug/m3). Only the median value for Harding High (St.Paul, MN) exceeded the lower range of the health benchmark for cancer. Excluding outliers and extremes, none of the data exceeded the upper range of the health benchmark. There was an indication that the highest levels were found in urban areas, while lower concentrations were found in small town and rural locations. Table 11 shows monitored benzene concentrations.

Table 11: Benzene Concentrations for Statewide Monitoring Network (1996-1999)

Site Name	**Site No.**	**Year Collected**	**N**	**Mean**	**Median**	**Standard Deviation**
Plymouth	260	1996-97	55	1.31	1.16	0.74
Harding High	871	1998-99	56	1.70	1.38	1.11
Minnehaha Academy	958	1997-98	57	1.44	1.20	0.76
International Falls 1241	1241	1996-97	57	1.37	0.98	1.15
Sandstone	1400	1996-97	52	0.67	0.63	0.34
Fergus Falls	2005	1997-98	48	1.18	1.10	0.45
Alexandria	2010	1996-97	58	1.22	1.02	0.57
Moorhead	2103	1998-99	52	0.98	0.90	0.47
Bemidji	2302	1998-99	56	1.23	0.95	0.77
Warroad	2401	1997-98	47	0.64	0.62	0.32
Little Falls	3049	1996-97	56	0.90	0.78	0.45
Elk River	3050	1997-98	58	0.95	0.82	0.54
St. Cloud	3052	1998-99	53	1.10	0.96	0.78
Pipestone	4002	1996-97	47	0.82	0.76	0.35
Granite Falls	4003	1997-98	45	0.93	0.73	0.99
Holloway	4500	1998-99	55	0.47	0.41	0.22
Rochester	5008	1997-98	59	1.11	0.95	0.46
Winona	5210	1998-99	51	1.36	1.04	1.04
Zumbrota	5356	1996-97	54	0.65	0.59	0.30
Hibbing	7014	1997-98	59	1.01	0.87	0.51
Duluth 7550	7550	1998-99	60	0.86	0.76	0.47
1996-97	--	1996-97	379	1.00	0.86	0.69
1997-98	--	1997-98	373	1.05	0.91	0.64
1998-99	--	1998-99	383	1.10	0.86	0.83
All Sites	--	1996-99	1135	1.05	0.87	0.73

Figure 4 includes SATMN data collected from 1996-1999. The center line within each box represents the median for the site. The box itself encompasses the 25th percentile to the 75th percentile. The bars at each end of the box represent the highest and lowest values that are not considered outliers. The vertical dotted lines are located at the values of the benzene health benchmark range (1.3-4.5 µg/m^3).

Figure 4: Benzene Concentrations by Site



When the SATMN five-year study is completed, some conclusions regarding geographic distribution of concentrations may be possible. Since this update only looks at three years of data, it is difficult to make any conclusions regarding geographic or urban/rural differences. However, as Table 12 indicates, there was evidence that the highest levels were found in urban areas, while lower concentrations were found in small town and rural locations.

Table 12: Benzene Concentrations by Range

Mean Range (1.70-1.31 ug/m3)			**Mean Range (1.23-0.98 ug/m3)**			**Mean Range (0.93-0.47 ug/m3)**		
Median Range (1.38-0.98 ug/m3)			**Median Range (1.10-0.95 ug/m3)**			**Median Range (0.78-0.41 ug/m3)**		
Site	**Year**	**Site Type**	**Site**	**Year**	**Site Type**	**Site**	**Year**	**Site Type**
Harding High	1998-99	SATMN-U	Fergus Falls	1997-98	SATMN-S	Sandstone	1996-97	SATMN-R
Plymouth	1996-97	SATMN-U	Alexandria	1996-97	SATMN-S	Holloway	1998-99	SATMN-R
Mhaha Academy	1997-98	SATMN-U	Moorhead	1998-99	SATMN-U	Warroad	1997-98	SATMN-S
I Falls	1996-97	SATMN-S	Bemidji	1998-99	SATMN-S	Little Falls	1996-97	SATMN-S
Winona	1998-99	SATMN-U	Elk River	1997-98	SATMN-S	Pipestone	1996-97	SATMN-S
			St Cloud	1998-99	SATMN-U	Granite Falls	1997-98	SATMN-S
			Rochester	1997-98	SATMN-U	Zumbrota	1996-97	SATMN-R
			Hibbing	1997-98	SATMN-S	Duluth	1998-99	SATMN-U

*In most cases, the high range is statistically different from the low range. The middle range is not statistically different from either the high or the low ranges.

Update on benzene trends

For benzene trend analysis, five sites in urban areas such as the Twin Cities and Duluth were analyzed. These monitoring sites have concentrations dating back to 1991 which allowed for long-term trend analysis.

As in the MPCA Staff Paper, there continued to be a statistically significant decrease in benzene concentrations in the metropolitan area and in Duluth. The regression coefficients (R^2 values) ranged from 0.042 at the Koch 420 site to 0.115 in Duluth. These relatively low regression coefficients indicate that the change in time accounts for only a small part of the variation in benzene concentration data. The regression equations show that the benzene concentrations have been decreasing by 0.14 $\mu g/m^3$ per year at Minneapolis public library, 0.12 $\mu g/m^3$ per year at Koch 420, 0.28 $\mu g/m^3$ per year at St. Paul Park, 0.10 $\mu g/m^3$ per year at Holman Field, and 0.19 $\mu g/m^3$ per year in Duluth.

Benzene concentrations were found to be decreasing by 0.02 $\mu g/m^3$ per year in the MPCA Staff Paper. The updated benzene concentration data indicates that benzene concentrations may be decreasing at a higher rate than previously found. It will take several years of monitoring to determine the robustness of the downward trend. Concentrations at some sites (especially the inner city sites) are still above the lower bound of the health benchmark. In addition, benzene is typically emitted from sources in close proximity to where people are breathing.

Figure 5 is a scatterplot of benzene concentrations is plotted with a smoothed trend line. The horizontal dashed lines are at the bounds of the health benchmark range for benzene (1.3-4.5 $\mu g/m^3$).

Figure 5: Trend in Benzene Measurements at the Minneapolis Library

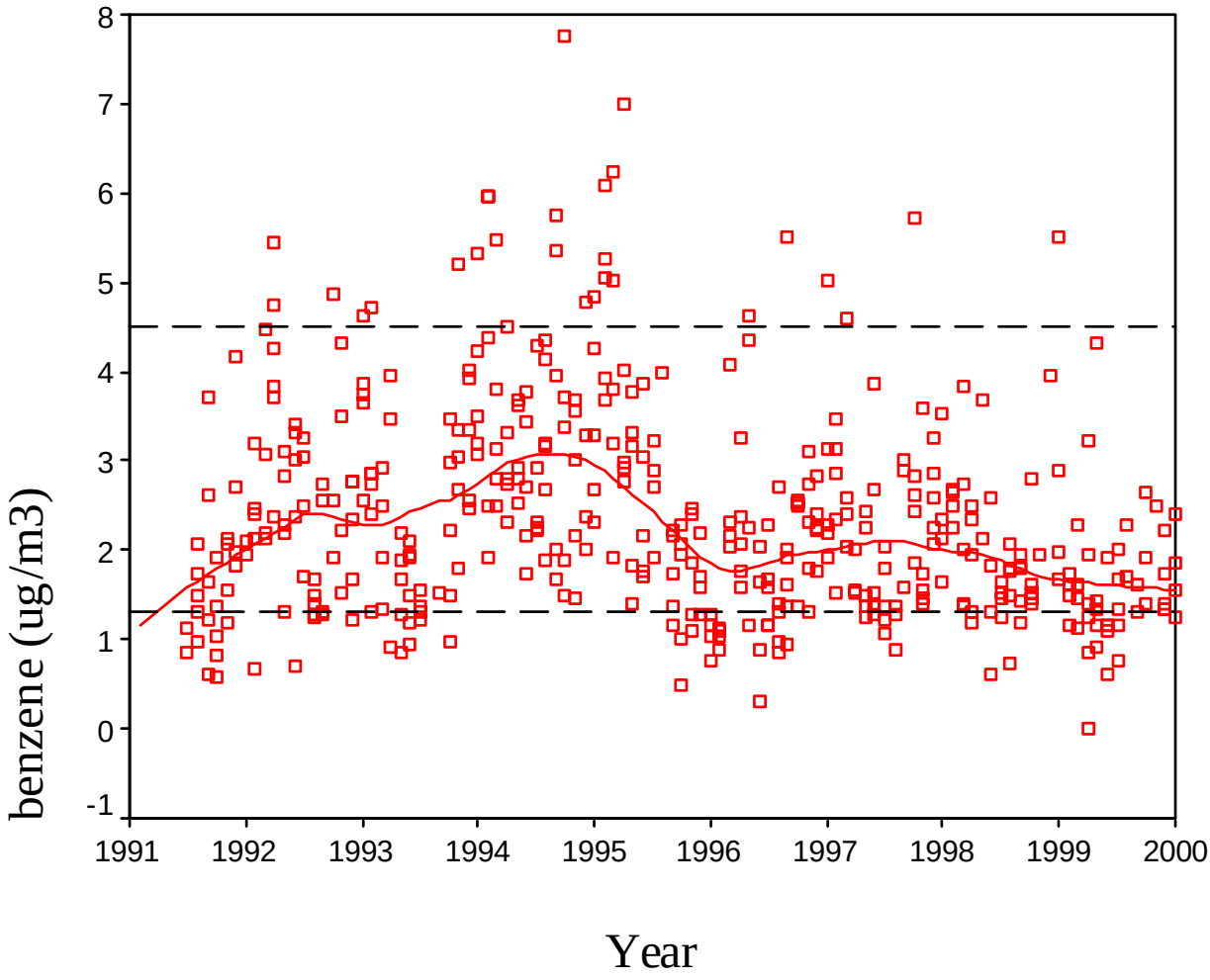
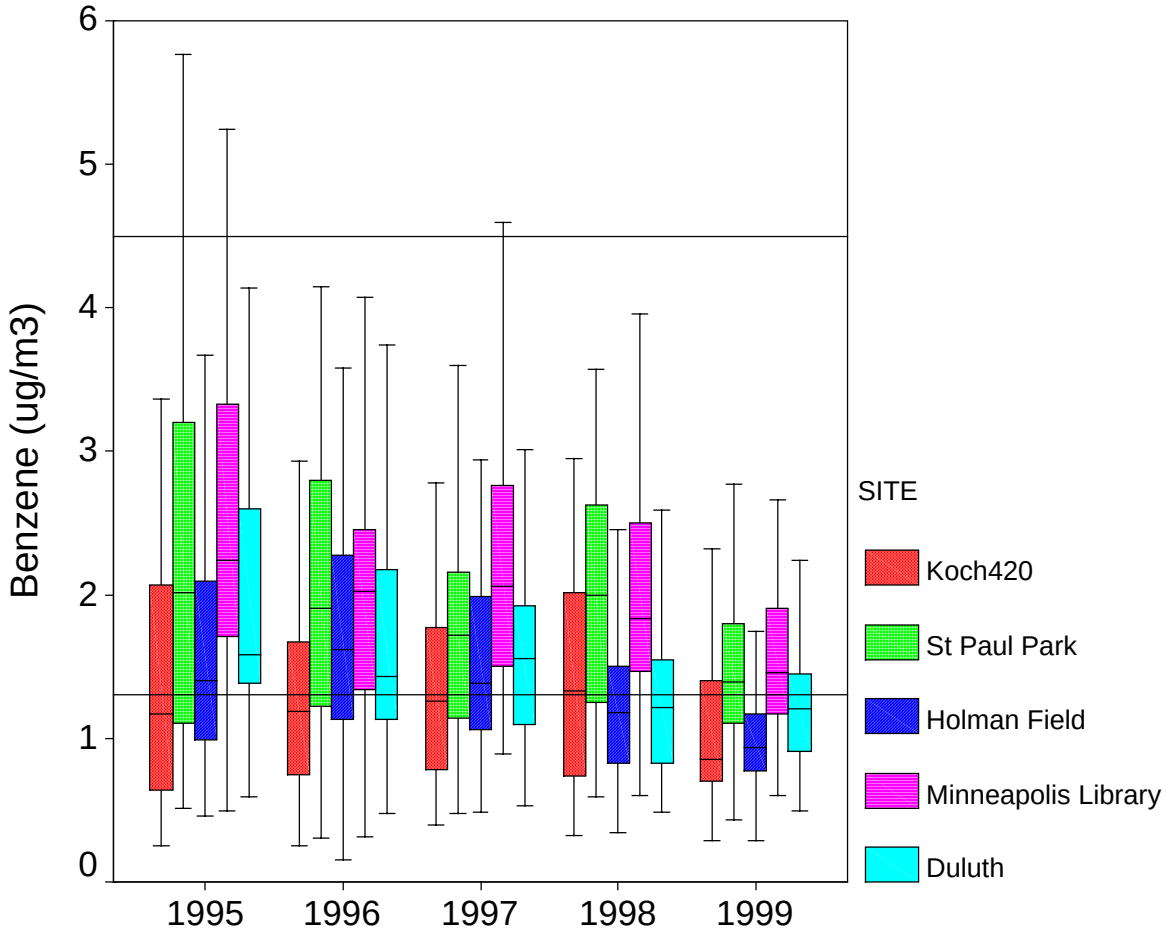


Figure 6 shows the concentrations of benzene at five sites in Minnesota. The center line within each box represents the median for the site. The box itself encompasses the 25th percentile to the 75th percentile. The bars at each end of the box represent the highest and lowest values that are not considered outliers. The vertical dotted lines are located at the health benchmark range for benzene (1.3-4.5 $\mu g/m^3$).

Figure 6. Benzene Concentrations at Several Long Term Monitoring Sites



According to the CEP final report (SAI, 1999), natural background levels of benzene in 1985 were 0.48 ug/m^3.

Carbon Tetrachloride Update

Conclusions from MPCA Staff Paper

Monitoring data from the MPCA Staff Paper showed that carbon tetrachloride exceeded the health benchmark of 0.7 ug/m3 throughout Minnesota. MDH did not find adequate information to develop a health risk value (HRV) for carbon tetrachloride, so this health benchmark was developed based on cancer potency information from the EPA IRIS database. Carbon tetrachloride has been banned internationally under the Montreal Protocol treaty, which limits production and emission of substances that destroy the stratospheric ozone layer. Despite the ban and the end of U.S. production in 1996, the monitoring data did not yet show a clear trend toward decreasing concentrations. The

high measured concentrations suggested a potentially important public health issue from carbon tetrachloride in the atmosphere. Therefore, carbon tetrachloride was listed as a pollutant of concern in the MPCA Staff Paper.

Update on carbon tetrachloride ambient concentrations

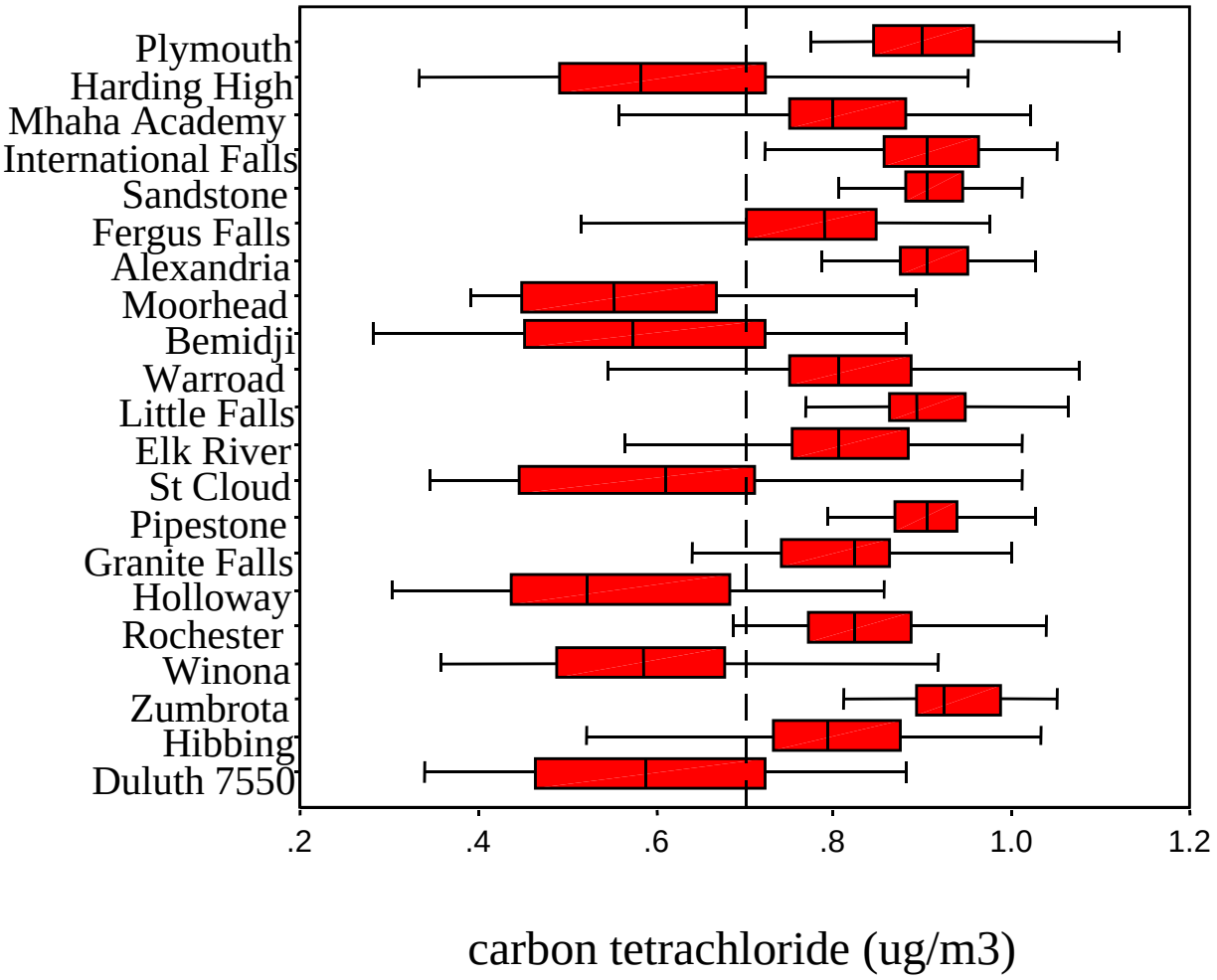
Table 13 lists carbon tetrachloride concentrations at SATMN monitoring sites. Mean carbon tetrachloride concentrations ranged from 0.93-0.54 ug/m^3 between sites. Median carbon tetrachloride concentrations ranged from 0.92-0.52 ug/m^3 between sites.

Table 13: Carbon Tetrachloride Concentrations for Statewide Monitoring Network (1996-9)

Site Name	**Site No.**	**Year Collected**	**N**	**Mean**	**Median**	**Standard Deviation**
Plymouth	260	1996-97	55	0.91	0.91	0.095
Harding High	871	1998-99	56	0.60	0.58	0.15
Minnehaha Academy	958	1997-98	57	0.80	0.80	0.12
International Falls 1241	1241	1996-97	57	0.91	0.91	0.077
Sandstone	1400	1996-97	51	0.91	0.91	0.061
Fergus Falls	2005	1997-98	48	0.78	0.79	0.13
Alexandria	2010	1996-97	58	0.92	0.91	0.088
Moorhead	2103	1998-99	52	0.57	0.55	0.17
Bemidji	2302	1998-99	56	0.57	0.57	0.17
Warroad	2401	1997-98	47	0.82	0.81	0.11
Little Falls	3049	1996-97	56	0.91	0.89	0.072
Elk River	3050	1997-98	59	0.79	0.81	0.16
St. Cloud	3052	1998-99	53	0.60	0.61	0.15
Pipestone	4002	1996-97	47	0.92	0.91	0.084
Granite Falls	4003	1997-98	46	0.77	0.82	0.19
Holloway	4500	1998-99	55	0.54	0.52	0.19
Rochester	5008	1997-98	59	0.81	0.82	0.12
Winona	5210	1998-99	51	0.60	0.59	0.13
Zumbrota	5356	1996-97	54	0.93	0.92	0.061
Hibbing	7014	1997-98	59	0.79	0.79	0.13
Duluth 7550	7550	1998-99	60	0.59	0.59	0.14
1996-97	--	1996-97	378	0.92	0.91	0.078
1997-98	--	1997-98	375	0.80	0.81	0.14
1998-99	--	1998-99	383	0.58	0.58	0.16
All Sites	--	1996-99	1136	0.76	0.81	0.19

Figure 7 includes SATMN data collected from 1996-1999. The center line within each box represents the median for the site. The box itself encompasses the 25th percentile to the 75th percentile. The bars at each end of the box represent the highest and lowest values that are not considered outliers. The vertical dotted line is located at the carbon tetrachloride health benchmark (0.7 µg/m^3).

Figure 7: Carbon Tetrachloride Concentrations by Site



When the SATMN five-year study is completed, some conclusions regarding geographic distribution of concentrations may be possible. Since this update only looks at three years of data, it is difficult to make any conclusions regarding geographic or urban/rural differences. However, as the tables below indicate, there does not appear to be geographic differences in carbon tetrachloride concentrations. Apparently the differences seen between sites is due to the monitoring year, not the site location. Carbon tetrachloride appears to be declining in concentration with time. The trends are shown in Table 14.

Table 14: Carbon Tetrachloride Concentrations by Range

Mean Range (0.93-0.91ug/m3)			**Mean Range (0.82-0.77ug/m3)**			**Mean Range (0.60-0.54ug/m3)**		
Median Range (0.92-0.89ug/m3)			**Median Range (0.82-0.79ug/m3)**			**Median Range (0.61-0.52ug/m3)**		
Site	**Year**	**Site Type**	**Site**	**Year**	**Site Type**	**Site**	**Year**	**Site Type**
Plymouth	1996-97	SATMN-U	Mhaha Academy	1997-98	SATMN-U	Harding High	1998-99	SATMN-U
I Falls	1996-97	SATMN-S	Fergus Falls	1997-98	SATMN-S	Moorhead	1998-99	SATMN-U
Sandstone	1996-97	SATMN-R	Warroad	1997-98	SATMN-S	Bemidji	1998-99	SATMN-S
Alexandria	1996-97	SATMN-S	Elk River	1997-98	SATMN-S	St Cloud	1998-99	SATMN-U
Little Falls	1996-97	SATMN-S	Granite Falls	1997-98	SATMN-S	Holloway	1998-99	SATMN-R
Pipestone	1996-97	SATMN-S	Rochester	1997-98	SATMN-U	Winona	1998-99	SATMN-U
Zumbrota	1996-97	SATMN-R	Hibbing	1997-98	SATMN-S	Duluth	1998-99	SATMN-U

*In most cases, the three ranges are statistically different from one another. The three monitoring years are statistically different from one another.

Update on carbon tetrachloride trends

Carbon tetrachloride appears to vary less by geographic location than by time. Although the statewide monitoring network is not designed for trend data, all of the site results indicate that the concentrations of carbon tetrachloride have trended downward each year. Table 15 includes all of the SATMN data through the 1999 sampling year.

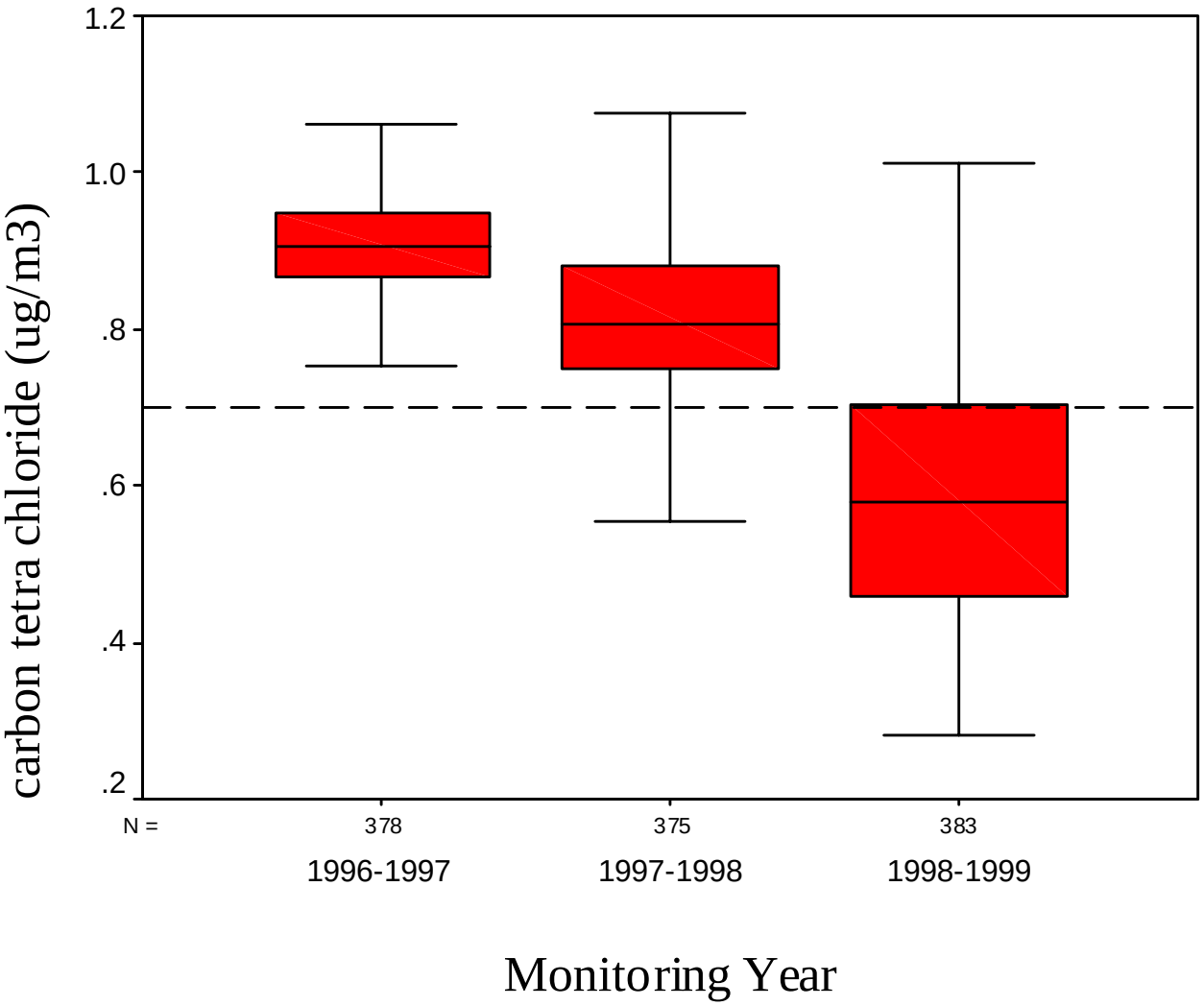
Table 15: Carbon Tetrachloride Concentrations by Monitoring Year

Monitoring Year	**Mean Range (ug/m^3)**	**Median Range (ug/m^3)**
1996-97	0.93-0.91	0.92-0.89
1997-98	0.82-0.77	0.82-0.79
1998-99	0.60-0.54	0.61-0.52

The differences between the years are statistically significant.

Figure 8 includes all of the SATMN data collected from 1996-1999. The center line within each box represents the median for the site. The box itself encompasses the 25th percentile to the 75th percentile. The bars at each end of the box represent the highest and lowest values that are not considered outliers. The horizontal dotted line is located at the carbon tetrachloride health benchmark (0.7 µg/m^3).

Figure 8: Carbon Tetrachloride Concentrations by Monitoring Year

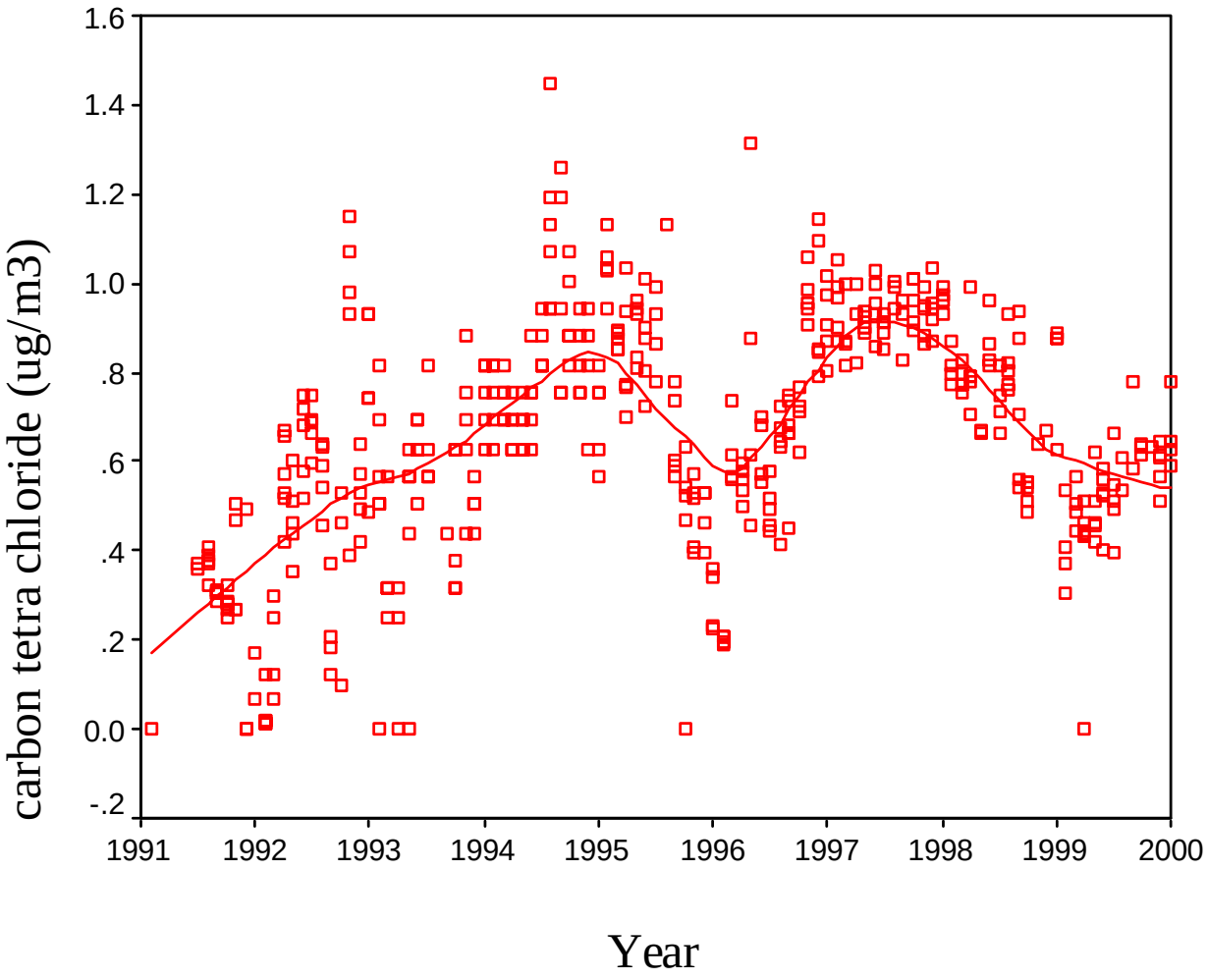


Five sites in urban areas such as the Twin Cities and Duluth were also considered for carbon tetrachloride trend analysis. These monitoring sites have concentrations dating back to 1991 which allowed for long-term trend analysis.

Updated data indicates that concentrations of carbon tetrachloride have been decreasing since 1997. The downward trend of carbon tetrachloride values indicates that average levels in Minnesota are now below the health benchmark of 0.7 ug/m^3. This coincides well with the banning of U.S. production of carbon tetrachloride in 1996 due to the Montreal Protocol.

Figure 9 shows carbon tetrachloride concentrations plotted with a smoothed trend line. The horizontal dashed lines are at the bounds of the health benchmark range for carbon tetrachloride (0.7 µg/m^3).

Figure 9: Trend in Carbon Tetrachloride Measurements at Minneapolis Library



According to the CEP final report (SAI, 1999), anthropogenic (human-made) background levels of carbon tetrachloride in 1990 were 0.88 ug/m^3.

Chloroform Update

Conclusions from MPCA Staff Paper

Ambient air monitoring data showed that chloroform concentrations were below the health benchmark of 0.4 ug/m3 used in the MPCA Staff Paper at all sites in Minnesota except one. MDH did not find adequate information to develop a cancer-based chronic health risk value (HRV) for chloroform, so this health benchmark was developed based on cancer potency information from the EPA IRIS database. The mean and median chloroform concentrations at the customs station site in International Falls exceeded the health benchmark. This site is adjacent to the Boise Cascade paper mill and across the river from the Stone Consolidated paper mill in Fort Francis, Ontario. It appears that emissions from one or both of these facilities caused the elevated chloroform concentrations at the customs station monitoring site. The chloroform concentrations at a second International Falls monitoring site about one mile southwest of the customs station was below the health benchmark value.

Update on chloroform ambient concentrations and toxicity assessment

Mean chloroform concentrations for the SATMN sites ranged from 0.17-0.03 ug/m^3 between sites. Median chloroform concentrations ranged from 0.14-0.000 ug/m^3 between sites. Recently MDH developed a policy recommending a health benchmark concentration of 100 ug/m3 for chloroform based on developmental effects, which MPCA will use for this report. None of the data (excluding outliers and extremes) was above the previous cancer health benchmark of 0.4 ug/m^3 or the revised health benchmark of 100 ug/m3

The SATMN sites do not include the International Falls monitoring location that had concentrations exceeding the previous cancer health benchmark. The mean chloroform concentration in 1998 at the non-SATMN International Falls location was 1.28 ug/m3 and the median chloroform concentration was 0.88 ug/m3. Chloroform was measured July-Nov 1998, so it is not a complete year of data. This high concentration is expected to be from a point source and not indicative of a regional ambient air concern.

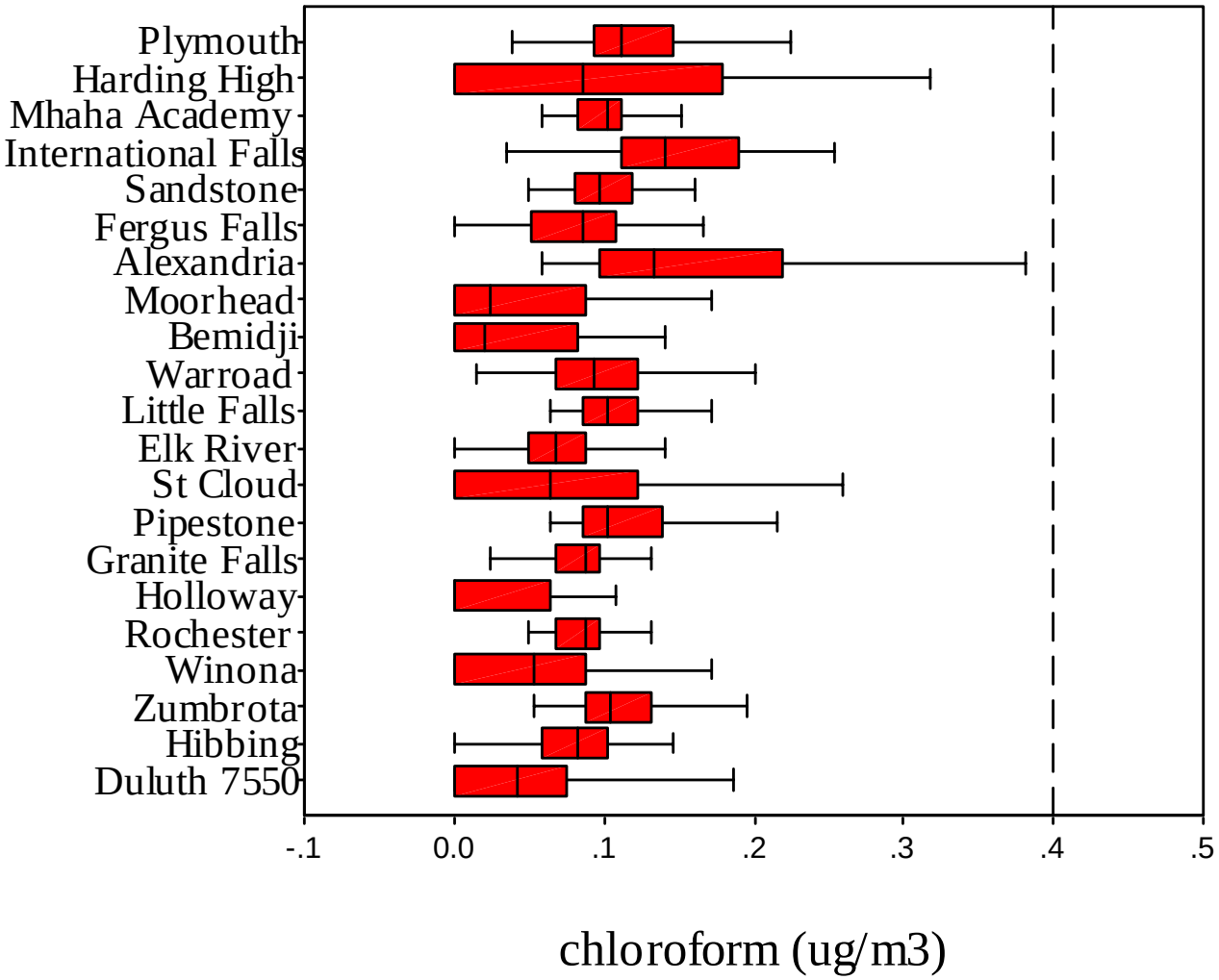
Table 16: Chloroform Concentrations for Statewide Monitoring Network (1996-1999)

Site Name	**Site No.**	**Year Collected**	**N**	**Mean**	**Median**	**Standard Deviation**
Plymouth	260	1996-97	55	0.13	0.11	0.070
Harding High	871	1998-99	56	0.099	0.085	0.094
Minnehaha Academy	958	1997-98	57	0.11	0.10	0.051
International Falls 1241	1241	1996-97	57	0.15	0.14	0.068
Sandstone	1400	1996-97	51	0.10	0.098	0.036
Fergus Falls	2005	1997-98	48	0.085	0.085	0.051
Alexandria	2010	1996-97	58	0.17	0.13	0.096
Moorhead	2103	1998-99	52	0.046	0.024	0.051

Bemidji	2302	1998-99	56	0.043	0.020	0.047
Warroad	2401	1997-98	47	0.10	0.093	0.056
Little Falls	3049	1996-97	56	0.11	0.10	0.038
Elk River	3050	1997-98	58	0.073	0.068	0.040
St. Cloud	3052	1998-99	53	0.071	0.063	0.064
Pipestone	4002	1996-97	47	0.13	0.10	0.066
Granite Falls	4003	1997-98	45	0.084	0.088	0.021
Holloway	4500	1998-99	55	0.030	0.000	0.037
Rochester	5008	1997-98	59	0.089	0.088	0.040
Winona	5210	1998-99	51	0.049	0.054	0.049
Zumbrota	5356	1996-97	54	0.11	0.11	0.032
Hibbing	7014	1997-98	59	0.082	0.083	0.040
Duluth 7550	7550	1998-99	60	0.044	0.041	0.047
1996-97	--	1996-97	378	0.13	0.11	0.066
1997-98	--	1997-98	373	0.088	0.088	0.045
1998-99	--	1998-99	383	0.054	0.049	0.062
All Sites	--	1996-99	1134	0.090	0.088	0.066

Figure 10 includes SATMN data collected from 1996-1999. The center line within each box represents the median for the site. The box itself encompasses the 25^{th} percentile to the 75^{th} percentile. The bars at each end of the box represent the highest and lowest values that are not considered outliers. The vertical dotted line is located at the previous chloroform health benchmark (0.4 $\mu g/m^3$).

Figure 10. Chloroform Concentrations by Monitoring Site



When the SATMN five-year study is completed, some conclusions regarding geographic distribution of concentrations may be possible. Since this update only looks at three years of data, it is difficult to make any conclusions regarding geographic or urban/rural differences. However, ANOVA statistical analysis did not show a geographical trend or urban/rural trend.

The data indicates that chloroform levels may be decreasing with time since the highest median and mean levels are all from 1996-97 while the lowest are all from the 1998-99 monitoring year.

Table 17: Chloroform Concentration by Range

Mean Range (0.17-0.13 ug/m3)			**Mean Range (0.11-0.071 ug/m3)**			**Mean Range (0.049-0.03 ug/m3)**		
Median Range (0.14-0.10 ug/m3)			**Median Range (0.11-0.063 ug/m3)**			**Median Range (0.054-0.000 ug/m3)**		
Site	**Year**	**Site Type**	**Site**	**Year**	**Site Type**	**Site**	**Year**	**Site Type**
I Falls	1996-97	SATMN-S	Fergus Falls	1997-98	SATMN-S	Holloway	1998-99	SATMN-R
Plymouth	1996-97	SATMN-U	Sandstone	1996-97	SATMN-R	Moorhead	1998-99	SATMN-U
Alexandria	1996-97	SATMN-S	Warroad	1997-98	SATMN-S	Bemidji	1998-99	SATMN-S
Pipestone	1996-97	SATMN-S	Little Falls	1996-97	SATMN-S	Winona	1998-99	SATMN-U
			Granite Falls	1997-98	SATMN-S	Duluth	1998-99	SATMN-U
			Elk River	1997-98	SATMN-S			
			St Cloud	1998-99	SATMN-U			
			Mhaha Academy	1997-98	SATMN-U			
			Harding High	1998-99	SATMN-U			
			Zumbrota	1996-97	SATMN-R			
			Rochester	1997-98	SATMN-U			
			Hibbing	1997-98	SATMN-S			

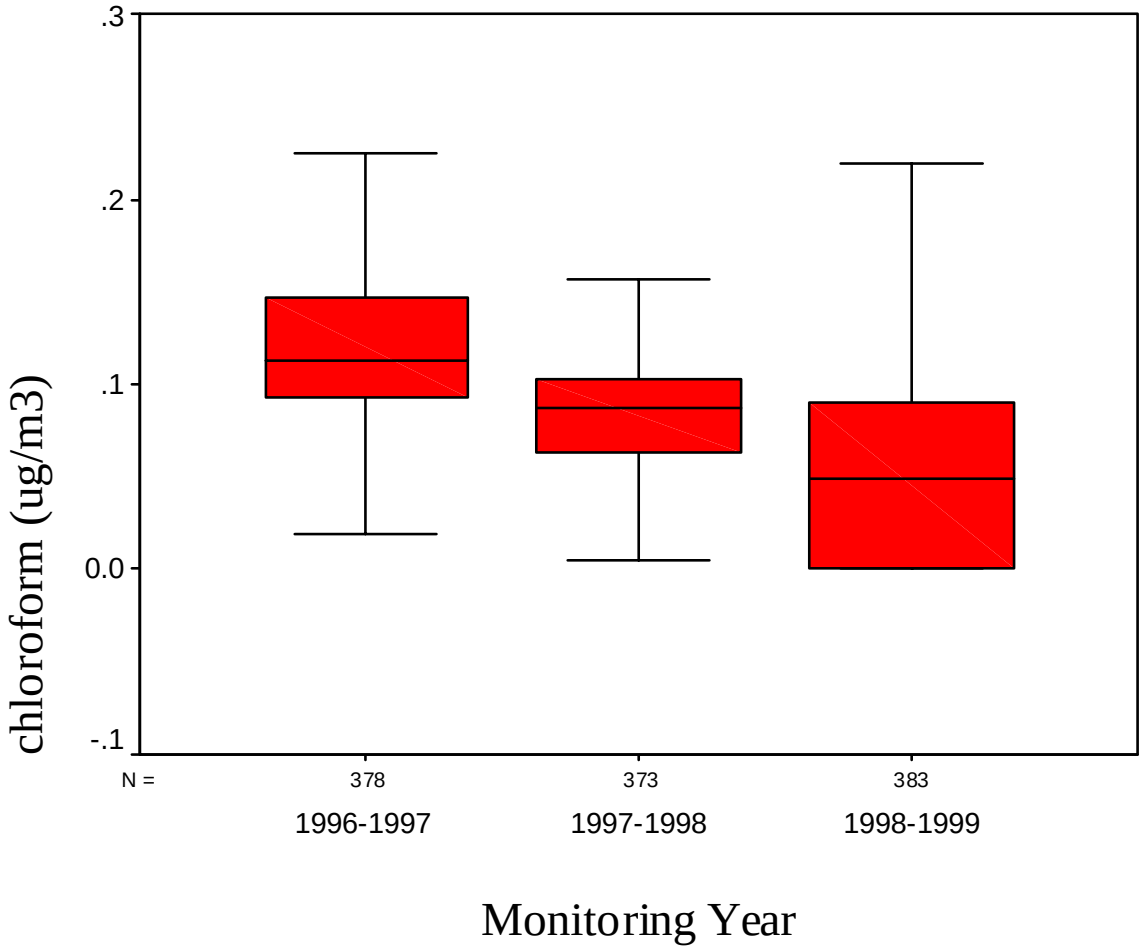
*In most cases, the high range is statistically different from the low range. The middle range is not necessarily statistically different from either the high or the low ranges. The chloroform ranges seem somewhat correlated with the monitoring year.

Update on chloroform trends

The SATMN data indicates that chloroform concentrations are decreasing over the last three monitoring years (1996-1999). However, the data from the SATMN is not definitive since the network was not designed to analyze time trends. The differences between years are statistically significant according to ANOVA analysis. All of the data is below the health benchmark of 100 $\mu g/m^3$.

Figure 11 includes all of the SATMN data collected from 1996-1999. The center line within each box represents the median for the site. The box itself encompasses the 25^{th} percentile to the 75^{th} percentile. The bars at each end of the box represent the highest and lowest values that are not considered outliers. The chloroform health benchmark (100 $\mu g/m^3$) is not shown.

Figure 11: Chloroform Concentrations by Monitoring Year



According to the CEP final report (SAI, 1999), natural background levels of carbon tetrachloride in 1990 were 0.083 ug/m^3.

Formaldehyde Update

Conclusions from MPCA Staff Paper

Statewide air monitoring data from 1991-98 showed that the mean ambient air concentrations of formaldehyde at 25 sites in Minnesota were above the health benchmark of 0.8 µg/m^3. This health benchmark is based on the MDH proposed health risk value (HRV), which was derived from the EPA IRIS database. The highest values were observed at the sites in and near the Twin Cities metropolitan area. Formaldehyde concentrations appeared to be stable from 1995-98. The widespread exceedances of health benchmarks for formaldehyde in ambient air suggested potential concerns about human health risks. Therefore, the MPCA Staff Paper listed

formaldehyde as a pollutant of concern for which current information warranted action by MPCA.

Update on formaldehyde ambient concentrations

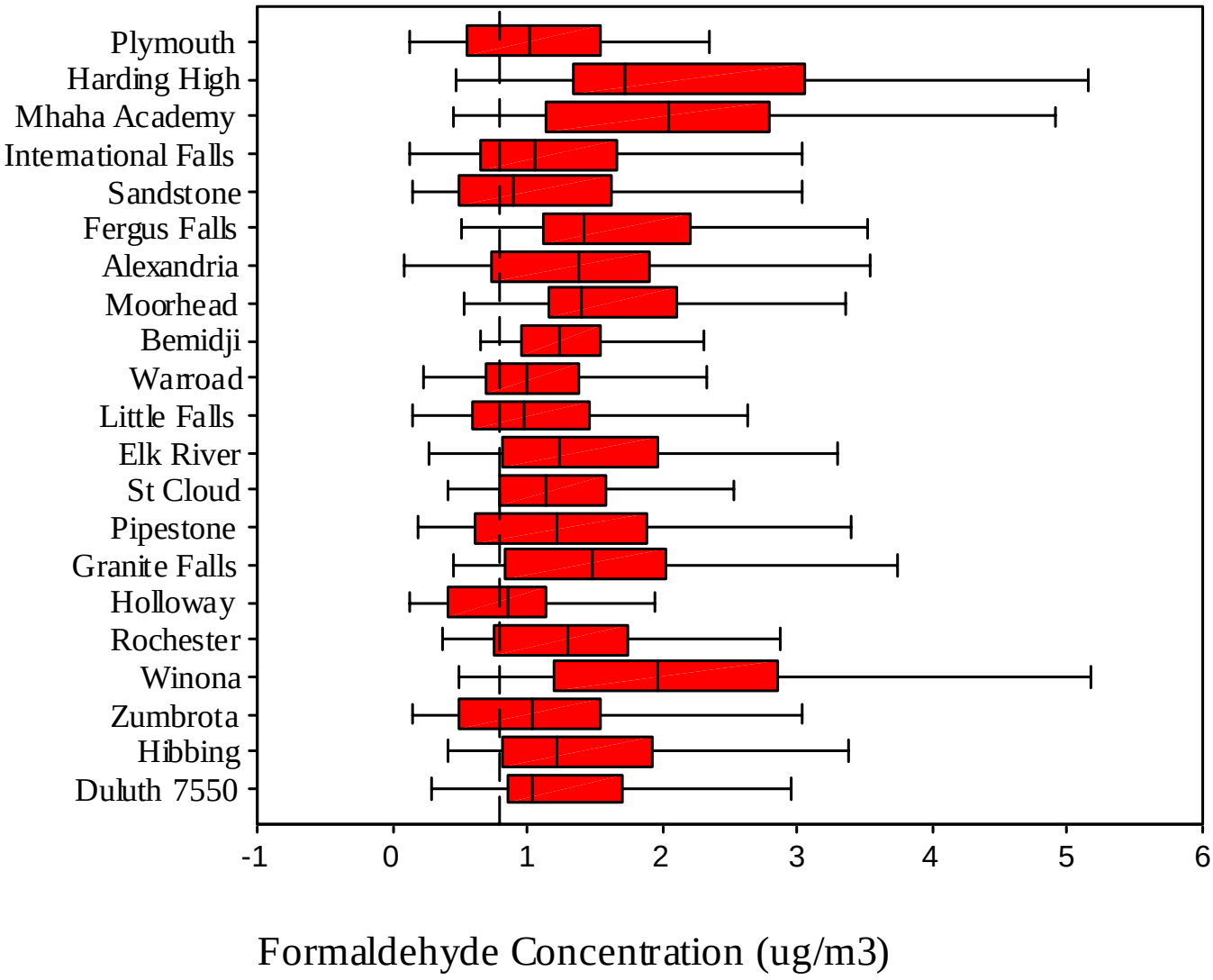
Mean formaldehyde concentrations ranged from 2.48-0.85 ug/m^3 between sites. Median formaldehyde concentrations ranged from 2.05-0.85 ug/m^3 between sites. All of the mean and median values at the SATMN sites exceeded the cancer health benchmark of 0.8 ug/m^3. The availability of fairly recent toxicity information relating to humans may result in this benchmark being somewhat increased in the future. However, all mean and median values were below the non-cancer benchmark of 3 ug/m^3.

Table 18: Formaldehyde Concentrations for Statewide Monitoring Network (1996-1999)

Site Name	**Site No.**	**Year Collected**	**N**	**Mean**	**Median**	**Standard Deviation**
Plymouth	260	1996-97	50	1.24	1.01	0.97
Harding High	871	1998-99	60	2.23	1.73	1.44
Minnehaha Academy	958	1997-98	56	2.48	2.05	1.96
International Falls 1241	1241	1996-97	57	1.28	1.05	0.85
Sandstone	1400	1996-97	48	1.17	0.89	0.87
Fergus Falls	2005	1997-98	59	1.66	1.42	0.80
Alexandria	2010	1996-97	56	1.42	1.38	0.87
Moorhead	2103	1998-99	58	1.70	1.40	0.90
Bemidji	2302	1998-99	55	1.38	1.25	0.56
Warroad	2401	1997-98	59	1.22	1.00	0.88
Little Falls	3049	1996-97	58	1.11	0.98	0.69
Elk River	3050	1997-98	61	1.43	1.23	0.83
St. Cloud	3052	1998-99	57	1.49	1.13	1.67
Pipestone	4002	1996-97	55	1.26	1.21	0.83
Granite Falls	4003	1997-98	53	1.98	1.47	2.74
Holloway	4500	1998-99	57	0.85	0.85	0.52
Rochester	5008	1997-98	60	1.36	1.30	0.67
Winona	5210	1998-99	59	2.16	1.97	1.22
Zumbrota	5356	1996-97	53	1.16	1.04	0.78
Hibbing	7014	1997-98	61	1.57	1.22	1.03
Duluth 7550	7550	1998-99	61	1.40	1.05	0.96
1996-97	--	1996-97	377	1.24	1.04	0.84
1997-98	--	1997-98	409	1.66	1.34	1.47
1998-99	--	1998-99	407	1.61	1.32	1.20
All Sites	--	1996-99	1193	1.51	1.24	1.25

Figure 12 includes SATMN data collected from 1996-1999. The center line within each box represents the median for the site. The box itself encompasses the 25th percentile to the 75th percentile. The bars at each end of the box represent the highest and lowest values that are not considered outliers. The vertical dotted line is located at the formaldehyde health benchmark (0.8 µg/m^3).

Figure 12: Formaldehyde Concentrations by Monitoring Site



When the SATMN five year study is completed, some conclusions regarding geographic distribution of concentrations may be possible. Since this update only looks at three years of data, it is difficult to make any conclusions regarding geographic or urban/rural differences. However, as Tables 19 and 20 indicate, urban sites tended to have higher concentrations of formaldehyde than small town or rural sites, although this observation was not entirely consistent.

Table 19: High Range of Formaldehyde Concentrations

Mean Range (2.48-2.16 ug/m3)		
Median Range (2.05-1.73 ug/m3)		
Site	**Year**	**Site Type**
Harding High	1998-99	SATMN-U
Mhaha Academy	1997-98	SATMN-U
Winona	1998-99	SATMN-U

Table 20: Low Range of Formaldehyde Concentrations

Mean Range (1.98-0.85 ug/m3)		
Median Range (1.47-0.85 ug/m3)		
Site	**Year**	**Site Type**
Plymouth	1996-97	SATMN-U
International Falls 1241	1996-97	SATMN-S
Sandstone	1996-97	SATMN-R
Fergus Falls	1997-98	SATMN-S
Alexandria	1996-97	SATMN-S
Moorhead	1998-99	SATMN-U
Bemidji	1998-99	SATMN-S
Warroad	1997-98	SATMN-S
Little Falls	1996-97	SATMN-S
Elk River	1997-98	SATMN-S
St. Cloud	1998-99	SATMN-U
Pipestone	1996-97	SATMN-S
Granite Falls	1997-98	SATMN-S
Holloway	1998-99	SATMN-R
Rochester	1997-98	SATMN-U
Zumbrota	1996-97	SATMN-R
Hibbing	1997-98	SATMN-S
Duluth 7550	1998-99	SATMN-U

*In most cases, the high range is statistically different from the low range. Both ranges are higher than the health benchmark.

Update on formaldehyde trends

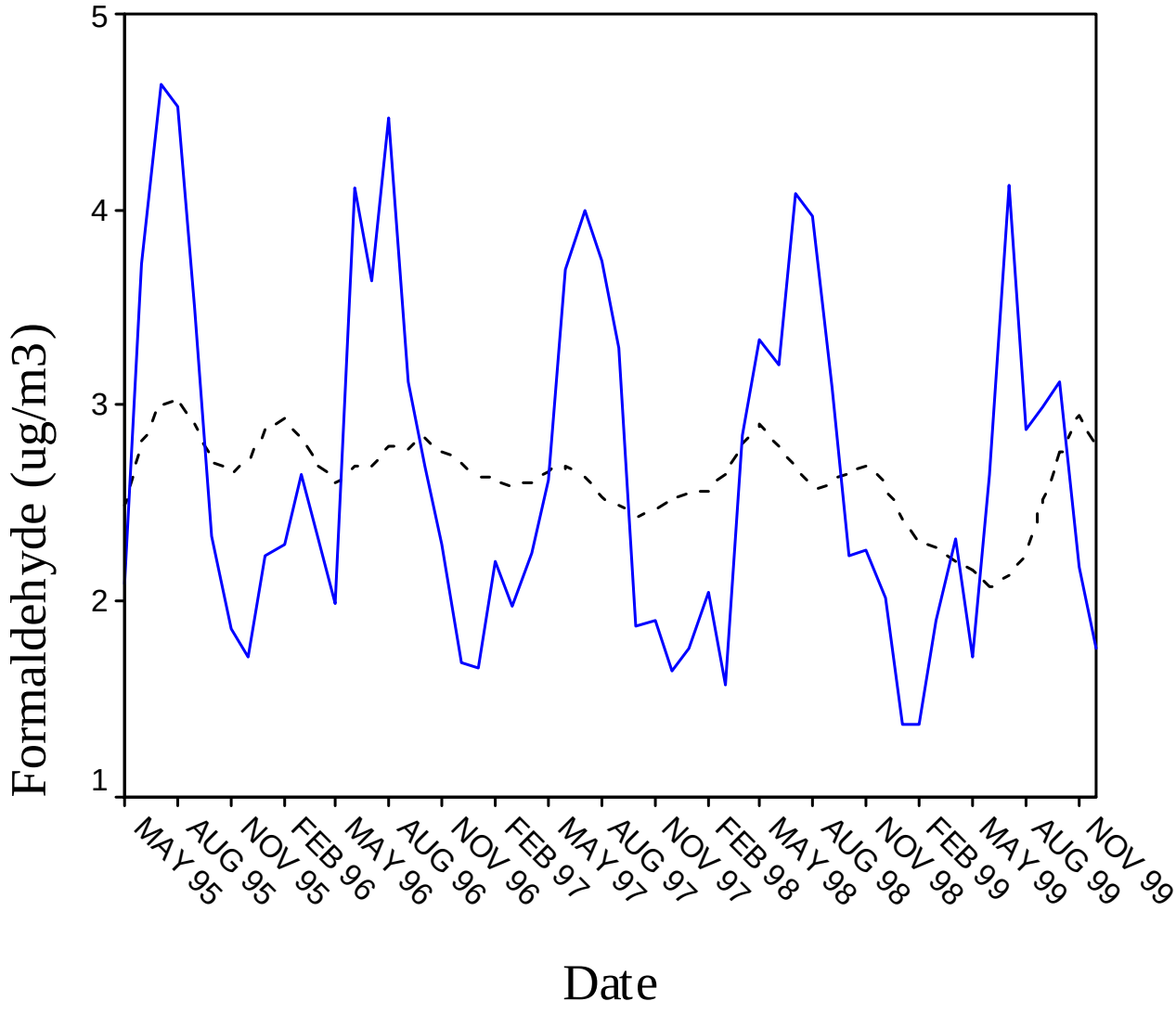
For formaldehyde trend analysis, five sites in urban areas such as the Twin Cities and Duluth were analyzed. These monitoring sites have concentrations dating back to 1991 which allowed for long-term trend analysis. In May 1995, the monitoring technique for carbonyls was changed by adding ozone scrubbing. Ozone present in ambient air will react with and destroy formaldehyde in a sample, so scrubbing the ozone will lead to higher and more accurate

measurements. Therefore, only data from May 1995 to the end of 1999 were analyzed for trends.

The formaldehyde data were seasonal, with maximum concentrations occurring in the summer and minimums in the winter. The Minneapolis Public Library site shows this seasonality most clearly, but the other four locations also show similar seasonal variation.

Figure 13 shows the Trend in formaldehyde measurements at site 945, the Minneapolis Public Library site. The solid line shows monthly average concentrations. The dotted line is a deseasonalized, smoothed trend line. All values are higher than the health benchmark for formaldehyde (0.8 µg/m^3).

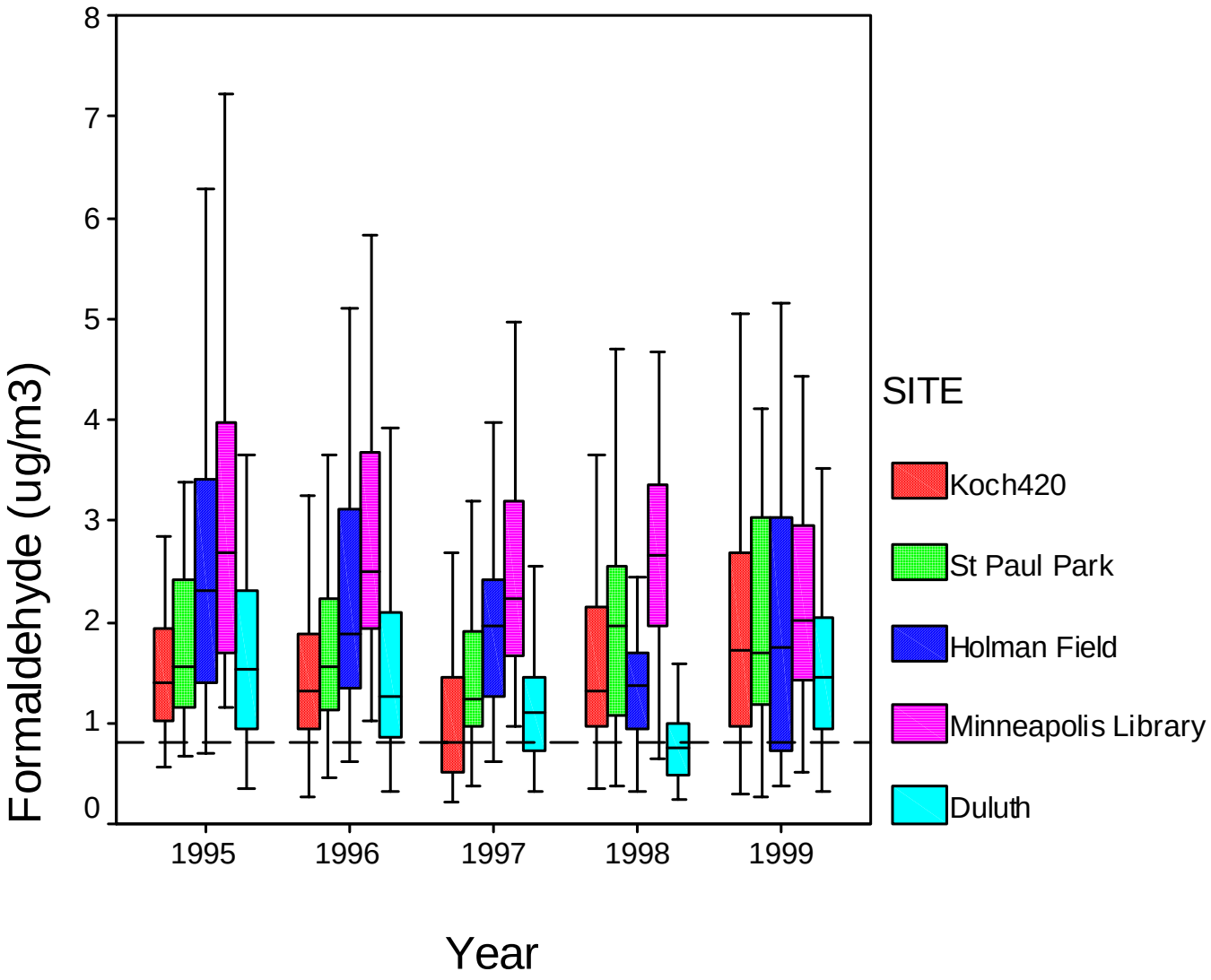
Figure 13: Formaldehyde Trends at the Minneapolis Library Monitoring Site



The Minneapolis Library site was the only site with a small, but statistically significant trend from 1995-1999. The Minneapolis Library site showed a small decrease in formaldehyde concentration of 0.086 µg/m^3 per year. The other sites did not show statistically significant changes in formaldehyde concentration for the five-year time-frame. Boxplots of the mean formaldehyde concentrations for the five trend sites are in the table below.

Figure 14 shows the concentrations of formaldehyde at five sites in Minnesota. The center line within each box represents the median for the site. The box itself encompasses the 25th percentile to the 75th percentile. The bars at each end of the box represent the highest and lowest values that are not considered outliers. The vertical dotted line is located at the formaldehyde health benchmark. (0.8 µg/m^3).

Figure 14: Formaldehyde Concentrations by Monitoring Site



According to the CEP final report (SAI, 1999), natural background levels of formaldehyde in 1981 were 0.25 ug/m^3.

Chemicals Below LDL

The following chemicals could not be analyzed in depth due to the low percentage of values above the lower detection limits. Some indications regarding concentrations can be derived from the monitoring data.

Arsenic

Only three percent of the arsenic monitoring data was above the LDL. However, the data indicates that arsenic concentrations across the state may be approaching the cancer health benchmark value of 0.002 ug/m^3 which is based on the MDH proposed health risk value (HRV). It would be helpful to analyze arsenic using a more sensitive technique than screening level x-ray flourescence.

1,3-Butadiene

1,3-butadiene began to be analyzed in the 1998-99 monitoring year. The adequacy of the monitoring technique is still somewhat uncertain. So far, only one percent of the monitoring data has been above the LDL. No exceedences of the cancer health benchmark of 0.04 ug/m^3 have been indicated by the SATMN data. This health benchmark is based on MDH's proposed health risk value (HRV). EPA will likely modify the 1,3-butadiene cancer assessment shortly (Koppikar, personal communication with MPCA, January, 10, 2001). This new assessment, if adopted by MDH, would result in a higher health benchmark.

There are indications that 1,3-butadiene breaks down too rapidly to be monitored at rooftop level monitoring sites. Street-level monitoring has resulted in higher concentrations being measured. If the benchmark is raised to a significantly higher value, there would likely be no need for a more sensitive analysis technique.

Chromium

Eighteen percent of chromium monitoring data was above the LDL. The data indicates the chromium levels may be approaching the chromium VI cancer health benchmark value of 0.0008 ug/m^3. The health benchmark for chromium VI is based on MDH's proposed health risk value (HRV). However, it is uncertain how applicable the chromium VI benchmark value is to the total chromium analyzed by MPCA. Minnesota-specific chromium speciation information is currently unavailable. It would be helpful to analyze chromium using a more sensitive technique than screening level x-ray flourescence.

Ethylene Dibromide

Only one percent of the ethylene dibromide data was above the LDL. The SATMN data indicates that a few sites may be approaching the cancer health benchmark of 0.05 ug/$m^{3.}$ This

health benchmark is based on the MDH proposed health risk value (HRV). According to the CEP final report (SAI, 1999), background levels of ethylene dibromide in 1991 were 0.0077 ug/m^3. A more sensitive monitoring technique would be helpful in further characterizing ethylene dibromide concentrations.

Nickel

Two percent of nickel data was above the LDL. However, the cancer health benchmark of $0.02ug/m^3$ is well above the LDL of 0.002 ug/m^3. This health benchmark is based on the MDH proposed health risk value (HRV) for nickel subsulfide which represents the most hazardous nickel compounds. The makeup of ambient nickel concentrations may be somewhat less hazardous. None of the SATMN data concentrations approach the cancer health benchmark. Therefore, it does not seem necessary to investigate a more sensitive monitoring approach for nickel at this time.

3.4 EPA's National-Scale Air Toxics Assessment (NATA)

On August 17, 2000, the Environmental Protection Agency (EPA) released the first two steps of a national assessment of the potential health risks associated with exposure to air toxics. The information includes 1996 estimated air toxics emissions and estimated outdoor concentrations of 32 common air toxics identified as posing the greatest potential risks to public health in urban areas. EPA will complete the next two steps of the assessment – estimates of exposure and health risk – and will submit the entire assessment for scientific peer review in early 2001.

When complete, the assessment will look at 34 air pollutants nationwide, in both urban and rural areas. Those pollutants include diesel particulate matter (DPM) and the 33 air toxics that the EPA identified in its Integrated Urban Air Toxics Strategy as posing the greatest potential risks to public health in urban areas. Diesel PM is an indicator of diesel exhaust, a pollutant mixture that EPA has recently proposed as a mobile source air toxic and is addressing in several regulatory actions. EPA plans to update this assessment every three years. The next assessment, due in 2003, will focus on 1999 emissions, concentrations and risks. These assessments will help EPA measure progress in reducing risks from exposure to toxics in the air.

In 1998, EPA released the findings of its Cumulative Exposure Project, which estimated 1990 outdoor levels of 148 air toxics nationwide. The NATA used the same computer model as the CEP, but predicts concentrations of just 34 pollutants. NATA is based on more recent meteorological and emissions data (1996) and will include a step that the Cumulative Exposure Project did not, that is the estimation national inhalation risk through computer modeling of inhalation.

The National-Scale Air Toxics Assessment comprises four steps, the first two of which were released on August 17, 2000:

1. A national inventory of air toxics emissions from sources in the contiguous 48 states, Puerto Rico and the Virgin Islands. The types of emissions sources in the inventory include large sources such as waste incinerators and factories and smaller sources,

such as dry cleaners, small manufacturers and wildfires. Also included in the inventory are emissions from on-road and non-road mobile sources, such as cars, trucks and boats. (Completed)

2. Estimates of average concentrations of toxics in the outdoor air. These estimates are developed using a computer model that analyzes a number of factors, including total emissions, the number of emissions sources in a particular area, weather patterns and pollution source characteristics. (Completed)

3. Estimates of population exposures. Exposure estimates are based on estimated outdoor concentrations and on a model that looks at the amount of an air toxic a person is likely to inhale in a year's time. The average concentration of a pollutant that people breathe is known as an exposure concentration. Estimating exposure is a key step in determining potential health risk. (Target date: early 2001)

4. Characterization of potential public health risks. This last phase of the assessment will look at cancer and other health problems potentially associated with breathing air containing toxics. This characterization will quantify, where appropriate, potential cumulative risks to public health caused by breathing air toxics in the outdoor air. It also will discuss the uncertainties and limitations of the assessment, and identify other potential risks to public health from air toxics. (Target date: early 2001)

About the NATA Emissions and Concentration Data

- In order to understand the overall performance and limitations of the concentration estimates, EPA compared them to available monitoring data. This quality assurance check was done for seven pollutants: benzene, perchloroethylene, formaldehyde, acetaldehyde, cadmium, chromium and lead. The results of the model-to-monitor comparison can be found at http://www.epa.gov/ttn/uatw/nata/nata2/draft5.html.

- The model-to-monitor comparisons generally showed reasonably good agreement between concentration estimates and monitored values. Due to uncertainties in modeled source locations, EPA cautioned that the model estimates are uncertain on a local scale, and that they are more reliably interpreted as being a value likely to be found somewhere within 30 kilometers of the census tract centroid location.

- In general, as shown in Figure 15, the model estimates tended to be lower than the monitored values. The medians of the model/monitor ratios were 0.92 for benzene, 0.52 for perchloroethylene, 0.65 for formaldehyde, 0.60 for acetaldehyde, 0.176 for lead, 0.18 for cadmium, and 0.15 for chromium. The performance of the model for metals was worse than for VOCs, in part because metals are emitted mainly from point sources, and the point source locations were often uncertain.

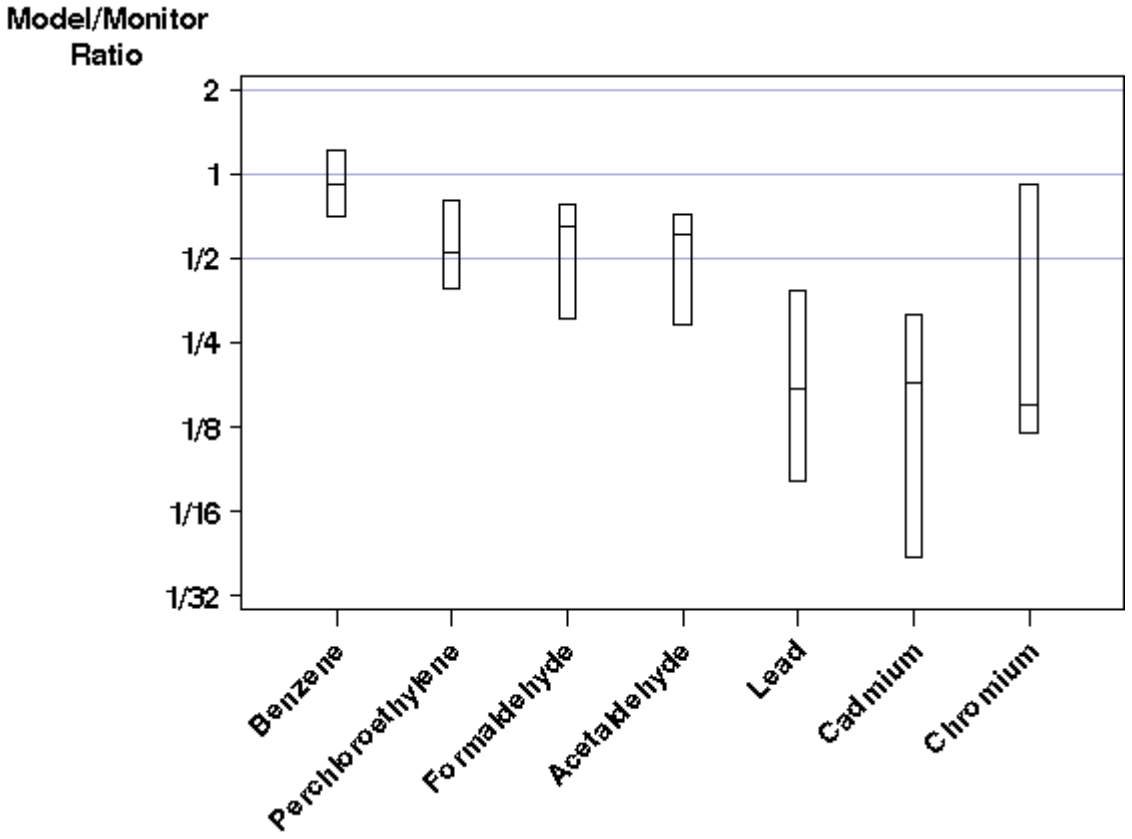


Figure 15. Box plot showing the distribution of model/monitor ratios for seven pollutants. The bottom of each box is the 25th percentile, the top is the 75th percentile, and the horizontal line in the middle is the median.

- The data show that both emissions and estimated concentrations of the 32 air pollutants generally were higher in urban than in rural areas. Urban areas tended to have heavier concentrations of factories, vehicles and other commercial activities that emit toxic air pollutants.

- Some pollutants, such as benzene (which is present in gasoline), were relatively evenly distributed across the country, while others, such as vinyl chloride, were linked to areas of industrial activity.

- No single state had the highest concentration of all 32 air toxics. Because different types of sources contribute to emissions in different areas of the country, the state with the highest average outdoor concentration varied by pollutant.

- No single type of source (major industrial, highway vehicles, non-road vehicles, and smaller sources) contributed the most to the estimated concentrations of all the 32 pollutants. However, results of the concentration analysis showed that, on a national level, smaller sources as a group dominated contributions for about half of the pollutants.

- The National-Scale Air Toxics Assessment web site is available at:

http://www.epa.gov/ttn/uatw/nata/

A Closer Look at the NATA Results for Minnesota

This analysis looks only at the county-level results from the NATA study. The more detailed census track-level results have recently become available but have not yet been fully analyzed by MPCA. The MPCA analyzed past EPA data from the Cumulative Exposure Project (CEP) in detail and compared the modeling results with monitored data (Pratt et al., 2000). In the future MPCA expects to conduct a similar analysis using the census tract level NATA results.

In the meantime we compared the NATA county level results with the CEP results aggregated to county level. Table 21 shows the comparisons that were made, and Figures 16-19 show the NATA/CEP comparisons graphically. In general, the NATA modeled concentrations compared favorably with the CEP modeled concentrations. Out of 33 pollutants (data on the 34th pollutant, diesel particles, were not available at the time of this analysis), the statewide average concentrations (averaged over all counties) were statistically equivalent between NATA and CEP for 17 pollutants. CEP concentrations were significantly higher for 6 pollutants, NATA concentrations were significantly higher for 5 pollutants, and comparisons were not possible for 5 pollutants. For most pollutants, the NATA and CEP county average concentrations were highly correlated.

For 19 of 27 pollutants where comparisons were possible, the NATA and CEP results were within a factor of two of one another (considered very good agreement for modeling studies). For most of the pollutants where the results were not within a factor of two, the reason for the discrepancy is believed to lie in suspect emissions data, either for NATA or for CEP.

Table 21 also shows the number of counties in which the NATA modeled average concentration of a pollutant exceeded a health benchmark value (identified in Table 22). Refer to Table 22 for information relating to the basis for selecting the health benchmarks used, including their basis, EPA's weight of evidence rating for carcinogenicity, and uncertainty factors for the noncancer-based health benchmarks. Benzene exceeded the lower bound of its benchmark in 11 counties. Acrolein concentrations exceeded the benchmark in 54 counties, 1,3-butadiene in 52 counties, carbon tetrachloride in 87 counties, chromium (when assessed using the benchmark for its most hazardous form) in 12 counties, and formaldehyde in 7 counties. The sum of 7 carcinogenic polycyclic aromatic hydrocarbons (PAHs) were assessed using a health benchmark that was adjusted to reflect the estimated proportion of their emissions (i.e., a benzo[a]pyrene equivalency approach) which resulted in exceedences in 0 counties. The emissions inventory for the 7 carcinogenic PAHs entails significant uncertainty and this screening assessment is likely to underestimate the risk for these compounds. Preliminary NATA inventory for diesel particulate ambient concentration information was available, and when screened against the California EPA health benchmark, there were exceedences in all 87 counties. Ambient concentrations for dioxins were not yet available so were not assessed.

Table 21. A comparison of the NATA and CEP modeling results for Minnesota counties.

Pollutant	NATA	CEP	Signifi-cance Level #	Correlation coefficient (r)	Ratio NATA / CEP	MPCA Health Benchmark Value	NATA - No. Counties Above Benchmark	Notes
Acetaldehyde	0.1340	0.1270	n.s.d.	0.97 **	1.06	5	0	
Acrolein	0.0490	0.0290	+++	0.89 **	1.69	0.02	54	
Acrylonitrile	0.000131	0.000264	n.s.d.	0.12	0.50	0.1	0	
Arsenic	0.000032	0.0002	+	0.57 **	0.20	0.002	0	suspect CEP emission factor
Benzene	0.8260	0.7930	n.s.d.	0.92 **	1.04	1.3	11	
Beryllium	0.0000036	0.0000035	n.s.d.	0.05	1.03	0.004	0	
1,3-butadiene	0.1050	0.0340	+++	0.92 **	3.09	0.04	52	suspect NATA emission factor
Cadmium	0.000092	0.000047	n.s.d.	0.53 **	1.94	0.006	0	
Carbon_tetrachloride	0.8800	0.8800	n.s.d.	0.94 **	1.00	0.7	87 (all)	
Chloroform	0.0839	0.0852	n.s.d.	0.67 **	0.98	100	0	
Chromium	0.000693	0.000307	+	0.7 **	2.26	0.0008	12	assumed hexavalent chromium
Coke Oven Emissions	0.0000	NA	NA	NA	NA	0.02	0	
1,3-dichloropropene	0.0160	0.0071	+++	0.98 **	2.27	3	0	
Ethylene_dibromide	0.0079	0.0077	n.s.d.	-0.07	1.03	0.05	0	
Ethylene_dichloride	0.0613	0.0614	n.s.d.	0.1	1.00	0.4	0	
Ethylene_oxide	0.0236	0.000236	+++	0.9 **	100.00	0.1	0	suspect NATA emission factor
Formaldehyde	0.4550	0.4390	n.s.d.	0.94 **	1.04	0.8	7	
Hexachlorobenzene	0.000093	0.000093	n.s.d.	0.13	1.00	0.02	0	
Hydrazine	0.0000001	NA	NA	NA	NA	0.002	0	
Lead	0.0008	0.0017	++	0.48 **	0.43	0.8	0	suspect CEP emission factor
Manganese	0.0004	0.0011	+++	0.54 **	0.36	0.2	0	suspect CEP emission factor
Mercury_compounds	0.0015	0.0016	+++	0.65 **	0.97	0.3	0	
Methylene_chloride	0.2040	0.2070	n.s.d.	0.9 **	0.99	20	0	
Nickel	0.0007	0.0010	n.s.d.	0.44 **	0.73	0.02	0	suspect CEP emission factor

Pollutant	NATA	CEP	Signifi-cance Level #	Correlation coefficient (r)	Ratio NATA / CEP	MPCA Health Benchmark Value	NATA - No. Counties Above Benchmark	Notes
7-PAH	0.0075	NA	NA	NA	NA	0.05	0	
PCBs	0.0004	0.0004	n.s.d.	0.03	1.01	0.1	0	
POM	0.1050	0.0512	+++	0.95 **	2.05	NA	NA	NATA includes wood burning emission factor
Propylene_dichloride	0.000004	0.000021	n.s.d.	0.04	0.21	4	0	
Quinoline	0.0000004	NA	NA	NA	NA	NA	NA	
1,1,2,2-tetrachloroethane	0.00014	NA	NA	NA	NA	0.2	0	
Tetrachloroethylene	0.1550	0.2150	+++	0.97 **	0.72	1.7	0	
Trichloroethylene	0.0960	0.1620	+++	0.88 **	0.59	5	0	
Vinyl_chloride	0.0009	0.0009	n.s.d.	0.22 *	0.97	1	0	
Diesel Particulates	0.94	NA	NA	NA	NA	0.033	87 (all)	

NA - no comparison possible
Whether the mean difference between NATA and CEP
(averaged over all counties) is significantly different from zero.
'n.s.d.' = no significant difference; '+' = p<.05; '++' = p<.01; '+++' = p<.001.
* - Correlation coefficient significant @ p=0.05; ** @ p=0.01; *** @ p=0.001

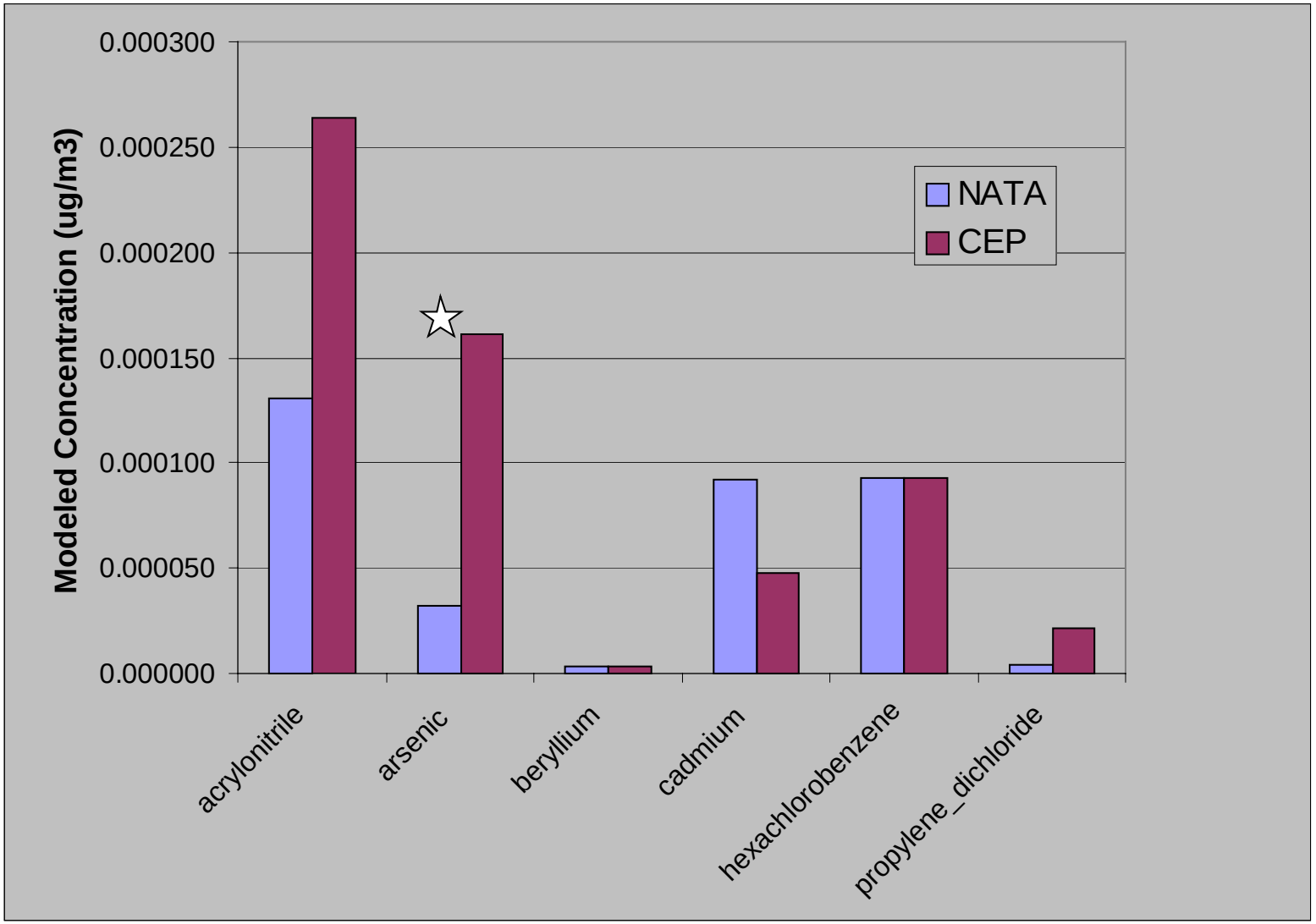
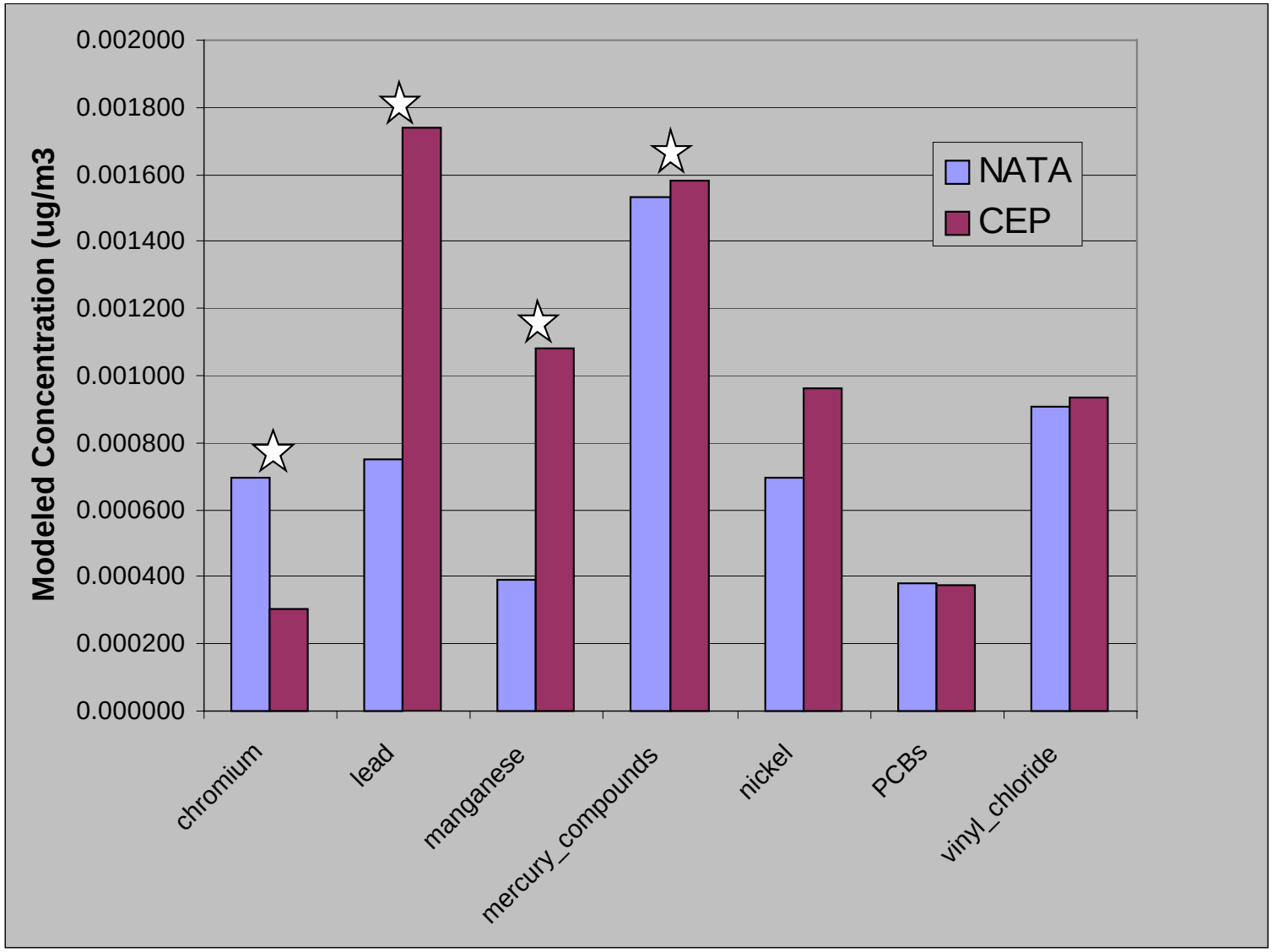


Figure 16. A comparison of the NATA and CEP average concentrations for Minnesota counties for selected pollutants. A star indicates that there is a statistically significant difference between the two estimates.



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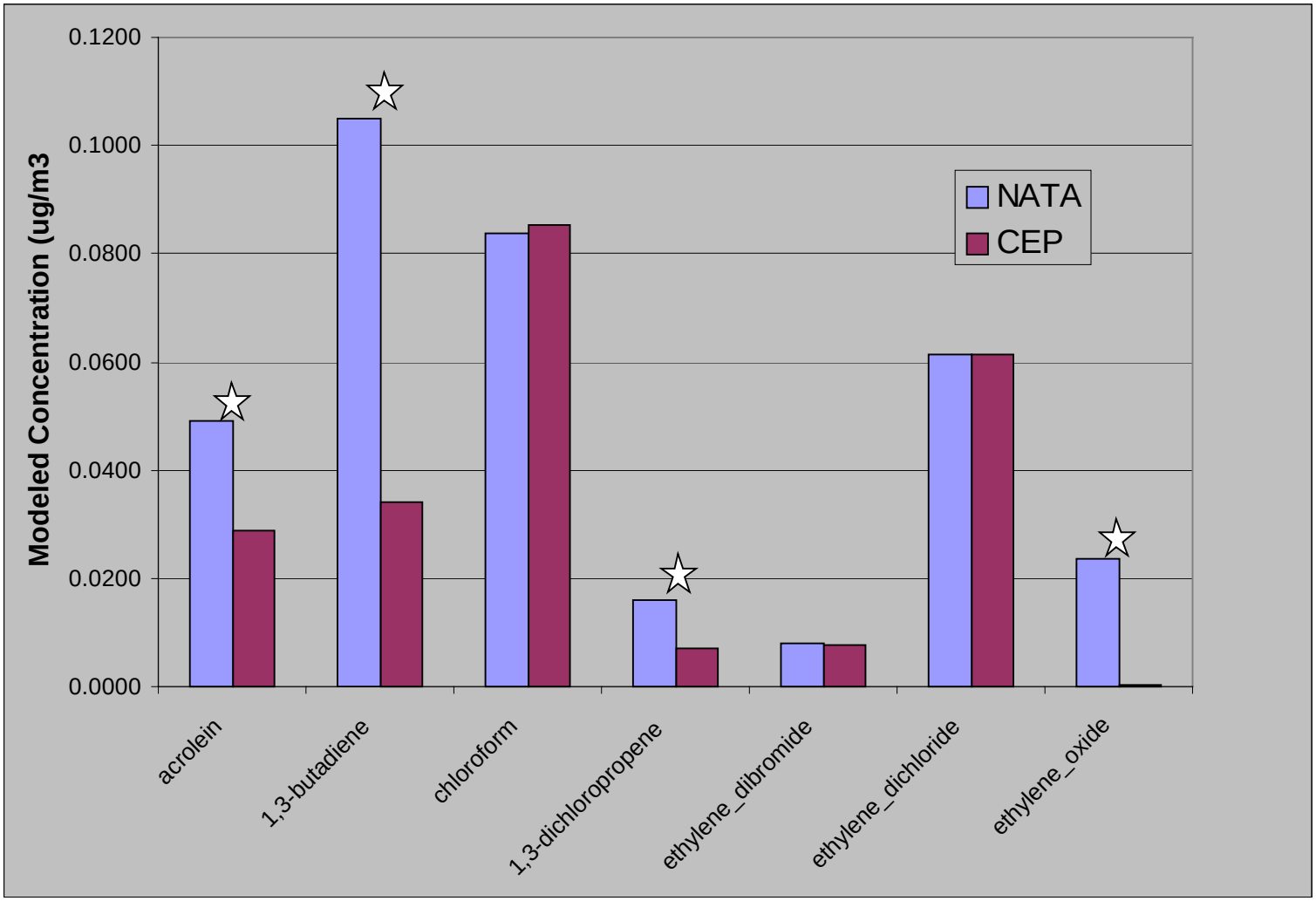

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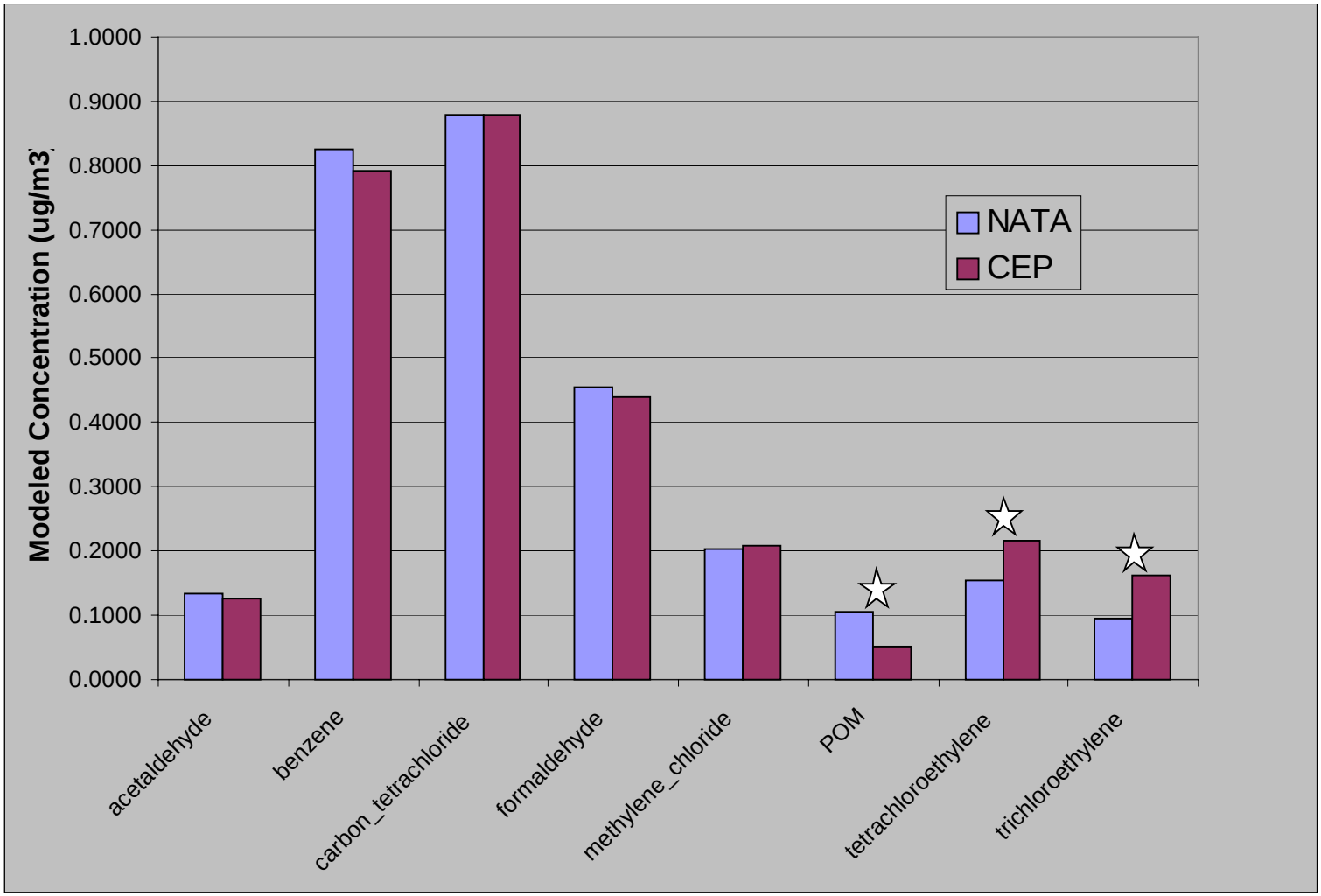

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4.0 Health Information

Health benchmarks are chemical concentrations in the air believed to be safe based on available information. They are developed and chosen in different ways by different organizations.

4.1 Health Benchmarks: Selection and Development

The MPCA relies on the following hierarchy to identify inhalation health benchmarks for protection from cancer or from other effects:

(1) MPCA's preferred benchmarks are the Minnesota Department of Health (MDH) proposed Health Risk Values (HRVs). The MDH proposed HRVs for chemicals in air if adequate health risk information was available.
(2) For chemicals lacking HRVs, MPCA used available air quality health benchmark information from other agencies including U.S. EPA (http://www.epa.gov/iris) and California EPA (http://www.oehha.ca.gov/air/hot_spots/index.html). and the most current version of the EPA's Health Effects Assessment Summary Tables (HEAST).
(3) For some chemicals, no health benchmark information was available from MDH or these other agencies. In this case, MPCA may assume a health benchmark developed for a different chemical approximates the health benchmark for the chemical of interest.
(4) In some cases, additional guidance from MDH or other additional information may supplement this hierarchy for identifying health benchmark values.

MDH Proposed Inhalation Health Risk Values (HRVs) for Long-term Exposures

The Minnesota Department of Health (MDH) proposed inhalation health risk values (HRVs) for Minnesota. These are concentrations of individual chemicals or chemical mixtures in air that MDH scientists are confident pose no appreciable risk to human health. As of January 2001, the HRVs have not yet been adopted into rule.

For exposures to many toxic air pollutants, the amount of harm depends on how long people breathe the polluted air. Proposed HRVs were calculated for short-term (acute) and/or long-term (chronic) exposures. Chronic HRVs, used for comparison with annual average ambient outdoor concentrations, are discussed in this appendix.

Sources of Toxicity Information

MDH scientists develop inhalation HRVs by reviewing scientific information about the harmful effects of the air pollutant. They use several types of information including epidemiological studies, animal studies, and in vitro studies, to understand how chemcials may harm people.

Epidemiology studies are used to investigate possible cause and effect relationships between a hypothesized risk factor (such as a chemical) and a human disease. Often these studies are done using information from worker exposures in occupational settings. These studies are challenging and involve an extensive resource commitment, but when done well can provide the best evidence of disease causation. Difficulties in epidemiology studies for cancer include: long times between exposure and the cancer outcome, lack of good exposure information, and confounding factors (e.g., smoking). By itself smoking is strongly related to several diseases, so this can overwhelm the effects of much less important causes of the same diseases. In order to determine that a particular risk factor, such as benzene, causes a particular disease, such as leukemia, a number of conditions must be met:

- Strength of Association – The larger the relative risk (i.e., the ratio of the amount of disease in the more chemically exposed population to the amount of disease in the less exposed population) the greater likelihood that the chemical is causally related to the disease.
- Consistent Association - Higher exposures should result in more disease.
- Logical timing – The chemical exposure must occur before the disease.
- Specific Association – The greater the extent to which the chemical exposure is a major factor in predicting the disease the better. When there are other key factors in disease causation, it is more difficult to show the link. For example, because smoking causes a large portion of the lung cancer deaths, it is difficult to detect the relatively small additional risk that toxic air pollutants, including diesel exhaust particles, may contribute.
- Biological Plausibility– A scientific explanation for how a chemical may cause the disease strengthens the link

Because human information is very limited for most toxic air pollutants, scientists often conduct studies on laboratory animals. Animal studies are performed under controlled laboratory conditions so that a variety of health effects can be studied by exposing animals to pollutants at varied concentrations and for varied time periods. When this information is extrapolated to humans, it is important to be aware of the differences between the human and animal response.

Short term tests on isolated tissues, cells, single celled organisms, or cellular components study whether a chemical may cause cancer by testing whether it will chemically alter DNA, (i.e., is it mutagenic).

Health Risk Value Derivation – Minnesota Department of Health

MDH is developing proposed HRVs for breathing toxic air pollutants using two general approaches depending on whether the chemical is believed to have a threshold for causing cancer or other types of adverse (noncancer) effects. In the future, as scientists better understand the biological mechanisms by which these chemicals cause harm, and specifically whether each chemical has a threshold for the various effects, this information may be used in developing health benchmarks.

MDH uses a conservative approach to develop the HRVs (i.e., by design MDH chooses to err in the direction of protecting public health). This approach is consistent with the traditional EPA risk assessment guidelines. Information describing the specific methodology and rationale for developing the HRVs can be obtained from MDH. A brief description of the HRV development method is provided below.

To develop proposed HRVs for chemicals that may cause cancer, MDH assumes even the smallest exposure has some potential to cause cancer. This approach assumes that as a person's exposure increases, the chance of getting cancer also increases.

Because it is assumed that exposure to a single molecule of a carcinogen could cause cancer, HRVs for carcinogens are derived based on what MDH considers a negligible target cancer risk level. Proposed HRVs for carcinogens are calculated lifetime exposure concentrations that may result in a 1 in 100,000 or less chance of getting cancer. This 1 in 100,000 estimate is an upper estimate of the cancer risk (typically a 95 percent upper bound) and the true cancer risk is likely to be lower and may be zero. One way to interpret this risk is that there could be one person or less, within a population of 100,000 people breathing this specific toxic air pollutant exposure for 70 years, who may develop cancer because of this exposure. Scientists believe there is at least a 95% chance there will be one or fewer additional cases of cancer from this air pollutant level of exposure.

The benzene HRV was developed in a similar manner with a few exceptions. The benzene HRV is a range and it was developed using the maximum likelihood estimate approach. Epidemiology studies of people exposed to benzene show a clear link between exposure and cancer (i.e., chiefly acute myelogenous leukemia in humans) at concentrations in the range of 30,000 ug/m3 benzene and above. The maximum likelihood estimate approach provides a more likely cancer risk estimate than the often used 95% upper bound estimate approach. The HRV for long term exposure to benzene is given as a range from 1.3 ug/m3 to 4.5 ug/m3. The range reflects some of the uncertainty in the assessment. Exposure to benzene concentrations in the HRV range, for a 70-year period, may cause a 1 in 100,000 chance of getting cancer.

In contrast to carcinogenic effects, the MDH approach to developing non-cancer benchmarks assumes that no adverse health effects will be observed from very small exposures to chemicals that do not cause cancer. A well-designed toxicity test will generally show that, for these chemicals, there is a level of exposure called the threshold, below which exposure is not harmful. This threshold is the amount of chemical that an animal can take into the body, metabolize, and pass out of the body without harm.

MDH develops proposed HRVs for protection from adverse effects other than cancer (noncancer effects) by first identifying an exposure concentration near or below the lowest threshold for any known health effects. The HRV is set at a lower concentration than the near threshold level by applying uncertainty factors. For example, MDH may use uncertainty factors to account for:

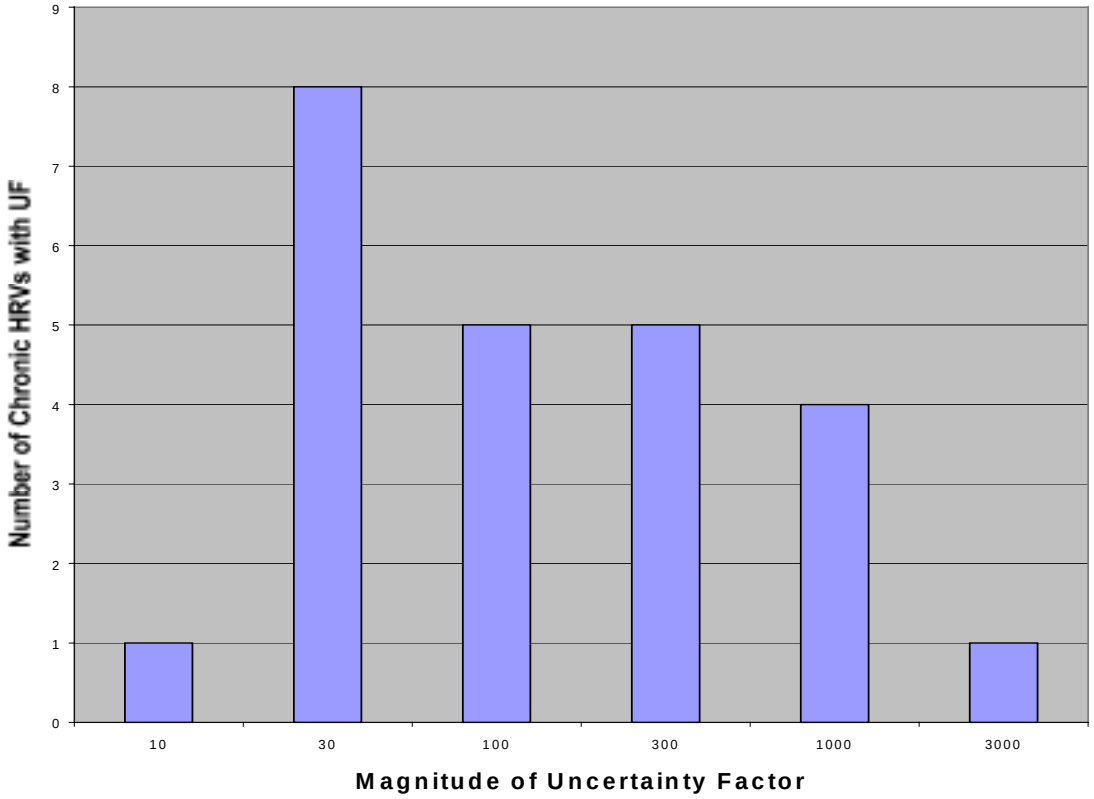
- the variation in sensitivity among the members of the human population;

- the uncertainty in extrapolating animal data to estimate human health effects;
- the uncertainty in extrapolating from data obtained in a study that is of less than lifetime exposure;
- the uncertainty in using the lowest observable adverse effect level data rather that the no observed adverse effect level data; and
- an incomplete data base, generally with regards to developmental or reproductive toxicity.

(excerpted from Minnesota Department of Health, Health Risk Values rule, Briefing Paper #8, October 1996).

The near threshold level is divided by a combination of these uncertainty factors to calculate the HRV. Overall most uncertainty factors range from 30 to 1000 and result in proposed HRV concentrations that are typically 30 to 1000-times lower than the lowest measured threshold for health effects. Figure 20 illustrates the distribution of uncertainty factors used in developing the proposed chronic HRVs for non-cancer effects.

Figure 20. Distribution of Chronic HRV Uncertainty Factors for Non-cancer Effects



Health Benchmarks Derivation - Other Agencies

For toxic air pollutants lacking MDH-derived proposed HRVs, MPCA used similar values available from other organizations (listed below). These organizations provide

reference air concentrations (in ug/m3) for protection against non-cancer effects and unit risk values (in m3/ug) for cancer effects. In a manner analogous to the HRV development process, health benchmark concentrations for cancer effects are calculated by dividing the 1 in 100,000 MDH target excess cancer risk value by the unit risk values.

- U.S. Environmental Protection Agency Integrated Risk Information System (IRIS) RfCs and unit risk values (http://www.epa.gov/ngispgm3/iris/index.html)
- California Cancer Potency Factors (unit risk values) and Reference Exposure Levels (RELs) (http://www.oehha.ca.gov/air/hot_spots/index.html)
- U.S. Environmental Protection Agency Health Effects Assessment Summary Tables (HEAST) RfCs and unit risk values (EPA, 1997)

Surrogate Health Benchmarks

For many toxic air pollutants there are no available proposed HRVs or scientifically derived regulatory health benchmarks specific to the substance in question. For these chemicals or mixtures it is not reasonable to assume that all concentrations are safe. Therefore, for these pollutants, and especially when available information suggests that environmental levels may be of concern, surrogate health benchmarks can be useful as very rough approximations of acceptable exposure concentrations. Surrogate health benchmarks are assigned by assuming pollutants with similar chemical structures have similar toxic properties and therefore should be assigned similar health benchmarks. An example of a surrogate health benchmark was the use of a benzo[a]pyrene health benchmark for particulate organic matter in the MPCA Staff Paper and a recent publication (MPCA, 1999, Pratt et al., 2000).

Like proposed HRVs and other health benchmarks, surrogate health benchmarks should not be interpreted as accurate measures of concentrations which will result in actual health effects. Rather, they are useful as health protective (precautionary) air concentrations when little other information is available. For chemicals lacking other health benchmarks, surrogate health benchmarks are used because without them it may falsely be concluded that pollutants lacking health benchmarks pose no risks at any concentrations.

Additional Sources of Benchmark Values

A final source of health benchmark information, that may supersede the standard hierarchy, includes specific recommendations from MDH. MDH may recommend alternate health benchmarks for MPCA to use based on updated toxicity information not yet available through EPA. An example is a recent policy memo relating to an increase in the chloroform health benchmark value. Benchmark information may also be used from other credible sources.

Health Benchmarks for Use in Assessing the NATA Concentrations for this Report

Table 22 provides a summary of the inhalation health benchmarks used to assess the pollutants of concern for this analysis.

Table 22. Health Benchmarks Used for Analysis of NATA data

	NATA Chemicals / Urban Hazardous Air Pollutants	CAS Number	MPCA Health Benchmark for NATA Comparison (ug/m3)	Source	EPA Wt. Evid.	Non-cancer Uncert-ainty Factor	Basis	Comment
	acetaldehyde	75-07-0	5	HRV	B2	1000	Cancer	
*	acrolein	107-02-8	0.02	IRIS		1000	Noncancer	
	acrylonitrile	107-13-1	0.1	HRV	B1	1000	Cancer	
*	arsenic compounds	7440-38-2	0.002	HRV	A	NA	Cancer	See note (6)
*	benzene	71-43-2	1.3	HRV	A	NA	Cancer	Lower bound HRV range; See note (6)
	beryllium compounds	7440-41-7	0.004	HRV	B1	10	Cancer	
*	butadiene(1,3-)	106-99-0	0.04	HRV	B2	NA	Cancer	See note (1)
	cadmium compounds	7440-43-9	0.006	HRV	B1	NA	Cancer	
*	carbon tetrachloride	56-23-5	0.7	IRIS	B2	NA	Cancer	
*	chloroform	67-66-3	100	MDH	B2	1000	Noncancer	MDH policy (1/11/01).
*	chromium VI	18540-29-9	0.0008	HRV	A		Cancer	For chromiumVI. Application to total chromium may overestimate risk. See note 6.
	coke oven emissions	8007-45-2	0.02	HRV	A		Cancer	
	dichloropropene(1,3-)	542-75-6	3	HRV	B2	30	Cancer	
	dioxin	1746-01-6	0.0000003	CAL EPA	A		Cancer	NATA emissions estimates not yet available. SAB draft for wt of evid.
*	ethylene dibromide	106-93-4	0.05	HRV	B2	NA	Cancer	
	ethylene dichloride	107-06-2	0.4	IRIS	B2	NA	Cancer	
	ethylene oxide	75-21-8	0.1	CAL EPA	B1	NA	Cancer	
*	formaldehyde	50-00-0	0.8	HRV	B1	10	Cancer	See note (2).
	hexachlorobenzene	118-74-1	0.02	IRIS	B2		Cancer	
	hydrazine	302-01-2	0.002	HRV	B2	NA	Cancer	
	lead compounds	7439-92-1	0.8	CAL EPA	B2		Cancer	
	manganese compounds	7439-96-5	0.2	HRV		100	Noncancer	
	mercury compounds	7439-97-6	0.3	IRIS		30	Noncancer	Elemental mercury
	methylene chloride	75-09-2	20	HRV	B2	100	Cancer	
*	nickel compounds	7440-02-0	0.04	CAL EPA	A	30	Cancer	For nickel subsulfide Not modeled in NATA

	polychlorinated biphenyls (PCBs)	1336-36-3	0.10	IRIS	B2		Cancer	
*	polycyclic organic matter (POM)	NA	NA		Varies		Cancer	Carcinogenic portion assessed as 7 cPAHS - may underestimate risks
	propylene dichloride	78-87-5	4	IRIS	B2	300	Noncancer	
	quinoline	91-22-5	NA		C			
	tetrachloroethane (1,1,2,2-)	79-34-5	0.2	IRIS	C		Cancer	
	tetrachloroethylene (perchloroethylene)	127-18-4	1.7	CAL EPA	B2-C	NA	Cancer	
	trichloroethylene	79-01-6	5	CAL EPA	B2-C	100	Cancer	
	vinyl chloride	75-01-4	1	HRV	A	30	Cancer	
	Diesel Particulates	NA	0.033	CAL EPA		30	Cancer	See Appendix E.
	7 Carcinogenic PAHs	NA	0.05	MPCA CALC.	B2		Cancer	CAL EPA's PEF; EPA benzo[a]-pyrene unit risk (See notes 3, 5, 7)
	Benzo[a]pyrene	50-32-8	0.011	EPA - NCEA	B2		Cancer	See note (4) Not modeled for NATA

Notes:
Cancer benchmarks for a given target risk level, e.g., 1 in 100,000 (or 10-5) are derived by dividing the target risk by the unit risk estimate (URE): 10-5/URE.
* Highlighted in the Staff Paper (MPCA, 1999)
HRV is the Minnesota Department of Health, Draft Health Risk Values, October, 2000.
IRIS is the U.S. Environmental Protection Agency Integrated Risk Information System, December, 2000.
CAL EPA is the California Environmental Protection Agency Office of Environmental Health Hazard Assessment. Cancer unit risks, April 1999; chronic reference exposure levels (RELs), May 2000.
(1) EPA's draft reassessment shows a 25 fold decrease in the cancer potency estimate (for a benchmark of 1 ug/m3) and a 2 fold decrease in the RfC (to 4 ug/m3) (Koppikar, 2001). As of 1/10/01 consensus review was incomplete
(2) Formaldehyde HRV may not be protective for hypersensitive individuals (MDH draft HRV rule, October, 2000). Note the IRIS unit risk may decrease in the future.
(3) PEF - Potency equivalency scheme for PAHs
(4) NCEA - EPA's National Center for Environmental Assessment provided a draft inhalation unit risk value for benzo[a]pyrene. This is very close to the CAL EPA value.
(5) Benchmark, adjusted for the relative proportion of 7 PAHs, was based on MN 96 Inventory estimates for 7 carcinogenic PAHs, the IRIS benzo[a]pyrene unit risk, and CAL EPA PEF weighting scheme for PAHs.
(6) Arsenic, benzene and chromium VI unit risks were derived using a maximum likelihood estimator (MLE) method rather than 95% upper bound
(7) Benchmark depends on relative proportion of 7 PAHs. This estimated benchmark was based on MN 96 Inventory estimates for 7 carcinogenic PAHs, the IRIS benzo[a]pyrene unit risk, and CAL EPA PEF weighting scheme for PAHs.
Koppikar, 2001. Dr. Aparna Koppikar, EPA's contact for the 1,3-Butadiene toxicity reassessment, provided this information to MPCA on January, 10, 2001.
NA - Not available

4.2 Health Benchmarks: Use and Uncertainty

Comparing ambient air concentrations with inhalation health benchmarks can provide a first estimate of toxic air pollutants that may be of concern. Several issues must be

understood when comparing health benchmarks to ambient concentrations and when interpreting risk descriptions.

Actuarial (Most Likely) Risks vs. Health Benchmark Risk Estimates

It is very important that people using health benchmark (or upper bound cancer risk) information understand what it means and what it doesn't mean. In daily life people hear about other risk estimates, for example, of the chance of being killed in a car accident. Records are kept of the actual number of auto-accident deaths that occur. These familiar actuarial risk estimates are close to being accurate, i.e., to the true likelihood or chance of being killed in a car accident. They can be developed with a reasonable amount of precision and certainty. It is easy to count these deaths and the cause of death is clear (auto accidents). Many common measures of public health risks, such as injury risks and certain disease rates, are of this nature.

Regulatory scientists develop health benchmarks based on a very different kind of risk information. Directly measured statistics describing the number of people who actually get cancer after being exposed to the relatively low levels of chemicals present in the ambient environment do not exist. For example, because cancers develop a long time following the exposure, and can occur for many different reasons, it is difficult to identify health effects specifically from low air pollutant exposure levels. Current epidemiological methods are not sensitive enough to detect an increased cancer risk of 1 in 100,000. In Minnesota, an individual's current lifetime risk of cancer from all factors (including smoking, diet, alcohol, etc.) is roughly 1 in 2. A study that could detect this additional risk would have to have the statistical power to detect roughly a 0.005% increase. Estimates of appropriate health benchmarks and cancer risks must be made based on findings from animal studies or human epidemiology studies involving exposures to much higher levels than the ambient concentrations in outdoor air.

The health benchmarks developed for cancer effects have been used to develop upper bound excess cancer risk estimates. For example, lifetime exposures to air concentrations at the health benchmark concentrations, by definition, would result in excess cancer risks of up to 1 in 100,000. Similarly, lifetime exposures to air concentrations two times the HRV would be associated with up to a 2 in 100,000 excess cancer risk.

These risk estimates probably don't predict how many people would really get cancer from the given chemical exposure. These upper bound excess cancer risk estimates are intentionally designed to be higher than the real chance of getting cancer from a chemical exposure situation.

Variable Quality of Health benchmarks

Health-benchmarks are developed to be air concentrations likely to be without appreciable risk of harmful effects on humans. However, depending on the chemical, the level that could cause harm may be slightly higher than, or far above, the health benchmark. Lower health benchmarks may occur either because the chemical is

relatively more dangerous or because it is a chemical for which little information is available. The use of health benchmarks for accurate prioritization is therefore problematic.

The health benchmarks are of varying quality with regard to how far they are below actual human effect levels. Although useful for setting protective levels below which appreciable harm is not expected, the health benchmarks are not designed to accurately predict risk and different health benchmarks involve different amounts of uncertainty. For chemicals with an extensive database of human toxicity information covering a broad range of concentrations, there is less uncertainty in setting the health benchmarks. For other chemicals for which information is limited, larger uncertainty factors or farther extrapolations are involved in developing the health benchmarks. In addition, health benchmarks are developed based on the available knowledge of adverse effects. For subtle and difficult to measure effects that have not been identified in toxicity or epidemiology studies, the health benchmark may not be protective of these unknown effects.

Health benchmarks are not available for many airborne chemicals for which there is essentially no toxicity information. Health benchmarks are available for some of the high-use chemicals, which are often better understood. The HRV development process is limited to the use of available peer reviewed toxicological and epidemiological information. Due to the intensive data requirements for HRV development, MDH has been unable to develop HRVs for many chemicals present in ambient air.

By policy, MDH has not developed HRVs for the criteria air pollutants (ozone, lead, nitrogen oxides, sulfur dioxide, carbon monoxide, and particulate matter). Similarly, EPA has not included toxicity information for these air pollutants in the IRIS database. Unlike many air toxic chemicals for which there is little toxicity information, extensive human health effect information is available in the literature and in EPA Criteria Documents for the criteria pollutants, which are well known to have caused measurable and serious effects at ambient concentrations. These effects lead to the passage of the Clean Air Act and the enforceable National Ambient Air Quality Standards (NAAQS).

MPCA suspects that if the HRV development protocol was used to develop HRVs for criteria pollutants such as fine particulate matter, the HRVs would be lower than the current NAAQS.

Uncertainty in Exposures

People’s exposures to chemicals in the air fluctuate daily and during their lifetimes. In contrast, health benchmarks are developed to reflect average lifetime exposure concentrations. Currently, most ambient air assessments based on measured air concentrations rely on monitors located at a central location. These may not accurately reflect an individual's actual exposures. For example, some sources of air toxics, such as motor vehicle exhaust, are close to the breathing zone. Personal exposures may therefore be higher than ambient monitored concentrations.

Uncertainty about Human Carcinogens

For many chemicals, there is uncertainty as to whether they can cause cancer in humans. National and international organizations publish their scientific judgements regarding the strength of evidence linking the chemical (in any amount) to human cancer. This weight of evidence approach, shown below, is how scientists report their level of uncertainty (or certainty). When interpreting cancer risk estimates, the evidence that these chemicals cause cancer should be considered.

For example, the EPA's cancer "weight of evidence" scheme is shown here:

U.S. Environmental Protection Agency (EPA)
A - Human Carcinogen
B1 - Probable Human Carcinogen - limited evidence in humans
B2 - Probable Human Carcinogen - sufficient evidence in animals
C - Possible Human Carcinogen - limited evidence in animals
D - Not Classifiable as to Human Carcinogenicity - inadequate evidence
E - Evidence of Noncarcinogenicity

The American Conference of Governmental Industrial Hygienists (ACGIH), the U.S. National Toxicology Program (NTP), and the International Agency for Research on Cancer (IARC) are other organizations that assign cancer weight of evidence ratings to chemical mixtures. They use similar rating schemes and typically report similar judgements.

Mixtures

In most cases, health benchmarks are developed for individual chemicals. Health benchmarks are available for exposures to a few specific mixtures (such as diesel exhaust). However, people are exposed to many chemical mixtures in daily life. Scientists would like better methods to estimate the health effects of exposures to combinations of chemicals. The overall harm caused by chemical mixtures may be more or less harmful than the sum of the effects caused by each one alone.

Variability in Human Populations

Various groups of people, such as children, the elderly, asthmatics, the immunocompromised, and others may be more sensitive than the general population to the effects of a given chemical. Lacking any specific information about these differences, some uncertainty factors have been incorporated to protect sensitive sub-populations from adverse non-cancer effects of chemicals.

HRVs are developed using public health protection practices that advocate the protection of the most sensitive portion of the population. However, HRVs may not be protective of every individual. As has been demonstrated in occupational settings which provide information to identify the hazards of chemical exposures, certain people are sensitized (develop an allergic immune response) by exposures to high concentrations of certain

chemicals. Well known examples include the heightened immune responses which infrequently occur to a fraction of the people after repeatedly exposures toluene di-isocyanate or latex. . MDH is unable to derive HRVs that would be protective of all sensitized individuals.

Health benchmarks Differ for Cancer vs. Non-Cancer Effects

Regulatory scientists use very different approaches to develop health benchmarks for protection from cancer vs. non-cancer effects. Some chemicals have been shown to cause both cancer and non-cancer effects. In most of these cases, health benchmarks derived for cancer protection are lower concentrations than those derived for protection from other effects. The health benchmarks this is more protective, based either on cancer or noncancer effects, is used.

Exposure to Air Toxics

With respect to a number of volatile organic compounds found in outdoor ambient air, such as benzene, personal exposures (i.e., the actual chemical concentrations a person breathes in daily life) are typically influenced to a large extent by what he or she does during the day, such as driving in their car, pumping gas, working in some occupations, and using consumer products in the home.

Recent efforts to identify priority toxic air pollutants have assessed risks of breathing a number of chemicals in air. Breathing the air is only one way that people are exposed to chemicals. Health effects may also result from chemical exposures due to eating food, drinking beverages, and contacting products and other chemicals on the skin. The environmental and human health impacts of air toxics that persist and accumulate in the environment and the food chain, such as mercury, dioxin, and certain pesticides, have not been included in these assessments, but are discussed in Appendix F.

As in the MPCA Staff Paper, this update compares monitored pollutant concentrations to health benchmarks which are concentrations of a pollutant in the ambient air below which there is likely to be no public health concern.

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APPENDIX E
DRAFT
Diesel Engine Exhaust

Introduction

The MPCA is concerned about the potential for health effects from diesel exhaust and intends to collect more information to better understand the seriousness of the concern for Minnesotans.

The scientific evidence collected to date demonstrates that diesel exhaust concentrations higher than current environmental (ambient) levels can cause lung cancer and other adverse effects in humans (i.e., diesel exhaust is a hazard). The potential for noncancer effects is also of concern. Recent evidence that diesel particulate matter (DPM) may exacerbate asthma symptoms in asthmatic individuals is of concern and an active area of research. As is the case with many environmental pollutants present at environmental (ambient) concentrations, researchers have not been able to prove whether or not current ambient diesel exhaust levels are causing lung cancer (i.e., the actual risk at environmental concentrations). However, the range in exposure concentrations believed to be associated with human lung cancer are much closer to actual ambient levels than is the case for many other chemicals for which risks at ambient concentrations have been estimated. For this reason, and because of the large populations exposed continuously, MPCA is concerned about environmental concentrations of diesel exhaust.

This appendix summarizes currently available scientific information about the sources of diesel exhaust, concentrations in the environment and workplaces, what is known about the health hazards, and key questions relating to potential health effects of environmental levels of diesel exhaust. In addition to the diesel-specific information summarized in this appendix, diesel particles constitute a sizeable amount of fine particulate matter concentrations, and thus contribute to the premature deaths, hospital admissions, asthma attacks, and other adverse health impacts described in the Particulate Matter Appendix.

1.0 Definitions

1.1 What is Diesel Exhaust?

Diesel exhaust is a complex mixture containing hundreds of organic and inorganic materials, in gaseous and particulate forms, from diesel engine combustion processes. Diesel engines include light- and heavy-duty engines in trucks, buses, some automobiles, train locomotives, marine vessels, industrial generators and farm and construction equipment. Diesel exhaust includes both gases and particles. The particles are typically described as diesel particulate matter (DPM). The gaseous fraction contains nitrogen, oxygen, carbon dioxide, water vapor, aldehydes, and many toxic substances. The

particles consist of an elemental carbon core with hundreds of organic compounds, sulfates, nitrogen oxides, heavy metals, trace elements, and irritants such as acrolein, ammonia and acids adsorbed to the surface. Specific toxic chemicals of concern include polycyclic aromatic hydrocarbons (PAHs) and nitroarenes (CAL EPA, 1998) which are concentrated in the particle phase. Diesel particulate matter is a subset of ambient particulate matter. EPA approximated that 90% of the diesel particles have diameters less than 1 um (HEI, 1995) and at least 94% are less than 2.5 um (CAL EPA, 1998).

1.2 Diesel Engine Exhaust Composition is Variable and Changing over Time

The particle size distribution and chemical composition of diesel exhaust emissions can vary greatly depending on the engine type (light vs. heavy duty), the speed and load at which it is run, the fuel composition, the lubricating oil, and the emission control technology (CAL EPA, 1998, NTP, 2000). The mass, composition, and particle size distribution of diesel exhaust have also changed over time. For example, by the early 1990's the emissions (by mass) of nitrogen oxides and particulate matter from onroad diesel engines were much lower than in prior years (HEI, 1995). No information relating to possible changes in offroad diesel engines was obtained by EPA (EPA, 2000a). These changes in diesel engine technology complicate the discovery of possible health effects, because most toxicological effect data was obtained from historic diesel emissions.

Despite the lower particulate mass emissions from newer engines, it is not yet clear whether the hazard from diesel particulates has similarly decreased (CAL EPA, 1998). Total mass may not be the best descriptor of health effects. If technology improvements lead to a larger number of smaller particles, with greater surface areas and depositional efficiency, then it is conceivable the hazards could increase with technology improvements. The health implications of the potentially higher numbers of ultrafine diesel particles (less than 0.01 um) are not yet known (Mauderly, 2000). With respect to the overall fleet of diesel engines in use, diesel engines are well known for their durability and many older models are still in use today. In addition, the consumption of diesel fuel in Minnesota is expected to continue increasing. EPA has concluded that it is not clear if the risk of diesel emissions has decreased over time (EPA, 2000a).

2.0 Sources and Emissions

Emission inventories estimate the mass of diesel emissions from various source categories. "Mobile" sources, such as onroad or offroad large trucks, diesel powered passenger vehicles, and some farm and construction vehicles, are the main sources of diesel exhaust emissions in Minnesota. Other sources include diesel generators used for emergency electricity.

2.1 Diesel Exhaust Emissions in Minnesota

As described in the Particulate Matter appendix, fine particles emitted from combustion sources, such as diesel engines, are derived directly as primary emissions and also

secondarily as gases emitted into the atmosphere, such as nitrogen oxides, sulfur oxides and volatile organic compounds (VOCs), condense and undergo chemical reactions. The following emission inventory information includes only the primary (direct) emissions of diesel particulate matter. The mass from secondary diesel particulate matter formation in Minnesota is not known at this time.

Table 1 illustrates that the majority of the inventoried diesel emissions in Minnesota result from on-road and non-road mobile sources rather than from large point sources.

Table 1. 1996 Total diesel particulate emissions

Source Category	Emissions (lb)	Percentage (%) of Direct Estimated Emissions
Point	173,580.00	1.31
Onroad	5,363,511.21	40.61
Nonroad	7,668,920.18	58.07
Total	13,206,011.39	100.00

No information on small diesel engines that are not counted in non-road mobile sources is included. However, the contribution of these engines is not significant.

By one estimate, on-road and non-road sources of diesel exhaust contribute similar amounts in the national inventory (EPA, 2000a). Based on the Minnesota inventory, the non-road mobile source diesel particulate emissions are about 50 percent higher than the onroad sources.

Table 2. 1996 Diesel particulate emissions from nonroad mobile sources

Source Category	Emissions (lb)	Percentage (%) of Direct Estimated Emissions
Construction	4,513,678.54	58.86
Farm	1,558,507.60	20.32
Railroads	778,014.59	10.15
Industrial	441,041.32	5.75
Airport Services	244,371.38	3.19
Light Commercial	86,418.03	1.13
Logging	28,163.32	0.37
Lawn & Garden	18,725.40	0.24
Total	7,668,920.18	

EPA estimated that mobile sources contribute 98 percent of all DPM emissions and that onroad heavy duty diesel vehicles (HDDVs) contribute a third and non-road equipment contributes the remainder (EPA, 2000b).

EPA also reported that on a national scale on-road diesel emissions (trucks, some cars) have been decreasing, while there is limited evidence suggesting off-road emissions (locomotives, ships, heavy-duty equipment) may be slightly increasing (EPA, 2000a).

In comparison with gasoline powered vehicles, diesel engines are superior in fuel economy and durability. They emit less carbon dioxide, carbon monoxide and hydrocarbons than gasoline engines, but they emit relatively more nitrogen oxides and particulate matter per mile traveled (HEI, 1999a). Thus the use of diesel rather than gasoline is advantageous in lessening global climate change gases (CO2) but disadvantageous in terms of generating higher fine particulate (PM2.5) emissions. PM2.5 is discussed in detail in the Particulate Matter Appendix.

3.0 Concentrations and Trends

The MPCA does not yet have measurements of how much diesel exhaust is in the ambient outdoor air that Minnesotans breathe or of their personal exposures. A concentration is the mass of a material in a cubic meter of air (e.g., ug/m3). Personal exposures are the overall exposures an individuals experience in their daily lives from the indoor, outdoors, commuting, working and in their daily activities. Personal exposure concentrations, also reported as ug/m3, can differ from the concentrations in outdoor air. For diesel exhaust, indoor residential concentrations have been estimated to be lower than the outdoor air concentrations (EPA, 2000b). MPCA has rough estimates of ambient air concentrations and a limited amount of additional information is currently being collected.

3.1 Estimates and Direct Measurements from Occupational Settings

Most of the direct human evidence of the adverse health effects of diesel stems from findings in certain occupational settings where diesel exhaust exposures have been higher than in typical outdoor or residential settings. For example, Woskie et al. (1988) estimated railroad workers' personal exposures to respirable particulate matter, reported as geometric means, to be 17 ug/m3 for clerks and 134 ug/m3 for locomotive shop workers. Overall, HEI estimated average DPM air concentrations in workplace settings to range from 4 ug/m3 to 1,700 ug/m3 (EPA, 2000a).

In 1989, the National Institute of Occupational Safety and Health (NIOSH) estimated that 1.35 million workers were exposed to diesel particles in about 80,000 U.S. workplaces. (NTP, 2000). Estimates of workplace eight-hour average diesel particulate matter exposures range from 1 to 100 ug/m3 diesel particulate matter in trucking or transportation occupational settings and from 100 to 1,700 ug/m3 for underground mining with diesel equipment (HEI, 1995).

In another study, diesel exposures were estimated by measuring a surrogate measurement, namely that of very fine elemental carbon ≤ 1 µm (EC_1). EC_1 measurements for workers of the trucking industry were measured in 1990 and found to average 1.6 ug/m3 for dock workers, 26.6 ug/m3 for mechanics, 5.4 ug/m3 for short-haul drivers, 5.1 ug/m3 for long haul drivers, 3.4 ug/m3 for roadside area samples and 1.4 ug/m3 for off-roadway area samples (HEI, 1999a). Using an estimated conversion factor of 1.04 to convert from EC_1 to diesel, the California Air Resources Board estimated an

overall range in diesel exhaust between 5.3 ug/m3 to 27.8 ug/m3 diesel particulate matter in these occupational settings (CAL EPA, 1998).

3.2 Estimates and Direct Measurements of Diesel Particles in Ambient Air

Currently methods don't exist to directly measure DPM in air. Air concentrations of DPM have been estimated using at least three general approaches.

1. Ambient air concentrations can be estimated from emission inventory data (lb. emitted per year) and air dispersion modeling.
2. Elemental carbon (EC), a major component of diesel particulate matter (DPM), (contributing approximately 50 to 85 percent of DPM in most ambient environments (EPA, 2000a)), has been used as a surrogate (marker) to estimate DPM concentrations. Note that additional sources of EC include gasoline particulate matter, combustion of coal, oil, and wood, charbroiling, cigarette smoke, and road dust. More than one method for measuring EC exists and can lead to different results (CASAC, 2000b).
3. Chemical mass balance (CMB) source apportionment models use a chemical-specific fingerprinting approach to identify sources of chemicals in mixtures.

On a national scale, average ambient exposures of the general public to diesel exhaust are generally believed to fall in the range of 1 ug/m3 to 10 ug/m3 (HEI, 1995). Urban DPM concentrations are generally higher than concentrations in rural areas. EPA estimated the U.S. annual average airborne diesel soot concentration in 1990 was 1.80 ug/m3, with urban and rural averages of 2.03 ug/m3 and 1.10 ug/m3, respectively (EPA, 1993).

3.2.1 Ambient Concentrations and Exposure Estimates

In outdoor air, Los Angeles' 1982 average monthly air concentrations of diesel were estimated to range from 1.7 ug/m3 to 3.3 ug/m3 in low pollution areas, and EPA estimated that the highest monthly average concentrations might be 10 ug/m3 in the most polluted areas during winter (HEI, 1995). It is likely that short exposures in street canyons (roads with high buildings on either side) of urban areas would be higher than 10 ug/m3 (HEI, 1995). Numerous methods to measure or predict DPM in a number of ambient locations during the 1980's and early 1990's estimated average concentrations ranging from 0.2 to 23 ug/m3 for 24-hour measurement periods (CARB, 1998).

The California Air Resources Board (CARB) used the 1990 PM10 inventory and air dispersion modeling to calculate the statewide exposure to diesel exhaust PM10. Stratified by air basin, the estimated outdoor population-weighted concentration of diesel exhaust PM10 ranged from 0.2 ug/m3 in the Great Basin Valley to 3.5 ug/m3 in the South Coast Air Basin. The population-weighted average outdoor diesel exhaust PM10 concentration in California for 1990 was 3.0 ug/m3. As would be expected, the population-weighted overall average is more reflective of the higher concentrations breathed in the densely populated South Coast Air Basin. The 1990 population-weighted estimate of 3.0 ug/m3 was extrapolated to reflect declining diesel particle concentrations

for 1995, 2000, and 2010. These estimated concentrations were 2.2 ug/m3, 1.8 ug/m3, 1.7 ug/m3, respectively (CARB, 1998).

Using measurements of EC, average annual diesel particulate concentrations ranged from approximately 2.5 ug/m3 to 4.5 ug/m3 across a number of communities in the vicinity of Los Angeles (South Coast Air Quality Management District, 1999).

Rough estimates of ambient diesel particulate matter concentrations in Minnesota can be surmised by considering information from other states. Ambient DPM monitoring information is available from Phoenix, AZ and Denver, CO. Measured ambient concentrations in two Colorado cities during 1996 were 1.7 ug/m3 and 1.2 ug/m3. Sampling in Phoenix, AZ during 1994 and 1995, measured an average concentration of 2.4 ug/m3 (EPA, 2000b).

3.2.2 Evidence of Higher Outdoor Concentrations

Short-term higher exposures may occur near diesel sources. For example, on busy urban streets, street level breathing zone concentrations of diesel exhaust particulate matter have been estimated to be as high as 30 ug/m3 (HEI, 1995). Diesel soot is considered a minor fraction of the fine particulate matter in most urban settings, but it constitutes a majority of the particulate matter from on-road vehicles (HEI, 1995).

One study measured PM2.5 and elemental carbon (EC) in an urban neighborhood (Harlem, New York City) with high diesel traffic (Kinney et al., 2000). In this study, 8-hour mid-day samples were taken at 4 locations during July 1996. The average $PM_{2.5}$ ranged from 37 ug/m3 – 47 ug/m3, while elemental carbon (EC), which was used as a surrogate measure of diesel exhaust particulate, ranged from 1.5 ug/m3 to 6 ug/m3.

Evidence based on the elemental carbon surrogate indicates that diesel particulate matter concentrations are measurably higher near common sources of diesel exhaust. For example, in the Netherlands a study of elemental carbon concentrations in the vicinity of schools reported average concentrations of 3.4 ug/m3 at schools within 400 meters of the freeway, compared to 1.4 ug/m at schools measured farther away (EPA, 2000b). Concentrations of EC were measured in vehicle on California roads ranged from 2.8 ug/m3 to 36.6 ug/m3, with the higher concentrations occurring when the vehicles were following large diesel vehicles (EPA, 2000b).

A number of studies have assessed the increase in diesel particulate levels near trafficked areas. California Air Resources Board (CARB) measured elemental carbon and organic carbon to estimate diesel PM10 exhaust and found diesel PM10 concentrations near roadways up to 8 ug/m3 for 24-hour samples (CARB, 1998). A Volkswagen study found diesel particulate concentrations of 7.1 ug/m3 at distances of four meters from the road and 8.8 ug/m3 at one meter from the curb near light-duty diesel traffic (CARB, 1998).

Minnesota-Specific Concentration Information

Currently the MPCA lacks specific information regarding measured diesel exhaust air concentrations for Minnesota. University of Minnesota researchers are studying diesel aerosol exposures within the Metro Transit system (http://www.healtheffects.org/program_summaries.htm). Personal and area samples were collected to better identify the contribution of diesel exhaust within ambient urban air. The results of this study will be available shortly.

EPA conducted personal exposure modeling for 1990 diesel particulate matter exposures in Minneapolis and nine other U.S. cities. As described in a recent summary of this effort (EPA, 2000b), the Hazardous Air Pollutant Emissions Modeling (HAPEM-MS3) model was used. The following estimates only reflect on-road DPM sources. Nationally, 99 percent of the DPM exposures from on-road vehicles were from heavy-duty diesel vehicles (HDDVs) (e.g., large trucks used for hauling freight), and 1 % were from light-duty diesel vehicles (LDDTs) (e.g., diesel powered pick-up trucks). The general population exposure was estimated to be 0.84 ug/m3 DPM. The Minneapolis-specific estimate of public exposure was 1.0 ug/m3 (EPA, 2000b).

As discussed in the Air Toxics Appendix of this report, EPA is in the process of conducting a National Air Toxics Assessment (NATA) of the 33 Urban Air Toxics and diesel particulate matter (more info at: http://www.epa.gov/ttn/uatw/nata/). Preliminary Minnesota information suggests that average diesel particulate matter may represent slightly over 1 ug/m3 in the more densely populated urban areas and about 0.4 ug/m3 in the rural counties, with a range in county average DPM concentrations from a low of 0.04 ug/m3 for Cook County to a high of 1.73 ug/m3 for Ramsey County. The statewide county average is approximately 0.9 ug/m3.

EPA (2000b) compared the exposure concentrations which have been shown to cause lung cancer, with estimated daily exposure experienced by the public, to calculate an approximate exposure margin (Table 3). Relatively small exposure margins indicate that ambient levels are fairly close to levels of concern. EPA considers an exposure margin of one or two orders of magnitude to be fairly small (EPA, 2000a). Note that the accuracy of the exposure margin depends on the accuracy of the concentration estimates, which for the occupational concentrations in particular are fairly uncertain. The details of this quantitative analysis is described in the report, which is accessible at: Regulatory Impact Analysis (EPA420-R-00-026) Chapter II: Health and Welfare, http://www.epa.gov/otaq/diesel.htm#documents.

Table 3. Occupational and Population Exposure to Diesel Exhaust, Environmental Equivalent Exposures and Exposure Margins

Occupational Group	Estimated Occupational Exposure (ug/m3)	Environmental Equivalent Exposure (ug/m3)	Exposure Margin Ratio – based on a 0.84 ug/m3 ambient exposure	Exposure Margin Ratio – based on a 4.0 ug/m3 ambient exposure
Non-coal Miners	38 – 1,280	8 – 269	10 – 320	2 – 67
U.S. Railroad Workers	39 – 191	8 – 40	10 – 48	2 – 10
Firefighters	4 – 748	0.8 – 157	1 – 187	0.2 – 39

Public Transit Workers, Dockworkers	2 –98	0.4 - 21	0.5 - 25	0.1 – 5

Excerpt from Table II.A-23 (EPA, 2000b)
Environmental Equivalent Exposure - Occupational exposure (40 hours per week) are recalculated as a continuous exposure (24 hours each day). The equation is environmental equivalent occupational exposure = 0.21 x occupational exposure.
For this example, the exposure margin (EM) is the ratio of the adjusted occupational exposures (those which caused effects) to the lower estimated ambient exposures. \Exposure margins are calculated using both high (4.0 ug/m3) and low (0.84 ug/m3) estimated exposure concentrations.

3.3 Diesel Particulate as a Portion of PM2.5

Because of their small size, diesel exhaust particles are primarily associated with particulate matter smaller than 2.5 microns (PM2.5). At this time it is not known for Minnesota precisely what fraction of PM2.5 is diesel particulate matter, or how this varies temporally and spatially across the state. It is expected that diesel sources may contribute a significant amount of PM2.5 to the ambient air, particularly in urban areas. EPA estimated that the fraction of DPM in PM2.5 is typically in the range of 10 percent, though it may exceed 30 percent in some urban settings (2000a). As a first approximation, if the Twin Cities has about 1.7 ug/m3 DPM, and an average of 12.3 ug/m3 PM2.5 (see the Particulate Matter Appendix), then DPM would be about 14 percent of the fine particulate matter by mass. This estimate is in line with estimates from the other cities. Additional information will be needed to characterize the contributions from other sources, such as power plants and woodburning, to Minnesota levels of PM2.5.

The Particulate Matter appendix includes more details on emissions, concentrations, and composition of fine particles.

4.0 Health Information

Diesel exhaust is one of multiple sources of fine particulate matter and gaseous air pollution, so it is difficult to distinguish the health effects of ambient diesel exposures from those of other pollutants (HEI, 1995). Often diesel exhaust health effects studies have focused on the particulate fraction and reported concentrations as ug/m3 diesel particulate matter. The lung is the primary organ adversely effected by diesel exhaust. Because of their small particle diameters (most are less than 1 um), diesel particles are readily inhaled and deposited deeply in the lung.

Information from past occupational exposures to diesel exhaust suggests that workers exposed to elevated diesel concentrations have been harmed by those exposures, suffering from bronchitis, lung function changes, and lung cancer (EPA, 2000a). Although the general public is usually exposed to somewhat lower amounts of diesel than those found in occupational settings, diesel exhaust is widely present in urban and rural areas.

In contrast to its potential for causing lung cancer, the noncancer effects of diesel

exposures may have at least as great, if not greater, public health impacts, in part because more people may be effected (CAL EPA, 1998). Potential allergenic effects of diesel exhaust are of growing interest. The World Health Organization (WHO, 1996) concluded that inhalation of diesel exhaust contributes to asthma. The major noncancer effects of diesel exhaust that the Health Effects Institute (HEI) identified as needing additional research include asthma, respiratory airway inflammation, and allergic responses (HEI, 1999b).

Urban particulate air pollution has been demonstrated to cause a range of adverse effects on the respiratory and cardiovascular systems (HEI, 1999a). The scientific evidence relating to diesel exhaust health effects is summarized below. It is described in terms of effects measured following acute exposures (to short term high levels) and chronic exposures (to lower levels for longer time periods). Both lung cancer and noncancer effects from chronic exposures are discussed.

4.1 Health Effects from Short-term, Elevated Exposures

Based on evidence derived from animal and human data, short-term exposures to high levels of diesel exhaust are believed to irritate the eyes, nose, throat, and bronchi (EPA, 2000a). Neurophysicial symptoms of exposures have included lightheadedness, dizziness, headache, nausea, vomiting, and tingling and numbness of the extremities (EPA, 2000a). Short-term animal studies found diesel exhaust can cause increased susceptibility to lung infection, chronic lung tissue inflammation, and decreased lung function (CAL EPA, 1998). In addition to the fine particles which may cause irritation, diesel exhaust contains respiratory irritants including sulfur oxides, nitrogen oxides, and aldehydes such as formaldehyde and acetaldehyde.

In sensitized individuals who are already allergic to certain allergens (such as pollen), it can worsen their allergic reactions. For example, human exposure to both diesel exhaust particles and ragweed pollen resulted in an immune response greater than that following either alone (Diaz-Sanchez et al., 1997). Similar studies with different fine particle sources have shown somewhat similar results (Mauderly, 2000).

CASAC (2000b) concluded that animal studies have shown cellular and chemical changes that are biological markers consistent with asthma (e.g., increased mast cell influx, increases in immunoglobulin E (IgE), goblet cell hyperplasia and cytokine changes), but that studies have not shown that the condition of asthma was caused (CASAC, 2000b). One commentor noted that 2/3 of the studies in the last 10 years have assessed the immunological changes associated with diesel exhaust and that acute exposures may be of more relevance than lifetime exposures (CASAC, 2000b). California (CAL EPA, 1998) considers it possible that diesel exhaust particles may increase the prevalence of asthma and other allergic respiratory disease such as hay fever (allergic rhinitis). The possible effects of diesel in causing asthma or in exacerbating asthma attacks (increasing the symptoms in asthmatics) are areas of active research.

Human exposure studies at concentrations in the range of 1,000 ug/m3 diesel particulate

matter for on hour caused slight lung inflammatory responses and altered macrophage function, but did not cause significant changes in lung function (Mauderly, 2000).

In its draft Health Assessment Document, EPA concluded that short-term high diesel exposures can cause reversible changes in human lung function (EPA, 2000a). Most studies found no significant decreases in lung function. However, the respiratory symptoms (cough, phlegm, chest tightness, wheezing) were observed sooner and at lower diesel exhaust concentrations than decreased lung function (EPA, 2000a). Some evidence suggests that smokers may be more sensitive to the effects of diesel exposures than nonsmokers (CAL EPA, 1998).

In animal studies (with rats, mice, hamsters, cats, guinea pigs) found inflammation of the airways but mild to no decreased lung function at concentrations of 6,000 ug/m3 diesel particulate matter (EPA, 2000a). A number of animal species were assessed for possible reproductive and teratogenic effects but no adverse effects were identified (EPA, 2000a).

4.2 Health Effects from Long-term Exposures

The specific evidence for cancer and noncancer effects from long-term diesel particulate matter exposures is described in the next two sections.

4.2.1 Cancer Health Effects from Long Term Exposures

The scientific community is in general agreement that diesel exhaust is likely to be a human carcinogen. Over 30 epidemiology studies have assessed the potential human carcinogenicity from occupational exposures to diesel exhaust. DPM exposure estimates for these epidemiology studies were based on the workers' job classifications, employment duration, etc., because more specific information was unavailable. Two studies in particular have been used extensively in evaluating lung cancer effects; these were studies of teamsters and of railroad workers (HEI, 1999a). Although none of these studies alone would point to diesel exhaust as a cause of lung cancer, as a group they consistently showed a weak association between diesel exhaust exposure and lung cancer (EPA, 2000a, HEI, 1999, CAL EPA, 1998). Additional information considered in judging whether diesel exhaust could cause cancer in humans includes animal studies and studies of the effects of diesel exhaust on genetic material.

In defining the cause of a disease, epidemiologists consider causal associations to be weak if the incidence of the disease (e.g., cancer) isn't at least found to be doubled in the exposed population compared to the non-exposed population. Weaker associations suggest that unrecognized other factors (i.e., confounding factors) may actually cause the disease or that the statistical finding may be influenced by unrecognized biases in study design. In contrast, an example of a strong association is that between smoking cigarettes and dying of lung cancer. In the Six Cities study (Dockery et al., 1993) current smokers who smoked an average of one pack of cigarettes daily for 25 years were found to have an 800% (8 times) higher greater chance of death from lung cancer than non-smokers.

Many organizations have evaluated the diesel exhaust evidence for human carcinogenicity and documented their findings, as summarized in Table 4.

Table 4. Health Organizations' Judgements on Diesel Exhaust Carcinogenicity

Organization	Characterization	Comments by Organization
National Institute for Occupational Safety and Health (NIOSH)	potential occupational carcinogen	Studied whole diesel engine exhaust, based on confirmatory animal and limited human evidence
International Agency for Research on Cancer (IARC) (1989)	Group 2A – Probably carcinogenic to humans	Studied whole diesel engine exhaust – sufficient evidence in experimental animals and limited evidence in humans
National Toxicology Program (NTP) (2000)	Reasonably anticipated to be human carcinogens	Studied diesel engine exhaust particulates – limited findings of elevated lung cancer rates in occupational groups exposed in occupational settings (railroad, mine, bus garage, and trucking company workers)
July 2000 Draft EPA Health Assessment Document for Diesel Emissions (2000a)	Diesel exhaust is a probable human carcinogen (Group B1) - Likely to be carcinogenic to humans by inhalation at any exposure concentration	Studied whole diesel engine exhaust
World Health Organization (WHO) (1996)	Diesel exhaust is probably carcinogenic to humans	Rat data support carcinogenicity, human data suggests probably a carcinogen but inadequate information for quantitative risk assessment
American Conference of Governmental Industrial Hygienists (ACGIH) (2000)	Suspected human carcinogen (2000 notice of intended changes)	Studied diesel exhaust particulate matter
California Environmental Protection Agency, Office of Environmental Health Hazard Assessment (OEHHA) (1998)	Reasonable and likely explanation for causing human lung cancer and rat data demonstrating carcinogenicity	Studied diesel exhaust particulate matter
Health Effects Institute (HEI) found a weak	Epidemiological data consistently showed a	Studied whole diesel engine exhaust

association (HEI, 1999b)	weak association between exposure and lung cancer	

Note that the EPA weight of evidence, B1, indicates stronger evidence that diesel exhaust is a human carcinogen than a number of other air toxics (see the Air Toxics Appendix for a description of EPA's weight of evidence scheme and the ratings for other air toxics).

How effectively may diesel exhaust cause lung cancer?

The Health Effects Institute (HEI) Diesel Work Group, reviewed the epidemiology studies of diesel exposures occurring from the 1950's through the 1980's and found 20% to 50% increased incidence of lung cancer in the exposed groups (i.e., overall, the exposed people of the study had a 20% to 50% higher chance of lung cancer than the non-exposed people) (HEI, 1999b). California EPA conducted a similar analysis and reported a 40% increase in the risk of lung cancer from occupational exposure. EPA concluded there is strong but not definitive evidence demonstrating an association between diesel exhaust exposure in workers and increased incidence of lung cancer (EPA, 2000a) and the Science Advisory Board reviewers agreed (CASAC, 2000b).

Some of the diesel epidemiology studies accounted for the confounding effect of smoking which, overall, is clearly the most important contributor to lung cancer incidence. Other potential confounding factors, such as asbestos exposure, diet, socioeconomic factors, environmental tobacco smoke, and nondiesel particles were considered less often, if ever, in these studies (HEI, 1995). Despite this source of uncertainty, the consistency of the statistical association has lead most authoritative organizations to judge diesel as a likely human carcinogen.

4.2.2 Non-cancer Health Effects from Long-term Exposures

Heavy exposure to diesel exhaust is clearly associated with upper airway pulmonary inflammation (CASAC, 2000a). The California Air Resources Board (CARB) concluded that long term chronic effects of diesel exhaust exposures in occupational workers may include a greater incidence of cough, phlegm, chronic bronchitis and reduced pulmonary function (CARB, 1998).

Most epidemiology studies have not found diesel to cause increased chronic respiratory disease (CAL EPA, 1998, EPA, 2000a). EPA's Clean Air Scientific Advisory Committee (CASAC) found that fibrosis, emphysema, pulmonary hypertension and associated heart disease occurred in heavily exposed animal studies, but did not consider these likely to occur in humans under environmental or most occupational exposure settings (CASAC, 2000a).

Particles from diesel exhaust can induce immunological allergic reactions and localized inflammatory responses in humans. At some level of exposure, diesel exhaust can cause

systemic and pulmonary inflammatory responses in healthy humans (EPA, 2000a).

Recent evidence suggests that heavy-duty truck traffic and environmental levels of diesel air pollution may cause respiratory symptoms, decreased pulmonary function and allergic symptoms in children and adults (CAL EPA, 1998).

Several studies have examined the relationship between various measures of traffic density and health effects in communities. One example is a study in Holland which identified children living closer to major freeways to have more coughs, wheezing, runny noses and more frequent doctor-diagnosed asthma than those children living farther away (EPA, 2000a). Additional studies by Brunkreef et al. have suggested possible associations between traffic density and children's lung function, bronchitis, and allergy to pets and dust (EPA, 2000a).

These traffic studies did not measure diesel exposures, nor did they specifically assess most other factors that may provide alternate explanations for the apparent relationship. These preliminary findings provide suggestive, but not conclusive, evidence that traffic is related to these illnesses. They are useful to generate theories about possible causative relationships that can be further tested with more rigorous epidemiological studies to better assess the possible disease causes.

4.3 What measures are used to assess whether exposures are too high?

The traditional regulatory approach for managing exposures to hazardous chemicals in air is to estimate concentrations of the chemicals in air that are judged to be acceptable. These may be developed for ambient air exposures by the public or for occupational exposures by workers. This report focuses on the measures designed for the public, but proves some information on occupational air concentrations for comparison. Because the occupational concentrations are developed assuming the workers are healthy, and that workday exposures only occur during working hours, they generally result in higher, less restrictive, concentrations than those developed for the general public.

Both for the general public and for workers there may be regulatory standards and/or various types of guideline concentrations. In some cases regulations provide enforcement authority for these concentrations (i.e., they are standards such as the National Ambient Air Quality Standard for particulate matter or the Occupational Safety and Health Administration's Permissible Exposure Limits (PELs)). There may also be recommended guideline concentrations (i.e., health benchmarks such as Minnesota Department of Health's (MDH) proposed Health Risk Value (HRV) for benzene or the American Conference of Governmental Industrial Hygienist (ACGIH) Threshold Limit Values (TLVs)). In either case, they may apply to either short-term (e.g., 1 hour, 3 hr, etc.) or longer-term (e.g., a year or a lifetime) exposure periods.

4.3.1 For Short Term Exposures and Non-cancer Effects

There are no specific short-term ambient air federal standards for the public addressing short-term exposures to diesel engine exhaust. EPA didn't propose to develop a health benchmark for short-term high level exposures to diesel exhaust because the dose response information for acute effects was inadequate (EPA, 2000a). Similarly, the Minnesota Department of Health (MDH) has not proposed a short term, acute health risk value (HRV) for diesel exhaust.

4.3.2 For Long Term Exposures for Protection from Non-cancer Effects

Several organizations have reviewed the toxicological literature on the health effects of diesel exhaust and proposed various guidelines (inhalation health benchmarks) for protection from the noncarcinogenic effects of inhalation exposures. The derivation and use of health benchmarks are described in some detail in the Air Toxics Appendix of this report. These health benchmarks are used to evaluate the concern about chemical concentrations in air the public breathes.

Available inhalation health benchmarks for protection from the non-cancer health effects of diesel exhaust are summarized in Table 5. Note that there is no enforceable workplace standard for diesel exhaust.

Table 5. Diesel Exhaust Benchmark Concentrations for Non-cancer Effects[a]

Organization	Benchmark	Comment
Minnesota Department of Health – Proposed Health Risk Value (HRV)	5 ug/m3	Developed using EPA's Integrated Risk Information System (IRIS) toxicity information
EPA Reference Concentration (RfC) (EPA, 2000a)	5 ug/m3	4 chronic inhalation rat studies – rats, mice, hamsters, monkeys all showed dose dependent increases in chronic inflammation and lung tissue changes- the RfC will be based on lung tissue changes
World Health Organization – 1996	2 ug/m3 to 21 ug/m3	Used same data as EPA and California
CAL EPA Recommended Exposure Level (REL) (1998)	5 ug/m3	Same toxicology data as EPA used and a benchmark dose calculation method
American Conference of Governmental Industrial Hygienists (ACGIH) (2000)	50 ug/m3 (2000 notice of intended changes)	Diesel exhaust particulate matter listed as suspected human carcinogen

[a]These benchmarks were all developed for lower respiratory system protection and are based on animal studies

RfC - An estimate (with uncertainty spanning perhaps an order of magnitude) of a continuous inhalation exposure to the human population (including sensitive subgroups) that is likely to be without an appreciable risk of deleterious effects during a lifetime.

4.3.3 Long-term Exposures - Protection from Possible Cancer Effects

To address cancer risks, regulatory scientists traditionally use an inhalation "unit risk factor" to describe how effectively a substance might cause cancer. This unit risk factor is used to characterize the highest amount of cancer that could occur in a population of people who breathe the substance for 70 years. Technically, the unit risk usually represents an upper bound estimate of cancer risk per million people exposed to 1 ug/m3 (a microgram of diesel exhaust particulate in a cubic meter of air) over a 70-year lifetime. The actual risk of cancer may be less than this upper bound estimate, possibly zero. The cancer risk is traditionally assumed to be directly proportional to the long-term average exposure concentration. Inhalation health benchmarks, based on protection from potential cancer effects, are developed from unit risk estimates by dividing the selected risk level (e.g., 1 in 100,000 or 10^{-5}) by the unit risk estimate.

The scientific regulatory community has a range of opinions about an appropriate unit risk estimate for diesel exhaust. These are summarized in Table 6.

Table 6. Summary of Diesel Exhaust Unit Risk Factors for Carcinogenic Potency

Organization	**Unit Risk factors[a]**	**Comments by Organization**
MDH	no value available	due to the uncertainty wait for better information for cancer-based HRV development
HEI	no values available	Garshick data is inconclusive; wait for better information
EPA SAB review of EPA 1999 Health Assessment of Diesel Emissions Document	no value should be listed	Too much uncertainty – Don't use rat data - Wait for better information
EPA's Scientific Advisory Board	no value should be listed	Too much uncertainty – Don't use rat data -- Wait for better information
EPA Health Assessment for Diesel (2000a) and CASAC (2000b)	No value selected. Instead for illustration, noted a range of possible upper bound cancer risks from diesel exposure to be 10^{-3} to 10^{-5}, and possibly as low as zero	Range from animal and human data using various calculation methods:
California Air Resources Board Scientific Review	use 3x10-4 as the best point estimate	Selected a point estimate from CAL OHEEA range

Panel		
California OHEEA Toxic Air Contaminant Documentation	1.3 x 10-4 m3/ug to 2.4 x 10-3 m3/ug is a range of unit risk estimates	Based on Garshick et al. Case control (1987) and cohort railroad worker studies (1988); Woskei, et al. (1988) exposure estimates

[a] Higher unit risk values indicate a higher potency to cause cancer

Clearly the appropriate unit risk value for diesel exhaust is uncertain. A human study that specifically measures the exposures to diesel exhaust in relation to lung cancer effects is needed to help confirm the potency for which diesel exhaust can cause cancer in humans. Ongoing studies should allow a more accurate estimate of the unit risk value. It is hoped that several ongoing studies will provide better exposure response estimates. The results are expected within a few years.

Although, based on the uncertainty, most organizations have chosen not to calculate cancer risk estimates from the available carcinogenic potency data, California has adopted a unit risk value and is using it to report upper bound diesel particulate matter cancer risks in the state. As described in the Air Toxics appendix, MPCA relies on California values in selecting potential inhalation health benchmarks.

California used these measurements estimating diesel particulate matter of 2.5 ug/m3 to 4.5 ug/m3 described in Section 3.2 along with the California Scientific Review Panel unit risk value of 3 x 10-4 m3/ug to estimate that diesel particulate matter accounted for the majority of the cancer risk in the air at all long-term monitoring sites. The reported upper bound excess cancer risk estimates ranged from 1,120 to 1,740 per million, based on average annual concentrations (South Coast Air Quality Management District, 1999).

Available evidence indicates that high exposure concentrations of both the adsorbed organics and the elemental carbon core of DPM are associated with the lung cancer hazard. Defining the mode of action for each and the degree to which each of these may cause cancer at lower concentrations is an area of active interest and research.

4.4 Issues for Additional Research

Although most scientists agree diesel exhaust most likely can cause lung cancer in humans, defining how potently it causes lung cancer at typical environmental levels is a matter of greater debate. Better understanding the following issues would improve the characterization of the risks Minnesotans face from diesel exhaust in the air.

4.4.1 Uncertainty in Exposure Estimates for Epidemiology Studies

Most regulatory and health organizations have not identified a cancer unit risk estimate for diesel exhaust due to uncertainties in defining the concentrations and from the epidemiology studies used to characterize the lung cancer hazard. Better exposure

estimates defining the composition of diesel exhaust are needed in epidemiology studies of the lung cancer effects to improve the development of a unit risk toxicity value.

4.4.2 Characterization of Potential Allergic and Asthma Effects at Lower Ambient Concentrations

The potential hazard that diesel exhaust may pose due to effects related to the immune response and asthma need to be better understood.

4.4.3 Does a Threshold Exist? What is the Mode of Action for Cancer?

Direct measurements of the relationship (dose response curve) between the amount of exposure and the harm diesel exhaust may cause at typical ambient concentration levels is not currently possible. Health risk estimates are based on extrapolations of effects measured from high exposures to estimated effects at ambient exposure levels.

A threshold is a concentration below which diesel exhaust will not cause health effects. Most scientists believe it is likely that diesel exhaust causes cancer in humans, but are not sure how this may occur. The mode of action by which a chemical causes cancer is relevant to understanding its hazard and whether it is a material that can cause cancer at very low doses or not. Two of the possible methods by which diesel exhaust might cause cancer are listed below, along with an explanation for why it makes a difference.

- DNA-Damaging (Genotoxic) - It is well known that many chemicals present on the diesel particles (such as benzo[a]pyrene) are likely to cause cancer. When diesel particles are inhaled, if these chemicals are absorbed into the lung cells, and they chemically react with, and alter, the DNA, cancer may result. If diesel exhaust chemicals cause cancer by altering DNA, then inhaling a very small amount of diesel exhaust may cause cancer.

- Particle Overload (Threshold) - Animal cancer effects also may result from the sheer presence of small particles. The rat appears to be the species most sensitive to the carcinogenic effects of diesel exhaust particles. Rats are well known to have difficulty clearing excessively high amounts of inhaled particles from their respiratory tracts. Studies in rats have shown that several types of particles sized similar to diesel particles, but which lack the cancer-causing chemicals, can cause cancer. It is believed that for these particles, the rat lungs don't clear the particles well, inflammation and immune reactions occur, some cells are damaged and others grow quickly. This chain of events can lead to cancer. This may only occur following exposures to excessively high particle concentrations, at levels greater than those typically found in ambient environments. HEI estimates suggest that in humans, the particle overload threshold may be at approximately 100 to 200 ug/m3 for continuous exposures or at 500 to 1,000 ug/m3 for 8 hours per day, 5 days per week (HEI, 1995). For particles which cause cancer due to this biological mechanism, at low enough concentrations, no cancer would occur. Stated another way, there might be a threshold exposure below which cancer would not occur. Given that this is uncertain,

regulatory agencies such as EPA typically conclude that it is prudent to assume that cancer may occur at low levels.

4.4.4 Ambient Concentrations and Exposures to Diesel Exhaust and DPM

Minimal Minnesota-specific measurements of diesel particulate matter are available. Better understanding of the best measures for describing exposures and actual personal exposure concentrations would improve efforts for risk characterization.

4.5 Other Sources of Health Information

See Research on Diesel Exhaust at:
http://www.healtheffects.org/program_summaries.htm

California EPA Office of Environmental Health Hazard Assessment (OEHHA)
http://www.oehha.org/air/diesel_exhaust/index.html

EPA Integrated Risk Information System Database
http://www.epa.gov/iris/subst/0642.htm

Health Effects Institute
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APPENDIX F
DRAFT
Persistent Bioaccumulative Toxics (PBTs)

Introduction

Persistent, bioaccumulative toxics, including some pesticides and combustion byproducts, pose a serious and long-term threat to human and ecological health. Once released into the environment, these chemicals travel long distances, move between air, water, and sediment, and remain in the food web for generations. Due to these and other unique characteristics, the health and ecological effects of PBTs are not well understood, although they may interfere with human endocrine systems, cause developmental problems, and impair the immune system. There are several national and international efforts to address these long-lived and wide-spread chemicals. High analysis costs prevent the MPCA from monitoring these pollutants.

1.0 Definition

The MPCA considers persistent, bioaccumulative toxics (PBTs) separately from other chemicals due to differences that exist between PBTs and air pollutants discussed in other appendices. PBTs are a unique group of chemicals that demonstrate three properties in varying degrees:

- They are persistent (P) in ecosystems, meaning they break down slowly, if at all, in the environment.
- They are bioaccumulative (B), are not easily metabolized and are collected in the tissues of fish, other animals and plants. These pollutants often become more concentrated as they move up the ecological food chain through consumption or uptake.
- They are toxic (T) and may be hazardous to human health or ecological receptors in a variety of ways, depending on the chemical and the organism that is exposed. The symptoms of contamination may not be immediate, and dramatic health effects may show up in subsequent generations.

PBTs are long-lasting pollutants that are noticeable due to their ability to travel long distances, to transfer and partition among environmental media, and to bioaccumulate in aquatic and/or terrestrial organisms. These qualities make PBTs pollutants of concern at the national and international levels.

For the reasons listed below, PBTs raise unique, often difficult, management challenges that the MPCA believes separate them from other toxic air pollutants.

- The priority PBTs listed in section 2.0 have all three characteristics of a PBT, while other air toxics may have only one or two of the three characteristics.
- There is no ambient air monitoring program for these chemicals at this time.

- In order to evaluate PBTs, there is a need for environmental monitoring in multiple media (both biotic and abiotic samples throughout the food web).
- The immediate concern with air toxics is the direct health impact on the exposed population. With PBTs, not only is the MPCA concerned with the direct impact on the first generation, but also the impact on their offspring and later generations.
- Although many PBTs are banned and have not been produced or consumed for many years, they are still present in environmental samples, including ambient air.
- In order to control the emissions or releases of PBTs into Minnesota's environment, both a multimedia approach within the MPCA and between the state's agencies is required, and there should also be national and international strategies to deal with these ubiquitous chemicals. The PBT problem is more of a global and international concern, whereas other air toxics are more state and local issues.

2.0 Sources and Emissions of PBTs

The PBT chemical products and byproducts are not generated by a single process, do not originate from the same source, and their distribution is not limited to a single medium. Because PBTs easily cross boundaries between environmental media, they are regulated by a variety of laws, regulations and programs.

Both man-made and natural PBTs cause environmental problems. Anthropogenic PBTs have existed for a relatively short time, while other PBTs, such as mercury and cadmium, occur naturally. PBTs also can be grouped as historical problem chemicals (*e.g.*, DDT and PCBs), as PBTs currently in production (*e.g.*, hexachlorobenzene and mercury) and as new PBTs that may enter the environment in the future (*e.g.*, Flame retardants and selected pharmaceutical products).

Table 1 is a list of PBTs of special concern in Minnesota and the primary sources of these chemicals. The list was derived from a combination of the Level I substances under the Binational Toxic Strategy, the U.S. Great Lakes Water Quality Guidance, Tier I and Tier II substances that form the baseline commitment under the Canada-Ontario Agreement, and the Resource Conservation and Recovery Act PBTs. All listed chemicals meet the criteria mentioned above. The list will be revised as more information becomes available, and as the MPCA receives comments from internal audiences, the Minnesota Department of Health, and other experts.

Table 1: Sources of Priority Persistent, Bioaccumulative Toxic (PBT) Chemicals

PBT Chemical	Sources
1. Dioxins/furans & dioxin like compounds	Formed as a byproduct in waste incineration, pulp and paper industry, power generation; cement kilns, cigarette combustion, metallurgical processes, chemical manufacturing and forest fires.

2. Mercury and its compounds	Incidental emissions during energy production from coal, petroleum, wood and natural gases (about 21% of total state emissions), volatilization during product disposal and incineration (about 69%) and emissions incidental to other activities, such as taconite processing, soil roasting and pulp and paper manufacturing (about 10%).
3. Polycyclic aromatic hydrocarbons (PAHs) or polycyclic organic matter (POM)	Result from incomplete combustion of organic compounds (*e.g.*, coal, petroleum, gasoline and diesel-engine exhaust), residential wood combustion, cigarette smoke, product of petroleum refining processes and iron/steel mill with coke oven. Transportation accounts for 1% of national PAH emissions and may account for 50% of urban PAH exposure
4. Polychlorinated biphenyls (PCBs)	Used in insulation for electrical cables and wires; production of condensers; used in epoxy, adhesive, caulk, plasticizers, additive for lubricants. Improper management, storage and disposal of PCB waste (*i.e.*, transformers). Banned – manufacture and use prohibited.
5. Hexachlorobenzene (HCB)	Used to manufacture chlorinated solvents, as a fungicide, in dye manufacturing, as a degreasing agent. Formerly used as a pesticide.
6. Cadmium and its compounds	Industrial uses and product sources, such as electroplating, deoxidizer in nickel plating, metal alloys, paints and batteries. Emitted hazardous waste combusters.
7. Toxaphene	Insecticide for cotton, soybeans, peanuts and maize; used on livestock, vegetables, and for fish management.
8. Other chlorinated pesticides: DDT (DDD, DDE), chlordane, Mirex, aldrin/dieldrin	Control insects that carry disease (*e.g.*, malaria and typhus). Control termites and insecticide for maize. Flame retardant, antioxidant, and paint additive. Soil insecticide to control rootworms, beetles. All are banned.
9. Alkyl-lead compounds: tetraethyl lead, tetramethyl lead	Leaded gasoline in aviation fuel, other fuels used by military and possible use in steel making.
10. Polybrominated Flame Retardants (BFR and PBDEs)	Additive flame retardants in plastics, paints, textiles, computer, machines and electronic devices
11. Alkyl phenols	

3.0 Health information and Other impacts

Persistence, bioaccumulation, and toxicity (the PBT criteria) are three characteristics of PBTs that are considered to be important determinants of potential adverse health effects to human, wildlife (birds and mammals) and aquatic life associated with actual or potential releases of chemicals. In the standard risk-assessment practices, toxicity is a characteristic reflecting the nature and severity of adverse effects in response to a given exposure, while persistence and bioaccumulation potential are two of the characteristics that influence the extent of exposure to (or contact with) chemicals. The health benchmarks used for the toxic air pollutants mentioned in the other appendices were based on the toxicity and adverse health effect on the general public, not other biological receptors. Persistence and bioaccumulation potential are important

criteria for PBTs in evaluating the adverse health effects on human and other biological receptors.

Although often emitted into the air, PBTs are not of primary concern solely based on their concentrations in the ambient air. Their health benchmarks (where they have been established) do not necessarily directly relate to their concentration in the air. Often, they are not even detected in the ambient air, yet can adversely affect humans, wildlife or aquatic life in other environmental media. In addition, routine ambient air monitoring does not exist for the PBTs of most concern.

Pollutants with PBTs characteristics remain in the environment for decades, often moving from one medium to another (*e.g.*, from air or water to soil and sediment). Additionally, they enter and are distributed through the food web, accumulating in the tissues of animals, including humans. PBTs may be present at harmful levels in the environment and remain for generations in humans, wildlife and aquatic life. They may interfere with the normal functioning of endocrine or hormone systems, central nervous systems and immune systems. They may cause a variety of problems with development, behavior and reproduction (*e.g.*, birth defects in humans and reduced populations and altered community structures within ecosystems) as well as cancer.

Minnesotans who eat large amounts of fish from local waters contaminated with certain PBTs are at increased risk for adverse effects. The developing fetus and child are especially at risk for developmental defects. The ability of wildlife and aquatic life at the top of the food chain to reproduce may be seriously threatened. Other adverse effects may also be observed.

4.0 Links to More Information on PBTs

The following is a clearinghouse of direct links to internet sites that contain useful information on a variety of PBT topics:

- Office of Pollution Prevention and Toxics – EPA's PBTs Initiatives: http://www.epa.gov/pbt and http://www.epa.gov/pbt/fact.htm

- US EPA's Great Lakes National Program Office (GLNPO) brings together Federal, state, tribal, local, and industry partners in an integrated, ecosystem approach to protect, maintain, and restore the chemical, biological, and physical integrity of the Great Lakes. Information at: http://www.epa.gov/glnpo

- One of US EPA's approaches for addressing PBTs in the environment refers to programs designed to "virtually eliminate" selected pollutants. These programs prevent any new releases of PBTs into the environment from all pathways (land, air, and water) and to eliminate the use of these target compounds wherever possible to minimize future release. More information on the Virtual Elimination Strategy at: http://www.epa.gov/reg5oair/glakes/velim.htm

- In keeping with the obligations of the Great Lakes Water Quality Agreement, Canada and the United States on April 7, 1997, signed the "Great Lakes Binational Toxics Strategy (BNS): Canada-United States Strategy for the Virtual Elimination of Persistent Toxic Substances in

the Great Lakes". This Strategy seeks percentage reductions in targeted persistent toxic substances so as to protect and ensure the health and integrity of the Great Lakes ecosystem. More information at: http://www.epa.gov/glnpo/bns

- The Toxics Release Inventory (TRI), published by the US EPA, is a valuable source of information about toxic chemicals that are being used, manufactured, treated, transported, or released into the environment. Using this information, citizens, businesses, and governments can work together to protect the quality of their land, air, and water. More information at: http://www.epa.gov/tri

- To encourage waste minimization nationwide, the US EPA developed a Waste Minimization National Plan. This initiative promotes a long-term national effort to minimize the generation of hazardous chemicals in waste regulated under the Resource Conservation and Recovery Act (RCRA). More information at: http://www.epa.gov/epaoswer/hazwaste/minimize

- In order to make the public aware of fish consumption advisories, the US EPA has set up this site to act as a data base for advisories as well as other resources including manuals on fish surveys and whether to eat fish or not. National Listing of Fish Consumption Advisories information at: http://www.epa.gov/ost/fish

- The Washington State's Department of Ecology has a very well rounded web site dealing with PBTs, including frequently asked questions, documents and other PBT links. Washington State's Department of Ecology's Initiative on Bioaccumulative Chemicals of Concern information at: http://www.ecy.wa.gov/programs/eap/pbt/pbtfaq.html

- A "Memorandum of Understanding" signed by the American Hospital Association and the U.S. Environmental Protection Agency, calls for eliminating the hazardous chemical mercury from hospital waste streams by 2005. In the health care setting, mercury is found in blood pressure monitoring devices, thermometers, fluorescent light tubes and batteries. The goals for the partnership include reducing the total volume of all types of waste generated in hospitals and health systems by one third by 2005 and ultimately by half by 2010. More information at: http://www.aha.org/MemOfUnder.html

- The MPCA worked with stakeholders to develop an emission reduction plan specifically for mercury. Details are included in the Mercury Appendix.

APPENDIX G
DRAFT
Mercury

Introduction

Mercury is considered separately from other air pollutants because it has been the subject of a special MPCA initiative, studied intensively, and its emissions quantified separately. Mercury emissions associated with electricity production and consumption in Minnesota are reported here, in accordance with Minnesota statute §116.925.

1.0 Sources and Emissions

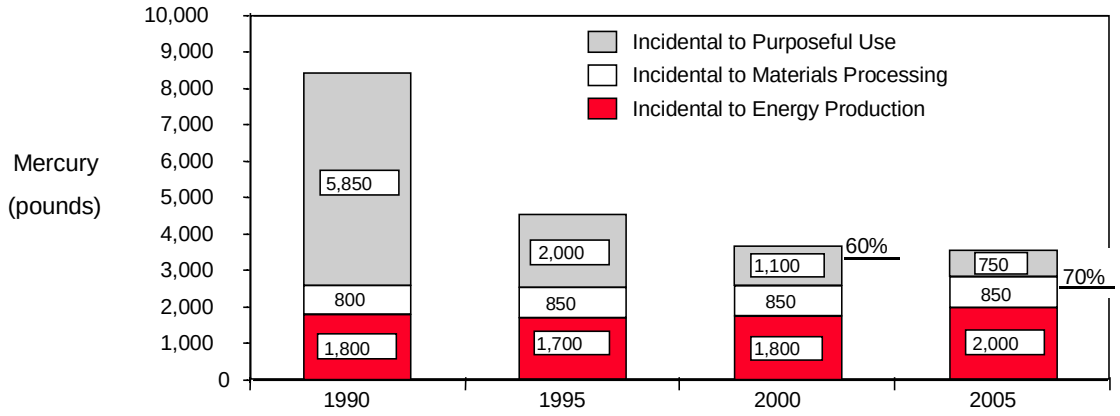
Nearly all (98 percent) of the mercury in Minnesota lakes comes from the air; very little comes from direct water discharges. Of the mercury deposited in Minnesota, about 90 percent is originally emitted by sources outside the state. A roughly equivalent amount of mercury, generated by Minnesota sources, leaves the state.

Nationally, the primary man-made sources of mercury are:

- incidental emissions from energy production (mainly from burning coal, which contains trace amounts of mercury);
- emissions from the disposal, use or manufacture of mercury-containing products or industrial wastes; and
- incidental emissions from processing mineral resources containing trace amounts of mercury (e.g., lead, iron or copper ores and limestone).

In 1990, air emissions of mercury from human activities in Minnesota were estimated to be about 8,500 pounds annually About 70 percent of this mercury was from intentional use, 20 percent was incidental to energy production and 10 percent was from minerals processing. By 1995, total air emissions of mercury had decreased to 4,600 pounds a year as a result of reduced use of mercury in products and decreased emissions from waste combustors. Emissions from other sources have remained relatively constant and are projected to remain constant or to increase, as shown in Figure 1.

Figure 1. Past mercury emissions in Minnesota, and projections for 2000 and 2005. Horizontal lines indicate the goals of a 60% reduction by 2000 and 70% reduction by 2005.



2.0 Ecological and Human Health Impacts

In spite of its well-documented toxicity to the human central nervous system, mercury continues to be used widely. Recent studies have revealed that small amounts of atmospheric mercury pollution can lead to mercury being deposited in remote lakes. There the mercury can concentrate in fish tissue enough to make eating the fish hazardous to humans and wildlife. As a result, the Minnesota Department of Health advises citizens to limit their consumption of fish from many lakes. The MPCA and EPA internet sites contain more information on the impacts of mercury in the environment.

MPCA: http://www.pca.state.mn.us/air/mercury-effects.html#health
EPA: http://www.epa.gov/grtlakes/bns/mercury/index.html#Heath

3.0 Reduction Initiatives

3.1 State Action

In 1999, following a two-year advisory council process, the Minnesota Pollution Control Agency (MPCA) recommended, and the Minnesota Legislature passed, a comprehensive mercury reduction law. That law includes the following items:

- Specific statewide mercury reduction goals;
- Reduction strategies, and
- Requirements for progress report submittal to the Legislature in 2001 and 2005.

The purpose of the initiative is to identify and implement appropriate actions for the MPCA and others to ensure that mercury releases continue to decline.

The mercury reduction law established statewide goals aimed at reducing mercury releases to Minnesota's air and water by 60 percent (compared to 1990 levels) by the end of year 2000 and

by 70 percent by the end of 2005. The 60% reduction goal could be met by reducing mercury releases from intentional uses, such thermometers, electric switches, and other products, and by improving the collection infrastructure for mercury-containing wastes. These are generally the most cost-effective approaches for reducing releases. To meet the 70% reduction goal, some coal-fired power plants and taconite-processing facilities will need to reduce their mercury emissions. Figure 1 shows the projections.

Ongoing reduction strategies include:

- encouraging voluntary commitments to reduce or work toward reducing mercury emissions;
- advancing strategies at the national level that will reduce mercury releases in other states as well in other countries;
- strategies to persuade businesses and consumers to reduce their purchases and use of mercury-containing products and to encourage proper collection and disposal of mercury-containing hazardous waste; and
- ongoing research on mercury sources and transport, options for reducing releases, and impacts on human health and wildlife.

One of the statewide mercury reduction strategies, the MPCA voluntary agreement program, challenges the private sector and other mercury sources to come up with their own innovative, cost-effective ways to reduce mercury releases. The MPCA is responsible for verifying and tracking results. The program is designed to minimize direct "command and control" regulations and resulting inefficiencies. Experimental reduction techniques and innovative research efforts are encouraged. Guidelines have been developed for the voluntary program.

Fourteen industrial mercury sources within the state are actively working toward reducing current or future mercury emissions through agreements filed with the MPCA. Participating facilities include electric utilities, taconite facilities, sewage treatment facilities, the state's major steel mini-mill, and the two major oil refineries. Over the next year, smaller mercury sources will be actively recruited into the program.

The industries have proposed numerous long-term research efforts, pilot projects, and long-term reduction efforts. Many industries have proposed or are carrying out actions that will lead to some mercury release reductions over this year and next.

The MPCA is currently involved with several other mercury reduction projects, including:

- Cooperative state project with Ramsey County, North Star Steel, and other counties to reduce the amount of mercury in auto scrap and other scrap that is released when the steel is recycled (reduction potential: 80-100 pounds per year.);
- Mercury in schools reduction partnership to find mercury stored or spilled in schools as well as in medical and industrial facilities. This program seeks to reduce the potential for children and teachers to be exposed to elemental mercury and at the same time reduce the amount of this mercury that is released into the environment. The program is evaluating several innovative mercury detection techniques.
- Ongoing efforts to integrate mercury reduction efforts under one statewide mercury policy that addresses air, water and land releases.

- Cooperative project with EPA Region 5 and others to assess new electronic communication tools that would provide (1) better management of currently dispersed mercury information—on program progress, health risks, current research, for example, and (2) quickly and effectively communicating relevant portions of this information to the public.

3.2 Federal Action

The Clean Air Act requires the U.S. EPA to study toxic air pollution from power plants to determine the necessity of additional regulations to protect public health. EPA reported its study on pollutants from electricity generation to Congress in February 1998. That study concluded that of all toxic pollutants examined, mercury posed the greatest concern for public health. The Clean Air Act also requires EPA to determine whether to proceed with the development of regulations.

On December 14, 2000 EPA announced its decision to regulate mercury air emissions from power plants. EPA will propose regulations by December 2003 and will begin developing those regulations shortly. Industry, the public, and state, local and tribal governments will have an opportunity to participate in the process. Then, EPA is expected to issue final regulations by December 2004. More information is available on EPA's mercury web site at: http://www.epa.gov/mercury.

As the federal regulatory process controlling mercury emissions from coal-fired power plants proceeds, another approach is being explored. Over the next two years, work will likely continue on a combined strategy to address all of the major pollutants emitted by power plants, including mercury, sulfur dioxide, nitrogen oxides and carbon dioxide. A comprehensive strategy that addresses all of these pollutants together will provide more certainty and flexibility to the electricity generation industry, making it the most cost-effective way to control the emissions.

3.3 Measuring Progress

The desired environmental outcome for the mercury reduction effort is reduced mercury contamination of Minnesota's fish.

Success will be measured through:
1. tracking the estimated annual rate of release of mercury emissions to air and water in the state,
2. analyzing atmospheric mercury deposition by measuring mercury in precipitation and lake sediments, and
3. measuring mercury concentrations in fish.

4.0 Mercury Emissions from Electricity Generation

In 1997 a state law took effect that requires the producers and retailers of electricity to report on the amount of mercury emitted through the generation of electricity (section §116.925). The MPCA is required by the law to summarize this emission information in its biennial air toxics report to the Minnesota Legislature. Emissions from 1998 and 1999 emissions are summarized in

Tables 1 and 2. Note that some data has not yet been submitted. The data will be updated on the MCPA internet site as the data is received (http://www.pca.state.mn.us).

Minnesota law exempts certain electricity generation facilities from reporting mercury emissions: 1) those that operate less than 240 hours per year, 2) combustion units less than 150 million British thermal units (Btu) per hour, and 3) generation units with a maximum output of less than or equal to 15 megawatts.

Submissions from over 20 generation units in Minnesota are summarized in Table 1. The major fuel for most units was coal, although some facilities depend on municipal solid waste for fuel.

The law also requires Minnesota retailers and wholesalers of electricity produced outside Minnesota to report mercury emissions associated with production; the information is summarized in Table 2.

About 40 Minnesota distribution cooperatives, which distribute electricity to consumers but do not generate any electricity, are required to report mercury emissions associated with the generation of the electricity that they distribute, most of which was generated in North Dakota, South Dakota, and Wisconsin. The information is provided to the distribution cooperatives by their suppliers, Great River Energy, Dairyland Power, Minnkota Power, and East River Electric Power Cooperative. The normalized mercury emissions per megawatt-hour from each supplier (milligrams per megawatt-hour, mg/MWh) are variable because of varying amounts of electricity purchased from the grid and from the use of hydroelectric power.

Table 1. Reported 1998 and 1999 emissions of mercury from non-exempt electrical production facilities in Minnesota.

Company	Facility	Major Fuel Type(s)	1998 Electricity Produced (MWh)	1998 Mercury Emissions (lb)	1998 Mercury Emissions per Megawatt-hour (mg/MWh)	1999 Electricity Produced (MWh)	M Emi
Blandin Paper Company	Grand Rapids Boilers 5,6	coal, wood, ties	NA	NA	NA	NA	
Champion International Corporation	Sartell Mill #3 boiler	coal, bark, sludge	NA	NA	NA	NA	
Hennepin Energy Resource Corporation	Minneapolis waste-to-energy	MSW	NA	NA	NA	NA	
LTV Steel Mining Company	Taconite Harbor Power Plant	coal	NA	NA	NA	NA	
Minnesota Power	Boswell Unit 1	coal	323,468	18.0	25	386,085	
Minnesota Power	Boswell Unit 2	coal	393,537	22.0	25	439,644	
Minnesota Power	Boswell unit 3	coal	2,143,278	115.0	24	2,206,999	
Minnesota Power	Boswell Unit 4	coal	3,556,331	197.0	25	3,140,045	
Minnesota Power	Laskin Unit 1	coal	292,135	18.0	28	570,634	
Minnesota Power	Laskin Unit 2	coal	285,537	18.0	29	combined with uni	
Northshore Mining Company	Silver Bay Power Plant	coal	NA	NA	NA	NA	
NSP	AS King 1	coal, gas, wood	2,843,610	48.5	8	3,471,370	
NSP	Black Dog 3	coal	519,680	17.4	15	1,493,820	
NSP	Black Dog 4	coal	1,074,160	32.9	14	combined with uni	
NSP	High Bridge 5	coal, gas	573,250	23.8	19	496,989	
NSP	High Bridge 6	coal, gas	1,061,880	40.8	17	782,899	
NSP	Red Wing 1 Waste-to-Energy	wood, RDF	69,904	166.6	1081	69,103	
NSP	Red Wing 2 Waste-to-Energy	wood, RDF	70,158	159.4	1031	59,457	
NSP	Riverside 6/7	coal	1,110,980	55.0	22	774,869	
NSP	Riverside 8	coal	1,636,390	47.9	13	1,539,980	
NSP	Sherco 1	coal	4,130,940	157.2	17	4,238,380	
NSP	Sherco 2	coal	4,780,060	185.3	18	5,104,380	
NSP	Sherco 3 (NSP owned portion)	coal	4,092,157	191.1	21	3,507,986	
NSP	Wilmarth 1 Waste-to-Energy	RDF, gas	71,343	15.5	99	69,884	
NSP	Wilmarth 2 Waste-to-Energy	RDF, gas	77,658	20.5	120	exempt	
Otter Tail Power Company	Hoot Lake Plant Unit 2	coal	342,657	18.8	25	312,911	
Otter Tail Power Company	Hoot Lake Plant Unit 3	coal	330,855	18.8	26	355,716	
Rochester Public Utilities	Silver Lake 3	coal	NA	NA	NA	NA	
Rochester Public Utilities	Silver Lake 4	coal	NA	NA	NA	NA	
Southern Minnesota Municipal Power Agency	Austin NE Power Plant	coal	NA	NA	NA	NA	
Southern Minnesota Municipal Power Agency	Sherco 3 (SMMPA-owned)	coal, oil	2,416,573	123.7	23	2,035,404	

Notes
MSW is municipal solid waste.
RDF is refuse-derived fuel, which is sorted and processed municipal solid waste.
NA indicates that data was either not available or not submitted to the MPCA.

Table 2. Reported 1998 and 1999 emissions of mercury from electrical production facilities outside Minnesota for which the electricity was likely consumed in Minnesota. Electricity and mercury figures for each company and facility are prorated to the amount of electricity likely consumed in Minnesota.

Reporting Organization	Facility or Supplier	Major Fuel Type(s)	1998 Electricity Consumed in Minnesota (MWh)	1998 Mercury Emissions (lb)	1998 Mercury Emissions per Megawatt-hour (mg/MWh)	1 Elec Consu Min (M
Interstate Power Company, Marshalltown, IA	Dubuque 1, Dubuque IA	bituminous coal	NA	NA	NA	
Interstate Power Company, Marshalltown, IA	Dubuque 5, Dubuque IA	bituminous coal	NA	NA	NA	
Interstate Power Company, Marshalltown, IA	Lansing 3, Lansing IA	bituminous coal	NA	NA	NA	
Interstate Power Company, Marshalltown, IA	Lansing 4, Lansing IA	subbituminous coal	NA	NA	NA	
Interstate Power Company, Marshalltown, IA	Louisa 1/Louisa Co. IA	subbituminous coal	NA	NA	NA	
Interstate Power Company, Marshalltown, IA	ML Kapp 2, Clinton IA	subbituminous coal	NA	NA	NA	
Interstate Power Company, Marshalltown, IA	Neal 4, Sioux City IA	subbituminous coal	NA	NA	NA	
NSP	Bay Front 1, 2, 5 (1998), 5 (1999)	coal, gas wood, RDF	343,783	11.2	15	
NSP	French Island 1 waste-to-energy, La Crosse WI	RDF, wood	34,970	4.4	57	
NSP	French Island 2 waste-to-energy, La Crosse WI	RDF, wood	46,505	8.2	80	
Otter Tail Power, Fergus Falls, MN	Big Stone Plant, Big Stone Lake, SD	subbituminous coal	842,738	47.8	26	
Otter Tail Power, Fergus Falls, MN	Coyote Plant, Beulah, ND	lignite coal	516,302	60.9	54	
People's Cooperative Power Ass'n	Dairyland Power Cooperative	coal	N/A	N/A	N/A	
Tri-County Electric Cooperative	Dairyland Power Cooperative	coal	N/A	N/A	N/A	
Freeborn-Mower Cooperative Services	Dairyland Power Cooperative	coal	N/A	N/A	N/A	
Agralite Electric Cooperative	Great River Energy	lignite coal	135,345	6.3	21	
Arrowhead Electric Cooperative	Great River Energy	lignite coal	48,389	3.2	30	
Benco Electric Cooperative	Great River Energy	lignite coal	NA	NA	NA	
Brown County Rural Electrical Ass'n	Great River Energy	lignite coal	107,184	5.2	22	
Connexus Energy	Great River Energy	lignite coal	1,561,431	106.2	31	1,
Cooperative Light and Power	Great River Energy	lignite coal	74,041	1.0	6	
Crow Wing Power	Great River Energy	lignite coal	N/A	N/A	N/A	
Dakota Electric Ass'n	Great River Energy	lignite coal	1,382,019	94.0	31	1,
East Central Electric Ass'n	Great River Energy	lignite coal	659,588	44.8	31	
Federated Rural Electric	Great River Energy	lignite coal	134,413	6.0	20	
Goodhue County Cooperative Electric Ass'n	Great River Energy	lignite coal	75,708	5.2	31	
Itasca-Mantrap Co-op. Electrical Ass'n	Great River Energy	lignite coal	122,319	8.3	31	
Kandiyohi Power Cooperative	Great River Energy	lignite coal	N/A	N/A	N/A	
Lake Country Power	Great River Energy	lignite coal	530,766	36.1	31	
Lake Region Electric Cooperative	Great River Energy	lignite coal	300,259	15.2	23	
McLeod Cooperative Power Ass'n	Great River Energy	lignite coal	143,563	9.0	28	
Meeker Cooperative Light & Power Ass'n	Great River Energy	lignite coal	124,473	6.7	25	
Mille Lacs Electric Cooperative	Great River Energy	lignite coal	8,281,585	527.2	29	8,
Minnesota Valley Electric Cooperative	Great River Energy	lignite coal	372,022	25.3	31	
Nobles Electric Cooperative	Great River Energy	lignite coal	106,431	3.5	15	
North Itasca Electric Cooperative, Inc.	Great River Energy	lignite coal	32,511	1.8	25	
Redwood Electric Cooperative	Great River Energy	lignite coal	55,055	1.7	14	
Runestone Electric Ass'n	Great River Energy	lignite coal	167,419	8.1	22	
South Central Electric Ass'n	Great River Energy	lignite coal	110,621	4.9	20	
Stearns Electric Ass'n	Great River Energy	lignite coal	NA	NA	NA	
Steele-Waseca Cooperative Electric	Great River Energy	lignite coal	165,942	11.3	31	
Todd-Wadena Electric Cooperative	Great River Energy	lignite coal	129,478	6.7	23	
Wright-Hennepin Cooperative Electric Ass'n	Great River Energy	lignite coal	NA	NA	NA	
Clearwater-Polk Electric Cooperative	Minnkota Power Cooperative	lignite coal	NA	NA	NA	

North Star Electric Cooperative	Minnkota Power Cooperative	lignite coal	NA	NA	NA
PKM Electric Cooperative	Minnkota Power Cooperative	lignite coal	NA	NA	NA
Red Lake Electric Cooperative	Minnkota Power Cooperative	lignite coal	NA	NA	NA
Red River Valley Cooperative Power Ass'n	Minnkota Power Cooperative	lignite coal	NA	NA	NA
Roseau Electric Cooperative	Minnkota Power Cooperative	lignite coal	NA	NA	NA
Wild Rice Electric Cooperative	Minnkota Power Cooperative	lignite coal	NA	NA	NA
Beltrami Electric Cooperative	Minnkota Power Cooperative	lignite coal	NA	NA	NA
Lyon-Lincoln Electric Cooperative	East River Electric Power Cooperative	N/A	75,507	N/A	N/A
Minnesota Valley Coop. Light & Power Ass'n	East River Electric Power Cooperative	N/A	N/A	N/A	N/A
Renville Sibley Cooperative Ass'n	East River Electric Power Cooperative	N/A	94,430	N/A	N/A
Traverse Electric Cooperative	East River Electric Power Cooperative	N/A	43,996	N/A	N/A

Notes

RDF is refuse-derived fuel, which is sorted and processed municipal solid waste.

NA indicates that data was either not available or not submitted to the MPCA.

Mercury emissions per megawatt-hour calculations for the cooperatives may vary in part due to consumption of hydroelectric powe

APPENDIX I
DRAFT
Mobile Sources Emissions and Trends

1.0 Mobile sources are major contributors to both air toxics and other air pollution problems

Motor vehicles emissions are related to the increased use of automobiles, trucks and off-road vehicles, which have grown steadily throughout the past century. This trend is clearly demonstrated in the Twin Cities and Minnesota. According to the State and Territorial Air Pollution Program Administrators, in virtually every state and city, mobile sources have been one of the largest sources over the last 30 years of criteria pollutants, air toxics and greenhouse gasses (STAPPA, 1999).

Concerns persist that increases in vehicle weight and increased vehicle miles traveled may increase fuel consumption and future mobile source emissions. Concern over increased fuel consumption and increased mobile source emissions persist despite the large reductions of vehicle emission rates of most pollutants, as a result of federal, state and local emission controls. Air quality concerns of increased mobile source emissions include health impacts from air toxics, particulates and ozone as well as greenhouse gas contributions to global warming and possible future non-compliance with federal particulate and ozone standards.

2.0 Vehicles and fuels are getting cleaner

Technology and Mobile Sources

Air pollution and cars were first linked in the early 1950's by a California researcher who determined that traffic was to blame for the smoggy skies over Los Angeles. At the time, typical new cars were emitting nearly 13 grams per mile hydrocarbons (HC), 3.6 grams per mile nitrogen oxides (NOx), and 87 grams per mile carbon monoxide (CO).
Since then, the Federal Government has regularly set increasingly stringent standards to bring down levels of these pollutants, and the auto industry responded by developing new emission control technologies. The current Federal certification standards for exhaust emissions from cars are 0.25 gram per mile HC, 0.4 gram per mile NOx, and 3.4 grams per mile CO.

This decrease constitutes a 98% reduction in HC, an 88% reduction in NOx, and a 96% reduction in CO. The reason for these massive decreases in vehicle emissions is technology.

Technology:

Technical advances in the automotive industry have been driven by a number of factors. Market demands, societal changes, economics, and government regulation are all factors in technical improvements within the automotive industry. Government regulations regarding tailpipe emissions had some of the most dramatic affects on the auto industry in the last 40 years. As a result of these technical improvements, cars today are cleaner and more efficient.

Specifically, the technology that has changed vehicle emissions can be lumped into three categories: pretreatment, which means before combustion takes place, post treatment, which means after combustion has taken place, and combustion treatment, which means during the combustion process. Each one of these categories controls the individual pollutants in a different way, combining to make the overall emissions control package as effective as possible. To understand what each of the pollution control components does and how it operates, it is important to understand where each of the individual pollutants comes from.

Sources of Auto Emissions:

The power to move a car comes from burning fuel in an engine. Pollution from cars comes from by-products of this combustion process (exhaust) and from evaporation of the fuel itself.

Gasoline and diesel fuels are mixtures of hydrocarbons, compounds that contain hydrogen and carbon atoms. In a "perfect" engine, oxygen in the air would convert all the hydrogen in the fuel to water and all the carbon in the fuel to carbon dioxide. Nitrogen in the air would remain unaffected. In reality, the combustion process cannot be "perfect," and automotive engines emit several types of pollutants.

"Perfect" Combustion:

FUEL (hydrocarbons) + AIR (oxygen and nitrogen) ==
CARBON DIOXIDE + water + unaffected nitrogen

"Typical" Engine Combustion:

FUEL + AIR == UNBURNED HYDROCARBONS + NITROGEN OXIDES +
CARBON MONOXIDE + CARBON DIOXIDE + water

Exhaust Pollutants:

1) Hydrocarbons (HC), Volatile Organic Compounds (VOCs) and Air Toxics

Hydrocarbon, volatile organic compounds and air toxics emissions result when fuel molecules in the engine do not burn or burn only partially. VOCs are defined in a regulatory sense as the subset of organic chemicals that are ozone precursors. Hydrocarbons react in the presence of nitrogen oxides and sunlight to form ground-level ozone, a major component of smog. Ozone irritates the eyes, damages the lungs, and

aggravates respiratory problems. It is also responsible for damage to trees, crops and other plants. A number of exhaust hydrocarbons are also air toxics. High percentages of several air toxics result from mobile source emissions.

2) Nitrogen Oxides (NOx)

Under the high pressure and temperature conditions in an engine, nitrogen and oxygen atoms in the air react to form various nitrogen oxides, collectively known as NOx. Nitrogen oxides, like hydrocarbons, are precursors to the formation of ozone. They also contribute to the formation of acid rain.

3) Carbon Monoxide (CO)

Carbon monoxide (CO) is a product of incomplete combustion and occurs when carbon in the fuel is partially oxidized rather than fully oxidized to produce carbon dioxide (CO2).

4) Carbon Dioxide (CO2)

In recent years, the U.S. Environmental Protection Agency (EPA) has started to view carbon dioxide, a product of "perfect" combustion, as a pollution concern. Carbon dioxide does not directly impair human health, but it is a "greenhouse gas" that traps the earth's heat and contributes to the potential for global warming.

Evaporative Emissions:

Hydrocarbon pollutants also escape into the air through fuel evaporation. With today's efficient exhaust emission controls and today's gasoline formulations, evaporative losses can account for a majority of the total hydrocarbon pollution from current model cars on hot days when ozone levels are highest. Evaporative emissions occur several ways:

Diurnal: Gasoline evaporation increases as the temperature rises during the day, heating the fuel tank and venting gasoline vapors.

Running Losses: The hot engine and exhaust system can vaporize gasoline when the car is running.

Hot Soak: The engine remains hot for a period of time after the car is turned off, and gasoline evaporation continues when the car is parked.

Refueling: Gasoline vapors are always present in fuel tanks. These vapors are forced out when the tank is filled with liquid fuel.

What Has Been Done to Control Automobile Emissions?

The Clean Air Act of 1970 gave EPA broad authority to regulate motor vehicle pollution, and the EPA's emission control policies have become progressively more stringent since the early 1970's. EPA standards dictate how much pollution autos may emit but automakers decide how to achieve the pollution limits. The emission reductions of the 1970's came about because of fundamental improvements in engine design, plus the addition of charcoal canisters to collect hydrocarbon vapors and exhaust gas recirculation valves to reduce nitrogen oxides.

The advent of "first generation" catalytic converters in 1975 significantly reduced hydrocarbon and carbon monoxide emissions. The use of converters provided a huge indirect benefit as well. Because lead inactivates the catalyst, 1975 saw the widespread introduction of unleaded gasoline. This resulted in dramatic reductions in ambient lead levels and alleviated many serious environmental and human health concerns associated with lead pollution.

The next major milestone in vehicle emission control technology came in 1980-81. In response to tighter standards, manufacturers equipped new cars with even more sophisticated emission control systems. These systems generally include a "three-way" catalyst (which converts carbon monoxide and hydrocarbons to carbon dioxide and water, and also helps reduce nitrogen oxides to elemental nitrogen and oxygen), plus an on-board computer and oxygen sensor. This equipment helps optimize the efficiency of the catalytic converter.

Provisions of the 1990 Clean Air Act are further reducing vehicle emissions. Mobile source provisions include even tighter tailpipe standards, increased durability, improved control of evaporative emissions, and computerized diagnostic systems that identify malfunctioning emission controls. In 2004, new rules will start taking effect that will require additional pollution control equipment on vehicles as well as low-sulfur fuel. The combination of the new pollution controls and low-sulfur fuel will result in substantial reductions of the pollutants that combine to create smog, or ground level ozone.

What is Currently Being Done to Control Automobile Emissions?

Government and industry are working together to develop new automotive technology. Areas of current focus include the following.

- Joint automotive technology research with a goal to triple fuel economy without sacrificing safety, performance and affordability.
- Study of piston engines that incorporate advanced technology such as turbocharging, multiple valves and lightweight materials.
- All electric vehicles that generate electricity by means of an on-board chemical reaction in a fuel cell.
- Hybrid electric vehicles that combine two different types of power sources in a single vehicle to take advantage of benefits of both.

- Advanced power sources such as gas turbines, flywheels, and ultracapacitors.
- Reducing energy demand by reducing aerodynamic drag , improving tire performance and improving energy performance of automobile accessories.
- Reducing energy losses through means such as regenerative braking which saves the energy usually dissipated as heat during vehicle braking and use it to power the car instead.

What Work is Being Done to Develop Clean Fuels?

The most familiar transportation fuels in this country are gasolines and diesel fuel, but any number of energy sources are capable of powering motor vehicles. These include alcohols, electricity, natural gas, and propane. Some vehicle fuels, because of physical or chemical properties, create less pollution than do today's gasolines. These are called "clean fuels."

Clean fuels have a number of inherent properties that make them cleaner than conventional gasoline. In general, these fuels emit less hydrocarbons, and the hydrocarbons they do emit are less reactive (slower to form ozone) and less toxic. Emissions from electricity, natural gas, or alcohol-powered vehicles can be as much as 90 percent lower in toxics and ozone-forming hydrocarbons than emissions from vehicles fueled with conventional gasoline. New gasoline formulations ("reformulated gasoline") are expected to reduce these emissions up to 25 percent over today's gasoline (EPA, 1994).

Use of clean fuels could also help slow atmospheric buildup of carbon dioxide, a "greenhouse gas" that contributes to the potential for global warming. Combustion of any carbon-based fuel produces carbon dioxide. But the overall impact of a given fuel on global warming depends on how the fuel is made. In general, fuels produced from biomass (crops, trees, etc.) and from natural gas generate less carbon dioxide when they are burned than fuels made from petroleum or coal.

Clean fuels have benefits that reach beyond their air quality advantage. New fuels in the marketplace give consumers new choices and could decrease our dependence on imported oil.

3.0 Causes for mobile source pollution

Vehicle Ownership and Vehicle Travel is Increasing in Minnesota.

Minnesota reflects the national trend of rapidly increasing growth rates of automobile and vehicle ownership. On a typical day in the Twin Cities region in 1998, transportation had the following characteristics:

- 9.1 million vehicle trips,
- 12.6 million person-trips,
- 71 million miles of motor vehicles traveled,
- 94% of motor vehicle trips in autos,
- 2.5% of trips utilized public transit, and
- 3.5% of trips utilized school buses.

(Metropolitan Council, 2000).

Automobile travel is increasing faster than population growth.

According to the Metropolitan Council's 1990 Travel Behavior Inventory report, from 1970 to 1990, the population of the Twin Cities seven-county area increased by 20% but daily vehicle-miles traveled (VMT) increased by 130%. People either drove or rode in automobiles for over 93% of all trips (excludes biking and walking). From 1970-1990, the average vehicle trip distance rose from 5.09 to 6.55 miles, an increase of 29%. There has been a 20% increase since 1997 Metro Transit ridership. This has occurred in part because of a 3.8 percent increase in service in 1998 and significantly more employers providing discounted passes.

Met Council projects that by 2020, as a result of population and income growth, there will be a significant increase in automobile ownership and use. Met Council also projects that by 2020 in the Twin Cities metropolitan area, vehicle ownership will increase by 30.9% and daily vehicle miles will increase by 39.3%.

There are a variety of reasons for the large increase in vehicle miles traveled relative to population increase. A major reason is the rapid overall growth of the workforce over the past three decades, which includes an increase in number of women working. Furthermore, larger numbers of workers travel to work in private automobiles compared to public transportation (University of Minnesota, Center for Transportation Studies, 2000).

The high level of automobile ownership and use are also influenced by sprawling land use patterns which often require frequent long trips because of large distances between many destinations and inadequate public transit to serve dispersed suburban populations.

Low Energy Prices Encourage More Driving

Despite energy crises in the 1970s, which raised prices and concerns about future price and availability of energy, overall energy consumption by highway vehicles has risen steadily. Energy consumption in the transportation sector has grown overall and is increasing its percentage of national energy consumption. One important factor for the increase in fuel consumption has been the decline in gasoline prices since 1980. Gasoline prices fell by 50% in constant dollars from 1980 to 1990. When gasoline prices are low, the variable cost per mile of driving is reduced as well as the proportion of the cost of purchasing, operating and insuring a car. Furthermore with cheap fuel, the proportion of automobile expenses devoted to gas and oil decreases (EPA, 2000).

Consumers Preferences for More Powerful Vehicles Are Resulting in Declining Fuel Economy

EPA reported in *Light –Duty Automotive Technology and Fuel Economy Trends 1975 Through 2000* that since 1988, average new light-duty vehicle fuel economy has declined 1.9 miles per gallon (MPG). This has occurred as a result of the increase of light truck and sport utility vehicle (SUV) market share and because fuel economy has been traded off for increased vehicle weight and engine size (performance). Key highlights of the EPA's evaluation include the following.

Highlight #1: Fuel Economy Remains at a 20-Year Low

Since 1988, there has been an overall decline in light vehicle fuel economy. The average fuel economy for all model year 2000 light vehicles is now 24.0 miles per gallon and is as low as it has been at any time since 1980. Average light vehicle fuel economy is now 7% lower than 1987 and 1988.

Highlight #2: Trucks Represent Nearly Half of New Vehicle Sales

Sales of light trucks, which include sport utility vehicles (SUVs) vans and pickup trucks, have risen steadily for over 20 years and now make up 46% of the U.S. light vehicle market- more than twice their market share as recently as 1983.

Highlight #3: Fuel Economy is Being Traded for Weight and Power

More efficient technologies such as fuel injection systems, extra gears and advanced transmissions are being used to increase light vehicle weight and acceleration rather than fuel economy (see Table 1). Based on accepted engineering relationships, however, had the new 2000 light vehicle fleet had the same average weight and performance as in 1981, it could have achieved 25% higher fuel economy (p.iv, above referenced in the EPA report).

Table 1
Percent Change from 1981 to 2000
In Average Vehicle Characteristics

Characteristic	Percentage Change
Fuel Economy	-0.4%
Weight (pounds)	+21%
Horsepower	+79%
Acceleration [seconds] (0-60 miles per hr)	-26%

Highlight #4: Ford and General Motors are Pledging to Increase Fuel Economy

Ford Motor Company recently pledged to increase the fuel economy of its entire line of sport utility vehicle sales by 25 percent by the 2005 model year. General Motors pledged to remain the truck fuel economy leader. If all manufacturers were to voluntarily increase the average fuel economy of their entire light vehicle fleets by 25% by 2005, average new light vehicle fuel economy would increase from 24 miles per gallon to 30 miles per gallon.

Highlight #5: The Honda Insight Hybrid is the Most Fuel Efficient U.S. Vehicle Since 1975

The model year 2000 Honda Insight is the most fuel-efficient vehicle sold in the U.S. since 1975 and likely the most fuel-efficient vehicle ever sold in the U.S. market. The Honda insight, which utilizes a gasoline/battery hybrid engine, is the first hybrid vehicle ever sold in the U.S. The Insight has a laboratory fuel economy of 76.3 miles per gallon (mpg) and *Fuel Economy Guide*/label ratings of 61-mpg city and 70 mpg highway. Toyota introduced a hybrid vehicle, the Prius, in the U.S. market in 2000. This compact car has a laboratory fuel economy rating of 57.6 mpg, and *Fuel Economy Guide*/label ratings of 52-mpg city and 45 mpg highway.

The MPCA purchased both a Honda Insight and Toyota Prius in 2000 as part of an effort to model and demonstrate new clean vehicle and fuel technologies in the Minnesota market. There has been a very high degree of public and media interest in these cars and other clean vehicle and fuel technologies to meet consumer transportation needs and reduce environmental emissions and impact from driving.

Replacing the National 55 Miles Per Hour Speed Limit With 65 Miles Per Hour Speed Limits on Urban Interstate Freeways Has Increased Vehicle Emissions

In 1996, President Clinton signed into law a bill that included a provision for eliminating the 55/65-MPH speed limits as a prerequisite for Federal highway funding, which had been in effect since 1974 during the energy crisis. The EPA evaluated the air quality emissions impact from highway vehicles resulting from eliminating the national speed limit. The EPA determined that increasing urban interstate freeway speed from 55 to 65 mph could increase total vehicle emissions about 7.5% for VOC (volatile organic carbon), 20.7% for CO (carbon monoxide) and 1.3% for NOx (nitrogen oxide).

4.0 Other costs of increased mobile activity: Growing traffic congestion and higher infrastructure costs

Compared to other metropolitan areas, the Twin Cities congestion today is not considered to be a serious problem. However, congestion is predicted to increase as the number of drivers, trips, vehicles per household and vehicle miles traveled increase during the next 20 years. The Minnesota Department of Transportation (Mn DOT) predicts that even with an investment of $3.5 billion for increased road capacity, there will be 129 miles of congested roadway by 2020. This is almost a 50% increase compared to the 87 miles of roadway that were congested in 1994 and will result in a 35% increase in average travel times during rush hour. MNDOT indicates that the rate of adding to freeway miles will decrease markedly from the past 30 years.

Under all growth scenarios being considered by the Metropolitan Council, results of computer modeling suggest that increasing congestion is likely. Increasing the extent of urban sprawl increases the difficulty in providing transit options due to the difficulty in providing viable transit service within a quarter mile of transit riders which is considered by planners to be the maximum distance transit riders are willing to walk to a transit stop. Metropolitan Council planners believe that a mix of housing and job locations and higher residential densities are required to provide more frequent transit service at a practical cost.

5.0 Future Trends

Although vehicles and fuels are getting cleaner recent trends of increased driving and demand for heavier, more powerful passenger vehicles raise concern over future increased mobile source emissions and increased air pollution problems.

Travel Projections*
Twin Cities Metropolitan Region

	1998	2020	Change
Population	3,036,600	3,704,7000	22.0%
Households	1,159,000	1,474,600	27.1%
Vehicles	2,685,000	3,514,000	30.9%
Daily Vehicle-Miles	71,000,000	100,500,000	39.3%

*Projections from *The Full Cost of Transportation in the Twin Cities Region*. August 2000. University of Minnesota

Modeling by the MPCA and Metropolitan Council Projects Increases in Pollutant Emissions from Vehicles after 2005.

Air emission modeling by the MPCA and Metropolitan Council has been performed to evaluate air emissions from transportation sources for a variety of scenarios and forecast years. The MPCA and Metropolitan Council used MOBILE5A (available at http://www.epa.gov/otaq/m5.htm) and EMIS air quality analysis models. The calculations were based on emission factors from MOBILE5A (in grams per vehicle mile), vehicle miles traveled (VMT) and estimated speed and travel throughout the Twin Cities highway transportation system. The modeling is part of a cooperative effort by the MPCA and MNDOT to develop Transportation Improvement Plans (TIP) for the Twin Cities Metropolitan area. TIP is a requirement for federal funding of transportation projects. The purpose of the TIP is to insure that transportation projects in our region are consistent with the region's priorities including the goal of clean air for both the present and the future.

Results of this analysis can be found in the following table titled "Daily Vehicle Emissions for the Twin Cities 7-County Region"

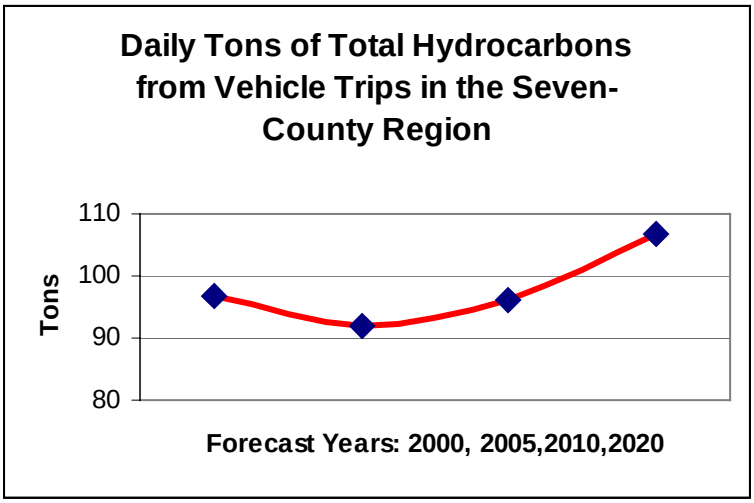
Daily Vehicle Emissions
for Twin Cities 7-County Region

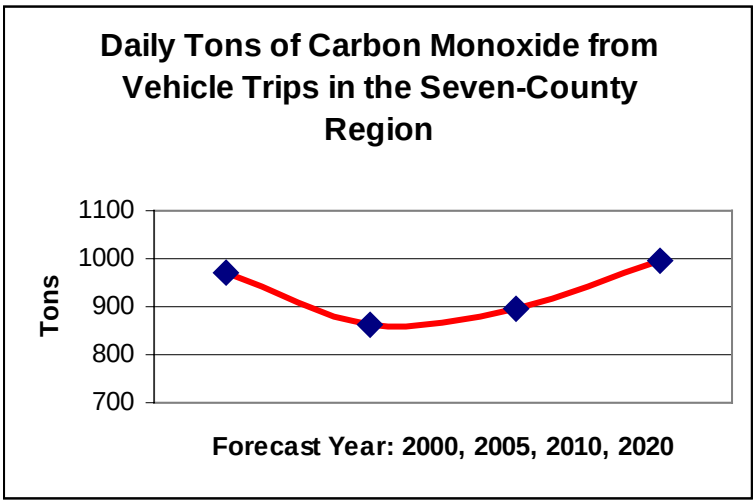
Year Emission	2000	2005	2010	2020
Total VOC	96.73	91.86	96.09	106.69
Exhaust HC	96.19	91.37	95.44	106.1
Evaporative HC	0.63	0.67	0.73	0.82
Total HC	96.82	92.04	96.17	106.92
CO	970.31	864.18	895.06	996.88
NOx	188.06	177.03	182.65	200.06

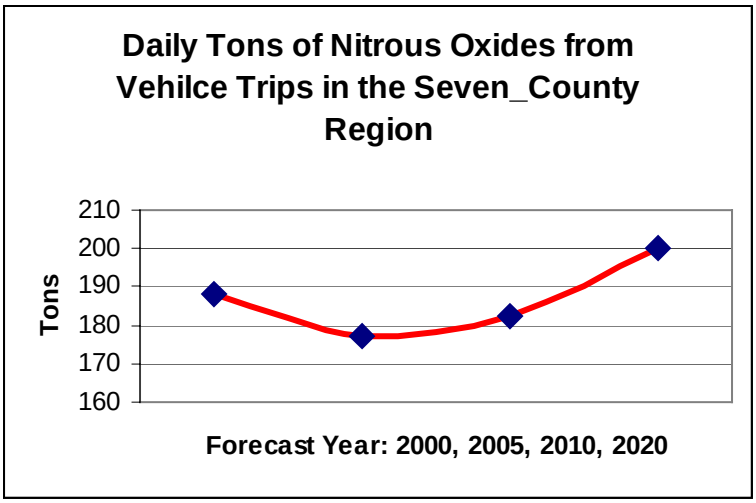
The modeling results indicate that although improvements in automobile technology are reducing the emissions of a wide variety of pollutants, such as nitrogen oxide, carbon monoxide, volatile organic carbon and particulate matter (PM10), the improvement is being offset by increases in vehicle miles traveled and recent consumer preferences for larger vehicles with larger engines.

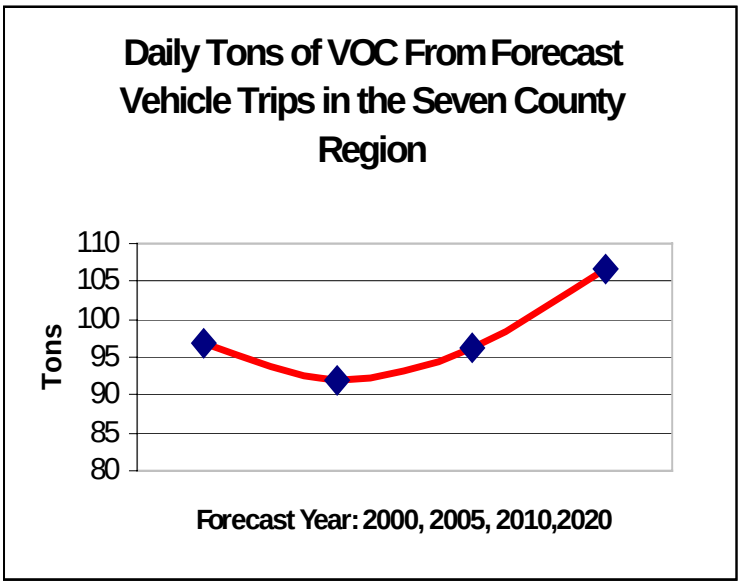
The figure indicates that for volatile organic compounds, (VOC), Hydrocarbons (HC), Carbon monoxide (CO) and Nitrogen oxide, (NOx), forecasted improvements due to cleaner fuels and vehicles are offset by increases in vehicle miles traveled between 2005 and 2010 and emissions for these pollutant are forecast to increase thereafter. Further analysis is currently underway to determine the impacts of proposed federal regulations mandating cleaner fuel and vehicles as well as the offsetting trend in Minnesota away from cars toward larger, heavier and less efficient trucks and sport utility vehicles for individuals and families.

EPA will soon release Mobile6, the latest version of their motor vehicle emission model. Mobile6 will take into account many of the recent federal regulations as part of predicting future vehicle emissions. In addition, the Metropolitan Council is updating its travel behavior study, which is also used to predict future vehicle emissions. Finally, the MPCA is collecting current vehicle data to use in the Mobile6 model. The new model and updated information will facilitate more accurate predictions of impact of vehicle emissions on Minnesota's air quality.


Daily Tons of Total Hydrocarbons from Vehicle Trips in the Seven-County Region
Tons
110
100
90
80
Forecast Years: 2000, 2005,2010,2020


Daily Tons of Carbon Monoxide from Vehicle Trips in the Seven-County Region
Tons
1100
1000
900
800
700
Forecast Year: 2000, 2005, 2010, 2020


Daily Tons of Nitrous Oxides from Vehilce Trips in the Seven_County Region
Tons
210
200
190
180
170
160
Forecast Year: 2000, 2005, 2010, 2020



Summary and Conclusion

Motor vehicle emissions related to the increased purchase and use of automobiles, trucks and off road vehicles have grown steadily in Minnesota as well as throughout the nation and the world.

Significant progress has been made since 1970 to develop cleaner fuels and motor vehicles and efforts are underway to significantly improve emissions from all mobile sources in the next decade.

However, fuel economy and vehicle emissions technological progress is being eroded by rapidly increasing demands on the transportation system including more trips, longer commutes, faster driving speeds, more drivers as well as heavier and more powerful vehicles. Furthermore, increased demands on the transportation system are resulting in growing traffic congestion and higher infrastructure costs

Computer modeling performed by the Metropolitan Council and the MPCA raise concerns that after 2005 mobile sources emissions may increase. The potential for increased mobile source emissions also raises concerns about increased health impacts, increased greenhouse gas emissions which could impact global warming and possible non-compliance with proposed federal particulate and ozone air quality standards.

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APPENDIX J
DRAFT
Current Efforts – Mobile Sources

The MPCA currently has three efforts underway to address mobile sources of air pollution. Another effort, the Vehicle Inspection Program, operated from 1991 to 1999 and was intended to reduce carbon monoxide pollution in the Twin Cities. As a result of this program and improvements in vehicles and fuels, carbon monoxide levels dropped in the Twin Cities to within the federal standards and the program was ended.

1.0 MPCA's Indirect Source Permiting program

The indirect source permit program was established to minimize the air quality and noise impacts from large developments and major highway projects. Any facility, building or other structure that attracts a certain level of automobile traffic is considered an "indirect source" of carbon monoxide (CO) and noise pollution, and is regulated under the program. Indirect sources include, but are not limited to:

- Airports
- Roadways
- Parking facilities
- Retail, commercial, and industrial facilities
- Recreation, amusement, sports and entertainment facilities
- Office and government buildings
- Apartment and condominium buildings
- Education facilities

An indirect source permit is a legally binding agreement, enforced by state and local governments that documents how the permittee will meet the state's air quality regulations and mitigate any traffic and noise impacts during construction and operation of the indirect source. Applicants must show how they will maintain adequate traffic flow near the indirect source so the project will not cause an exceedance of the state's CO standards. The MPCA issues about 15 indirect source permits each year.

2.0 MPCA's Modelling the Way Effort

Through its use and purchasing of vehicles and fuels and through its support of less polluting commuting and work travel, the state can demonstrate positive examples for choices and policies to reduce vehicle pollution. The MPCA is working with other state agencies to improve the environmental performance of the state's motor vehicle fleet. The MPCA is also working with other agencies to increase the state's support of commuting choices that reduce environmental impacts. The following are examples of

the specific steps taken by the MPCA to improve its fleet and to support commuter choices:

- Purchase of two highly efficient hybrid gasoline/electric vehicles for MPCA staff use.
- Policy to purchase the most fuel-efficient vehicle that meets business needs.
- Policy to purchase flexible fuel vehicles if a model is available.
- Instructions to use E85 in all flexible fuel vehicles when possible.
- Testing of propane and natural gas powered vehicles for possible addition to the fleet.
- Participation in the Metropass program— the MPCA was the first public agency to offer annual bus passes to its employees.

3.0 MPCA's Outreach Effort

The mobile sources outreach efforts is designed to raise public awareness of the link between transportation choices and environmental impacts. The MPCA is encouraging people to take steps to reduce their contribution to the pollution problem and understand how their behaviors contribute to the problem. The outreach effort uses education and encouragement to strengthen commitment for environmentally beneficial activities, at the level of personal behavior and public policy. The MPCA is working with partners in state and local government as well as the private and non-profit sectors to:

- Increase awareness of the link between transportation choices and environmental impacts among the general public, especially to increase public support for specific measures to reduce environmental impacts of transportation.

- Inform public and private sector decision-makers of the environmental impacts of transportation so that they will consider these impacts in making decisions that could have a positive or negative effect.

- Encourage behavior changes that reduce the environmental impacts of transportation.

Examples of current activities:

- Presentations to numerous groups including school, community, business and other interest groups about the environmental impacts of transportation and cleaner choices.
- Display of the MPCA's hybrid gasoline/electric vehicles at numerous events including the Minnesota State Fair.
- Contact with reporters that led to media coverage of Insight and Prius (hybrid vehicles) including cable and broadcast television, radio and newspaper.
- Working with automotive reporters who cover alternative fuel and hybrid vehicles on television, radio and newspaper.
- Sponsorship of Earth Day 2000 Clean Transportation Fair at the State Capitol.

4.0 Efforts of other State Agencies

In addition to the efforts of the MPCA, other state and metropolitan entities address mobile sources of air pollution as well. Minnesota Planning and the Metropolitan Council, for example, work at the state and regional level to address a host of land use planning issues, including air and water quality impacts.

The Minnesota Department of Transportation (MnDOT), MetroTransit and the Twin Cities' Transportation Management Organizations actively promote alternatives to single passenger automobile use, such as car pools, transit, bicycles, and walking, as a means to improve regional air quality. Additionally MnDOT has entered into partnerships with the MPCA and Metropolitan Council to implement congestion management practices such as ramp metering, preferential high occupancy vehicle lanes, use of roadway shoulders, incident management strategies, and enhanced information on traffic conditions. These efforts are designed to help safely accommodate traffic and reduce air quality emissions and energy consumption.

Other state agencies, such as the Departments of Commerce and Administration, have worked with the MPCA to ensure that the state's motor vehicles fleets model the way in terms of using fuel efficient vehicles, and alternative fuels. Finally, the Office of Environmental Assistance has addressed air quality issues through its information to citizens and businesses about steps they can take to reduce air pollution.

5.0 Current Federal Efforts

5.1 New Federal Standards for Gasoline Powered Vehicles

EPA announced more protective tailpipe emissions standards for all passenger vehicles, including sport utility vehicles (SUV's), minivans, vans and pick-up trucks. This regulation marks the first time that SUV's and other light duty trucks are subject to the same national pollution standards as cars. The regulations will take effect between 2004 and 2009.

The Clean Air Act Amendments of 1990 (P.L. 101-549) established more stringent federal emission standards for all new vehicles manufactured for sale in the United States. It established Tier 1 standards that replaced less stringent 1977 standards. The Clean Air Act generally prohibits states from developing stricter vehicle emission standards that are different than federal standards with the exception of California. To reduce the impact on manufacturers, the standards were phased in over three years beginning in model year 1994. Passenger automobiles and smaller light trucks weighing up to 3,750 pounds are subject to more stringent standards than larger light trucks (including many sport utility vehicles and minivans) weighing between 3,751 and 5,750 pounds. Heavier duty light trucks weighing more than 5,750 pounds are subject to the least stringent standards.

Under the 1990 CAA, Congress reduced the exhaust standards for cars from 0.41 to 0.25 grams per mile hydrocarbons. The carbon monoxide emission standard was changed as well. Specifically, if carbon monoxide levels are too high in selected cities, cold weather emission standards will drop to 3.4 gpm for 2002 models. The CAA also set a standard for the oxygen content of gasoline sold during the winter in cities that exceed national air quality standards for carbon monoxide pollution.

Tier 2 Tailpipe Emission Standards announced by EPA in December 1999 establish a standard of 0.07 gpm for nitrogen oxide for all classes of passenger vehicles beginning in 2004. This includes all light-duty trucks, as well as the largest SUVs. Vehicles weighing less than 6,000 pounds will be phased-in to this standard between 2004 and 2007. For the heaviest light duty trucks, the program provides for interim steps in 2004 through 2007 with interim levels of 0.6 gpm and 0.2 gpm with a final performance level of 0.07 gpm for nitrogen oxides in 2009. Vehicles weighing between 8,500 and 10,000 pounds have additional flexibility with a final performance level of 0.07 gpm.

EPA determined that the current Tier 2 and heavy duty 2007 standards are the most feasible controls for emissions, fuels and vehicles to reduce mobile sources of air toxics at the present time, however, additional research will be conducted and additional rulemaking will be completed no later than July 1, 2004 to determine the need for additional nonroad and on-highway engines and vehicles and their fuels.

In December 2000, the EPA issued a final rule addressing emissions of hazardous air pollutants (air toxics) from mobile sources. This rule identifies 21 mobile source air toxics, sets new gasoline toxic emission performance standards and sets out a Technical Analysis Plan to continue to conduct research and analysis on mobile source air toxics. Based on that research, EPA will conduct future rulemaking, to be completed no later than July 1, 2004, to revisit the feasibility and need for additional controls for nonroad and highway engines and vehicles and their fuels.

5.2 New Federal Standards for Gasoline

EPA also announced lower sulfur standards for gasoline, commencing in 2004, to insure the effectiveness of low emission–control technologies in vehicles. The new Tier 2 tailpipe emission standards combined with the lower sulfur standards for gasoline will result in passenger vehicles that are 77 to 95 percent cleaner than 1999 models and reduce sulfur content of gasoline by up to 90%.

Reformulated Gasoline. In 1995, the Clean Air Act required all gasoline sold in ozone nonattainment areas to contain a minimum oxygen content and a maximum benzene content. It was estimated that reformulated gasoline will achieve a 15-17 percent reduction in both ozone forming hydrocarbons and toxic emissions from motor vehicles. By 2000, gasoline sold in these cities (does not include the Twin Cities) will achieve a 25-29 percent hydrocarbon reduction, a 20-22 percent toxics reduction, and a 9-10

percent reduction in nitrogen oxide emissions. Many cities have voluntarily chosen to use this cleaner gasoline.

EPA announced on December 21, 2000 that toxics emission performance requirements are being set for conventional gasoline and cleaner-burning reformulated gasoline. Under these new requirements, refineries must maintain their average 1998-2000 toxics performance levels, which are better than what regulations require, for benzene, formaldehyde, acetaldehyde, 1,3-butadiene, and POM, identified as "toxic air pollutants".

U.S. refineries will be subject to additional regulations to limit sulfur in gasoline. Beginning in 2004 national refineries will have production capped at 300 parts per million (ppm) and the annual corporate average sulfur level limited to 120 ppm. In 2005, the refinery average will be set at 30 ppm with a corporate average of 90 ppm and a cap of 300 ppm. Finally, in 2006, refineries will be required to meet a 30 ppm average sulfur level with a maximum cap of 80 ppm. Refineries will be required to provide to the public diesel fuel for use in highway vehicles with a sulfur content of no more than 15 parts per million (ppm) by September 1, 2006. Refineries in the western United States will have additional flexibility during the interim period with 30 ppm average/80, ppm cap by 2007.

5.3 New Federal Standards for Diesel Vehicles and Fuels

The heavy-duty engine and vehicle standards and highway diesel fuel sulfur requirements regulate the heavy-duty vehicle and its fuel as a single system. New emissions standards will begin to take effect in model year 2007 and will apply to heavy-duty highway engines and vehicles. These standards are based on the use of high-efficiency catalytic exhaust emission control devices or comparably effective advanced technologies. EPA is also planning to reduce the level of sulfur in highway diesel fuel by 97 percent by 2006.

EPA is completing additional standards for heavy –duty highway engines and vehicles in 2007. These standards will reduce particulate matter emissions to 0.01 grams per brake-horsepower-hour (g/bhp-hr), NOx emissions to 0.2 g/bhp-hr, and emissions of Non-methane hydrocarbons to 0.14 g/bhp-hr. Gasoline engines will be subject to these standards on a phase in between 2008 and 2009.

6.0 Summary of EPA's Non-road Engine Emissions Control Programs

6.1 Land-Based Diesel Engines.

The category "non-road diesel engines" includes tractors, bulldozers, generators, backhoes, forklifts and pumps. These engines currently produce about 25% of the NOx and 40% of the PM10 that comes from mobile sources. The EPA has developed three tiers of standards for new engines – to be phased in by 2008. The EPA has also developed a voluntary program to encourage production of very-low emitting engines. The EPA projects that emissions from new non-road diesel engines will be reduced by 60

percent for NOx and 40% for PM when compared with emissions from engines meeting the Tier 1 standard (applicable standard in 2000).

6.2 Small Gas Engines.

The category "small gas engines" means non-road small gas engines, such as chainsaws, lawn mowers, leafblowers, edgers and augers. These engines currently emit about 9% of all VOCs from mobile sources. The EPA set new standards for small gas engines in 1997 and is developing a second phase of standards. The existing EPA standard is expected to result in a 32% reduction in hydrocarbon emissions from small gas engines (this represents a comparable reduction in VOCs).

6.3 Large Gas Engines.

The category "large gas engines" refers to larger gas powered engines for non-road use, such as forklifts, airport ground service equipment, generators and compressors.[1] The EPA is currently pursuing an emissions control plan for these engines that would essentially extend the existing California standards for the rest of the nation. Applying the existing California standards nationwide would reduce NOx and hydrocarbon emissions from these engines by 70 to 90%.

6.4 Marine—Gas Outboards & Personal Watercraft.

Gas-powered outboard motors and personal watercraft account for about 5% nationally of all VOC emissions from mobile sources. This percentage is higher in parts of the country with large numbers of watercraft. The EPA has developed new standards for these engines beginning in the 1998 model year and phased in over nine years. The EPA predicts that by the end of the phase in period, each manufacurer will have achieved, on a corporate-average basis, a 75% percent reduction in total hydrocarbon emissions.

6.5 Marine--Commercial Diesel Engines.

Commercial diesel engines account for about 8% nationally of all NOx from mobile sources and 1% of PM from mobile sources. These percentages are higher in areas with large commercial ports or near busy shipping lanes. The EPA has issued new requirements for emissions from new diesel marine engines to take effect in 2004. The EPA is evaluating a more stringent standard that would begin in 2008.

6.5 Locomotives.

[1] On December 7, 2000, the EPA issued advanced notice of proposed rulemaking concerning recreational vehicles using spark ignition engines such as off-highway motorcycles, all-terrain vehicles, and snowmobiles; and recreational marine diesel engines and marine spark ignition sterndrive and inboard engines. In this announcement, the EPA was also seeking comment about whether to pursue new emissions standards for highway motorcycles.

Locomotives produce about 9% of all NOx emissions from mobile sources. The EPA has issued three tiers of rules related to the manufacture of locomotives as well as remanufacturing of locomotive engines built since 1973.[2] The final tier of rules will take effect in 2005. As a result, emissions of NOx from locomotives will decrease by two-thirds and emissions of PM and hydrocarbons will decrease by half.

6.7 Aircraft.

Although aircraft produce about 2% of NOx from mobile sources nationwide, they are more significant contributors in some cities. The EPA also believes that aircraft emissions may be important contributors to global climate change as well as to the depletion of the stratospheric ozone layer. In 1997, the EPA adopted the existing standards for NOx and CO emissions from gas turbine engines as established by the International Civil Aviation Organization. This international body is an agency of the United Nations and is the most appropriate forum for setting aircraft standards because the aviation industry is international.

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US EPA(a), 12/2000, Control of Emissions of Hazardous Air Pollutants from Mobile Sources.

US EPA(b), 12/1999, EPA's Program for Cleaner Vehicles and Cleaner Gasoline.

US EPA(c), 2/2000, Federal and California Exhaust and Evaporative Emission Standards for Light-Duty Vehicles and Light-Duty Trucks.

[2] Regulating the remanufacutring process for locomotives is important because they are remanufacurer between 5 and 10 times. Locomotives have the longest service lives of any diesel vehicle: more than 40 years.

US EPA(d), 12/2000, Heavy-Duty Engine and Vehicle Standards and Highway Diesel Fuel Sulfur Control Requirements.

US EPA(e), 8/1994, Motor Vehicles and the Clean Air Act.

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APPENDIX K
DRAFT
Current Efforts – Stationary Sources

Introduction

The Clean Air Act authorizes the MPCA, under authority delegated from the EPA, to address air pollution from large stationary sources such as power plants, factories and incinerators. (However, this authority is limited for facilities built before 1970 – most notably coal-fired power plants.) This authority extends to smaller contributors of air pollution such as auto body shops, gas stations, and drycleaners.

The MPCA has traditionally focused its efforts on larger stationary sources to reduce emissions of "criteria" pollutants through federal programs developed by the EPA. (The criteria pollutants are PM10, ozone, nitrous oxides, sulfur dioxide, carbon monoxide and lead.) Stationary source reduction efforts have also addressed, to a lesser degree, smaller sources such as dry cleaners, electroplaters and gas stations, that have collective impact because of their numbers and can have local impacts because they are often located near residential areas.

In addition to administering federal programs focused on criteria pollutants, the MPCA also implements the EPA's program (National Emission Standards for Hazardous Air Pollutants) to address air toxics from large emitters in specific industries. While the EPA is required to evaluate whether these standards ensure that public health and the environment are protected, the timing for completion of that work remains uncertain. The EPA has started to collect data to develop its Integrated Urban Air Toxics program, which targets 33 pollutants from 29 source categories, but again timing of emission reductions is uncertain.

This appendix contains information primarily about state and federal efforts to reduce air toxics. For information about efforts to reduce other pollutants, see these appendices: Particulate Matter, Criteria Pollutants, Mercury, and Global Climate Change. This appendix also describes efforts to estimate criteria and air toxics emissions.

1.0 Regulatory History of Air Toxics in Minnesota

The history of the MPCA's air toxics efforts is summarized below. (Mercury efforts are described in the Mercury Appendix.)

1.1 Air Toxics Rulemaking History

1985 – EPA called for states to develop air toxics programs. 19 states had air toxics programs, and another 23 were developing programs. Minnesota reviewed the existing programs and decided to use the "Michigan approach" which uses screening based on threshold limit values.

1988-1993 –Air Toxics Technical Advisory Committee met and discussed various versions of a Minnesota toxics rule. During this time, the "Air Toxics Source Review Guide" was used to assess high profile sources in the absence of a rule.

1993 - Environmental groups and others worked with legislators to author an amendment to the Toxic Pollution Prevention Act requiring the MPCA to submit a 5-year air toxics strategy to the Legislature and a report every two years thereafter.

1994 – MPCA withdrew a draft air toxics rule citing the air toxics reduction requirements in the1990 CAAA National Emission Standards for Hazardous Air Pollutants.

1994- MPCA and the Minnesota Department of Health (MDH) sign Memo of Agreement that MDH is to establish health-based air toxics "standards".

Spring, 1996 – MDH creates a Health Risk Values work group. MPCA create a Health Risk Applications work group.

Fall, 1999 – MPCA releases *Staff Paper on Air Toxics* which contains first comprehensive look at air toxics monitoring data.

Winter, 2001 – MDH is expected to promulgate Health Risk Values.

1.2 History of Waste Combuster Regulatory Efforts

In 1994, the MPCA adopted statewide standards that established stringent dioxin and mercury emission limits for municipal, medical, commercial and industrial waste combustors. The emission limits were established to minimize the environmental impact from dioxins and mercury from the practice of burning solid waste. Waste incineration has been estimated to contribute 40% of Minnesota' total mercury releases in 1990 (MPCA 1999). As of 2000, mercury emissions from waste incineration has dropped significantly due to closing medical, commercial, industrial and small on-site waste combustors, more aggressive waste separation programs, and more stringent mercury emission limits. Waste incineration now contributes about 10% of the total amount of mercury released to the air in Minnesota.

In 1997, MPCA revised the standards for the largest municipal waste combustors in Minnesota to incorporate federal emission limits that further lowered mercury emission limits, and imposed lead and cadmium emission limits. EPA also promulgated federal emission limits for medical waste combustors in 1997. Rather than comply with the standards, 27 of 29 hospitals in Minnesota ceased operating their on-site waste combustor. After August 2001, only one hospital's medical waste combustor will remain operating in Minnesota.

EPA adopted federal standards of performance for small municipal waste combustors and commercial/industrial waste incinerators in 2000. When these two standards are adopted

and implemented in Minnesota, the contribution of waste incinerators to overall mercury and dioxin emissions to the air will have dropped by greater than 95% from 1990 levels.

2.0 MPCA's Legal Authority to Regulate Air Toxics

The MPCA has authority to gather information that is relevant to pollution or to MPCA rules or statutes. Representatives of the MPCA may examine facility records and have access to facility property to obtain information or to conduct surveys or investigations. [Minn. Stat. § 116.091.] For air permits, a permit applicant is required to provide all information required by state or federal rules and must supplement the application if all relevant facts have not been supplied.

The MPCA also has authority to craft permit conditions to prevent pollution and to protect human health and the environment, even though the requirements do not specifically exist in rule. [Minn. Stat.§ 116.07, subd. 4a and Minn. R. 7007.0800, subp. 2.] The general permitting rule also authorizes the MPCA to craft permit conditions that protect human health and the environment. [Minn. R. 7001.0150, subp. 2.]

The MPCA often uses its general authorities in the development of permits and in enforcement actions. Staff require information, records, data, testing, monitoring, reports and similar submittals before making permit or enforcement decisions. Many permits contain facility-specific conditions based on the MPCA's general authority to prevent pollution and to protect human health and the environment. The MPCA's general authorities are important tools to insure that MPCA staff has the flexibility it needs to respond to individual situations.

3.0 Minnesota's State Air Toxics Program

The primary MPCA activity that serves to reduce toxic emissions from sources is the implementation of the federal National Emission Standard for Hazardous Air Pollutants (NESHAP) program. A description of the NESHAP program as well as other activities that are part of the state's air toxics program follows.

3.1 National Emission Standards for Hazardous Air Pollutants

NESHAPs are technology-based standards designed to control "routine" emissions from each major source within an industry category. These standards – also known as "maximum achievable control technology standards"- are based on emissions levels that are already being achieved by the better controlled facilities in an industry. The U.S. Environmental Protection Agency (EPA) believes that these technology-based standards assures citizens that each major source of hazardous air pollutants will be required to employ effective measures to limit its emissions. Congress listed 189 hazardous air pollutants in the Clean Air Act Amendments of 1990. See http://www.epa.gov/ttn/uatw/pollsour.html for the current list.

Most NESHAPs are written to regulate major sources of toxics. A major source is defined as having the potential to emit greater than 10 tons per year of an individual hazardous air pollutant, or 25 tons per year of any combination of hazardous air pollutants. Implementation of the NESHAP program for major sources is primarily

accomplished through the air quality permitting process. Several NESHAPs also apply to smaller hazardous air pollutant emitters who traditionally do not receive permits: chromium electroplating, dry cleaning, and halogenated solvent cleaning operations. Gasoline marketing, which EPA intends regulate under a future NESHAP, may also be another standard for a traditionally nonpermitted source type.

According to the Second Report to Congress on the Status of Hazardous Air Pollutant Program under the Clean Air Act, of the 47 source categories for which NESHAPs had been promulgated by 1997, the NESHAPs have nationally reduced air toxics emissions by an estimated 983,000 tons per year and criteria pollutants (PM and VOCs) by an estimated 1,810,000 tons per year.

MPCA efforts are focused on implementation of the federal NESHAP program through outreach, education, and tracking as MPCA resources allow. The MPCA Small Business Program has undertaken several sector initiatives to inform and consult with sources affected by NESHAP. Several sectors addressed recently include wood furniture manufacturers, dry cleaners, and fiberglass resin users. The MPCA also adopts the federal standard by reference into state rule as part of its agreement with EPA to receive delegation for this program. The MPCA has adopted 22 of the NESHAPs into state rule.

Implementation of the dry cleaner NESHAP in Minnesota has resulted in a reduction in perchloroethylene air emissions by dry cleaners by 54 percent. (Phone conversation, Dwyer; MPCA, 1997a) MPCA analysis of data reported by facilities subject to the halogenated solvent cleaning standard shows halogenated solvent usage in Minnesota has been reduced approximately 60% between 1995 and 1999 (571,858 lb. in 1995, 226,248 lb. in 1999) in part through implementation of the NESHAP. These reductions have a significant impact on the air quality in the immediate vicinity of the facilities. Since many of these facilities are located in or near residential areas, these reductions favorably impact the exposure of those residents.

The MPCA has identified about 600 sources that are subject to a NESHAP. Some are major sources and have the NESHAP requirements included in their air permits. Major sources receive Minnesota's Federal Permit (Title V), smaller sources receive an individual state permit or a state registration permit. Table 1 shows the number of facilities in Minnesota currently in MPCA's NESHAP database.

Table 1
Number of Facilities Subject to NESHAP 40 CFR 63 from NESHAP Database
(Information obtained from MPCA database in August, 2000)

No. Facilities Subject	Description
2	Refinery MACT
2	Off Site Waste and Recovery Operations
1	Mineral Wool Production
1	Hazardous Waste Combustors
11	Printing / Publishing Surface Coating
304	Dry Cleaning
1	Pesticide Active Ingredient (PAI) Production
34	Chromium Emissions from Hard & Decorative Chromium Electroplating & Chromium Anodizing Tanks
66	Halogenated Solvent Cleaning
1	Secondary Lead Smelting
1	Polymers & Resins I
2	Refinery MACT
4	Ethylene Oxide Emissions Standards for Sterilization Facilities
28	Secondary Aluminum Production
4	Pulp and Paper
2	Benzene Waste Operations
168	Wood Furniture Manufacturing Operations
1	Magnetic Tape Manufacturing Operations
1	Aerospace Industries, Surface Coating
1	Hazardous Air Pollutants for Industrial Process Cooling Towers
14	Gasoline Distribution Facilities (Bulk Gasoline Terminals & Pipeline Breakout Stations)
1	Polymers & Resins II

3.2 Case-By-Case Evaluations

Under the Clean Air Act Amendments of 1990, EPA is required to regulate large or major industrial facilities that emit one or more of 188 listed hazardous air pollutants (air toxics). On July 16, 1992, EPA published a list of industrial source categories that emit one or more of these hazardous air pollutants. EPA is required to develop standards for listed industrial categories of "major" sources (those that have the potential to emit 10 tons per year or more of a listed pollutant or 25 tons per year or more of a combination of pollutants) that will require the application of stringent controls, known as maximum achievable control technology (MACT).

The section 112(g) provision is designed to ensure that emissions of toxic air pollutants do not increase if a facility is constructed or reconstructed before EPA issues a MACT or air toxics regulation for that particular category of sources or facilities.

In effect, the 112(g) provision is a transitional measure to ensure that facilities adequately protect the public from toxic air pollutants until EPA issues a MACT standard that applies to the facility in question. EPA believes that section 112(g) will yield the most public health and environmental benefits by requiring stringent controls on newly constructed or rebuilt large sources of toxic air pollutants (where uncontrolled emissions are likely to be the highest), where an applicable air toxics regulation has yet to be issued.

The MPCA has delegation to implement the 112(g) program in this state. Less than ten facilities in Minnesota have undergone a case-by-case MACT determination and have permit conditions that require emission limits equal or more stringent than the emission limits achieved in practice by the best controlled similar source.

For additional information about the 112(g) program, go to:
http://www.epa.gov/ttn/uatw/112g/112gpg.html

3.3 Risk Assessment of High Profile Point Sources

Currently, major new air sources (typically four to six facilities a year) that must undergo an environmental review in Minnesota are also required to assess the risk that they pose to neighboring communities. Where there is local or agency concern, other smaller or existing facilities have also been reviewed. The MPCA has concerns about the relatively significant amount of resources that these reviews use within the MPCA and at affected facilities. An revised Air Toxics Review Guide was developed in 1999 to help facilitate the review process. Neither state rules nor statutes have been developed for a program that clearly defines to what level a facility is required to reduce its air toxics emissions through the permitting process. Additional description of individual facility reviews and MPCA plans to revise this process may be found in Appendix M, Action Steps - Stationary Sources.

3.4 Development of State Health Risk Values

The Minnesota Department of Health is expected to publish rules that will establish health benchmarks for air toxics in winter of 2001. This rule will establish health benchmark concentrations or “Health Risk Values” for 43 air toxics with chronic health effects, 21 air toxics with subchronic health effects, 42 air toxics with acute health effects and 9 persistent multimedia chemicals. The Health Risk Values will be used to perform site specific risk assessments and may be used in other venues. The rule itself will not dictate how the Health Risk Values will be used. However, the Health Risk Values will be valuable as a “measuring tool” and possible uses include:

- A gauge to compare against in responding to public or citizen concerns.
- Assessing local air quality.
- Gauging a facility’s performance.
- To determine if the quality of air is acceptably “safe”.

3.5 Dioxin Initiative- Burn Barrels

Description of Burn Barrel Initiative

The Office of Environmental Assistance (OEA) is currently working with the Bi-National Toxics Strategy on a dioxin sub-group; discussing strategies for reducing the dioxin emissions from residential burning of waste, primarily in burn barrels. Staff also partner with counties and local governments on education, incentive, and infrastructure programs such as Chisago county's Burn Barrel Buy-Back program and Western Lake Superior Sanitary District's burn barrel survey and education project. The OEA will continue to work with these and other counties and the Legislature to reduce the use of burn barrels in Minnesota.

In addition to working with counties and local units of government to develop backyard burning reduction programs, the OEA has awarded numerous grants and has compiled a number of resources designed to help counties reduce backyard burning and on-site disposal. A copy of those resources can be obtained for free by contacting our Education Clearinghouse at 1-800-877-6300. Questions regarding state and county burn barrel efforts can be directed to Mark Rust at 651-215-0198.

Dioxin Emissions from Burn Barrels in Minnesota

Comparatively large quantities of dioxin are produced by burning chlorine-containing plastics and paper. The dioxin accumulates in the soil in areas surrounding burn barrels. A recent EPA study found that a family of four burning trash in a barrel in their backyard - still a common practice in many rural areas - can put as much or more dioxin and furan into the air as a well-controlled municipal waste incinerator serving tens of thousands of households.

"Open burning of household waste in barrels is potentially one of the largest sources of airborne dioxin and furan emissions in the United States, particularly as EPA standards force major reductions in emissions from municipal and medical waste incinerators," says Paul Lemieux, Ph.D., with the EPA's National Risk Management Research Laboratory in Research Triangle Park, N.C, one of the study's co-authors.

Counties in Minnesota reported that 80,000 tons of MSW was disposed by residents through on-site disposal methods in 1999. On-site disposal generally refers to waste disposed in burn barrels, fire pits, fireplaces, home incinerators or on-site dumps. In addition to annual county data, a recent study conducted by the Western Lake Superior Sanitary District (WLSSD) reported that 18% of all Minnesotans still burn their household wastes on-site. Based on local data, national trends, and the WLSSD survey findings, the OEA estimates the actual tonnage of MSW burned or buried in MN could be as high as 250,000 tons/year. Regardless of whether it is 80,000 or 250,000 tons per year, this is clearly a significant source of pollution from many standpoints including heavy metal deposition, VOC's, and dioxin production. The EPA's formula of "one average family of four burning waste in a burn barrel being equivalent to a 200 ton per day municipal waste incinerator" provides estimates for amounts of waste burned by people in Minnesota. Using EPA's formula, the amount of dioxin produced from burn barrels in

Minnesota is equivalent to the dioxin produced from 60,000 to 180,000 full-scale municipal waste incinerators.

4.0 Comparison of Minnesota's Air Toxics Program With Other States

The MPCA's toxics reduction program is less stringent compared to many other states. While Minnesota may be leading most states in air toxics monitoring, it lags behind many other states both regionally and nationally in terms of activities that reduce air toxics for stationary sources. Table 2 contains a comparison of Minnesota's air toxics program with those other states in EPA Region V.

Table 2 Comparison Of Minnesota's Air Toxics Activities with Other States in Region

Air Toxics Reduction Activity*	**Minnesota**	**Wisconsin**	**Illinois**	**Michigan**	**Indiana**	**Ohio**
Air toxics screening of all new and modified permitted sources		✔	✔	✔		
Rigorous air toxics screening of select large new sources	✔	✔	✔	✔	✔	✔
Air toxics screening of existing sources		✔	✔			
Number of toxic pollutants evaluated in routine screening		>400	>300	>800		
Implement federal NESHAP program	✔	✔	✔	✔	✔	✔
Early implementation of NESHAP/ more stringent NESHAP					✔	
Air Toxic Information Gathering Activities						
Emissions inventory prepared at least every three years	✔	✔	✔	✔	✔	✔
Number of air toxic pollutants inventoried (based on 1997)	104	546	82	241	82	82
Facilities required by state law to submit toxics emissions inventory (beyond Toxics Release Inventory)		✔			Proposing rule	
Implementing federal 112r (Accidental Release Prevention Program)						✔
Number of air toxics monitoring sites in place as of 12/99 (data from STAPPA/ALAPCO survey)	18	3		7		4

*Unless noted otherwise, the information in this table was gathered through informal phone interviews conducted in July, 2000, with staff at the respective state agencies.

As can be seen from above, state programs in Region V vary widely in their scope and approach to addressing air toxic emissions as well as in their collection of monitoring and emissions estimates. A national look at state programs shows even greater variability

among states in terms of programs. For example, while all of the Region V states participate in the Great Lakes Regional Air Toxics Emission Inventory, other states outside of Region V do not do their own toxics emissions inventory.

From a sampling of 15 states that submitted air toxics program descriptions in July, 2000, to EPA as background material for the Urban Air Toxics Strategy Workgroup recommendations, an informal analysis showed that Oklahoma, New York, Californa, Illinois, Lousiana, Massachusetts, New Hampshire, and New Jersey all have more more stringent programs for stationary sources than Minnesota. (As described above, basically, Minnesota implements the federal program plus does intensive risk assessment for a few high profile facilities per year.) Minnesota's program appears to be about the same or slightly more stringent than Nebraska, Colorado, Florida, and Maine.

In 1998 EPA issued a report that asked to what extent do a state's air pollutant control programs (regulatory and voluntary programs, and toxic air pollutant and criteria air pollutant program) address the cancer risks and noncancer effects and cumulative risks from exposure to the 33 hazardous air pollutants that are part of the urban air toxics study. The study first looked at the effectiveness of criteria air pollutant programs for ozone and particulate matter as a means to obtain reductions in emission of air toxics from area sources in cities. Reduction of VOCs, primary aerosols, and precursors of particulate matter may also have more benefits than the reduction of the criteria pollutants they are primarily intended for. Thus the report stated that criteria pollutant programs may have collateral benefits related to the goals of reducing air toxics. A passage from this report is included below:

> "Our most important finding is that states typically employ multiple policy instruments to reduce emissions of toxic air pollutants, regardless of the number of HAPs and types of source that they regulate. California illustrates: the state has two rather different programs – the Toxic Air Contaminant Program and Air Toxics Hot Spots Program – and it maintains an air toxics emission inventory and targets HAPs for pollution prevention. More specifically, the programs together employ technology requirements, dispersion modeling, risk assessment, and public information. Further the state has specific goals for improving public health, some of which directly relate to the types of health effects caused by toxic air pollutants. California has an exceptionally diverse portfolio for protecting public health from air pollution." (EPA(b), 1998)

As defined by EPA, currently all areas of the state meet the criteria pollutant standards - except one small area near the Mississippi River in St. Paul that does not meet the particulate matter standard. There are relatively few other cities of the Twin Cities' size that have always met the ozone standard. Reasons for this may include distance from other large metropolitan areas, the jet stream from Canada, relatively flat topography that promotes mixing, plus numerous other reasons. However, because of Minnesota's attainment status for particulate and ozone standards, some of the relatively simple means to reduce VOCs (an ozone precursor) are not required in Minnesota and thus are often not employed. For example, many other metropolitan areas of the Twin Cities' size require

that gas stations employ Stage I control (capture of the fumes released when filling the large storage tanks by transport trucks). In Minnesota this relatively simple measure is employed by a minority of service stations. (See Appendix M, Action Steps-Stationary Sources for more information about stage-one vapor-recovery implementation at gas stations.)

5.0 Federal Toxics Reduction Efforts

Prior to the Clean Air Act Amendments (CAAA) of 1990, the Clean Air Act (Act) established a purely health-based approach to regulating hazardous air pollutants. The Act required EPA to list the hazardous air pollutants it would regulate, and to establish emission standards for the listed pollutants. Each National Emission Standard for Hazardous Air Pollutant (NESHAP), was to be set "at the level which in [EPA's] judgement provides and ample margin of safety to protect the public health…" In the twenty years after section 112 was enacted in 1970, EPA listed only eight hazardous air pollutants and promulgated NESHAP for only seven of them. (State Attorneys General Guide to the Clean Air Act Amendments, National Association of Attorneys General, 1992) The standards fell far short of addressing the hundreds of pollutants emitted and did not cover all the sources emitting the few pollutants that were listed.

In Title III of the CAAA (1990), Congress substituted a combined technology and health based approach for the solely health based program that was originally outlined in section 112 of the Act.

EPA's new toxics program is geared toward addressing these goals:

National Air Toxics Goals

EPA set this goal to meet requirements of the Government Performance and Results Act which requires the Agency to report on the status of its progress in implementing programs:

> "By 2010, reduce air toxic emissions by 75% from 1993 levels to significantly reduce the risk of the population of cancer and other serious adverse health effects caused by airborne toxics."

In the future EPA expects to change the goal to a more health-based/ecological approach:

> "By 20xx, eliminate unacceptable risks of cancer and other significant health problems from air toxic emission for at least 95% of the population and substantially reduce or eliminate adverse effects on our natural environment."

In addition, EPA outlined specific goals for its Integrated Urban Air Toxics Strategy which was published on July 19, 1999. These goals may be found in Appendix P, Goals and Measures.

Following is a description of the activities EPA is undertaking to meet the above goals.

5.1 Continued Development and Implementation of National Emission Standards for Hazardous Air Pollutants (NESHAP)

Phase 1 – Technology Based Standards

Section 112 of the Clean Air Act Amendments (CAAA) of 1990 requires the EPA to use a technology-based approach to reduce emissions air toxics from major sources – the NESHAP program mentioned in section 1.3. Under this program, the EPA listed 174 industry categories, and as of July 19, 1999, the agency had promulgated 43 standards regulating 78 industry categories. The EPA is continuing to develop the standards. Although all are required to be promulgated by November, 2000, it is expected that most will not be promulgated until 2002. Compliance is typically required within three years after the promulgation date for existing sources. Full implementation of all the NESHAP standards is not likely to occur until at least 2005.

This website lists the NESHAP source categories that EPA has promulgated:
http://www.epa.gov/ttn/uatw/mactfnl.html

This website lists the NESHAPs that have been proposed:
http://www.epa.gov/ttn/uatw/mactprop.html

This website lists the NESHAP that are still pending, not yet proposed or promulgated:
http://www.epa.gov/ttn/uatw/mactupd.html

(It should be noted that some of the sources covered by the NESHAPs do not exist in Minnesota.)

Phase 2- Residual Risk Program

The residual risk program is a requirement of the federal CAAA and applies to all source categories for which a federal MACT standard has been promulgated by EPA. Residual risk refers to the public health and environmental risk remaining after technology-based standards have been promulgated and applied to emission sources of HAPs. If the EPA finds that the level of remaining or residual risk does not provide an "ample margin of safety to protect public health" or "prevent…an adverse environmental effect," then the EPA must set additional standards. The Residual Risk Report to Congress was prepared by the Office of Air Quality Planning and Standards, Research Triangle Park listed as EPA–453/R99-001, March 1999, and contains EPA's general framework for assessing risks to public health or the environment. The EPA is currently conducting analyses on 13 of the earliest-promulgated MACT standards. None of these risk assessments has been completed.

Additional information about the residual risk program may be found at:
http://www.epa.gov/ttn/oarpg/t3/reports/risk_rep.pdf

5.2 Continued Development and Implementation of the Integrated Urban Air Toxics Strategy

The Urban Air Toxics Strategy is a program developed by EPA that will seek to reduce emissions of 33 key from 29 area source categories. This includes mobile sources using diesel engines. Thirty of these HAPs have been identified as coming from small industrial sources (or area sources). The EPA timeline for developing and implementing the Urban Air Toxics Strategy is five years, which includes a series of reports, development of vehicle and fuels standards, and promulgation of standards for new area source categories.

On July 19, 1999 under the authority of sections 112(k) and 112(c)(3) of the 1990 Clean Air Act Amendments (CAAA) the EPA published the National Air Toxics Program: the Integrated Urban Strategy, in the Federal Register, Vol. 64, No. 137, 38705-38740, Docket 99-17774.

The CAAA provides the foundation for the EPA's current air toxics program. EPA intends that the program "be designed to characterize, prioritize and equitably address the serious impacts of hazardous air pollutants on the public health and the environment through a strategic combination of regulatory approaches, voluntary partnerships, ongoing research and assessments, and education and outreach." Although the title of the *Strategy* includes the word "urban," the *Strategy* itself outlines a program that addresses reduction of toxics nationwide with a special focus on urban areas. Most of the program activities outlined in the *Strategy* are in the planning phase.

The Integrated Urban Air Toxics Strategy includes:

- a description of risk reduction goals;
- a list of 33 hazardous air pollutants (HAPs) judged to pose the greatest potential threat to public health in the largest number of urban areas, including 30 HAPs specifically identified as being emitted from smaller industrial sources known as "area" sources; and
- a list of area source categories which emit a substantial portion of these HAPs, and which are being considered for regulation.

The EPA's overall approach to reducing air toxics consists of four components. The four components as outlined in the *Strategy* are listed below.

1. Source-specific standards and sector-based standards

The NESHAP program described in section 1.3 is part of EPA's plan. In addition, EPA intends to use the technology-based approach to develop standards for the new area source categories listed in the *Strategy* not already scheduled for regulation. These new categories listed include gasoline distribution Stage I, paint-stripping operations, and municipal landfills plus ten other categories.

2. National, regional and community-based initiatives to focus on multimedia and cumulative risks

Section 112(k)(4) of the Act requires the EPA to "encourage and support areawide strategies developed by the state or local air pollution control agencies." In the *Strategy* under this program component, the EPA describes required risk studies that are underway or completed: Utility study, Great Waters Program, Mercury study and Urban Air Toxics Strategy.

3. National air toxics assessments

Activities under this component of the program include expansion of air toxics monitoring, improving and updating emissions inventories, modeling, continued research on health effects and exposures to both ambient and indoor air, and use and improvement of exposure and assessment tools.

For more information about EPA's national air toxics assessment activities go to: http://www.epa.gov/ttn/uatw/nata/

4. Education and outreach

In this program component, the EPA hopes to do more education and outreach on air toxics in both the ambient air and indoor air.

6.0 Why do more than just implement the federal program?

The MPCA agrees with the reasons offered by the Oregon Work Group on Hazardous Air Pollutants as to why a state may want to take additional measures beyond implementing the federal toxics program:

Substances: EPA's program for stationary sources focuses on 188 HAPs, its urban air toxics strategy only 33. There are thousands of chemicals and the MPCA does not know what the emissions are from these unlisted substances.

Source Categories: EPA's program covers only those sources that emit over the 10/25 ton thresholds and are not listed as an area source. There may be source categories that fall outside of both criteria and still may be a concern from a health and emissions perspective.

Level of Control: Since the NESHAP are technology-based there still could be emissions that are of a concern from a health perspective. EPA is supposed to address as part of residual risk program within eight years after promulgation of a NESHAP. EPA is behind on this and to date not one residual risk evaluation has been completed for a source category.

Timing: The implementation and timing of any controls resulting from EPA's urban air toxics strategy remain uncertain.

Cumulative Effects: Current pollutant thresholds are established based on the effects of one pollutant. Little research has been conducted as what level of pollutant is safe when people are exposed to multiple pollutants. Therefore, a preventative approach would advocate for simple, reasonable steps to reduce pollutants that are classified as toxic.

Communication: Getting information out to the public about emissions and exposures is a huge gap. The federal government will not be as effective as state or local efforts. In addition, communicating indoor and personal exposures in comparison to outdoor levels and what actions can be taken will most likely not be done by EPA.

7.0 Collection of Emissions Information – Criteria pollutants and air toxics

7.1 MPCA Emissions Inventories

Each December, the MPCA sends all facilities that require air quality permits in Minnesota a criteria pollutant emission inventory packet. The criteria pollutants are: carbon monoxide, nitrogen oxides, particulate matter [PM], particulate matter smaller than 10 microns [PM10], lead, sulfur dioxide, and volatile organic compounds, The emission inventory packet includes several types of inventory forms designed to meet the needs of the permittees. There are forms for Option B, C and D registration permittees, a form for nonmetallic mineral processing permittees and yet another form for all other state and federal permittees (from here on referred to as 'regulars'). Each inventory packet contains a cover letter and the inventory forms. Option C, Option D, nonmetallic and regular permittees also receive a summary that shows the emissions calculated from last year's inventory. Thus, the December 2000 packets contain the 2000 Emission Inventory and a summary showing the 1999 emissions. Facilities have until April 1 of the following year to submit a completed inventory. For example, the 2000 Emission Inventory is due on April 1, 2001.

For air toxic pollutants, Minnesota does not have a rule mandating that point source facilities report their emissions. However, the MPCA sent a letter to facilities requesting that they voluntarily provide air toxics emission information. The facilities contacted are the larger emitters based on the sum of known particulate matter and volatile organic compounds emissions as reported in the criteria pollutant inventory. About 200 facilities received the letter for the 1996 and 1997 emission inventory, and about 400 facilities for the 1999 emission inventory. The number of facilities responding to MPCA's request for air toxics emissions data is in a range of 20% to 40%. The air toxics emissions information submitted by the facilities is reviewed by MPCA staff. Also, the quality assured lead emissions in the criteria pollutants emission inventory are adapted to the air toxics emission inventory to maintain consistency between these two MPCA inventories.

If directly reported values are not available, an emission factor method is used. An emission factor is defined as "a representative value that attempts to relate the quantity of a pollutant released to the atmosphere with an activity associated with the release of that pollutant" (EPA(c), 1995). Emission factors can be either source-specific or generic. Emission factors from the EPA Factor Information Retrieval (FIRE) Data System were

used as generic emission factors (EPA(d), 1998). Source-specific emission factors are derived from source-specific emission testing, mass balance, or chemical analysis. Air toxics emissions are calculated by multiplying an emission factor by activity data. Activity data are reported by each facility in the Minnesota criteria pollutant emission inventory. Therefore, the activity data are source-specific regardless of the type of emission factors. (More information on the MPCA's toxics emission inventory is available in the Air Toxics Appendix.)

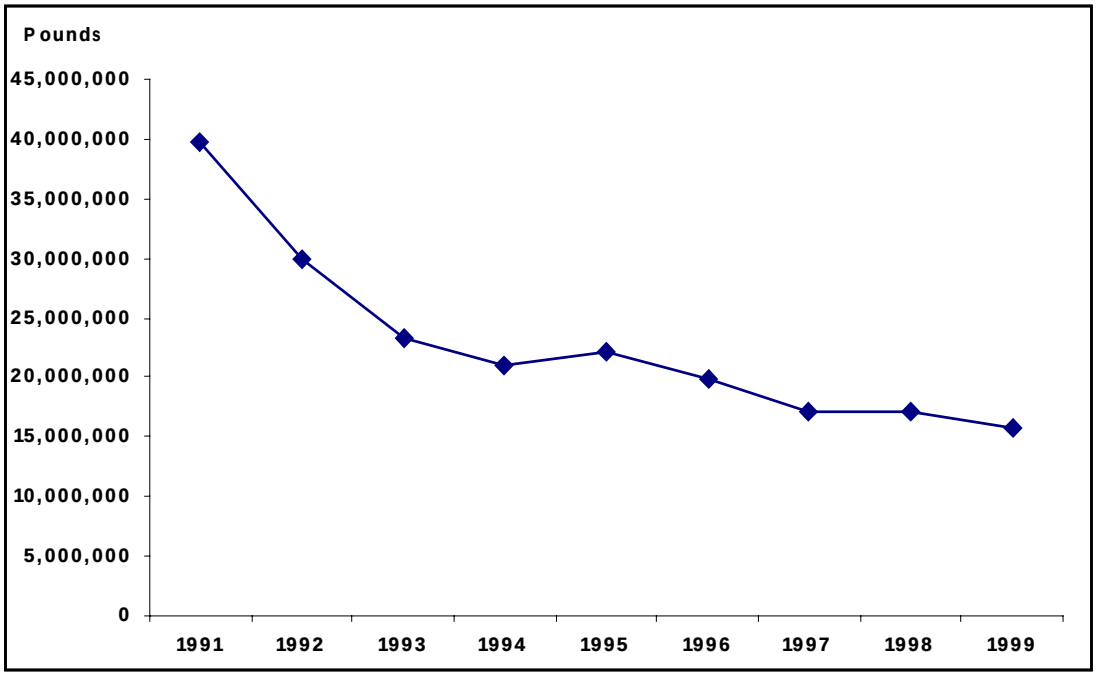
If neither the directly reported emissions nor emission factor estimated emissions are obtainable, then values from the Toxic Release Inventory (TRI) are used when available. The TRI report is prepared by the Minnesota Department of Public Safety.

7.2 Toxics Release Inventory

Description of Toxics Release Inventory

The federal Emergency Planning and Community Right to Know Act requires businesses that meet reporting thresholds to self-report the types and quantities of any of approximately 600 TRI chemicals they generate. The Minnesota Emergency Response Commission (located in the Department of Public Safety) collects this data from Minnesota businesses. The following chart shows changes in the amounts of these chemicals that have been released to the air from 1991 through 1999.

Total Toxic Release Inventory Chemicals Released to Air, 1991-1999



Data courtesy of Minnesota Emergency Response Commission

Toxic Release Inventory data shows a significant decline in toxic chemical air releases from reporting facilities from 1991 to 1993, primarily due to installation of pollution control equipment. Reductions in air releases have been more gradual since that time, plateauing at approximately 16 million pounds per year since 1997.

Of the 395 facilities required to report in 1999, styrene at 1.9 million pounds was the chemical released in largest quantity, followed by toluene and N-hexane at 1.6 million pounds each. Out of the 103 chemicals reported in 1999, eleven make up more than 80% of the total quantity of air releases.

Top Eleven Chemicals Listed by Quantity Released to the Air

Chemical	Total lb. Air Releases	Chemical	Total lb. Air Releases
Styrene	1,903,964	Glycol Ethers	777,497
Toluene	1,680,205	N-butyl Alcohol	717,156
N-hexane	1,613,076	N-butyl Alcohol	717,156
Methanol	1,558,391	1,1dichloro1fluoroethane	705,725
Xylene (mixed isomers)	1,446,558	Hydrochloric Acid-aerosol	436,746
Ammonia	1,130,026	**Sum of eleven chemicals**	**12,822,382**
Methyl Ethyl Ketone	853,038	**Sum of all chemicals**	**15,781,384**

Ranking TRI Chemicals by Potential Risk versus by Quantity

The MPCA continues to research models to prioritize chemicals based on risk to health and the environment. Until new models are adopted, the Emergency Response Commission utilizes the MPCA's existing steady-state fugacity model which assigns a numeric risk-value to chemicals so that, in addition to listing chemicals by quantity of release, chemicals can be listed to indicate potential risk as well. Since the current PCA model emphasizes bioaccumulation, metals rank high. Due to the complexities of chemical interactions, no single ranking system addressees all concerns. The following table shows the100 chemicals that are reported under TRI in Minnesota, out of a total of more than 600 possible TRI chemicals reported nationally. Data from 395 reporting facilities is ranked by potential risk and by the quantity released to the environment.

Chemical Ranking Summary

Substance	Total Quantity (pounds/yr) of Air Emissions	Rank by Potential Risk from Releases to Air, Water and Land	Rank by Potential Risk from Releases to Air Only	Rank by Quantity Released to Air
lead (Pb)	10,897	1	1	36
chromium (VI)*	4,816	2	2	41
copper	27,915	3	3	23
nickel	21,743	4	4	26
antimony	562	5	5	54
zinc	19,796	6	6	28
barium	80,294	7	7	19
manganese	15,713	8	8	30
arsenic	71	9	9	58
aluminum	25,039	11	10	24
selenium	50	12	11	61
chloroform	8,700	13	12	39
chromium (III)*	4,816	15	13	42
bromomethane (methyl bromide)	10,213	16	14	37
dichloromethane (methylene chloride)	108,860	17	15	18
tetrachloroethylene	109,824	18	16	17
trichloroethylene	341,900	19	17	10

formaldehyde	174,644	20	18	13
diethylhexylphthalate (2-)	174	21	19	57
styrene	1,903,964	22	20	1
acrylic acid	13,601	23	21	32
hexane (n-)	1,613,076	24	22	3
acetaldehyde	52,270	26	23	22
methyl ethyl ketone (MEK)	853,038	27	24	7
ammonia	1,130,026	28	25	6
aluminum oxide	467	29	26	55
benzene	20,170	30	27	27
dioxane (1,4-)	12,484	31	28	33
ethylene oxide	5,800	32	29	40
butadiene (1,3-)	676	33	30	52
methyl isobutyl ketone (MIBK)	220,562	34	31	12
propylene oxide	750	35	32	51
hydrogen chloride	436,746	36	33	9
xylenes	1,446,558	37	34	5
chlorine dioxide	1,011	38	35	48
toluene	1,680,205	39	36	2
chlorine	12,039	40	37	34
pentachlorophenol	1	41	38	64
dimethylamine	896	42	39	49
ethylbenzene	144,058	43	40	15
ethoxyethanol (2-, = "cellosolve")	18,974	44	41	29
methanol	1,558,391	45	42	4
phenol	119,324	46	43	16
n-butyl alcohol	717,156	47	44	8
vinyl acetate	15,158	49	45	31
tert-butyl alcohol	3,099	50	46	46
cyclohexane	65,525	51	47	20
dimethylformamide (n,n-)	9,897	52	48	38
ethyl acrylate	3,717	53	49	44
naphthalene	11,609	54	50	35
sulfuric acid	279,712	55	51	11
carbon disulfide	9	56	52	62
ethylene glycol	23,660	57	53	25
pyridine	64	59	54	59
methyl acrylate	3,279	60	55	45
maleic anhydride	598	61	56	53
dimethyl phthalate	310	62	57	56
phthalic anhydride	757	63	58	50
catechol	9	64	59	63
methyl methacrylate	53,769	65	60	21
biphenyl (diphenyl)	1,460	66	61	47
chromium and chromium compounds	4,816	67	62	43
anthracene	57	69	63	60
trimethylbenzene	155,007	73	64	14

Data courtesy of Minnesota Emergency Response Commission

Pollution Prevention

Pollution Prevention offers an opportunity to stop emissions from being created, potentially eliminating the need for control technology. The Office of Environmental Assistance (OEA) has responsibility for technical and financial assistance for pollution prevention through Minnesota Stats.115D.04 and 115A.0716. Significant progress has been made identifying the technologies which prevent pollution at its source.

Savings from pollution prevention continue year to year as long as the preventative alternative is in place. Documented aggregated savings for releases to air, water and land through OEA's financial and MN Technical Assistance Program for the last four years is 280 million pounds of waste, 150 million gallons of water and 13 million dollars for Minnesota businesses.

Where to find more information

For Minnesota's Toxics Release Inventory go to: http://www.erc.state.mn.us
For national information on the Toxics Release Inventory go to: http://www.epa.gov/tri

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APPENDIX L
DRAFT
Action Steps – Mobile Sources

1.0 How the MPCA selected its action steps.

The MPCA developed its action steps after numerous and lengthy consultations with from other state agencies, local units of government, public interest groups and citizens (i.e. "stakeholders"). The stakeholder input helped define the issue, potential action steps and offered the MPCA insight about what role others thought was appropriate for the agency to play to address emerging air quality issues.

After the stakeholder input was collected, MPCA staff evaluated efforts undertaken by other states, especially those that have areas that violate federal air quality standards ("nonattainment areas"). The lessons learned from nonattainment areas were useful information for the MPCA to prepare a preventative plan.

1.1 Stakeholder input

This report was prepared with input from a number of different stakeholder forums (for more information, see Appendix A, Section 2.2). First, as part of each stakeholder event, the MPCA informed the stakeholders about what the agency knew about the issue. Second, the MPCA sought input from stakeholders about the nature of the problem and its causes, potential solutions, and the appropriate role(s) for the MPCA. The stakeholder forums were not designed to build consensus among the stakeholders. Instead the events were designed to inform the MPCA's approach to addressing air toxics and mobile sources of air pollution.

The MPCA chose to focus subsequent stakeholder events toward mobile sources of air pollution because mobile sources constitute nearly 60% of all emissions of air toxics. Mobile sources also produce major shares of certain criteria pollutants as well as global warming gases. The stakeholder input was aimed at developing solutions to reduce air pollution. Consequently, the forums focused on the sources of the pollution rather than on specific pollutants. In this way, the solutions considered to address air toxics, for example, could be looked at in terms of their ability to reduce other pollutants of concern that are also emitted from mobile sources, such as ozone precursors and global warming gases.

To collect meaningful stakeholder input, the MPCA narrowed the scope of the issues to present to stakeholders to five separate approaches or strategies that could reduce air pollution from mobile sources. These strategies were prepared to create specific starting places for stakeholder discussions. MPCA staff tested these strategies by meeting with

staff from other state agencies who have some involvement in issues related to air quality. From these starting points, the MPCA intended to develop a shared understanding of the problem and to build support for specific actions to reduce mobile source pollution.

1.2 Criteria for action steps

Based on its understanding of the problem, the MPCA used the following criteria to assess various action steps. The criteria included the following:

- Reduce health risk/impact
- Focus on causes of pollution not effects
- Addressing multiple pollutants
- Build support for future action
- Ability to implement
- Time frame – short/long
- Measurable outcomes

1.3 The approach the MPCA is taking to address the problem

Given the criteria listed above, the MPCA developed the following hierarchy of approaches to reduce emissions of pollutants of concern.

Reduce fuel and energy consumption.
This approach has the benefit of reducing emissions of all air pollutants. This approach addresses a root cause of air polution: the use of fuel and energy. The MPCA's approach focuses mainly in the areas of land use and transportation. The MPCA envisions playing a supportive role to other agencies and units of government that have primary responsibility in these areas. Specifically, the MPCA would serve as a source of information about the air-quality impacts of various land use and transportation decisions. The actions the MPCA proposes to influence address decision-making that has environmental consequences over a longer timeframe.

Substitute cleaner fuels for existing ones.
This approach would produce short-term benefits and have a lasting effect, but it would not address all pollutants of concern. The MPCA envisions taking a graduated approach from voluntary programs, as a preventative measure, to requirements where the concern about a pollutant is more immediate.

Increase the use of technologies that reduce air pollution.
This approach is designed to help create short-term results and identify areas where it makes sense environmentally and financially to go beyond the minimum federal requirements in terms of reducing mobile-source air pollution. The U.S. EPA has taken a number of steps to reduce mobile source pollution, such as stricter emissions standards for new vehicles and requiring cleaner-burning gasoline and diesel. There are opportunities in Minnesota to hasten the compliance with the national standards at a faster pace than required by rule, or to go beyond those standards.

1.4 Action Steps Selected

The MPCA has concluded that there is no one solution that will address all of the emerging concerns the MPCA has about air pollution. No one solution is possible because the factors influencing air quality in Minnesota are too numerous and not completely understood. The MPCA intends to take a number of first steps aimed at making short term improvements in air quality while also making efforts to better understand the air pollution trends in Minnesota. Additionally, the MPCA intends to serve as an information resource to other agencies and bodies of government responsible for decisions that have long term consequences for the state's air quality, such as in the areas of land use and transportation. To implement its recommendations, the MPCA will take a variety of approaches, from voluntary to regulatory to influence decisions made everyday by citizens, businesses and various levels of government.

The MPCA's action steps related to mobile sources are:

- Lowering the benzene content of gasoline.
- Promote the use and distribution of alternative fuels.
- Promote the use of fuel-efficient vehicles and good maintenance practices.
- Increase the availability and use of transit in the metropolitan area.
- Re-examine the goals of indirect sources permitting program.
- Join the multi state diesel initiative.

Each of these action steps is described in further detail below in section 2.0.

1.5 Potential Future Steps

The MPCA believes the following efforts may be useful next steps:

- Increase the turnover of passenger and commercial vehicles, including buses.
- Increasing the turnover of off-road engines.
- Target gross polluting vehicles.
- Increase the use of alternative fuels.
- Provide incentives for the purchase and use of more fuel efficient vehicles.

Each of these potential future action steps is described in further detail below in section 3.0.

2.0 More information about the current action steps

2.1 Lower benzene content in gasoline

Pollutants reduced:

Benzene. Benzene concentrations at some locations in Minnesota currently exceed the health benchmark for cancer.

Type of program (regulatory, incentive, education, etc.)

The MPCA intends to initiate a voluntary program to have 25% of all gasoline sold in Minnesota to contain low benzene by December 2001. If this goal is not achieved and benzene levels are still of concern, the MPCA will pursue rulemaking to require low benzene gasoline.

Anticipated Results

According to the US EPA, current average benzene concentration in gas in this region of the country is 1.37% benzene. Reducing this to 1% (low-benzene gas) would result in about a 28% reduction in benzene fro mthe current average concentration. The MPCA's voluntary goal is to have 25% of all gasoline sold to contain low benzene – this would result in a reduction of about 7% by December 2001 from the current average concentration.

Where is it being done now?

The Clean Air Act Amendments of 1990 require that reformulated gasoline contain no more than 1% benzene. Reformulated gasoline is currently sold in areas of the country that exceed federal air quality standards for ozone. Reformulated gasoline is not used in Minnesota because the state is in compliance with federal ozone standards.

Where to go for more information.

Draft Technical Support Document: Control of Hazardous Air Pollutants from Motor Vehicles and Motor Vehicle Fuels (US EPA, July 2000).
http://www.epa.gov/otaq/regs/toxics/d00003.pdf)

2.2 Promote the use and distribution of alternative fuels

Generally speaking, alternative fuels have characteristics that make them more environmentally friendly, in one way or another, than gasoline. Most of the alternative gaseous fuels have characteristics that enhance the oxidation of the combustion process, thus reducing the hydrocarbon or the carbon monoxide that comes out the tailpipe. For example, natural gas and propane produce less carbon monoxide and hydrocarbon because their molecular structure is such that oxygen from the atmosphere attaches to the fuel molecules easily during combustion, thus promoting more complete combustion. Conventional gasoline molecules are more complex, so it takes more chemical reactions to complete the combustion process.

Some fuels, including natural gas and propane, contain less energy per gallon (equivalent), so the vehicles overall miles per gallon will drop if compared to traditional gasoline. When this occurs, there is an additional amount of CO2 that is released as a byproduct of burning the additional amounts of fuel. Other liquid or gaseous fuels intended to replace gasoline have characteristics that make them environmentally friendly in a number of different ways, but they all have some impact on the environment. The following table was developed by the US EPA and outlines some of the benefits of various alternative fuels.

FUEL	ADVANTAGES	DISADVANTAGES
ELECTRICITY	• Potential for zero vehicle emissions • Power plant emissions easier to control • Can recharge at night when power demand is low	• Current technology is limited • Higher vehicle cost; lower vehicle range, performance • Less convenient refueling
ETHANOL	• Excellent automotive fuel • Very low emissions of ozone-forming hydrocarbons and toxics • Made from renewable sources • Can be domestically produced	• High fuel cost • Somewhat lower vehicle range
METHANOL	• Excellent automotive fuel • Very low emissions of ozone-forming hydrocarbons and toxics • Can be made from a variety of feedstocks, including renewables	• Fuel could initially be imported • Somewhat lower vehicle range
NATURAL GAS (METHANE)	• Very low emissions of ozone-forming hydrocarbons, toxics, and carbon monoxide • Can be made from a variety of feedstocks, including renewables • Excellent fuel, especially for fleet vehicles	• Higher vehicle cost • Lower vehicle range • Less convenient refueling
PROPANE	• Cheaper than gasoline today • Most widely available clean fuel today • Somewhat lower emissions of ozone-forming hydrocarbons and toxics • Excellent fuel, especially for fleet vehicles	• Cost will rise with demand • Limited supply • No energy security or trade balance benefits
REFORMULATED GASOLINE	• Can be used in all cars without changing vehicles or fuel distribution system. • Somewhat lower emissions of ozone-forming hydrocarbons, nitrogen oxides, and toxics	• Somewhat higher fuel cost • Few energy security or trade balance benefits

The MPCA supports the use of alternative fuels by using E85 (a fuel containing 85 percent ethanol) in all of its flexible-fuel vehicles. The MPCA will also continue to test alternative-fuel vehicles, and will encourage other state agencies and the public to use

E85, low sulfur gasoline, propane, compressed natural gas, biodiesel and other alternatives.

Pollutants reduced:

Ozone forming pollutants, air toxics, carbon monoxide, carbon dioxide and particles.

Type of program (regulatory, incentive, education, etc.)

The MPCA is working with its partners to promote the use and distribution of alternative fuels through its involvement in the Twin Cities Clean Cities Coalition. This coalition of public, private and non-profit entities is part of The U.S Department of Energy's Clean Cities program, a voluntary approach to alternative fuel vehicle and fuel development. The Clean Cities program is designed to encourage the use of alternative fuel vehicles and their supporting infrastructure throughout the nation.

Anticipated Results.

Different alternative fuels provide different reductions in air pollution as compared with gasoline. E85 (gasoline that contains 85% ethanol), is currently the most common of alternative fuels in Minnesota. E85 produces about 25% less NOx and CO than reformulated gasoline sold in parts of the country that currently do not meet federal air quality standards. Because it is a renewable fuel made mostly from crops grown in Minnesota, the production and use of E85 produces about 35% less carbon dioxide compared to petroleum and supports the domestic economy

Anticipated Results.

By encouraging alternative fuel vehicle use, the Clean Cities program will help achieve energy security and environmental quality goals at both the national and local levels.

Where is it being done now?

The greatest success in Minnesota, to date, has been the expansion of the E85 infrastructure that includes approximately 50 public fueling sites throughout the state with other sites in planning stages. This cleaner-burning fuel can be used in over 50,000 flexible fuel vehicles currently on the road in Minnesota. Education to these vehicle owners is needed to increase the use of this fuel.

In addition, the state fleet currently has over 600 flexible fuel vehicles capable of using E85 fuel. The MPCA is working with other state agencies to maximize the use of E85 in their vehicles. In addition to E85, the MPCA, through the Twin Cities Clean Cities Coalition and the state fleet, will work to promote other cleaner alternative fuels such as natural gas, propane and biodiesel.

Where to go for more information.

The US Department of Energy sponsors the Clean Cities programs. The Clean Cities web site is located at: http://www.ccities.doe.gov/

The "Clean Cities Guide to Alternative Fuel Vehicle Incentives and Laws" (funding resource guide) contains up-to-date information on how and where stakeholders can find funding for alternative fuel vehicle-related programs, contacts at alternative fuel vehicle companies, in government and in other Clean Cities coalitions, plus additional useful, hard-to-find information. This information is available at: http://www.fleets.doe.gov/fleet_tool.cgi?$$,benefits,1

The US DOE's Alternative Fuels Data Center publishes a "Tax Guide for Alternative Fuels" that describes the various tax provisions relating to alternative fuels for all states. It is located at: http://www.afdc.doe.gov/documents/taxindex.html

2.3 Promote the use of fuel-efficient vehicles and good maintenance practices

Pollutants reduced:

Ozone-forming chemicals (hydrocarbons and nitrogen oxides), air toxics, carbon monoxide, particles, and carbon dioxide (global warming gas).

Type of program (regulatory, incentive, education, etc.)

Education, outreach and behavior change. One of the easiest and least expensive ways to reduce air pollution from motor vehicles is to promote proper vehicle maintenance. An out of tune motor vehicle has a much larger impact on our environment than a vehicle in a good state of tune. A poorly maintained vehicle typically does an inefficient job of combusting the fuel in the engine, which impacts fuel efficiency as well as emissions. Inefficient combustion increases air pollution by allowing the unburned fuel to enter the atmosphere.

The use of more fuel efficient vehicles results in less air pollution from motor vehicles. According to a recent EPA study, the US car and light-duty truck fleet has the potential to be almost 15% more fuel efficient if cars and trucks matched the fuel economy of the best in class for each size of vehicle. The same EPA report also notes that new technologies, such as gas-electric hybrids, could yield fuel economy improvements of 50 to 100%. (EPA, 2000).

Anticipated Results.

The education efforts are designed to increase public awareness about the connections between our transportation choices and air quality. The outreach activities are designed to increase public awareness about simple and affordable steps individuals cans take to reduce fuel consumption and air pollution by maintaining their vehicles and using the most fuel efficient vehicle that meets their needs. Ultimately, by using behavior change tools such as social marketing, the public will make choices that result in less fuel consumption and emissions.

Where is it being done now?

The MPCA is working with a variety of stakeholders to raise awareness of less polluting vehicle choices and behaviors. A highlight of the past year, the MPCA used two highly efficient, low polluting hybrid gasoline/electric cars owned by the state to raise awareness via numerous media contacts and special events.

Where to go for more information.

The MPCA's web page includes information on vehicle purchasing, operation and maintenance practices to reduce vehicle pollution at:
http://www.pca.state.mn.us/air/mvpollution.html.

A description of outreach efforts undertaken with EPA support can be found at:
http://www.epa.gov/otaq/rfp/proj9700.pdf

Reference

United States Environmental Protection Agency. Light-Duty Automotive Technology and Fuel Economy Trends, 1975 Through 2000. December, 2000.

2.4 Increase the availability and use of transit in the metropolitan area

Pollutants reduced:

Ozone-forming pollutants (NOx and hydrocarbons), carbon monoxide, carbon dioxide and air toxics.

Type of program (regulatory, incentive, education, etc.)

Provide technical support to the transit providers and transportation management organizations. Specifically, the MPCA can provide environmental information and endorsement of the environmental benefits of transit.

Anticipated Results.

According to a 1991 study conducted by the American Public Transportation Association, emissions of NOx, CO and Hydrocarbons from transit (measured in grams of pollutant per passenger mile for work trips) was less than that of a single person auto as follows:

	Nitrogen Oxides	Carbon Monoxide	Hydrocarbons
Single Person Auto	2.06	15.06	2.09
Transit Bus	1.54	3.05	0.2
Rail Transit	0.47	0.02	0.01
Vanpool	0.38	2.42	0.36
3 person carpool	0.69	5.02	0.7

Consequently, moving people from single person autos to other transit modes yields reductions in the air pollutants described above.

Where is it being done now?

The Met Council's Metro Commuter Services, along with the Minnesota Department of Transportation and a number of transportation management organizations provide services and support to employers and citizens to increase the use of transit.

Metro Transit and the Minnesota Department of Transportation provide transit services in the Twin Cities and throughout Minnesota. Current expansions of transit service include: expanding bus service and the addition of light rail and commuter rail.

Where to go for more information.

The American Public Transportation Association has information on its web site about the environmental benefits of transit. This information is located at:
http://www.apta.com/gifs/pollreduct.gif

The US EPA currently operates a “Commuter’s Choice” program with information about programs to support commuting choices. A number of states have implemented incentive programs to support mass transit. Information about the state and local programs is available at http://yosemite.epa.gov/aa/programs.nsf

2.5 Re-examine the goals of indirect sources permitting program

Pollutants reduced:

Currently carbon monoxide, although current efforts do yield reductions in other pollutants.

Type of program (regulatory, incentive, education, etc.)

Regulatory - the Clean Air Act Amendments of 1990 require state transportation plans to conform to state air quality requirements as set forth in the state's implementation plan. This process is referred to as "conformity". Because the Twin Cities had exceeded the federal standards for carbon monoxide, the state developed the indirect source permit program, among other efforts, to address the policy dimensions and trade-offs between transportation and air quality improvement in terms of carbon monoxide.

Anticipated Results.

Since the indirect source permit concerns emissions from vehicles, it could conceivably address other pollutants from vehicles such as ozone precursors, particles and global warming gases.

Where is it being done now?

A number of U.S. metropolitan areas are in violation of federal air quality standards and consequently are required to apply the conformity process to their transportation plans.

Where to go for more information.

More information about the conformity process, including a recently completed "Conformity Assessment Project" conducted by Harvard University for the US EPA and US DOT is available at: http://www.epa.gov/oms/transp/traqconf.htm

2.6 Join the multi-state diesel initiative

Pollutants reduced:

NOx and diesel particles.

Type of program (regulatory, incentive, education, etc.)

Regulatory. This multi-state clean diesel initiative is intended to ensure that the heavy-duty diesel engines manufactured and sold in 2005 and 2006, are as clean as those sold from 2002 through 2004, thus filling a two-year regulatory gap that will exist until more stringent federal requirements take effect in 2007.

Anticipated Results.

If Minnesota did not adopt the California standard, then truck manufacturers could sell the higher polluting trucks in 2005 and 2006. The difference in emissions from the cleaner models versus the current models is equivalent to the emissions from 30 million passenger vehicles, according to the State and Territorial Air Pollution Program Administrators/Association of Local Air Pollution Control Officials.

Even though the higher polluting trucks could only be sold for 2 years, the emissions reductions are significant; heavy-duty trucks have a 20-year life span and travel all across the nation.

Where is it being done now?

On November 20, 2000, 13 states -- Connecticut, Delaware, Georgia, Maine, Massachusetts, Nevada, New Hampshire, New Jersey, New York, North Carolina, Rhode Island, Texas and Vermont – announced their intent to "opt-in" to California's Not-to-Exceed requirements for on-road heavy-duty diesels in 2005 and 2006. California intends to adopt these requirements in 2001, clearing the way for other states to follow suit, pursuant to authority provided under Section 177 of the Clean Air Act.

Where to go for more information.

STAPPA/ALAPCO (State and Territorial Air Pollution Program Administrators/Association of Local Air Pollution Control Officials). The STAPPA/ALAPCO web site is located at: http://www.4cleanair.org/

3.0 More information about potential future action steps

3.1 Increase the turnover of commercial vehicles, including buses.

Pollutants reduced:

Pollutants from vehicles such as ozone precursors, particles and global warming gases.

Type of program (regulatory, incentive, education, etc.)

Incentive.

Where is it being done now?

The California Air Resource Board (CARB) received an allocation in the 2000/2001 Budget of $50 million to establish a Lower-Emission School Bus Program. The CARB staff, in coordination with the California Energy Commission and the local air pollution control districts, is developing guidelines for this program that will provide criteria for the purchase of new school buses and retrofits of existing school buses to reduce particulate matter emissions.

Anticipated Results.

The goal of the program is to replace older buses with safe and clean new buses and clean up in-use buses. This will reduce school children's exposure to harmful diesel exhaust emissions.

Where to go for more information.

More information about California's school bus incentive program is available at: http://www.arb.ca.gov/msprog/schoolbus/schoolbus.htm

The US EPA has developed the Voluntary Diesel Retrofit Program to address pollution from diesel construction equipment and heavy-duty vehicles that are currently on the road today. More information is available at: http://www.epa.gov/otaq/retrofit/

The New York City Transit Authority has a voluntary diesel retrofit program. More information is available at: http://www.epa.gov/otaq/retrofit/retronyc.htm

The Massachusetts Turnpike Authority and the North East States for Coordinated Air Use Management describe their experiences with the Clean Air Construction Initiative at: http://www.epa.gov/otaq/retrofit/retrobigdig.htm

3.2 Increase the turnover of off-road engines.

Due to technical advances over time, vehicles produced today are much cleaner and more fuel efficient than older vehicles. The same holds true for off-road engines. Advances in fuel delivery systems, emissions controls, as well as electronics have resulted in engines that produce far less tailpipe emissions than engines of the same size from years past. With this in mind, any time an older engine is replaced with a newer one, there will be a reduction in air pollution.

Pollutants reduced:

Ozone forming chemicals – NOx and VOCs, and particles.

Type of program (regulatory, incentive, education, etc.)

Incentives.

Where is it being done now?

- Arizona, Maryland and Oregon have had cash for lawn equipment programs.

- Vermont has recently begun a voluntary program related to outboard engines.

- The California Air Resources Board received a one-time appropriation, part of which will finance incentives in 2000/2001 to cover the incremental cost of clean on-road, off-road, marine, locomotive and stationary agricultural pump engines, as well as forklifts and aircraft ground support equipment.

Anticipated Results.

In addition to the emissions reductions from the trade-in of gas powered lawn equipment for electric or manually powered equipment, these events were also part of a larger public education campaign to increase awareness about air pollution.

Where to go for more information.

The US EPA maintains a directory of incentive programs located at:
http://yosemite.epa.gov/aa/programs.nsf

Information about California's incentives for cleaner heavy-duty engines can be found at:
http://www.arb.ca.gov/msprog/moyer/moyer.htm

3.3 Target gross polluting vehicles.

Pollutants reduced:

Pollutants from vehicles such as ozone precursors, particles and global warming gases.

Type of program (regulatory, incentive, education, etc.)

Regulatory and incentives.

Where is it being done now?

These programs were attempted in several states during the mid 1990's.

Anticipated Results.

Although state programs were successful in getting gross polluting vehicles off the road, the benefits were believed to be less than anticipated. Many of the vehicles taken off the road were not driven much anyway and did not have much useful life left at the time they were scrapped.

Since these programs were implemented, new methods have been developed to target gross polluting vehicles, such as remote sensing. Remote sensing would avoid the need for every vehicle to be taken to an inspection site. The MPCA would need to develop a program that would avoid some of the difficulties experienced in other parts of the country.

Where to go for more information.

The US EPA's Office of Transportation and Air Quality is the national center for research and policy on air pollution from highway and off-highway motor vehicles and equipment. The address is:

EPA National Vehicle and Fuel Emissions Laboratory,
2565 Plymouth Road, Ann Arbor, MI 48105.

Telephone: (734) 214-4333.

Internet: http://www.epa.gov/otaq/

3.4 Increase the use of alternative fuels.

Pollutants reduced:

Ozone precursors, air toxics, carbon monoxide, carbon dioxide and particles.

Type of program (regulatory, incentive, education, etc.)

Regulatory and incentives. In addition to the voluntary efforts described above in section 2.2, the state could offer incentives to increase the use of alternative fuels, or to increase the ethanol content of gasoline, or require that diesel fuel contain bio-diesel.

Where is it being done now?

Minnesota offers incentives for the production of ethanol. Several Minnesota natural gas utilities also offer incentives for the purchase or conversion of natural gas vehicles (NGVs), including a $250-$1,000 rebate from Minnegasco, Northern States Power, and others.

The greatest success in Minnesota, to date, has been the expansion of the E85 (85% ethanol fuel) infrastructure that includes approximately 50 fueling sites throughout the state with other sites in planning stages This cleaner-burning fuel can be used in over 50,000 flexible fuel vehicles currently on the road in Minnesota. The state fleet currently has over 600 flexible fuel vehicles capable of using E85 fuel. Other than incentives for the production of ethanol, Minnesota does not offer any incentives for alternative fuel vehicles (AFVs).

Anticipated Results.

Different alternative fuels provide different reductions in air pollution as compared with gasoline. E85, currently the most common of alternative fuels in Minnesota, for example, produces about 25% less NOx and CO than reformulated gasoline sold in parts of the country that currently do not meet federal air quality standards. Because it is a renewable fuel made mostly from crops grown in Minnesota, the production and use of E85 produces about 35% less carbon dioxide compared to petroleum and supports the domestic economy.

Where to go for more information.

The National Association of State Energy Officials maintains a list of alternative fuels legislation for each state. This information can be found at:
http://www.naseo.org/energy_sectors/stateenergy/alt_fuels.html

3.5 Provide incentives for the purchase and use of more fuel efficient vehicles

Pollutants reduced:

Ozone forming chemicals – NOx and VOCs, air toxics, carbon dioxide and particles.

Type of program (regulatory, incentive, education, etc.)

Incentives and expanded education for the purchase and use of more fuel-efficient vehicles.

Where is it being done now?

Policy makers in some states have proposed providing monetary incentives to purchase more fuel efficient vehicles. These include feebate programs that levy a surcharge on less efficient vehicles to provide to subsidize rebate to people who purchase more efficient vehicles. Such a program was recently implemented in Pennsylvania. Others have proposed annual registration fees that reward fuel efficiency. All of these policies could structured to be revenue neutral, keeping the average costs to consumers the same. The states of Maine and Connecticut offer incentives to purchase highly efficient vehicles. In Connecticut, hybrid gasoline vehicles are exempt from the state's sales tax. California recently began offering incentives for the purchase of zero-emission vehicles.

Anticipated Results.

Improving the fuel efficiency will reduce all pollutants. The effectiveness of this approach will depend on the strength of the incentive chosen.

Where to go for more information.

Information on California's new ZEV Incentive Program can be found at http://www.arb.ca.gov/msprog/zevprog/zip/zip.htm.

APPENDIX M
DRAFT
Action Steps – Stationary Sources

Introduction

Stationary sources of air pollution are generally divided into two groups; small and large sources. The programs that regulate these sources generally call the group of large sources "major" sources. Small sources are generally called "minor," "non-major," or "area" sources or are not given any name. The threshold at which a source is regarded as a large source varies with the pollutant that is being regulated and the program under which that pollutant is being regulated. For example, a source that has the potential to emit more than 100 tons per year of any of the criteria pollutants is consider a "major" source under Title V of the Clean Air Act Amendments of 1990. A source would be considered a "major" source under Title III of the Clean Air Act Amendments if it has the potential to emit more than 10 tons of any of a list of 188 air pollutants. These 188 pollutants are defined in the Clean Air Act Amendments as "hazardous air pollutants." The group of pollutants called "hazardous air pollutants" is a subset of a larger group of pollutants called "air toxics" although these terms are sometimes used interchangeably.

This portion of this report focuses on the strategies to reduce emissions and ambient concentrations of air toxics from stationary sources. The discussion of the sources of these pollutants will be in terms of "large" and "small" sources rather than "major" or "minor" except where the discussion regards a specific program such as the National Emission Standards for Hazardous Air Pollutants (NESHAP) program.

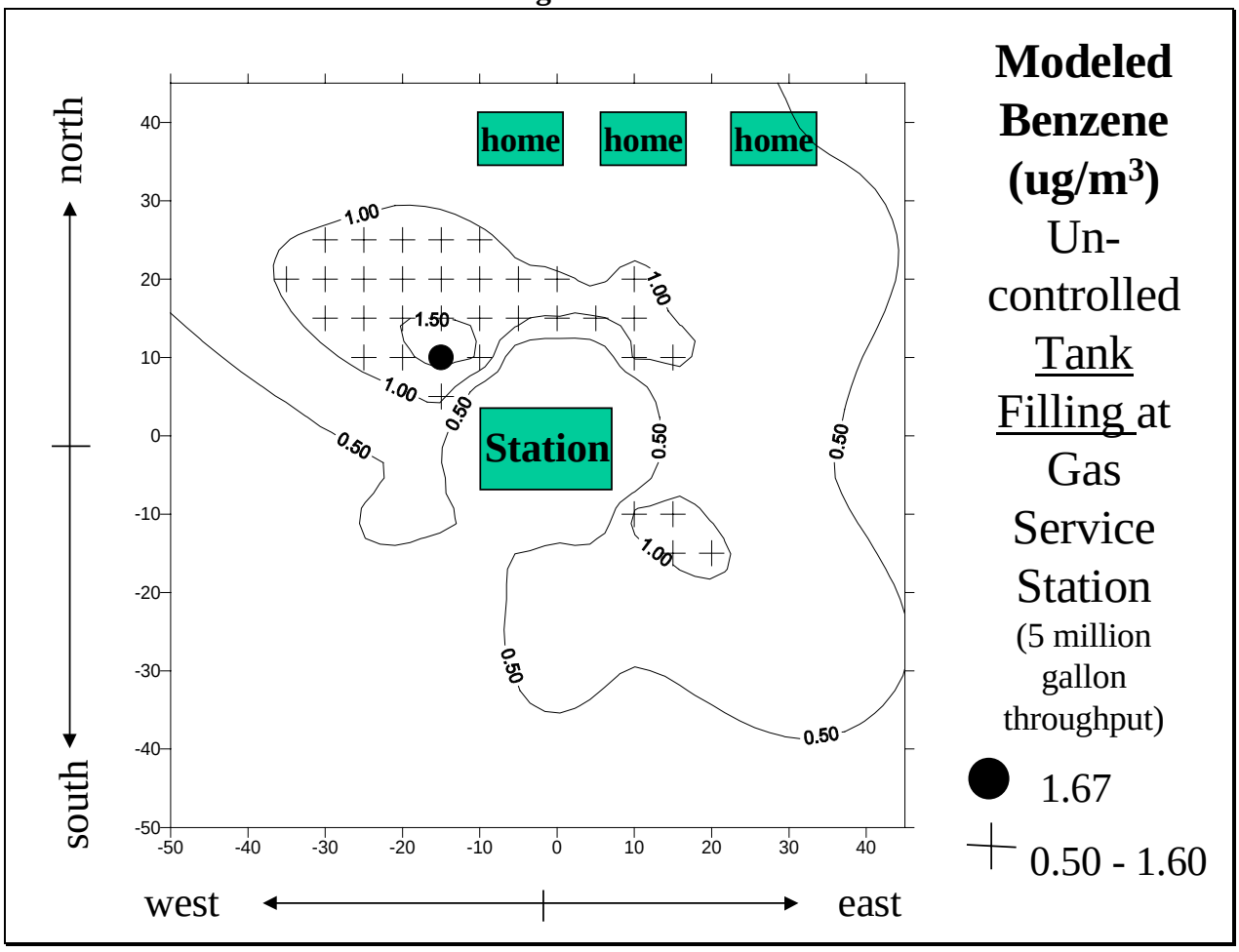
Local versus Distant versus Global Impact of Pollutants

An important consideration in the discussion of the environmental impact of a source is the difference of the effects the emissions have on the local environment versus distant environments versus the global environment. In general, the distance air pollution travels from a source is dependent upon the height at which the pollution is emitted. The shorter the stack height, the closer the pollution will remain to the source. This also means that the area of impact for some pollutants may be smaller. The taller the stack, the farther away from the source the greatest impacts will occur and the area of the impact will be larger.

The greatest impact of many hazardous air pollutants (HAPs) is local. That is the pollutant concentration is greatest within very short distances (feet to miles) of the source rather than hundreds of miles from the source. For example, as illustrated in figure 1, the greatest concentration of benzene emitted from a gas station is predicted to be on the property or at the property line. The benzene concentration modeling for the hypothetical gasoline service station in figure 1, resulting from filling large underground storage tanks

at the facility, shows that the highest concentration of benzene occurs in the immediate vicinity of the tank's vent pipe and decreases rapidly as the distance from the pipe increases. However, not all pollution impacts are affected by stack height. In the case of the hypothetical gasoline service station, the greatest impact from volatile organic compound (VOC) emissions may be tens to hundreds of miles away due to the ozone formation that results from the reaction of VOCs in sunlight.

Figure 1



Larger stationary sources are more likely to have taller stacks than are smaller sources. These stacks typically have been used for combustion sources (i.e. large boilers at power plants). As such, pollutants emitted from those stacks are more dispersed and the impacts of those pollutants occur at a much greater distance from the source than those pollutants emitted at low levels. However, since some pollutants are not emitted through the tall stacks, even large sources with tall stacks may emit pollutants at low elevations and have an impact on local ambient air. Most smaller sources do not have tall stacks and, therefore, the highest ambient concentrations of pollutants emitted from these sources

occurs closer to the source. The MPCA took these characteristics into consideration when developing the recommended reduction strategies for stationary sources.

1.0 Large Stationary Sources

In November, 1999, the MPCA released the *Staff Paper on Air Toxics*. The paper identified source categories as "point" (large stationary sources), "area" (small stationary sources) and "mobile" (cars, trucks and other off-road sources), and pointed out that in some cases, area and mobile sources were contributing more of a particular air toxic than point sources.

Historically, the focus of toxics control programs at the MPCA has been on stationary sources, and primarily on large sources. Large or "point" sources were defined in the *Staff Paper on Air Toxics* as those required by Minnesota rule to obtain an air emissions permit. Under the EPA Title V air emissions operating permit program, air emission facilities are required to calculate and report in their permit application the amount of hazardous air pollutants the facility has the potential ability to emit.

1.1 Summary of the air toxics strategy for point sources

The air toxics strategy as established in 1995, consists of three objectives: (1) smooth, fair implementation of the Clean Air Act of 1990, (2) protect public health and the environment, and (3) collect more information. (MPCA, 1995)

The three objectives themselves remain important and timely for point sources, however, the changes recommended below are necessary to improve the efficiency and equity in applying the strategy's objectives. It is also clear that the strategy must be broadened to include addressing smaller sources (discussed in Section 2.0) because of their overall contribution to air emissions.

The MPCA has committed to:

- Complete the development and implementation of air toxic evaluation screening tools for assessing emissions allowed in air emission permits. The screening tools will be used starting in February 2001.
- Distribute the screening tools to facilities after piloting the screening tools in 2001, so that they can assess their own facilities prior to the MPCA initiating air emission permit activity.

The MPCA will analyze the results of the screening processes, and from that analysis, may:

- Identify industrial sectors to focus toxic reduction efforts.
- Initiate rulemaking to codify those air toxic assessment procedures that are fixed for every assessment.
- Initiate rulemaking to reduce toxic emissions from industrial sectors where it appears more equitable and efficient to apply standards across the industry.

1.2 Quantification of Emissions from Large Stationary Sources

Minnesota Stat. 115D.15, subd. 2 requires the MPCA to prepare a list, prioritizing and categorizing facilities emitting toxic air contaminants, in its biennial report on air toxics.

The 1996 Minnesota toxics emissions inventory was used in a number of ways to determine if there are source groups or chemicals that can be quickly identified for reductions. The inventory contains information about the type of processes releasing chemicals and the chemicals released. Toxicity values from Minnesota Department of Health, U.S. EPA's Health Effects Assessment Summary Tables and EPA's IRIS database, and California Office of Environmental Health Hazard Assessment were used.

Toxic emissions were ordered by the type of process releasing the pollutants. Table 2 orders the 1996 Minnesota toxics emissions inventory by source classification code (SCC). This is a code to describe emission units and the process generating the pollution, not necessarily the business type generating the toxic release.

Table 1. Emission source groups releasing greater than 50,000 pounds per year, grouped by Standard Classification Code.

SCC	Emissions (lb)	% of Total Emissions	Cumulative % Total of Emissions	Description of SCC group	NESHAP Applies? *
Total emissions by all SCC	10,743,867.75				
402	4,094,557.52	38%		surface coating operations	y**
UNC	3,211,525.17	30%	68%	unclassified	
307	1,037,292.08	10%	78%	pulp and paper and wood products	y
390	420,102.13	4%	82%	in-process fuel use	
406	405,557.76	4%	85%	transportation and marketing of petroleum products	y
401	320,690.53	3%	88%	organic solvent evaporation	y
306	318,106.32	3%	91%	petroleum industry (refining)	y
308	248,937.00	2%	94%	rubber and miscellaneous plastics products	y
303	235,155.11	2%	96%	primary metal production	y
405	113,924.90	1%	97%	Printing /Publishing petroleum and solvent evaporation	y
403	91,655.98	1%	98%	Evaporation from petroleum products stored at the refinery	n
101	78,421.58	1%	99%	Electric generation	n

*An individual NESHAP itself will describe the source to which it applies. Generally, NESHAPs apply to facilities defined as a "major source" which has the potential to emit greater than 10 tons per year (20,000 pounds) of an individual hazardous air pollutant, or 25TPY of all HAPs. Because the NESHAP often applies to only "major" sources, the standard will not apply to most facilities within the group.

**Through the "Coatings and Composites Coordinated Rule Development", EPA is developing NESHAPs for 18 categories of industrial surface coating operations and composite operations.

There are SCC groups that are emitting less than 50,000 pounds per year of chemicals, contributing less than 1% of the total toxics in the 1996 inventory, that are not listed in

Table 1. It also must be noted that the 1996 toxics inventory above does not include hydrogen chloride, an acid gas that has acute effects. If this chemical was included, the SCC group 101 (electric utilities) would contribute substantially more, due to the amount of hydrogen chloride released from coal-fired utilities.

Eighty-five percent of toxic releases inventoried are released from five main groups. The largest emissions group is the process "surface coating". The second largest group are unclassified source types because it was difficult to assign process to a code group or facility managers didn't provide sufficient information to assign a source code. The pulp and paper industry is the third largest source group releasing toxics to Minnesota's atmosphere. "In-process fuel use", the fourth largest source, is the emissions from the burning of fossil fuels (natural gas, wood, coal, oil etc.) during production of other products, and the fifth group "transportation and marketing of petroleum" is the release of volatile chemicals during loading and unloading tankers, etc of liquid chemicals and fuels.

From this analysis of large point sources, MPCA staff concluded that there is not an obvious group or facility that can be identified as a primary contributor to Minnesota's air where toxic reductions could be achieved swiftly.

1.3 The Effectiveness Of Current Point Source Toxics Control Activities

Point sources, while not contributing the majority of many air toxics on a mass basis, have a disproportionate impact on their locales. Individual facilities with short stacks and/or poor dispersion of released pollutants can cause unacceptable levels of air pollution within a facility's neighborhood or community. Even if the facility's emissions are well-controlled, poor dispersion may still cause problems.

1.3.1 Using ambient air monitoring to address point source contributions

Ambient air monitoring results from the MPCA's statewide monitoring prompted two Minnesota businesses and the MPCA in the past two years to undertake actions to lower toxic releases.

Higher ambient concentrations of chloroform were recorded at an ambient air monitor in International Falls. There are two paper mills in the International Falls vicinity (one in International Falls, another across the border in Fort Frances, Canada) that emit chloroform, a chemical unique in this area to the papermaking industry. The mill in Minnesota is making changes to the plant that will reduce the amount of chloroform in the air—the mill may change operations, and/or better control emissions to meet the federal NESHAP for pulp and papermaking facilities, and is improving dispersion characteristics from the plant. These two activities together are expected to lower ambient air concentrations.

The MPCA measured elevated levels of toxics in the ambient air (and associated health risks) at Ross and Bush Street in St. Paul. Within several blocks of this monitor are several manufacturing facilities and Interstate Highway 94, all large contributors to the

area's levels of toxics. One company has taken initial steps at one of their plants to improve air quality in this area by agreeing to an emission limit for formaldehyde that is lower than what the plant is currently emitting, and complying early with the hazardous air pollutant emission limit of the paper and other-web surface coating NESHAP. The MPCA is pleased with these commitments by this company to lower their formaldehyde emissions by 50% by the year 2002 and is incorporating these steps into the plant's Title V permit. The permit will be placed on public notice in mid-2001.

The MPCA will continue to use ambient air monitoring results to support requiring controls and/or assessment of point sources when there are reasonable links between measured ambient air concentrations and local point source contributions. It should be noted that this is a limited tool, however, since it is not feasible to place monitors near all large facilities, nor is it feasible to monitor all pollutants emitted.

1.3.2 Conducting air toxic reviews

Since 1995, the principle effort related to controlling toxics from point sources has been to conduct health-based risk evaluations of air toxics emissions during a facility's environmental review and air quality permitting (MPCA, 1997). The MPCA uses risk evaluations as part of its permitting decisions, using the results of risk evaluations to minimize threat to human health or the environment. The aim of the risk evaluation is to determine what level of control or release from a facility is necessary to minimize risk.

This risk evaluation is called an "air toxics review" (ATR). The MPCA's most recent policy is to require a project proposer to conduct an ATR when an environmental assessment worksheet or environmental impact statement is required [e.g. **new** construction that has the potential to emit greater than 100 tons of a criteria pollutant]. New construction is reviewed so that improved pollution control and energy-saving practices can be included during construction, rather than attempting to retrofit later. The MPCA requires an ATR of **existing** facilities if:

a) substantive comments are received during the public notice of an air quality permit that might be resolved through an ATR;
b) an air emission source is applying for a permit with pre-authorized flexibility to change processes to emit significant amounts of a variety of air toxics (a "flexible air permit");
c) a review is required through an air emissions permit;
d) an air emission source is the cause of significant number of complaints, or is suspected of being an emitter of toxic substances that potentially represent a significant public health or environmental risk. (MPCA, 2000)

Air toxic assessments are conducted to evaluate the effect of breathing a chemical (the "inhalation pathway" for exposure). Because a chemical may have different or more significant effect when it comes in contact with skin or is ingested, the MPCA, MDH and others are interested in developing procedures for conducting "multipathway" air toxic assessments. The MPCA has not routinely required multipathway assessments, due to the resource cost to properly conduct a multipathway assessment and obtain useful

results. For compounds for which the MPCA has substantial evidence of risk to human health from exposure through pathways other than inhalation, the MPCA is interested in expanding the use of multipathway assessments. This is of particular interest in the case for bio-accumulative, persistent chemicals like dioxins where evidence shows a strong effect at extremely low levels of exposure.

The effects of the NESHAP program has been laudable in lowering the amount of toxics from major toxic emitters, however their application does not necessarily address local exposure issues. A facility may lower its releases to avoid complying with a NESHAP, but there's no assurance that the levels of control are health protective. In fact, EPA reports that the NESHAP standards for dry cleaners, chrome platers, coke ovens and halogenated solvents may need to be further revised in order to meet acceptable risk thresholds set by the Clean Air Act. (Inside EPA, 2000)

Because of the growing economy, many Minnesota businesses are expanding their facilities. The MPCA has not been able to keep pace with new facility construction and at the same time continue to evaluate existing facilities' toxics emissions. The MPCA is including the requirement to conduct air toxic reviews in permits only if the facility appears to emit significant levels of toxics in very close proximity to residents, and facility owners have not committed to an action plan to reduce the facility's toxic emissions.

The ambient air quality information being collected showing exceedances of health benchmarks, and reduced MPCA staffing since the last legislative report, and the construction of numerous large air emission sources means that there is considerable amount of risk assessment work yet to be done.

There is significant interest by regulated facilities, the general public, and the MPCA in conducting useful assessments. Regulated facilities are interested in conducting toxic assessments to demonstrate to its host community that it is a responsible corporate citizen. They also expect to conduct assessments that meet project construction schedules, and at a reasonable price. The MPCA is interested in conducting timely reviews, identifying "risk-driving" chemicals and/or processes and minimizing their risk, and providing accurate information to Minnesota citizens. Further, the MPCA is charged with protecting the health of all citizens, not just those near newly-constructed facilities or those citizens who take the initiative to comment on a facility's permit. The MPCA must therefore also address how and when existing facilities should come under assessment, in addition to the newly-constructed facilities.

In order to accomplish this work, the risk assessment process must become more efficient and equitable.

1.4 Develop a More Streamlined Process

There has been considerable frustration by regulated facilities and the MPCA with the past execution of the MPCA's risk assessment and risk management process. Complaints common to both regulated parties and the MPCA included the view that air toxics

assessment was an ad hoc practice, the assessment took too long, used too much staff time and cost too much.

In light of these concerns, the MPCA in September 1999 outlined the scope of a broader, more streamlined risk assessment and risk management program. The gains made in efficiency would be used to focus efforts on making measurable environmental improvements. The MPCA is now in the process of constructing and implementing this program.

1.5 Guidance Documents and Training

The MPCA believes a key first step in streamlining is to develop guidance documents that set forth air toxic assessment procedures and practices currently in use by the MPCA. The use of guidance documents, routinely revised to contain recent developments in policy decisions and risk assessment techniques, establishes common expectations for toxics assessment work, and makes the results comparable between assessments. In addition to guidance documents, the MPCA believes "risk" training for all parties involved will help air toxics assessments proceed more efficiently.

1.5.2 Air toxics review guide

The MPCA has already produced the first of two planned guidance documents. As of July 1999, the MPCA Environmental Outcomes and Policy and Planning Divisions have authored an "Air Toxics Review Guide". This guide describes the procedure and product expectations of the MPCA when requiring a facility to conduct a site specific air toxics review. The MPCA has termed this document as an "interim draft" document, committing to revise it periodically as further developments occur in the risk evaluation field. In fact, the guide was revised and released in March 2000, and is likely to be revised in June 2001. The June 2001 revisions will focus on more specific procedures for estimating emissions, and providing guidance on when and how to conduct multipathway risk assessments . The MPCA is pleased to have completed this guide, as we had identified in the 1999 Air Toxics Legislative Report the lack of progress on this basic building-block as a potential shortfall to having a reliable assessment program in place.

1.5.3 Permit writers guide

The second document, a permit writers guide, is currently under development. The permit writers guide tentatively consists of a method for "screening" air toxic emissions from an air emission facility to determine which chemical released by a regulated facility exceed thresholds of safety for that chemical. Because of recent federal activities to address the health concerns of particulate matter, the MPCA is also considering methods within the guide to assess criteria pollutants' impacts to ambient air.

The screening tool under development allows a permit writer to input dispersion values and chemical emission rates to compare the resulting ambient air concentrations against the chemical's toxicity value. The MPCA and the facility would be able to examine the results of this screening process to identify chemicals which appear to exceed safety

thresholds. The MPCA is also considering whether it is important to account for the similar health effects of different chemicals (for example, if a facility emits both of the acids hydrogen chloride and hydrogen fluoride), in this screening process. If so, some technique of combining chemicals that have similar effects may be included in the guide.

Some possibilities for responding to exceedances of thresholds include: conducting site-specific dispersion modeling to better describe actual conditions, improving emission estimates, imposing permit limits limiting the use of certain types of chemicals, imposing permit limits that control the amount of chemical released, and/or requiring that the discharge stack be changed to improve dispersion characteristics. The guide will provide suggested standard permit requirement language to speed permit writing and to help provide equitable treatment between regulated sources.

With a screening procedure the MPCA (and a facility owner) can quickly assess emissions, and help facility owners focus toxic control efforts to the chemicals or emission sources that appear problematic. A routine, consistent method of assessing chemicals will help the MPCA identify source groups or chemicals that are routinely exceeding thresholds, develop risk management requirements for these sources, and prioritize groups of similar sources for further follow-up, like industrial sector pollution reduction initiatives or possibly developing standards through rules.

The screening process is under development now, and will be piloted in 2001. Once the pilot is completed, the MPCA will release the guidance for general use. Facility owners and their environmental staff and/or consultants would able to use these tools themselves to address toxic release issues in the course of preparing air emission permit applications.

The screening process may have other uses as well. Currently, facilities conducting air toxic reviews start with a list of 100 chemicals the facility can potentially release. A list this size presents a difficult data management task, easily prone to errors or miscalculations. Should this screening process prove successful, the MPCA will likely evaluate its use in limiting the scope of full air toxic reviews in order to focus efforts on "risk driving" chemicals, and potentially streamline that process.

1.5.4 Risk management training

The risk management decision faced by MPCA staff and managers balances many factors when determining under what enforceable conditions a project or facility is permitted. Factors include possible net air quality benefits of replacement equipment, incorporation of all feasible risk reduction measures, the expected life of the facility, or the benefits of the project to society.

To improve understanding of these factors, the MPCA has contracted with the University of Minnesota to develop "risk training". Training is likely to be offered in fall 2001 to MPCA managers and staff. Minnesota businesses and industry are also participating in the development of the training, and will be able to use the training as well.

1.6 Potential Future Action Steps

Depending upon the sucess of implementing the steps described above, the MPCA may recommend a shift in its resources and investigate additional and alternative methods of reducing air toxic releases. Some of the possible activities include:

1.6.1 Sector initiatives

One measure of the screening process' effectiveness is if it identifies groups of facilities or industry sectors for specific attention, thus minimizing businesses claims of "competitive disadvantages" if control programs are necessary.

For example, assessing plating facilities in the Twin Cities areas reinforces the need to control their emissions. These businesses are located close to residential neighborhoods, have low or no stacks, and even after complying with the federal NESHAPs, some of them are still emitting levels of chemicals that are higher than health benchmarks. The MPCA has responded to these concerns by adding air toxic control issues to its current outreach efforts to platers. Should voluntary efforts not lead to marked reductions, the MPCA may need to consider rulemaking.

1.6.2 Conduct rulemaking

The MPCA relies on guidelines to implement toxic control strategies due to the evolving nature of risk assessment. Guidelines are not rules, and do not prevent facility owners from using other parameters or attempting other methods of assessing air toxic emissions than those described in guidelines. If MPCA staff is unfamiliar with the alternatives, then staff time must be devoted to reviewing and affirming or rejecting alternative methods. No efficiencies are gained in this instance.

The MPCA often crafts permit conditions to prevent pollution and to protect human health and the environment. Minn. Stat. 116.07, subd. 4a and Minn. R. 7007.0800, subp. 2. Minnesota lacks either statute or rule that specifically defines a toxic emitter's responsibility to control toxic emissions other than this general authority to protect human health and the environment.

While addressing toxics through permitting, the MPCA must be mindful of the general attributes of using rules to control toxic emissions. While sometimes contentious and time consuming up-front, rules establish common expectations between facilities, the MPCA and the general public about each parties' role in addressing toxics concerns.

The MPCA is now in a position to reconsider air toxic control rulemaking as a tool to achieve program efficiencies. For instance, if the air toxics review guide and permit writers guide (the "screening process") can establish generally accepted procedures for conducting reviews and assessments, there may be sufficient long-term resource savings by codifying those generally-accepted procedures into rules.

The federal air toxics control program elements of the 1990 Clean Air Act have been developed and are now being implemented. The extent of the federal program, the pollutants and source groups unregulated or controlled is now known. The MPCA has significantly more information about sources and their toxic releases gathered through the Title V permitting program, the Toxics Release Inventory, and our own 1996 toxics inventory. These information sources can be used to develop air toxic control requirements that are specific, rather than general in scope.

Further, as sector initiatives show promise or lack thereof in reducing air toxics, it may be appropriate for the MPCA to conduct rulemaking for that sector. One first activity might simply be to extend the applicability of NESHAP standards to facilities that currently are exempt under federal standards. Another might be to act on federal residual risk analysis and require toxic controls beyond those required under the federal NESHAPs.

1.6.3 Early compliance with federal requirements

The MPCA could investigate compliance with NESHAPs earlier than the 3 years allowed under the Clean Air Act. For example, styrene emissions are the fourth single largest toxic chemical released as inventoried in the 1996 emissions inventory. Styrene is an irritant at high short-term exposures, and affects the central nervous system if exposure occurs over long periods of time. EPA is now proposing standards of performance to control styrene emissions from fiberglassing operations that would reduce styrene emissions by 95% from any single source. Once promulgated, a facility has up to three years to come into compliance with a NESHAPS.

2.0 Small Sources

Much of the discussion of small sources of air toxics has included the term “area” sources. “Area” sources are defined in federal regulations as sources of air toxics that do not emit, or have the potential to emit 10 tons or more per year of a single HAP or 25 tons per year of two or more HAPs combined. “Major" sources are those that do emit, or have the potential to emit 10 or more tons of a single HAP or 25 or more tons of two or more HAPs combined.

Major sources are regulated under the federal Nation Emission Standard for Hazardous Air Pollutants (NESHAP) program. Some area sources are also regulated under this program. Prior to the compliance date established in each standard, major sources have the option to make themselves area sources through the elimination or reduction of the amount of HAP emitted by the source. These reductions can be achieved through eliminating the source, implementing a pollution prevention program and/or accepting conditions, which legally limit the potential to emit of the source to less than the 10/25 ton per year thresholds.

In broader discussion of sources of air toxics, the term “area” sources has been used to mean facilities that do not meet the federal definition but simply groups of sources that are small, large in number and dispersed, sources such as gas stations. While most gas

stations are "area" sources with regard the federal definition, some are major sources. For purposes of the discussion that follows, the sources will be described as small sources without regard to the sources' status as an "area" source or "major" source.

2.1 Current MPCA Actions To Reduce Emissions From Small Sources

Given the analysis and considerations set forth in this appendix, the MPCA is taking the following actions to reduce emissions of air toxics from these small stationary source categories:

1. Residential wood burning, voluntary stove change-out program
2. Gasoline marketing, voluntary stage-one vapor recovery program
3. Electroplating, Strategic Goals Program

2.1.1 Residential wood burning: voluntary stove change-out program

Particles, especially fine particles emitted from combustion sources, has a significant impact on health. (See Particulate Matter Appendix.) Burning wood in older equipment emits significantly more pollution than burning wood modern equipment. Old conventional wood stoves emit twice as much particulate as new wood stoves. Modern stoves are also more efficient than conventional wood stoves (US EPA(a), 10/96)

This action step, a voluntary wood stove change out program, uses a public outreach campaign to encourage owners to exchange old stoves for those that meet EPA standards through incentives provided by the stove manufacturers. MPCA involvement would extend to "signing on" to a pre-packaged public education/manufacturers' incentive campaign, and providing access to local media outlets. The appeal of the considered action is the potential for a win-win situation for the environment, MPCA, owner, and wood stove manufacturer:

- The emissions to the environment of many pollutants, including very small particulate, formaldehyde, benzo (a) pyrene and other PBTs, are reduced,
- The cost of administering the program to the MPCA is extremely low,
- The owner has a more efficient, less polluting wood heater at a lower cost, and
- The manufacturer sells more stoves.

It is not anticipated that the number of people participating in this program would be large enough to have a significant impact on the ambient pollutant concentrations in Minnesota. While this action may not have a significantly impact on the state as a whole, it will reduce the concentration of these pollutants in the vicinity of a participating owner's residence.

Even modern solid fuels such as wood and coal emit significantly more quantities of particulate matter than residential oil or natural gas furnaces. Anthracite coal and wood pellet stoves (among the cleanest residential wood and coal burners) emit approximately 200 times as much filterable particulate matter as does a residential oil or natural gas furnace (US EPA(b), 10/96; US EPA(c) 9/96; US EPA(d) 7/98).

If the price of home heating fuels continues to increase and remain high for an extended period of time, more people may switch to burning wood as was common in the '70s and '80s. There also appears to be some interest in switching to burn coal as a supplemental fuel. Much of the wood burning now takes place in more rural areas where the number of people affected by the emissions is reduced due to the lower population density. If wood or coal burning becomes popular in the urban areas again, the ambient concentrations of pollutants emitted will increase and the number of people exposed to those higher concentrations will also increase. Therefore, the MPCA believes reasonable steps, such as this incentive program, to lower the emissions from wood stoves are warranted.

2.1.2 Gasoline marketing: voluntary or mandatory stage-one vapor recovery

The *MPCA Staff Paper on Air Toxics* reported average monitored benzene concentrations in Minnesota ranging from 0.649 to 3.185 $\mu g/m^3$. Modeled benzene emissions from filling gasoline storage tanks increase those concentrations by as much as 1.521 $\mu g/m^3$ (MPCA, 9/1995) at the property line and in the vicinity of the tanks respectively. The health benchmark for benzene is 1.3 to 4.5 $\mu g/m^3$. Volatile organic compound emissions from the filling of gasoline storage tanks also contribute to ozone concentrations in and around the metro areas of the state. With the installation of stage-one vapor recovery equipment and the turnover of the vehicle fleet in Minnesota (to vehicles with on-board vapor recovery), the modeled increased ambient benzene concentration from gasoline service stations would decrease to 0.216 $\mu g/m^3$ (MPCA, 9/1995).

Koch Industries and Holiday Station Stores together are about to voluntarily install and operate stage-one vapor recovery systems at all Holiday Station Stores in the Twin Cities. The MPCA will encourage other station owners to follow this lead. With the exception of the recent Koch/ Holiday Station Stores decision, the MPCA has had little success in past attempts to persuade gasoline station owners to install stage-one vapor recovery systems. Even though more recent ambient measurements at several sites indicates benzene levels are declining (see Air Toxics Appendix); benzene levels in the ambient air warrant reasonable steps to further reduce concentrations, especially in the vicinity of gas stations.

Using voluntary agreements, the MPCA will work with gas stations so that by July 2003, 85 percent of gasoline sold in urban areas of the state will come from stations operating stage-one vapor controls. If a voluntary program to install vapor recovery systems is unsuccessful, one action under consideration is for the MPCA to mandate the installation and use of these systems.

There are several questions to be considered if a voluntary effort is not effective. These questions include:

- Should all gasoline service stations be required to install stage one vapor recovery or is there some lower limit at which the owner would be exempted?
- Should the requirement apply to only large stations?
- Should the requirement to large stations and those of all sizes that are in close proximity to other stations?

- Should all areas of the state be subject to this requirement or should it only apply to the metro areas, or only the seven county metro area?

The MPCA estimated the costs to install and operate stage-one vapor recovery systems in a 1995 draft report (MPCA, 1995). In this report, the MPCA estimated the cost to retrofit vapor recovery equipment at gasoline service stations ranged from $554.65 to $1,904.50 per tank.

The estimated cost to retrofit vapor recovery equipment on tanker trucks ranged from $500 to $4,000 per truck. The gasoline distribution NESHAP (40 CFR part 63, subpart R) was promulgated since those costs were estimated. This NESHAP requires stage-one vapor recovery at gasoline distribution centers and, as a result, tankers hauling fuel from these distribution centers must accommodate vapor recovery. Therefore, owners of fuel tanker trucks will have already incurred the largest portion of the cost of vapor recovery (retrofitting necessary piping to the tanker trucks). Additional costs not included in the original estimates include:

- Additional time is required to deliver a load of fuel from a tanker truck to a gas station using vapor recovery equipment. This additional time is estimated to be seven to 10 minutes per tank due to the additional time hook up the additional hoses (needed for the vapor recovery) and slower filling rate (due to smaller filler tube used in coaxial systems).
- The cost of additional fittings, hoses, etc. to allow simultaneous delivery of fuel to two or more tanks.

One estimate suggests that the total additional cost to the fuel transporter would result in an increase of 2% to the fee to deliver fuel to the gasoline service station. The majority of this cost is the result of the increased time to deliver a load of fuel (Guggisberg, 2000).

Facilities with underground storage tanks were required to upgrade their tanks with corrosion protection and leak detection by US EPA by 1998. In anticipation of the need to eventually install stage-one vapor recovery equipment, anecdotal evidence suggests that many of the tanks were installed with the necessary fittings.

EPA is considering a NESHAP that would require stage-one vapor recovery equipment for gas stations. Due to the uncertainty of when, if ever, the rules will be promulgated; and what size of facilities will be subject to the standard, the MPCA does not want to wait for EPA to take action on this issue.

If EPA does promulgate the gas station NESHAP as intended, one concern is that the NESHAP may only apply to the largest gas stations leaving the majority of the gas stations unaffected by the rules. This would leave many smaller gas stations located in residential areas unchanged and still allowed to have a significant negative impact on local ambient air quality affecting the health of local residents. There is also a matter of time; should Minnesota wait some unknown number of years (certainly greater than three since this rulemaking activity is not on any schedule at this time) for EPA to act when significant reductions can be achieved earlier. If EPA failed to promulgate the gas station NESHAP, Minnesotans, in particular those living close to one or more gas stations,

would continue to be exposed to higher levels of benzene and other HAPs when a relatively inexpensive means to reduce this exposure goes unimplemented.

2.1.3 Electroplating: Strategic goals program

Electroplaters emit acutely toxic chemicals (including hydrochloric acid, chromium, nickel, halogenated solvents and cyanide), have low or no stacks to disperse pollutants, and are often located next to homes and other small businesses. Chromium electroplating and anodizing operations includes hard chromium, decorative chromium, decorative trivalent chromium, and chromic acid anodizing. Chromium electroplating and anodizing operations produce chromic acid mists. As these mists escape into the air, acid and chromium emissions are released. As a result, these operations can have a significant impact on the air quality in the vicinity of the facility.

Chromium electroplating and anodizing operations are regulated by the NESHAP for Hard and Decorative Chromium Electroplating and Chromium Anodizing Tanks, finalized on January 25, 1995. Recent MPCA emergency response and enforcement activity at electroplaters have emphasized the issue that federal air toxic standards for electroplaters do not sufficiently address toxic releases from these businesses. The Minnesota Department of Health conducted a study of a chrome plating operation and concluded that there was a significant health risk to people living in the vicinity of the facility even if the facility complied with the NESHAP and all other state and federal requirements (MDH 12/99).

The Minnesota Metal Finishers Association along with University of Minnesota's Minnesota Technical Assistance Program (MnTAP) and the MPCA are working to reduce the environmental impact of the metal finishing industry in Minnesota including air toxics. This will be accomplished through a permitting program focused on improving process operations and/or the additional of control equipment to lower toxic emissions, and implementation of the US EPA's Strategic Goals Program. The intent of the Strategic Goals Program is to achieve emission reductions through education, technical assistance, and implementation of pollution prevention. Following through on this commitment will ensure reductions of air toxics from this source group.

The of the seven core environmental goals under Strategic Goals Program are as follows:

1) 50% Water Reduction

This goal is met when a facility has an annual water usage that is 50% or less of its baseline water usage, adjusted for any changes in the facility's level of production. Companies with zero discharge for the current year automatically achieve this goal.

Companies may select to base progress on either the volume of water purchased or volume of metal finishing process wastewater discharged. Water purchased is a

more accurate measurement because it is easily tracked using water bills and/or totaling water meters. However, many companies have a significant disparity between volume purchased and volume of process wastewater discharged. This is due to evaporative losses plus non-metal finishing process uses of water such as lavatories, cooling, and the presence of non-metal finishing industrial processes. In these cases, companies may submit calculated values for discharges based on total water purchased and subtracting out non-process water uses. In any event, the same methodology should be used for completing the baseline and current year worksheets. The company should retain supporting records or calculations.

2) 25% Energy Reduction

This goal is achieved when a facility's total annual energy consumption is 25% less than its baseline total energy consumption. Captive metal finishing facilities may choose to track progress on the 25% reduction in energy use goal on a facility-wide basis or just for the metal finishing portion of their plant.

Progress on the 25% energy reduction goal is based on all sources of energy purchased by the facility, including electricity, natural gas, fuel oil, and propane. A reduction of each energy source is not necessary to achieve this goal. To calculate progress, the value of each energy source is converted to BTUs and summed. The goal is met if the sum of BTUs for the current year is 25% or less than the baseline year.

3) 50% Reduction in Land Disposal of Hazardous Sludges and an Overall Reduction in Sludge Generation

This goal is achieved when a facility reduces its baseline annual quantity of hazardous wastewater treatment sludge that is disposed of in landfills by 50% or more and achieves an overall reduction in the quantity of wastewater treatment sludge generated. Companies with zero wastewater sludge generation for the current year automatically achieve this goal.

Companies may achieve the 50% reduction goal by decreasing the quantity of sludge shipped to landfills, recycling sludge off-site, and/or delisting their sludge. Sludge quantity is calculated on a dry weight basis.

4) 50% Reduction in Metals Emissions to Water and Air

This Goal is achieved when the sum of annual emissions of TRI metals and cyanide to air and water from a facility are reduced by 50% from the baseline year quantity. Companies with zero emissions for the current year automatically achieve this goal.

To achieve this goal it is not necessary to reduce emissions for each individual metal or cyanide. The comparison of baseline and current year data is based on the sum of all TRI metals plus cyanide.

5) 98% Metals Utilization

This goal can be achieved in one of two ways: (1) a facility is land-disposing 2% or less of TRI metals used or (2) a facility reduces their overall wastewater treatment sludge generated by 50% or more from their baseline year quantity.

The optional sludge reduction measurement was recently implemented because many companies operate processes that do not lend themselves to the utilization calculation. For example, processes such as etching and electropolishing remove metal from the parts, which makes tracking utilization difficult or impossible. Companies are free to select either method of tracking progress toward the 98% utilization goal.

The "land-disposing of 2% or less" method does not require baseline data; the calculation is based on current year data only. The following rules help to define this goal:

Land disposing includes discharging to a POTW and disposing of metals in landfills (includes disposal of hazardous or non-hazardous sludges, spent solutions, and other forms of wastes). Metals recycled off-site are considered as utilized. "Metals used" are defined as the quantity of TRI metal used for finishing purposes (i.e., added to a tank as anodes or chemical compounds). It does not include the base metal (i.e., part being plated). Cyanide is not considered in the utilization calculation; only TRI metals are considered. When chemical compounds are used, the quantity is expressed as "metal." For example 100 lb. of chromic acid flakes (CrO3) contains 52 lb. of chromium as metal. 98% utilization of each TRI metal is not necessary to achieve this goal. The weights of all TRI metals are summed during the utilization calculation.

The overall 50% sludge reduction method is based on a comparison of baseline and current year data. Sludge quantity is determined on a dry weight basis. Companies with zero sludge generation for the current year automatically achieve this goal.

6) 90% Reduction in Organic TRI Emissions

This Goal is achieved when sum of the annual emissions of TRI organic compounds to air and water from a facility are reduced by 90% from the baseline year quantity. Companies with zero emissions for the current year automatically achieve this goal.

It is not necessary to achieve 90% reduction for each TRI organic compound used. The weights of all TRI organics are summed during the utilization calculation.

7) Reduction in Human Exposure to Toxic Materials in the Facility and the Surrounding Community

This Goal is achieved when a company has performed or updated all actions identified in the "reduction in human exposure to toxic chemicals" section of the worksheet in the reporting year. Note that this goal does not compare the baseline and current year activities. If a particular action is not applicable (e.g., solvent tanks are covered when not in use") it is counted as achieved.

* The baseline quantity is that quantity consumed or generated in 1992.

The MPCA's goal is to reduce the concentrations of targeted air pollutants in the vicinity of metal finishing operations to healthful levels and minimize the regulatory burden placed on these small to mid-sized businesses.

2.2 Method of Determining and Evaluating Area Source Emission Reduction Strategies

MPCA staff analysis of HAP emissions from small sources resulted in a list of sixteen small source categories with significant emissions of hazardous air pollutants (MPCA, 1999; Wu, C.Y. and Bergland, O., 2000; Wu, C. Y., 2000). The majority of these source categories represent facilities that are located in or near residential areas and therefore have the ability to significantly impact the quality of the air that people breathe. These small source categories are:

- Architectural Surface Coating;
- Residential Fossil Fuel Combustion;
- Gasoline Marketing;
- Commercial / Consumer Solvent Products;
- Autobody Refinishing;
- Residential Wood Burning;
- Industrial Surface Coating;
- Dry Cleaners;
- Solvent Cleaning;
- Pesticides – Agricultural;
- POTW facilities;
- Graphic Arts;
- Traffic Markings;
- Municipal Solid Waste Landfills;
- Marine Vessel Loading; and
- Chromium Electroplating.

The MPCA first evaluated these source categories on the basis of the toxicity of the pollution from each of these source categories.

The MPCA knows that it's resources are limited and that it is unable to address all identified issues immediately and that the best approach is to address the most significant pollution issues first. For the purposes of this section, "most significant" means the greatest number of people exposed to the pollutants with the highest toxicity. In an effort to compare source categories that emit different pollutants with different types of toxicity, different toxicity values and different numbers of pollutants, a matrix was developed and a scoring system devised.

Placement of the source category in each column is based on the source category's toxicity ranking in Analysis of the 1996 Air Toxics Emissions Inventory for Area Sources. The order of the source categories in a column in Table 3 is the order of appearance of the source category when ranked by toxicity (cancer, acute non-cancer or chronic non-cancer)(Wu, C. Y., 2000). For example, chromium electroplating is the first source category that appears in the ordered cancer toxicity ranking due to chromium VI emissions and, therefore, it appears in the first row of the first column in Table 3.

To better evaluate the source categories with multiple pollutants emitted, the emissions / cancer toxicity value (quantity of pollutant emitted divided by the cancer toxicity value) are summed for all listed pollutants for each source category. Also, emissions / acute non-cancer value and emissions / chronic non-cancer toxicity value rankings for all of the listed pollutants are averaged for each source category. The source categories are then ranked by the sum of the emissions / cancer toxicity values and average of the emissions / acute non-cancer values and emissions / chronic non-cancer values.

Source categories are scored by adding the points assigned to each row for all occurrences of a sector in each row in Table 3. For example, residential wood burning appears once in the first row twice (2 x 16 = 32 pts), second row once (15 pts), fourth row once (13 pts), fifth row once (12 pts) and sixth row once (11 pts) for a total of 83 points. The small source categories were ranked using this system. The results of this ranking are shown in Table 2.

Source Category Overall Toxicity Ranking
Table 2

Source Categories	Score	Rank
Residential Wood Burning,	15 + 16 + 16 + 13 + 11 + 12 = 83	1
Residential Fossil Fuel Combustion,	12 + 12 + 15 + 14 + 16 + 11 = 80	2
Gasoline Marketing,	11 + 13 + 14+ 11 + 9 + 9 = 67	3
Commercial / Consumer Solvent Products,	14 + 14 + 12 + 7 + 14 + 5 = 66	4
Autobody Refinishing,	7 + 9 + 10 + 16 + 8 + 13 = 63	5
Chromium Electroplating,	16 + 15 + 1 + 1 + 13 + 16 = 62	6
Dry Cleaners,	13 + 10 + 5 + 12 + 4 + 15 = 59	7
Solvent Cleaning,	9 + 8 + 13 + 9 + 6 + 6 = 51	8
Architectural Surface Coating;	4 + 4 + 7 + 10 + 15 + 10 = 50	9
POTW facilities	10 + 11 + 11+ 5 + 7 + 4 = 48	10a
Graphic Arts;	6 + 5 + 9 + 8 + 12 + 8 = 48	10b
Industrial Surface Coating,	8 + 6 + 8 + 6 + 10 + 7 = 45	12
Traffic Markings,	1 + 1 + 6 + 15 + 3 + 14 = 40	13
Municipal Solid Waste Landfills	5 + 7 + 4 + 4 + 5 + 3 = 28	14
Marine Vessel Loading;	3 + 3 + 3 + 3 + 2 + 2 = 16	15
Pesticides – Agricultural;	2 + 2 + 2 + 2 + 1 + 1 = 10	16

This ranking is by no means intended to say or imply that these are the only significant small source categories in Minnesota. There are many small source categories for which MPCA has insufficient data, such as agricultural pesticides, which may be of concern. This ranking is also subject to the limited toxicity information for many chemicals. If toxicity information is not available for a chemical, the toxicity value is assumed to be zero. This assumption certainly resulted in one or more source categories being ranked lower than what would have resulted if all the toxicity information was known. The assumption that the toxicity of a chemical is zero if no toxicity information is available is not accurate.

This ranking is not intended to say or imply that those small source categories included in the ranking, but not included in the final strategy, are not significant air toxics small source categories. Further study of the issue of air toxics from small sources will affect this ranking and may affect the source categories that MPCA chooses to expend resources on to address in the future.

The following matrix was produced from MPCA small source emissions and toxicity information (Wu, C. Y., 2000):

Small Source Category Toxicity Ranking Matrix
Table 3

Score	Ranking By Cancer Highest Ranked Pollutant	Ranking By Cancer Ranking by Sum of Emissions / Toxicity of	Ranking by Acute Highest Ranked Pollutant	Ranking by Acute Average Ranking of Pollutants **	Ranking by Chronic Highest Ranked Pollutant	Ranking By Chronic Average Ranking of Pollutants **

		Pollutants *				
16 pt	Chromium Electroplating	Residential Wood Burning	Residential Wood Burning	Autobody Refinishing	Residential Fossil Fuel Combustion	Chromium Electroplating
15 pt	Residential Wood Burning	Chromium Electroplating	Residential Fossil Fuel Combustion	Traffic Markings	Architectural Surface Coating	Dry Cleaners
14 pt	Commercial / Consumer Solvent Products	Commercial / Consumer Solvent Products	Gasoline Marketing ***	Residential Fossil Fuel Combustion	Commercial / Consumer Solvent Products	Traffic Markings
13 pt	Dry Cleaners	Gasoline Marketing ***	Solvent Cleaning	Residential Wood Burning	Chromium Electroplating	Autobody Refinishing
12 pt	Residential Fossil Fuel Combustion	Residential Fossil Fuel Combustion	Commercial / Consumer Solvent Products	Dry Cleaners	Graphic Arts	Residential Wood Burning
11 pt	Gasoline Marketing ***	POTW facilities	POTW facilities	Gasoline Marketing ***	Residential Wood Burning	Residential Fossil Fuel Combustion
10 pt	POTW facilities	Dry Cleaners	Autobody Refinishing	Architectural Surface Coating	Industrial Surface Coating	Architectural Surface Coating
9 pt	Solvent Cleaning	Autobody Refinishing	Graphic Arts	Solvent Cleaning	Gasoline Marketing ***	Gasoline Marketing ***
8 pt	Industrial Surface Coating ***	Solvent Cleaning	Industrial Surface Coating ***	Graphic Arts	Autobody Refinishing	Graphic Arts
7 pt	Autobody Refinishing	Municipal Solid Waste Landfills	Architectural Surface Coating	Commercial / Consumer Solvent Products	POTW facilities	Industrial Surface Coating ***
6 pt	Graphic Arts	Industrial Surface Coating ***	Traffic Markings	Industrial Surface Coating ***	Industrial Surface Coating ***	Solvent Cleaning
5 pt	Municipal Solid Waste Landfills	Graphic Arts	Dry Cleaners	POTW facilities	Municipal Solid Waste Landfills	Commercial / Consumer Solvent Products
4 pt	Architectural Surface Coating	Architectural Surface Coating	Municipal Solid Waste Landfills	Municipal Solid Waste Landfills	Dry Cleaners	POTW facilities
3 pt	Marine	Marine vessel	Marine	Marine	Traffic	Municipal

	vessel loading	loading	vessel loading	vessel loading	Markings	Solid Waste Landfills
2 pt	Pesticides – Agricultural	Pesticides – Agricultural	Pesticides – Agricultural	Pesticides – Agricultural	Marine vessel loading	Marine vessel loading
1 pt	Traffic Markings	Traffic Markings	Chromium Electroplating	Chromium Electroplating	Pesticides – Agricultural	Pesticides – Agricultural

* To better rank the source categories with multiple pollutants emitted, the emissions / cancer toxicity numbers were summed for all listed pollutants. These summations and the associated source categories were ranked from greatest to least.

** To better rank the sources with multiple pollutants emitted, acute and chronic toxicity rankings for each of the listed pollutants for each source category were averaged and then the averages and the associated source categories were ranked from greatest to least.

*** EPA source category data upon which the MPCA's toxicity ranking analysis was conducted included two erroneous emission factors that were originally included in MPCA emission estimates (Wu, C. Y., 2000). The following corrections have been made and the source category rankings reflect the corrected estimates.

- 1,3-Butadiene is a product on incomplete combustion (not an evaporative emission) and therefore, is not emitted from the gasoline marketing source category
- Ethylene Oxide is not emitted by the Industrial Surface Coating source category.

The MPCA evaluated the need for reducing HAP emissions from small source categories and any action the MPCA may consider to reduce HAP emissions from small sources using three main criteria. The results of this evaluation are summarized in Table 4. The criteria by which the need and considered actions were judged were; 1) cost, 2) effectiveness, and 3) ability to implement. Each of these criteria can be further broken down into subcriteria. For example, cost includes the cost to those directly impacted by the proposed action and secondarily impacted. Any requirement to install stage one vapor recovery equipment at gasoline service stations would also require fuel transporters to install and use compatible equipment resulting in a cost to them.

1) Cost:

This is the cost to those impacted by the considered action. For the residential wood combustion category, it is the cost to replace an old wood burner with a modern controlled wood burner. This would also include secondary costs, such as the cost fuel transport companies would incur in upgrading hauling equipment to accommodate vapor recovery equipment used at gasoline service stations. This does not include the cost to the MPCA to implement action considered. A full circle indicates lower external cost for the considered action.

2) Effectiveness:

There are a lot of methods of determining the effectiveness of an action. Examples include:

- Tons of pollutants not emitted as a result of the action,
- Reduced average ambient concentrations of a pollutant across MN,
- Reduced ambient concentrations in the immediate vicinity of a facility, and
- Reduced occurrences of reactions (asthma attacks, hospitalization, etc.) to pollution.

Most considered actions for small sources have a more significant impact on the ambient air quality in the immediate vicinity than on the state as a whole. One exception to this is the use of reformulated gasoline because RFG affects the evaporative emissions of the gasoline service station, the refineries that produce the fuel, the bulk station that stores the fuel, the vehicles that transport the fuel and vehicles that burn the fuel as well as the exhaust emissions of the vehicles. This would have a significant impact on ambient concentrations of benzene, 1-3 butadiene and other HAPs locally and across the state. A full circle indicates an action that would meet one or more of the above-stated effectiveness measures.

3) Ability to Implement:

Many things impact the ability of the MPCA to implement the considered action including:

- Legal authority,
- Partners (public and private) willing to participate in the considered action,
- Technical feasibility of the considered action, and
- Political acceptability of the considered action.

Air Toxics Small Source Category Decision Matrix
Table 4

Recommended Reduction Strategy	Small Source Category	Action to address air toxics	Cost (external)	Effectiveness	Ability to implement
√	Residential Wood Burning	Voluntary stove change-out program	◒	◒	●
		Mandatory stove change-out program	○	◒	○
		Develop and promulgate a standard of performance for stand alone wood burning boilers	◒	●	○
√	Gasoline Marketing	Voluntary stage one vapor recovery	●	◒	●
		Mandatory stage one vapor recovery	●	●	●
		Voluntary gasoline formulation change	○	◒	●
		Mandatory Reformulated Gasoline Program	○	●	○
√	Chromium Electroplating	Strategic Goals Program	●	◒	●

Additional Subcriteria Evaluated

In addition to the toxicity ranking, the following subcriteria were yardsticks by which each source category was evaluated to determine if the source category should be included in the small source reduction strategy:

– Potential for reductions

  - Amount of reduction
  - Technical fix exists
    - Readily available fix
  - P2 opportunities
- Reduction efforts already in place
  - Applicable NESHAP
  - Further reduction efforts by other states
- Human exposure evaluation
  - Most exposed person
  - Largest number of people exposed
    - Cursory evaluation
    - Modeling evaluation
- Costs to fix
  - MPCA
  - Affected industry
  - Others
- Cost to not fix
- Strong partner / infrastructure to tap into
- Potential for quick success
- Data availability (do we know enough to make a decision or do we need more info)
- Correlated benefits (reductions of other pollutants)
  - PBTs
  - CO_2
  - PM
  - VOCs
  - Other

Information for each source category, for each of these criteria was not available and in many cases the information available was qualitative rather than quantitative. This should not be interpreted to mean that the decisions are baseless. Rather it means that all available information was used and the quality of the information was considered in making the decisions and recommendations included in this report.

2.3 Background Information for Source Category Ranking

This section contains background information considered while developing and evaluating emission reduction strategies. Information varies by source category and may include:

- A description of the source category, a list of pollutants emitted by the source category,
- An estimate of the number of facilities included in the source category,
- A discussion of possible actions other than the recommended reduction strategies, and
- Other relevant information.

2.3.1 Residential wood burning

Residential wood burning occurs in three major types of equipment: woodstoves, furnaces, and fireplaces. Woodstoves and furnaces are commonly used in residences for primary and supplemental heating, and fireplaces are commonly used for pleasure burning. Minnesota does not currently have regulations in place for residential wood burning, but most of the woodstoves, furnaces, and fireplaces are equipped with some emission reducing technology or features. This section will focus on the emissions from residential wood burning throughout Minnesota.

Hazardous air pollutants emitted by residential wood combustion
Table 5

Pollutant
Acenaphthene
Acenaphthylene
Anthracene
Benzene
Benz(a)anthracene
Benzo(a)pyrene
Benzo(b)fluoranthene
Benzo(g,h,i)perylene
Benzo(k)fluoranthene
Cadmium
Chromium
Chrysene
Copper
Dibenz(a,h)anthracene
Fluoranthene
Fluorene
Indeno(1,2,3-cd)pyrene
Manganese
Naphthalene
Nickel
Phenanthrene
Phenol
Pyrene
2,3,7,8-TCDD
2,3,7,8-TCDF
PCDD
PCDF
Toluene
o-Xylene

Facility Identification

Residential wood burning data were obtained from the 1995-1996 Minnesota Residential Fuelwood Survey. The survey provides information based on the Minnesota Forest Service Survey Units classified by location. There were a total of 5 units (Table 7). The survey supplied information relative to total volume of wood consumed for pleasure, supplemental and primary heating, average number of cords burned per survey unit, geographic data, and percent of wood burned in fireplaces, woodstoves, and furnaces.

A summary of the required parameters to estimate emissions is listed in Table 7 below.

Estimated Average Annual Wood Consumption and Percent of Households that Burn Wood
Table 7

Unit	% of Households Burning Wood	Avg. # Cord Burned per Household for heating (cords/house/year)	Avg. # Cords Burned per Household for pleasure (cords/house/year)
Metro MN	21%	1.74	0.64
Central MN	25%	2.90	0.29
South-West MN	17%	2.90	0.70
East MN	31%	3.89	0.70
North MN	36%	4.9	0.94

Standard Cord: 4ft x 4ft x 8ft or 128 standard cubic ft

Wood combustion (primarily wood stoves) contributes 58% of the benzo (a) pyrene emissions, as well as substantial quantities of particulate emissions, in the States and Provinces surrounding the Great Lakes. Wood stoves manufactured after 1988 are required to meet EPA standards and have only about 10% of the emissions of older wood stoves. Because wood stoves have an extremely long life (about 90% of existing wood stoves were manufactured before 1988), they have a very low replacement rate.

Catalytic and non-catalytic stoves reduce PM_{10} and CO emissions by up to 53 percent and total organic compound emissions by up to 77 percent. In addition to the reduced emissions from catalytic and noncatalytic wood stoves compared to conventional woodstoves, the net efficiency of these stoves is greater than conventional stoves, 68 vs. 54 percent (US EPA(a), 10/96).

A number of Minnesota residences are heated with outdoor wood heaters. These are larger units used to provide comfort heating and hot water to a single residence and are not subject to the New Source Performance Standards with which new wood burning stoves and fireplace must comply. The units are operated with a low fire. Low fires tend to promote incomplete combustion and can result in higher HAP emission rates and smoke much more than other modern fireplaces and wood stoves. These units are largely unregulated by Minnesota or EPA. The MPCA could undertake a rulemaking to establish a standard of performance for these units. This would have a very significant impact on air quality in the vicinity of these units. The difficulty of this action is the need to collect emissions data and develop a reasonable, enforceable standard (presumably a construction standard that would apply to the manufacturer of the unit).

2.3.2 Residential fossil fuel combustion

Residential fossil fuel combustion is energy consumed by private households, which includes apartment complexes and farm households. Residential fossil fuel combustion includes the burning of coal, fuel oil, natural gas, and liquid petroleum gas. This section focuses on the uncontrolled emissions generated from residential fossil fuel combustion in Minnesota.

Pollutants Emitted by Distillate Fuel Oils Grades 1 and 2 Combustion
Table 8

Pollutant
Arsenic
Benz(a)anthranc ene
Cadmium
Chromium
Cobalt
Copper
Lead
Mercury
Manganese
Nickel
PCDD
PCDF
2,3,7,8-TCDD
2,3,7,8-TCDF

Pollutants Emitted by LPG and Natural Gas Combustion
Table 9

Pollutant
Benzene
Cobalt
Copper
Chromium
Formaldehyde
Lead
Manganese
Nickel
Toluene

1995 Minnesota Annual Residential Fuel Consumption for Various Fuels (MDPS, 6/97)
Table 10

Fuel Type	1995 Residential Fuel Consumption	Fuel Consumption in BTUs
Natural Gas (Million Mcf)	131.7	1.38×10^{14} Btu (72%)
Coal (1000 Tons)	3.3	8.58×10^{10} Btu (0.05%)
Distillate Fuel Oil (Million Gallons)	136.3	1.91×10^{13} Btu (10.0%)
LPG (Million Gallons)	192.1	1.81×10^{13} Btu (9.5%)

Replacing coal with natural gas could reduce emissions of nickel by approximately 97%. This would impact local ambient air quality. Replacing coal or distillate oil with natural gas or LPG burners could reduce arsenic emissions but would increase formaldehyde emissions.

Possible actions include:

- Public education and outreach campaign to discourage use of new coal burners for residential heating.
- Public education and outreach campaign to encourage people to keep furnaces tuned up and, when replacing a furnace, replace it with the most efficient heating unit available.

2.3.3 Gasoline Marketing

Currently, there are essentially two types of fuel dispensed at gasoline service stations to consumers in Minnesota, unleaded gasoline and diesel. As a result of the low volatility of diesel fuel, the evaporative emissions from diesel fuel at service stations are very small

and considered negligible. However, the evaporative emissions from gasoline fuel are significant and will be discussed in this section.

Each of the following accounts for approximately one third of the evaporative emissions from gasoline service stations:

a) stage I (transfer of gasoline from tank trucks to storage tanks at service stations);
b) stage II (transfer of gasoline from storage tanks at service stations to the vehicle gasoline tank);
c) spillage.

Stage-one vapor recovery captures vapors displaced from fuel tanks at gasoline service stations when the tanks are refilled. These vapors are then transported back to the terminal or refinery where the are recovered through condensing them or flared off.

Stage 2 vapor recovery captures vapors displaced from vehicle fuel tanks when the vehicles are refilled. All passenger cars since 1996 are required to recover these vapors and then burn them as fuel. The fleet of light duty trucks is currently under going the same change and soon all new light duty trucks will be similarly equipped.

VOC Speciation Profile of Gasoline Vapor
Table 11

Pollutant
Benzene
Ethylbenzene
Naphthalene
Toluene
Xylenes

A stage-one vapor recovery NESHAP for gasoline service stations is included in the list of future standards under EPA's Integrated Urban Air Toxics Strategy. The details and schedule for promulgation of this standard are unknown.

Another means although more difficult, of reducing Minnesotans' exposures to benzene and other HAPs from gas stations is to change the formulation of gasolines sold in Minnesota. Reformulated gasolines (RFG) that are sold in other parts of the country are intended, among other things, to reduce the benzene content of the fuels. Reducing the benzene content of the fuel has the added benefit of reducing the benzene emissions from the refinery, the distribution system, gas stations and cars. According to the Bay Area Air Quality Management District, the average ambient levels of benzene dropped significantly in 1996 due to the widespread marketing of Phase 2 reformulated gasoline (a different formulation), which began in the Bay Area in the second quarter of 1996. The average benzene levels for 1998 were about one half of those observed in 1995 (BAAQMD, 12/99).

EPA has not in the past been receptive to states that are in attainment with the ozone National Ambient Air Quality Standards opting into the RFG program. Refineries would probably incur significant costs to be able to produce RFG and it would take some time for the refineries to be able to produce enough RFG to meet the demand.

2.3.4 Commercial / Consumer Solvent Products

Commercial and consumer solvent products are nonindustrial products such as maintenance and cleaning products containing volatile organic compounds (VOC) including personal care products, household products, automotive aftermarket products, adhesives & sealants, coatings & related products, and misc. These organic compounds produce emissions through volatilization during product application.

Targeted Pollutants, Source Categories, and References
Table 12

Pollutant	Source Categories[1]
Acetone	3
Benzene	3
Carbon tetrachloride	6
Chlorobenzene	5, 6
Chloroform	3, 6
CFC-11	1
1,4-Dichlorobenzene	2, 5
o-Dichlorobenzene	3
1,2-Dichloroethane	1, 2
Ethyl benzene	2, 3, 4, 5, 6
Ethylene oxide	5
Formaldehyde	2, 4, 5, 6
Glycol ethers	1, 2, 3, 4, 5, 6, 7
Methylene bromide	5
Methylene chloride	2, 3, 4, 5, 6, 7
Naphthalene	2, 3, 4, 5, 6
Perchloroethylene	2, 3, 4, 5, 6, 7
Toluene	1, 2, 3, 4, 6, 7
1,1,1-Trichloroethane	1, 2, 3, 4, 5, 6, 7
Trichloroethylene	2, 3, 4, 6
Xylenes	2, 3, 4, 5, 6, 7

Notes:
The source categories are referenced as follows: 1 - personal care products, 2 - household products, 3 - automotive aftermarket products, 4 - adhesives & sealants, 5 - FIFRA regulated products, 6 - coatings & related products, 7 - miscellaneous.

EPA has promulgated rules regulating the VOC content under section 183(e) of many products under this category and is scheduled to promulgate more VOC content rules in 2001 - 2003. It is unclear what impact this rule has had (or will have) on HAP emissions from these products. Given that many of the HAPs in these products are VOCs, it is likely that the HAP contents of these products have been or will be decreased. Since the data on which the HAP emissions for this report predate (mostly from 1996) the changes

in these products as a result of the VOC rules, it is reasonable to delay action on this source category.

Consumer And Commerical Products Schedule For Regulations
Table 13

Product Group	Schedule for regulation
Group I:	
Consumer products (24 categories)*	1997
Shipbuilding and repair coatings	1997
Aerospace coatings.	1997
Architectural coatings	1997
Autobody refinishing coatings	1997
Wood furniture coatings	1997
Group II:	
Flexible package printing materials	1999
Group III:	
Aerosol spray paints	2001
Industrial cleaning solvents	2001
Flat wood paneling coating	2001
Lithographic printing materials	2001
Group IV:	
Paper, film, and foil coatings	2003
Letterpress printing materials	2003
Plastic parts coatings	2003
Metal furniture coatings	2003
Auto and light truck assembly coatings	2003
Petroleum drycleaning solvents	2003
Miscellaneous metal products coatings	2003
Large appliance coatings	2003
Fiberglass boat manufacturing materials	2003
Miscellaneous industrial adhesives	2003

*Product categories included in ‘‘Consumer products (24 categories)’’ grouping: Aerosol cooking sprays, Air fresheners, Auto windshield washer fluids, Bathroom and tile

cleaners, Carburetor and choke cleaners, Charcoal lighter materials, Dusting aids, Engine degreasers, Fabric protectants, Floor waxes and polishes, Furniture maintenance products, General purpose cleaners, Glass cleaners, Hair sprays, Hair mousses, Hair styling gels, Household adhesives, Nonagricultural insecticides, Laundry prewash treatments, Laundry starch products, Nail polish removers, Oven cleaners, Shaving creams, Underarm antiperspirants and deodorants.

2.3.5 Autobody Refinishing

Autobody refinishing is categorized as nonindustrial surface coating. Automobile refinishing is the repainting or coating of worn and damaged automobiles, light trucks and other vehicles. The coatings are applied by a spray, a brush, or a roller. Coating of new manufactured vehicles is not included in this category.

Pollutants Emitted in Autobody Refinishing
Table 14

Pollutant
Benzene
Dibutyl Phthalate
Naphthalene
Toluene
Isomers of Xylene

Possible methods of reducing HAP emissions from businesses in this industry include:

- reduce the HAP content of the coatings;
- reduce the quantity of coatings used (more efficient paint application);
- improve capture efficiency for PM (use a booth, paper filters);
- improve the dispersion characteristics of the emissions (eliminate obstructions to flow out the stack, improve stack height and velocity);
- use thermal oxidizers on vents; and
- use water borne (California) paint.

California paint requirements are intended to address VOC emissions, not HAP emissions. The HAP content difference of California paints vs. “49 state” paints is not substantial. Also, given the significant variability of the weather in MN, water borne paints would require a substantial investment in environmental controls to allow the use of these paints in MN. Additional and more sophisticated climate controls [temperature and humidity] would be required. This variability is currently dealt with through the use of different hardeners used in the paint mixtures (Hilvosky, 8/2000).
EPA promulgated a VOC rule under section 183(e) in1997. It is apparent that this rule has had little impact on HAP emissions from autobody refinishing products. Minnesota could require paint manufacturers to reduce the HAP content of paint sold in Minnesota. Particulate matter is also generated in repairing and refinishing autobodies. It is unknown whether or not PM is generated in sufficient qualities to be a health problem outside the building in which the work is done.

Autobody shops are everywhere; some located in areas that are primarily residential (although, these are probably smaller shops). Small shops may use only a couple hundred gallons of VOC containing material annually.

2.3.6 Chromium Electroplating

Chromium electroplating and anodizing operations include hard chromium, decorative chromium, decorative trivalent chromium, and chromic acid anodizing. Chromium electroplating and anodizing operations produce chromic acid mists. As these mists escape into the air, chromium emissions are released. As a result, these operations produce significant emissions of hexavalent chromium and chromium compounds. This section will focus on chromium emissions from chromic acid operations, hard and decorative hexavalent chromium electroplating operations. Decorative trivalent electroplating operations will not be included due to lack of information available for estimating emissions. Chromium electroplating and anodizing operations are regulated by the NESHAP for Hard and Decorative Chromium Electroplating and Chromium Anodizing Tanks, finalized on January 25, 1995.

Pollutants Emitted from Chromium Electroplating
Table 15

Pollutant
Chromium
Chromium VI (hexavalent chromium)

The universe of facilities that are subject to this standard is identified very well. It is the opinion of staff in the Small Business Assistance Program that facilities are making an effort to achieve the intended emission reductions available through the NESHAP (or at least most of the reductions). However, it is also likely that the facilities are not doing all that is required by the NESHAP in terms of achieving emissions reductions and most certainly are not doing all that is required in terms of administrative requirements. Most, if not all, of these facilities are also subject to the solvent cleaning NESHAP.

2.3.7 Dry Cleaners

Commercial dry cleaners are the largest sources of perchloroethylene (PERC) emissions. This section will focus on the emission of PERC by commercial dry cleaners throughout Minnesota. Coin operated laundries and cleaning, which are operated by the customers, and pick-up stores are waived by NESHAP standards and therefore are not included in this section.

Pollutants Emitted from Dry Cleaners
Table 16

Pollutant
1,1,1-trichloroethane
Ethylbenzene
Naphthalene
Perchloroethylene
Toluene
Xylenes

The MPCA has had more than one outreach effort to inform dry cleaner owners and operators of the NESHAP and its requirements. However, the industry has a history of frequent turn over and it is likely that a significant portion of the notification forms that the MPCA received are now out-of-date. This would imply that there is probably a significant portion of the dry cleaners in Minnesota that are unaware of the NESHAP and are therefore unable to comply with its requirements. Effectively implementing this and other area source NESHAPs (National Emission Standards for Hazardous Air Pollutants: Halogenated Solvent Cleaning) should be a central part of the MPCA's air toxics strategy.

2.3.8 Solvent Cleaning

In this category, the use of solvents is broken into two broad classifications. The classifications are solvent cleaning (which is composed of cold cleaning and vapor/in-line cleaning), and solvent cleanup (predominantly wipe cleaning of external surfaces).

Pollutants Emitted from Solvent Usage
Table 16

Pollutant
Benzene
Naphthalene
Toluene
Xylene, m
Xylene, o
Xylene, p
Xylenes iso

Since the emissions of methylene chloride, perchloroethylene, 1,1,1 trichloroethane, and trichloroethylene have already been counted in the halogenated solvent cleaners, these pollutants were not included in this sector.

The categories of industries considered in this category are:

- Furniture
- Magnetic Tape

- Packaging
- Photographic supplies
- Automotive – manufacturing
- Automotive - trucks and buses
- Automotive - parts/accessories
- Automotive - stamping
- Electrical equipment

Significant reductions can be achieved if the NESHAP is followed. This is a complex standard and it is very important for the MPCA to make a concerted effort to effectively implement the NESHAP. Effectively implementing this and other area source NESHAPs should be a central part of the MPCA's air toxics strategy.

2.3.9 Architectural Surface Coating

Architectural surface coating is typically considered to be a nonindustrial category which homeowners and painting contractors used for coating of interior and exterior of houses, buildings, and other surfaces. Two types of paints are used to categorize architectural surface coating. They are water-based and solvent-based paints. Solvent-based paint typically contains substantially higher volatile solvent contents than water-based paint.

The targeted compounds for the solvent-based paint profile are Acetone, Ethylbenzene, and Toluene. The targeted compounds for the water-based paint profile are Benzene, Methylene Chloride, and Methyl Chloride. All compounds are classified as VOC.

Speciation Profile for Architectural Surface Coating (CARB, 1991)
Table 17

Pollutant	
Solvent based paints	Acetone
	Ethylbenzene
	Isomers of xylene Toluene
Water based paints	Benzene
	Methylene chloride
	Methyl chloride

These products are subject to the VOC content rules under Clean Air Act section 183(e) promulgated in 1997, 40 CFR, part 59, subpart D, National Volatile Organic Compound Emission Standard for Architectural Coatings. While hazardous air pollutant emissions from these products were considered in the rulemaking, it was not the intent of the promulgated rules to reduce HAP emissions from their use. Hazardous air pollutant reductions would have to be achieved through some form (voluntary or mandatory) of reduction in the use of architectural surface coatings or reduction of the HAP content of the coatings. Hazardous air pollutant content limits would probably be the more effective of the two options.

California Air Resources Board (CARB) has promulgated VOC limits for architectural surface coating products that are more stringent than the federal rules promulgated under section 183(e). These rules also do not specifically address the HAP content of these products; these rules address VOC content. However, like the federal rules, since many VOCs are also HAPs, these rules will reduce HAP emissions from these products. The MPCA could pursue similar rules for Minnesota. The cost of promulgating such rules is difficult to estimate. On one hand, the organization State and Territorial Air Pollution Program Administrators and the Association of Local Air Pollution Control Officials (STAPPA/ALAPCO) has published guidance to assist other states to promulgate similar rules (STAPPA/ALAPCO, 10/2000). On the other hand, the effort would require the MPCA to invest considerable time to modify the CARB rules to fit conditions in Minnesota.

2.3.10 Publicly Owned Treatment Works

Publicly owned treatment works (POTWs) are municipal treatment facilities where wastewater from different industrial, commercial, and residential sources is directed for treatment. Hence, POTW wastewater may have large concentrations of many toxic compounds. Specific industrial and commercial activities are the largest source of organic compounds entering the municipal collection systems. However, other residential sources of organic compounds such as home maintenance and cleaning products contribute to the total organic compounds that enter the POTWs. These organic compounds produce emissions through volatilization at the surface of the wastewater during treatment processes. POTWs are significant sources of volatile organic compounds (VOC) in the United States.

Pollutants Emitted from POTWs
Table 18

Pollutant
1,1,1-Trichloroethane
1,2-Dichloroethane
Acetaldehyde
Benzene
Carbon tetrachloride
Chloroform
Ethylbenzene
Ethylene dibromide
Formaldehyde
Methylene chloride
Perchloroethylene
Styrene
Toluene
Trichloroethylene
Vinyl chloride
Vinylidene chloride
Xylenes

There were a total of 204 POTW facilities with treatment processes in Minnesota for 1996 excluding those with stabilization ponds, surface water discharges, and spray irrigation systems (small systems). A system with a stabilization pond and a surface water discharge or spray irrigation, has a wastewater flowrate which is small enough that the wastewater has time to biodegrade.

2.3.11 Graphic Arts

Graphic arts and printing operations emit volatile organic compounds (VOC) during operation. The graphic arts industry includes six segments, separated by technology: rotogravure, flexography, offset lithography. letterpress, screen, and plateless printing. The small source inventory includes printing operations not included in the point source inventory. The emission estimates do not include large operations previously accounted for in the point source section of the Minnesota emission inventory.

Pollutants Emitted from Graphic Arts Industry
Table 19

Pollutants
Toluene
Xylene
Benzene.
Ethylbenzene
Trimethylbenzene

The Printing Industry of Minnesota, Inc. (PIM), the Minnesota Pollution Control Agency, the Minnesota Technical Assistance Program, Citizens for a Better Environment and the St. Paul Neighborhood Energy Consortium together established the Great Printers Project in Minnesota. According to PIM, "(t)he primary objective of the Great Printers Project is to make pollution prevention and waste reduction a standard practice at printing companies."

To be listed as a Great Printer, printers must:

- Operate companies in compliance with environmental, health and safety requirements;
- Pledge to go beyond compliance by minimizing wastes, reusing or recycling wastes and maximizing energy efficiency; and
- Pursue continuous environmental, health and safety improvements.

Sixty-two companies are listed as Great Printers by PIM.

2.3.12 Industrial Surface Coating

Surface coating operations involve the application of a thin layer of coating (paint, lacquer, enamel, varnish, ink, etc.) to an object for decorative or protective purposes. This is accomplished by brushing, rolling, spraying, flow coating or dipping operations. This category does not include architectural surface coatings, traffic markings, automobile refinishing or aerosols. Since the use of surface coatings by manufacturing industries is so widespread, it is extremely difficult to identify all of the industries in which coating materials are consumed.

Table 20

Industries that Perform Surface Coating
Mobile homes
Prefabricated buildings and components
Reconstituted wood products
Wood products, not elsewhere classified
Wood furniture
Metal furniture
Metal cans
Fabricated structural metal
Sheet metal work
Architectural and ornamental metal work
Miscellaneous structural metal work
Automotive stampings
Metal stampings, not elsewhere classified
Electroplating, plating, polishing, anodizing, and coloring
Coating, engraving and allied services
Farm machinery and equipment
Lawn and garden equipment
Construction machinery and equipment
Mining machinery and equipment
Pumps and pumping equipment
Air and gas compressors
Air conditioning and warm air heating equipment
Household appliances
Motor vehicle and passenger car bodies
Aircraft
Ship, Boat building and repairing
Travel trailers and campers
Musical instruments
Sporting and athletic goods
Signs and advertising specialties

Pollutants Emitted During Surface Coating
Table 21

Pollutant
Naphtha
Butyl acetate
Butyl alcohol
Cellosolve
Methyl alcohol
Dimethylformaldehyde
Hexylene glycol
Ethylene oxide

Emissions from these facilities typically come from surface preparation, coating application and flash-off, and curing. Surface preparation is often performed to clean the substrate and improve adhesion. Types of chemicals for pretreatment include aqueous caustic solutions, phosphate, chromate rinse, and organic solvent cleansers. After cleaning, parts are usually dried in an oven prior to coating application steps. Surface preparation can also involve paint stripping, blasting (with sand, shot, or other blast media), and other methods to physically alter the surface prior to coating application. There are several coating application techniques used in the different industry sectors. Variations in emissions from the application of solvent-based coatings are most commonly attributed to transfer efficiency, evaporation and flash-off. Possible emission reduction techniques for coating application include the use of waterborne coatings, high-solids coatings, powder coatings, and add-on control devices. Many sectors of the category, however, may have performance requirements for their coatings that would not allow the use of many of these more innovative technologies.

Business in these industries may be subject to one or more NESHAPs including:

- Aerospace MACT,
- Wood Furniture MACT,
- Boat Manufacturing MACT,
- Auto & Light Duty Surface Coating MACT,
- Large Appliance MACT, and
- Halogenated Solvent Cleaning MACT

Many of the VOC containing products used in these operations will be subject to a VOC content rule under section 183(e) of the CAA. These rules are scheduled for completion in 2001 – 2003.

2.3.13 Traffic Markings

The use of traffic markings is entirely a small source. Two types of generally used traffic marking paints are water-based and solvent-based paints. Solvent-based paint typically contains substantially higher volatile solvent contents than water-based paint.

Minnesota Department of Transportation (MNDOT) stated that 90 percent of the 1996 traffic marking paint usage was water-based and 10 percent was solvent-based during a telephone survey on 12/16/98. According to the MSDS that was provided by the paint manufacturer, toluene was the only air toxic in the solvent-based paint, while the water-based paints were free of air toxics. Since we didn't know the ratio of white and yellow traffic marking usage, we assumed equal usage for the white and yellow paints for both the water-based and solvent-based paints.

2.3.14 Municipal Solid Waste Landfills

In Minnesota, approximately 1.8 million tons of solid waste is landfilled each year. Landfill gas is produced from the disposed waste in these landfills by the biodegradation of organic matter. Landfill gas emissions can occur either on-site or in surrounding areas. The principal components of landfill gas are methane, carbon dioxide, and other non-methane organic compounds (NMOCs). For 1996, 132 landfills were included in the inventory; of those, 14 had flaring or combustion facilities.

Due to the growing concerns about the environmental impacts of air emissions from landfills, emissions from MSW landfills are sometimes controlled by installing a gas collection system and destroying the gas through the use of combustion technologies such as internal combustion engines or flares. Flaring with no energy recovery is the most common technologies for Minnesota MSW landfills. The main purpose of a flare system is to control landfill gas emissions and reduce odors.

Table 22

LFG Pollutants
1,1,1-Trichloroethane
1,2-Dichloroethane
Carbon Tetrachloride
Methylene Chloride
Ethylbenzene
Tetrachloroethylene
Trichloroethylene
1,1,2,2-Tetrachlorethane
1,1-Dichloroethane
1,1-Dichloroethlenen
1,2-Dichloropropane
Benzene
Chlorobenzene
Chloroform
Ethylene Dibromide
Toluene
Vinyl Chloride
Xylene (Total)
m-Xylenes
o-Xylenes
Acetone
Acrylonitrile
1,1,2-Trichloroethane

Table 23

LFG Flaring Pollutants
Benz(a)anthracene
Benz(o)pyrene
Benzene
Carbon Tetrachloride
Chlorobenzene
Chloroform
Chrysene
Fluoranthene
Methylene Chloride
Naphthalene
PCBs
PCDD
PCDF
1,1,1-Trichloroethane
2,3,7,8-TCDF
Tetrachloroethylene
Toluene
Trichloroethylene
Vinyl chloride
Xylenes
o-Xylene

Hazardous air pollutant and VOC emissions can be reduced through flaring landfill gas. This however will produce some pollutants that otherwise are not emitted (combustion products)

2.3.15 Marine Vessel Loading

Marine vessels are used to transport petroleum liquids, including crude oil, gasoline, jet naphtha, distillate oil, and residual oil between ports. Emissions occur during transport and loading. Organic vapors are released when the petroleum liquid displaces the gases in the ships' tanks. Transit losses occur when the petroleum vapor contracts and expands in the tanks. Emissions from fuel used to power the vessels are not included in the marine vessel loading category. Only one port in Minnesota reported petroleum liquids as cargo: Duluth Superior Harbor in St. Louis county. Crude petroleum, distillate fuel oil, residual fuel oil, and petroleum coke were imported in Duluth in 1996.

Products included in this category are crude oil, residual oil, distillate oil, gasoline, and kerosene.

Volatile organic compounds evaporate from the petroleum liquids during transfer and transport. Benzene, toluene, and xylene are among the organic compounds emitted.

2.3.16 Pesticides – Agricultural

The MPCA believes that pesticides may pose a greater risk than is represented through this prioritization method. The prioritization method itself may underestimate the impact of pesticides. This belief is based on the following:

- the toxicity values for pesticides are only for inhalation;
- major factors in the environmental impacts of pesticides are their persistence and bioaccumulation, but these factors are not taken into account in this prioritization method;
- pesticides are designed and intended to be toxic and to be biologically active, and in the normal course of their usage they are dispersed in the environment;
- pesticides are being transported through the atmosphere hundreds of kilometers and being deposited in areas where the pesticide application is not intended (Thurman and Cromwell, 2000; Kidd Schindler, Muir, Lockhart, and Hesslein, 1995); and
- there is a positive association between pesticide usage and cancer in agricultural regions of Minnesota (Schreinemacher, Creason and Garry, 1999).

These factors indicate an information gap that needs to be filled. There is sufficient evidence of a human health impact from the use of these chemicals that further investigation is warranted.

Pesticides are used in the production of corn, soybean, and many other crops in the United States. Atrazine and trifluralin are the most widely used pesticides in Minnesota's three major agricultural crops (corn, soybean, and spring wheat), however; trifluralin was not used on the spring wheat crop in 1996. Pesticide are also used in residential lawns, nurseries, gardens, etc

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APPENDIX N
DRAFT
Action Steps – Research/ Planning

Introduction

This appendix summarizes the MPCA's research and planning efforts currently underway as well as potential future steps. To encourage the emission reduction of air pollutants, the MPCA will provide technical assistance and support to other state agencies' planning efforts. The MPCA will also conduct additional research about air pollutants of concern.

1.0 Action Steps – Planning

1.1 Provide environmental analysis of state energy/electricity planning

In the 2001 legislative session, the Minnesota Department of Commerce (DOC) will propose electricity reliability legislation. The DOC projects the need for a 30 to 50 percent increase in electricity generation capacity within the next five years. The MPCA, along with the DOC, are named in the Administration's Big Plan as responsible for the development of the Adminstration's energy and electricity plan. Electricity production accounts for between 30 and 70% of the state's air emissions of criteria pollutants, particulate toxic metals, greenhouse gases, and pollutants implicated in long-range transport problems e.g., acid rain, ozone, regional haze. As the lead environmental protection agency, one possible role for the MPCA that has been discussed, is the development of environmental goals for long-term energy planning and the analysis of the potential environmental effects of the Administration's energy and electricity plan.

The MPCA is committed to an interagency effort in the environmental analysis of short-term and long-term energy strategies. The MPCA plans to analyze the environmental consequences of both the DOC's energy generation forecasts and the Adminstration's energy and electricity plan, paying particular attention to the potential effects to air quality. The MPCA will advocate "clean energy" strategies including the increased use of wind power, solar energy, biomass-based fuels, and natural gas.

1.2 Provide environmental analysis of state land use and transportation planning

A central part of the agency's approach for reducing pollution from mobile sources is to work with other agencies and external stakeholders to develop the most effective and appropriate means of reducing mobile source pollution. The MPCA's objective is to inform stakeholders about the environmental issues and data that appear most important from the MPCA's perspective and build support for public policies to reduce mobile source pollution. The MPCA does not play a lead role in land use or transportation planning. The MPCA envisions it role to be that of bringing its environmental data and

analysis to the table and working with other agencies and communities to address land use, transportation and air quality issues.

1.2.1 Land use planning

The EPA has taken a number of steps to reduce air pollution from mobile sources, mainly through requirements on fuels, vehicles and engines. The EPA has not taken steps related to land use because it has no authority to do so. Section 131 of the Clean Air Act states: "nothing in this Act constitutes an infringement on the existing authority of counties and cities to plan or control land use, and nothing in this Act provides or transfers authority over such land use."

States and local units of government may choose to control land use in ways that yield air quality benefits. The EPA may offer credit to state and local governments for those reductions as part of a State Implementation Plan (SIP). The Clean Air Act requires states to produce a SIP if an area within the state exceeds a federal air quality standard. The SIP describes how the state will ensure that federal air quality standards will be met in the future.

The EPA has drafted guidance that offers credit to states that incorporate land use policies and projects into their air quality planning processes.[1]

EPA's land use strategies
These strategies reduce air pollution through land development that makes it easier for people to get around without the need to use a vehicle. Examples of these sorts of land use strategies include:

- Transit-oriented development: encouraging moderate to high-density development along a regional transit system.
- Infill development: new development within existing built-up areas, including brownfields development.
- Mixed use development: a development that blends various land uses such as residential, services, retail, offices and public facilities within walking distance of each other.
- Jobs/housing balance: efforts to reduce imbalances between available housing and employment opportunities within a sub-region.

These strategies could be used more frequently and more readily accomplished through zoning regulations, design controls and/or incentive programs.

[1] "Recognizing the Air Quality Benefits of Local and State Land Use Policies and Projects in the Air Quality Planning Process, (public comment draft)" (US EPA, June 2000).

MPCA support for land use strategies that reduce air pollution

The following are examples of ways the MPCA can improve air quality through support of state agencies and others involved in land use issues. The MPCA's support of these efforts will take the form of providing technical analysis and support.

- General Environmental Impact Statement on Urban Development (Urban GEIS).

The Urban GEIS is intended to "examine the long-term effects of urban development, past, present, and future upon the economy, environment, and way of life of the residents of the state." After a public review and comment phase, the Environmental Quality Board (EQB) approved the final scoping document and budget on December 21, 2000. With legislative approval, the GEIS work will begin in July 2001.

- Community Based Planning.

Minnesota Planning's "Community Based Planning" sets forth a new framework intended to integrate sustainable development principles into local comprehensive plans. The law stresses the need to plan for growth. Different ways of handling growth have very different results for the environment, the cost of providing public services, and the character of a community. Minnesota Planning administers financial and technical assistance for local planning. The goals of this planning initiative include incorporating Smart Growth principles into local development plans.

- State Development Strategy.

The state development strategy is a 20-year state development strategy led by Minnesota Planning in coordination with the Metropolitan Council and the commissioners of Transportation, Trade and Economic Development, and Natural Resources. The strategy includes forecasts, issues, goals and policies relating to development and the connections between transportation, land use, environmental protection, energy and economic development. It identifies major development and transportation corridors in the state, along with cultural and natural features and resources of statewide, local and regional significance.

The state development strategy also includes recommendations for coordinated state infrastructure investments and ways to coordinate local government decisions with the strategy and encompass community-based planning goals. Minnesota Planning must submit to the 2001. Legislature a proposal for a state development strategy based on development of a "prototype strategy" for the I-94 corridor between the Twin Cities and St. Cloud.

1.2.2 Transportation Planning

The MPCA intends to support transportation planning in ways that reduce pollution and, to the extent possible, relieve congestion on the roads. This effort has direct ties with the

agency's efforts related to land use decision-making. The MPCA's role with respect to transportation planning concerns the link between transportation and its environmental and quality of life impacts. The MPCA can provide technical analysis and support at the planning stage, recommend important source control measures and avoid after-the-fact concerns later in the process about air quality impacts.

The MPCA is currently involved in certain transportation issues through the issuance of indirect source permits. The purpose of these permits is to ensure that large development and construction projects, including highway construction, do not increase vehicle traffic to the point where state standards are violated for carbon monoxide. The process by which transportation plans are reviewed to ensure consistency with the Clean Air Act, state standards and state air quality plans is called the conformity process.

The Conformity Process

The Clean Air Act Amendments of 1990 (CAAA) require state transportation plans to conform to state air quality requirements as set forth in the state's implementation plan (SIP). This process is referred to as transportation "conformity". Conformity is designed to bring present and future air quality impacts into the planning process and raise the policy dimensions and tradeoffs between transportation and air quality decisions to policy officials, elected officials and stakeholders. In a recent study of the conformity process, however, researchers found "it can sometimes be problematic to move discussion of conformity problems beyond the relatively small circle of transportation and air quality professionals and the few stakeholder representatives that deal with it on a regular basis. In some of the study areas, this has led to considerable delay in confronting the roots of their conformity problems."[2] The reasons for this delay include:

- Conformity analysis is highly complex and technical – often there are disputes about the modeling.
- Conformity analysis involves long range projections -- much time spent first to verify the projections.
- Planning for transportation and air quality is done separately, with different timeframes and involving different stakeholders. Additionally, through each process, the issues are often bundled together which makes subsequent changes more difficult to make.
- Conformity is a regulatory process for nonattainment and maintenance areas. Large amounts of federal aid are at stake. Often the transportation plans must be modified, as intended under the CAAA, to accommodate the SIP.

Lessons learned that can be applied to Minnesota and the MPCA

Although Minnesota is currently meeting federal air quality standards, the state could benefit from the experiences of other metropolitan areas that have been required to use

[2] "Linking Transportation and Air Quality Planning: Implementation of the Transportation Conformity Regulations in 15 Nonattainment Areas," (Howlitt and Moore, March 1999).

the conformity process. For example, additional information sharing could help in a preventative mode versus a regulatory mode. Also, there are areas where closer connections during the early planning phases would enable the transportation and air quality issues to be addressed earlier in their respective processes. Given the results of the conformity process in other parts of the country, there may be areas where the MPCA can work up-front with transportation planners to address the policy aspects of transportation and air quality in a preventative approach, working beyond the Clean Air Act's non-attainment requirements.

The goal of this preventative effort would be to ensure people can get around and in ways that minimize air pollution. According to the Center for Transportation Studies, air pollution from transportation sources alone in the Twin Cities results in about $1 billion in health care and other costs each year. The CTS report goes on to note, however, that the share of costs that are external is relatively small, policies should be tailored carefully to address them without reducing the very large benefits of transportation by more than they reduce the smaller external costs of transportation. In other words, the remedies to address the costs of air pollution from transportation should avoid reducing the benefits of the transportation system.

More information about the conformity process, including a recently completed "Conformity Assessment Project" conducted by Harvard University for the US EPA and US DOT is available at: http://www.epa.gov/oms/transp/traqconf.htm

2.0 Action Steps – Research

2.1 Introduction

The MPCA will participate in two projects to measure concentrations of pollutants in areas that are thought to have elevated levels of certain pollutants ("hot spots"). As additional monitoring and modeling information becomes available, the MPCA will consider monitoring at other potential hot spots.

2.2 Monitoring Hot Spots of Particulate Matter less than 2.5 microns in diameter (PM2.5)

The MPCA will cooperate and coordinate with the University of Minnesota to further the state of knowledge of fine diesel particles in Minnesota. Specifically, the MPCA will support the University of Minnesota's research proposal on fine particle (nanoparticle) aerosol characteristics at transportation related hot spots. The MPCA believes this type of research will be helpful to not only the diesel research community, but also to state air regulators. Knowledge of the characteristics of diesel-related particles will help inform the MPCA's air pollution reduction efforts. The MPCA will share its monitoring data with the University of Minnesota, involve the University of Minnesota in developing its monitoring plans, and assist the University of Minnesota in selecting monitoring sites for this project.

2.3 Identify Sources of Particulate Matter less than 2.5 microns in diameter (PM2.5)

The MPCA began monitoring PM2.5 in April, 1999. Since then data has been collected from 31 locations throughout Minnesota. Monitoring is currently being conducted at 23 locations. These sites are designed to measure the concentration of PM2.5 in the outdoor air. (See Particulate Matter Appendix, section 3.1, for additional information.) Beginning in 2001, the MPCA will be adding three PM2.5 speciation sites to its PM2.5 monitoring network. These speciation sites will be part of a national network of about 300 monitoring sites.

Over time, these speciation sites will help tell us how much of the particles in the atmosphere come from diesel combustion, other mobile source, power plants, and other sources. At a minimum, the speciation sites will quantify mass concentrations and significant PM2.5 constituents which include trace elements, sulfate, nitrate, sodium, potassium, ammonium, and carbon. In addition, EPA anticipates that physical and chemical speciation data will provide valuable information for:

- Assessing trends in mass component concentrations and related emissions, including specific source categories.
- Characterizing annual and seasonal spatial variation of aerosols.
- Determining the effectiveness of implementation control strategies.
- Helping to implement the PM2.5 standard by using speciated data as input to air quality modeling analyses.
- Aiding the interpretation of health studies by linking effects to PM2.5 constituents.
- Understanding the effects of atmospheric constituents on visibility impairment and regional haze. (EPA, 1999)

The MPCA began sampling at the first site (Andersen Elementary School in the Phillips neighborhood of Minneapolis) on January 7, 2001. The Phillips site has been designated as the long-term trend site with samples collected on a 1 in 3 day schedule. The MPCA expects sampling to begin at the two supplemental sites in fall/winter of 2001/2002. The proposed sites are Harding High School in East St. Paul and Ben Franklin Elementary School in Rochester. Samples will be collected on a 1 in 6 day schedule at these sites.

For additional information about EPA's speciation sites go to:
http://www.epa.gov/ttn/amtic/speciepg.html

2.4 Airport Monitoring

Description of Action: The MPCA will monitor air toxics and PM2.5 at a site near the Minneapolis-St. Paul airport (MSP Airport) beginning in spring 2001 and lasting for one year.

Rationale: Environmental organizations such as the National Resources Defense Council, citizen groups and others are becoming more concerned about air pollution-related health impacts near large airports. While airport noise issues have received much attention, airports have been largely understudied in the past in terms of their impact on ambient air in the surrounding community. Ambient air issues become even more of a concern as airports continue to expand to meet rising air travel demand – including the MSP airport. The MSP airport has residential areas in close proximity to its operations and further development of areas very near the airport is expected. Recent information points to the need for additional ambient monitoring data near the airport:

- EPA's Cumulative Exposure Project modeling based on 1990 emissions data predicted the area near the airport to have elevated concentrations of toxics – higher than most other areas of the Twin Cities.
- According to a 1999 EPA study, from 1990 to 2010 increases in commercial aircraft nitrogen oxide (NOx) emissions for the 10 cities studied are expected to range from 50 to 110 percent. In addition, the study showed that in 2010 commercial air craft are projected to contribute as much as 10 percent of total regional mobile source NOx emissions in at least two of the cities studied.
- According to 1996 Minnesota emissions inventory estimates, the airport contribution to total Hennepin County toxic air pollutants is:
  - -26 % of formaldehyde emissions
  - -61% of acrolein
  - -3.4% of 1,3-butadiene
  - -1.6% of benzene
- Activity at the airport is expected to increase due to ever-rising demands for air travel. Currently a new north-south runway is under construction to help accommodate this increasing demand.
- Various citizen group representatives as well as legislators have requested monitoring near the airport.

What is the goal of siting a monitor near the airport?

- To obtain a "fingerprint" of the ambient levels of VOCs and carbonyls in public areas near the airport prior to further expansion.
- To help substantiate the relative accuracy of model predictions.
- To provide data that will help determine how much the airport is contributing to ambient concentrations of toxics and certain other pollutants.
- Provide additional data to determine the priority of lowering emissions from airport operations.

Pollutants

Emissions from the airport come from not just aircraft but from ground support equipment and ground access vehicles, maintenance operations, and other sources. Pollutants include VOC, NOx, PM (both PM2.5 and PM10), SOx and CO. Other air pollutant species include polycyclic aromatic hydrocarbons (PAHs) found in the particulate emissions and certain semi-volatile compounds. Certain VOCs, PM, or semi-volatile compounds are also air toxics, such as benzene, arsenic, or benzo(a)pryrene.

Airport Emissions Reduction Efforts at the National Level

Some airports are working with state air authorities to reduce emissions on their own. For example, cars, buses, tractors, shuttles and even lawn mowers used at Dallas/Fort Worth Airport would have to be converted to alternative fuels within five years, according to a plan being developed by airport executives to reduce air pollution.

At the national level, a stakeholder process involving EPA's Office of Transportation and Air Quality and the Federal Aviation Administration as well as aviation industry representatives, airports, state and local air pollution control officials, and environmental organizations is underway. The goal of the group is to develop a voluntary program to reduce pollutants from aircraft and other aviation sources that contribute to local and regional air pollution.

Some of the measures being evaluated by the group include retrofitting older aircraft engines, low polluting technology for future aircraft engines, more efficient operating practices (e.g., reduced aircraft idling and taxi time), electrification or use of alternative fuels in ground support equipment and ground access vehicle, and others.

Having ambient data to supplement modeling data for the airport will help determine the priority of implementing this type of voluntary program at the MSP airport.

Siting of Monitor

MPCA staff has surveyed the airport and its perimeter for acceptable monitoring sites. Site selection is still under consideration. The criteria for site selection include:

- A public location not on Metropolitan Airport Commission grounds,
- One or two story building with good access or ground-based sites with good security,
- Minimal influence from road traffic,
- Close proximity to high activity area of the airport, and
- Downwind of prevailing winds (dependent on season – but typically from northwest in winter, southeast in summer).

3.0 Potential Future Action Steps

3.1 Science Advisory Panel

The MPCA is concerned that some of the most significant public health and ecological impacts from air pollution – and the best ways to reduce these impacts – are not well identified or understood. Even when federal ambient air quality standards or MDH Health Risk Values are available, they may not fully account for risks to human health or the environment. For example, the MPCA believes that ambient (outdoor) air concentrations of fine particles are currently causing many premature deaths, hospitalizations, and other adverse effects in Minnesotans each year. This is occurring at fine particle air concentrations that meet the current ambient standards for particulate matter (the PM_{10} and PM2.5 standards).

In order to enhance the information available on the risks of specific air pollutants and options for addressing them, the MPCA recommends convening a multidisciplinary scientific advisory panel to assess the human health and ecological impacts of ambient air pollutants in Minnesota. The findings would be used by the MPCA to help inform, prioritize, and focus air pollution reduction efforts. An initial effort should focus on the risks of fine particulate matter in outdoor air.

Specific objectives for the panel would include:

- Assess the evidence for cause-and-effect relationships between key air pollutants and impacts
- Provide health-based information to be used in prioritizing air pollution reduction efforts
- Identify key information gaps in characterizing air pollution impacts (e.g., essential health surveillance information, exposure studies, monitoring data, etc.)
- Develop health-based information that can be used to estimate the societal costs of air pollution in Minnesota

<u>Issues to be Addressed</u>

Identifying priority air pollution problems will require, at a minimum, consideration of the following:

- Various measures of the impact of ambient pollutants (e.g., the number of people effected, the number of years of life lost or disabled)
- Adverse impacts specific to population subgroups (e.g. the elderly, children, sensitive individuals, more highly exposed individuals)
- Health impacts from all significant exposure routes, both through the air and the food chain
- The different types and severity of adverse health effects plausibly associated with outdoor air pollution in Minnesota (e.g., various cancers, heart disease, worsening asthma, respiratory disease, watery eyes, neurological effects, etc.) and the uncertainty in these associations
- The relative priority given to concerns based on well-established, cause-and-effect relationships vs. possible, yet unproven or uncertain, relationships

- The available ambient air monitoring and modeling information, and data on the relative exposure contributions from outdoor air, indoor air and personal exposures
- Minnesota-specific health statistics and disease trends (e.g., increasing asthma, leukemia, etc.) and any potential contribution of air pollution to these illnesses

Participants

At a minimum, the following areas of expertise should be represented on the panel: public health, environmental epidemiology, environmental chemistry, medicine (cardiovascular, pulmonary, allergy, immunology, oncology), particle physics, ecology, and toxicology. The panel should also include national experts currently working in areas related to air pollution related health issues, at least in an advisory role. The MPCA and others with expertise in ambient air monitoring and emission sources will need to provide Minnesota-specific information to the panel members.

3.2 Expanded Monitoring of Toxic Pollutants (PBTs)

The MPCA 5-year strategic plan calls for reducing the exposure to toxic air pollutants and characterizing the extent and severity of damage to humans and wildlife from emerging pollutants like persistent, bioaccumulative toxics (PBTs) and endocrine disruptors. The Great Waters Program, signed into law in 1990, directs the U.S. EPA to develop measures that will prevent harm from air pollution falling on the Great Lakes and other designated waters. The Great Waters Program identifies 15 PBTs of special concern in our nation's great waters, and recommends continuing monitoring and research efforts involving these pollutants be undertaken by all partners. A large number of Minnesota lakes and rivers have fish consumption advisories due to the presence of these PBTs, but, at present only one of the 15, mercury, is monitored in Minnesota's air.

The existing Statewide Air Toxics Monitoring Network (SATMN, MN Statutes 116.454) addresses mainly volatile, nonpersistent substances, and does not include PBTs because of the difficulty and expense of measuring them. The monitoring procedure consists of collecting gas and particle air samples (24-hour samples collected approximately every twelve days) using dedicated particle samplers with backup polyurethane foam/XAD resin gas collection media. The samples are returned to the laboratory, extracted, and analyzed using liquid chromatography and mass spectrometry.

The purpose of this new monitoring effort would be to understand the movement of PBTs between environmental media, including the extent to which they accumulate in specific compartments such as sediments, fish tissue, and other biota. This type of information is crucial for the protection of critical habitat, since it addresses air pollutants that are persistent and bioaccumulating so that, even though the pollutants may be emitted to the air, the primary impacts are expected through other media.

Some of the pollutants of high concern today (persistent, bioaccumulating toxics, PBTs) cycle through multiple environmental media (air, water, soil, sediment, etc.), but are transported mainly through the air. These pollutants may accumulate in certain

compartments in the environment to levels causing human health and environmental concerns. A basic step in understanding the movement and accumulation of PBTs is knowing the air concentrations and how they vary over space and time.

The approximate cost of this monitoring is $100,000 per site per year.

3.3 Create Comprehensive Inventory of Air Emissions

Emission inventory information is the foundation for many decisions on improving air quality. An accurate comprehensive inventory would be helpful for assessing the cause and extent of air pollution problems as well as supporting and evaluating reduction strategies for emissions of air pollutants. Currently, MPCA has an emission inventory for criteria pollutants for large stationary sources, and an emission inventory for 104 air toxics for small and large stationary sources and mobile and biogenic sources, and an emission inventory for green house gases from small and large stationary sources and mobile sources. The MPCA could expand the current inventory scope to include emissions of criteria pollutants from mobile and small stationary sources; emissions of all hazardous air pollutants (the whole list of air toxics will be more than 200 pollutants) for small and large stationary sources and mobile sources; and direct emissions of fine particles and their precursors from small and large stationary sources and mobile and biogenic sources. The current and potential future coverage of source categories and pollutants by each emission inventory is summarized in Table 1. The sub-source categories covered in small stationary sources could also be extended.

Table 1. Source categories and pollutants covered by each emission inventory now and future

	Criteria Pollutant	Air Toxics	Green House Gases	PM2.5*	PM2.5 Precursors
Now					
Number of Pollutants	6	104	5	1	
Large Stationary Sources	x	x	x		
Small StationarySources		x	x		
Mobile Sources		x	x		
Biogenic Sources			x		
Future					
Number of Pollutants	6	> 200	> 5	1	
Large Stationary Sources	x	x	x	x	x
Small Stationary Sources	x	x	x	x	x
Mobile Sources	x	x	x	x	x
Biogenic Sources			x		x

- The inventory for PM2.5 will include direct emissions only.

The quality of MPCA emissions inventories could be improved, particularly for air toxics from large stationary sources. As indicated previously in the Current Efforts – Stationary Sources Appendix, Minnesota does not have a rule mandating point sources to report air toxics emissions. Most air toxic emissions are estimated based on generic emission factors. These emission factors may not represent the actual emissions from individual facilities.

A study was conducted on the comparison of emissions estimated by using generic emission factors and source-specific emission factors for taconite facilities and coal-burning utility facilities (Wu, et al, 1999). Results suggest that currently available generic emission factors are not adequate for estimating emissions from metal mining/iron ore processes and gives poor representations of toxic pollutant emissions from the industry. For example, no emissions were estimated by using generic emission factors, but hundreds, even thousands pounds of emissions were estimated by using source-specific emission factors for antimony, benzene, cobalt, copper, toluene, and xylenes. For utility facilities, although more generic emission factors are available, using these emission factors yields results that are much different from emissions derived from source-specific data. Combustion processes and many other industrial processes seem to be in the same situation as utility combustion processes and the metal mining/iron ore processes, respectively. Therefore, it is preferrable to collect source-specific data from industry directly.

The MPCA staff has contacted about 400 industrial representatives and many iindicated they are willing to provide source-specific emission data and appreciate the opportunity to help the MPCA compile an accurate emission inventory. Large resources are required to collaborate with the industry. The MPCA staff must provide guidance on a source-specific basis, review and perform quality assurance on the information from industry, and incorporate the source-specific information with the generic information. Even the data entry could be labor intensive because the emission data is reported at a process-level and one facility might have hundreds of processes. Electronic data submittals could be developed in the future.

To better support strategy-making activities and improve public access to the emission inventory data, the locational information for emission sources also could be collected. With locational information, emission data can be presented on a map at a state level, a county level, a zip code level, and a facility level.

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APPENDIX O
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Action Steps the MPCA Can Accomplish by Shifting Funding from Existing Resources

1.0 Background on the funding Shift

The MPCA intends to shift funding for approximately three staff positions to accomplish additional work on air quality issues. The additional work involves:

- Developing and implementing a statewide Air Quality Communication Plan
- Analyzing future ozone trends in Minnesota, and
- Strengthening MPCA's implementation of the National Emission Standard for Hazardous Air Pollutants (NESHAP) program

By dedicating additional resources to air quality, the MPCA hopes to raise awareness among stakeholders and citizens about air pollution, to increase the MPCA's scientific understanding of emerging air issues, and to more effectively implement the air toxics NESHAP program.

The shift of resources better positions the MPCA to educate Minnesotans about new air pollution issues facing the state and to take steps to address them. The following are examples of the specific actions the MPCA will take after shifting existing resources from other MPCA programs and re-direct those resources to towards air quality issues.

2.0 Develop and Implement an Air Quality Communication Plan

Many pollutants affect air quality in Minnesota and the nation. The MPCA has historically divided some of these pollutants and their sources into subgroups in order to better understand the problem and come up with effective solutions.

The shifting of funding resources (3 staff positions) to air toxics and mobile sources will allow the MPCA to devote adequate resources to developing and implementing a statewide Air Quality Communication Plan.

While developing the air quality communication plan, the MPCA will conduct research to better understand public perceptions, concerns and values regarding air quality and common sources of air pollution. This input will help provide a clear focus for the

communication goals of the plan. Specific communication goals will include many areas of air pollution, including air toxics, criteria pollutants, mobile sources, global warming, mercury and persistent bioaccumulative toxics.

Objectives of the communication plan are listed below.

Objectives:

- To communicate consistent messages about the quality of air in Minnesota
- To coordinate communication activities about air quality among MPCA staff.
- To provide assistance and expertise, when necessary, to program-specific air quality communication activities.
- To incorporate consistent and effective general messages into the planning of all air quality communication activities. MPCA will use scientific and customer research data to assist in the development of the air quality messages.
- To create mechanisms at the MPCA for sharing relevant environmental data.

Outcomes:

The successful implementation of the air quality communication plan will support MPCA's on-going air programs and accomplish the following outcomes:

1) stakeholders, sister agencies and public- and private-sector decision-makers will be informed and aware, and will consider air quality issues in their work;
2) the public will have an increased awareness of the link between individual and community behavior and air quality;
3) the public will increasingly support measures to address the problem

Audiences for the Air Quality Communication Plan

Two audience categories benefit from an MPCA air quality communication plan. The primary audience is MPCA staff who deliver air quality messages. These staff communicate daily with the public through phone calls, presentations and fact sheets. By sharing knowledge and expertise, and working together to develop consistent air quality messages, MPCA air staff will produce stronger and more effective communication products. By creating a common repository for communication pieces on air quality, all MPCA staff will have access to common materials for presentations on air quality.

The second audience category are recipients of the air quality messages, key stakeholders and partners, as well as the general public.

> **Primary audience**: Information officers and air quality program staff who are responsible for presentations and working with news media; sister agencies who use MPCA air quality messages in their own work.

Secondary audience: Stakeholders, sister agencies, legislators, academia, school children and the general public.

Below are some possibilities for how the MPCA can ensure that consistent air quality messages are developed and delivered.

Possible Communication Tools for Developing Consistent Messages:

- Organize an air quality lateral team that would meet three or four times a year to hear issues, consider policy and to decide on key air quality messages.
- Develop a general introduction, to be included in all MPCA air quality presentations, giving context to the broad array of issues currently affecting air quality, both locally and nationally. Examples include:
  - How is the air in Minnesota today?
  - What are the pollutants of concern and why? (i.e.greenhouse gases, air toxics, smog-forming pollutants and Hg)
  - What are the main sources of these pollutants?
  - What are the clean air choices an individual can make?
- A wrap-up statement at the end of all MPCA presentations on air quality, re-stating the context in which air quality issues relate to each other.

Possible Communication Tools for Delivering Consistent Messages:

- Revise the front page of the MPCA web site on air to include a link to "How is the air in Minnesota".
- Develop an air quality information packet for general inquiries
- Offer staff air quality presentations to internal and interagency work groups and to external stakeholder organizations.
- Develop informational articles for the "Minnesota Environment" magazine (print circulation is 25,000) and for EnviroLine, the MPCA's electronic newsletter..
- Develop and sponsor educational conference exhibits. The traveling information booth display could be used at the State Fair, Earth Day and other special events or local environmental meetings.
- Assure Commissioner's speeches to stakeholders and the public carry air messages.
- Develop an air quality brochure insert to be include in MPCA mailings.
- Network with environmental partners (other state agencies, industry and educators). Use their communication tools (web pages and publications). Provide information and talking points to their staff and management.
- Work proactively with news media to place air quality stories carrying MPCA messages.

3.0 Better Understanding of the likelihood of ozone non-attainment

Shifting internal resources would enable the MPCA to better understand future ozone trends in Minnesota, and potential environmental and economic impacts resulting from those trends.

Ozone is formed by the reaction of VOCs and NOx in the presence of heat and sunlight. The amount of ozone formed is limited by the availability of either VOCs or NOx. Areas of the country that exceed federal standards for ozone, conduct modeling research to determine whether VOCs or NOx is the limiting factor in the formation of ozone in their area. This information is important to reducing the amount of ozone formed in a given part of the country.

The MPCA will use the additional resources to first determine how close the Twin Cities area is to exceeding the Federal ozone standard. The MPCA will also try to determine whether ozone formation in the Twin Cities is limited by the availability of VOCs or NOx. This information will enable the MPCA to clarify what sort of reduction strategies would be most beneficial and better determine the likelihood of ozone non-attainment. Its is also important to view the trend in this area given the likely reductions in NOx and VOCs from the implementation of new federal requirements over the next ten years.

4.0 Strengthen Implementation of Federal Sector-based air toxics standards

The National Emission Standard for Hazardous Air Pollutants (NESHAP) program is a federal program under which standards are promulgated by EPA and implemented (primarily) by state agencies for the purpose of regulating and reducing emissions of toxic air pollutants. The level of regulatory control is based on a technical analysis of the emissions source and the ability to reduce those emissions.

To effectively implement the NESHAP program, the MPCA needs to shift staff resources from within to work on this program. Current staffing levels are not adequate to meet the needs of the NESHAP program.

As the NESHAP program is currently being implemented, two MPCA enforcement staff are assigned the duties of determining compliance with and enforcing the NESHAP regulations for all affected facilities in Minnesota. In the past, staff were able to effectively implement the NESHAP program because there were only a handful of NESHAPs promulgated, and only a few facilities subject to the regulations. However, now there are 43 standards promulgated, and about 60 more that are proposed or upcoming. The MPCA also has a considerable backlog of initial notifications and compliance notifications. For example, the MPCA recently sent out initial notification forms to 183 facilities that staff believes may be subject to the recently promulgated Secondary Aluminum Processors NESHAP. Fewer than 100 returned the notification by

the deadline. Currently, the MPCA does not have the resources to follow up with these facility owners to determine if they are subject to this standard. The Small Business Assistance Program, Customer Assistance Center, the MPCA's Pollution Prevention Program and the University of Minnesota's Technical Assistance Program have provided some assistance and outreach to businesses regarding NESHAPs but are not delegated by EPA to conduct the compliance determination or enforcement functions. These functions are imperative to a credible and effective program.

Increasing staff resources would allow the MPCA to better carry out two important functions to implement NESHAP standards, seeing that a standard is implemented throughout Minnesota, and then following up with compliance determination activities.

In the first function of implementing a standard, the MPCA reviews each NESHAP standard to identify what notifications, reports and types of information affected facilities will be submitting to the MPCA in order to meet the monitoring and reporting requirements of a NESHAP. The MPCA may also identify potential technical issues to achieve and maintain compliance with a standard. The MPCA then conducts a notification campaign of affected facilities of new NESHAPs, pointing out key control requirements and notifications, and reminding affected facilities of compliance/notification deadlines.

The second key function of the NESHAP program is to follow up with compliance determination activities. The MPCA must ensure that facilities have correctly identified whether they are subject to a standard, and have implemented control, record-keeping and monitoring correctly in order to ensure continued reductions in toxic pollutant releases. Sometimes compliance determination activities lead to referrals for outreach and training. Other times it leads to enforcement actions.

Appendix P
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Goals and Measures

1.0 Goals

The MPCA has developed long-range goals to set a direction for reducing the effects of fine particles and ozone and to take precautionary steps with air toxics, about which less is known in terms of their health effects. These goals are:

1. By 2010, reduce emissions of pollutants that contribute to fine particulate and ozone by 20 percent from 2000 levels.
2. By 2010, reduce measured concentrations of air toxics to below health benchmarks.

In addition, in early 2001, the MPCA will develop goals for reducing Minnesota's contributions to global climate-changing gases or greenhouse gases. Although Minnesota's contribution to overall greenhouse gas emissions is small, the MPCA believes it is important for Minnesota to do its part. The likely impacts on Minnesota's forests, lakes, wildlife, and fish justify the MPCA setting greenhouse gas reduction goals to reverse the trend of increasing greenhouse gas emissions in Minnesota. (See the Global Climate Change Appendix for further information.)

Goal #1 –Particulate and Ozone Emissions Reduction

In its 1999/2000 Environmental Partnership Agreement with EPA, the MPCA has general reduction goals for particulate matter and ozone as well as other criteria pollutants (see section 2.0 below). The MPCA has chosen to stress reduction goals for fine particulate and ozone emissions for these reasons:

- Current scientific data shows that, on the whole, particulate matter has the greatest health impacts compared with any other class of air pollutants. (See the Particulate Matter Appendix.)
- Particulate matter and ozone levels are close to the new federal standards. There is a larger margin between measured levels of the other criteria pollutants (SO2, Nox, CO, and lead) and the federal standards. (See the Criteria Pollutant Appendix.)
- Many of the chemicals that contribute to levels of fine particles and ozone are also air toxics and therefore reductions of air toxics will also be realized with reductions of particles and ozone.

Trends in mobile source emissions and energy-production related emissions are forecast to increase over the next decade. (See the Mobile Source Emissions and Trends Appendix and the Global Climate Change Appendix.) Although predicted emissions are dependent on a number of assumptions and therefore uncertain, the MPCA believes it is important to set a reduction target to help offset anticipated increases in emissions. The chosen reduction target of a 20 percent reduction in emissions by 2010 is not a magic number, which once reached the air quality is satisfactory. Rather, 20 percent is a number to help

the MPCA focus its reduction efforts to move emissions in the right direction and will make the air safer to breathe and provide a comfortable margin of attainment for ozone and fine particles. With additional information (such as new monitoring data or improved knowledge of health impacts), this number may be adjusted over time.

Goal #2 – Reduce Measured Air Toxics Concentrations to Below Health Benchmarks
The MPCA will compare the concentrations of pollutants measured with federal and state health benchmarks and focus reduction efforts to bring levels below health benchmarks for the various pollutants measured by 2010. The MPCA will use its air toxics monitoring network (one of the best air toxics monitoring networks in the nation) to make a comparison with health benchmarks. Health benchmarks are air concentrations (or measures) below which there is little appreciable risk of harmful effects on humans from an individual pollutant. Health benchmarks are not enforceable standards and can vary depending on the criteria used by the organization establishing the benchmark. Benchmarks can also change as new scientific data becomes available. The MPCA will work with the Minnesota Department of Health to develop a hierarchy of health benchmark sources to use for comparison against measured air toxic pollutant concentrations.

Current science cannot tell us whether the relatively low concentrations of many air toxics are causing effects such as cancer or reproductive disorders. However, the MPCA believes that a precautionary approach with air toxics is appropriate because of the relative lack of knowledge about their health effects. Targeting reduction efforts at those pollutants that are above health benchmarks will help focus MPCA's resources on toxic pollutants of most concern because of their levels in the air.

2.0 Background Information on Existing Goals and Measures

Presented here are the various goals and measures currently in place at the state level for air quality and federal level for air toxics.

2.1 MPCA Goals and Measures

Here are the goals and measures stated in the July 1, 1999 through June 30, 2001 Environmental Performance Partnership Agreement related to the MPCA's mission of clean and clear air. The MPCA goals and measures are updated biennially and the goals shown below will be revised for the July 1, 2001 Agreement to reflect the increased understanding of pollutants and their impacts and sources. The goals included are only those related to criteria pollutants and ozone.

Goal: To ensure clean, clear air that is protective of human health and the environment

Subgoal A1: "To protect human health and the environment from the effects of criteria air pollutants."

Environmental Objective:
a) To meet national goals for visibility improvement in the Boundary Waters Canoe Area and Voyageurs and Isle Royale National Parks.

Environmental Outcome Measures:
Pressure Indicators:
1. % of sources of PM2.5 that meet requirements for Best Available Control Technology
State Indicators:
1. Visual range (in deciviews) measured in the BWCA, Voyageurs Park, and Isle Royale.
2. PM2.5 levels in the BWCA, Voyageurs Park, and Isle Royale.

Environmental Objectives:
b) To continually meet all federal and state ambient air quality standards by 2002.
c) To reduce the levels of criteria pollutants emissions to below 1998 levels.
d) To reduce emissions of ozone and PM2.5 precursors.

Environmental Outcome Measures:
Pressure Indicators:
1. Tons of criteria air pollutants emitted from all Minnesota sources (stationary, area and mobile). (potentially corrected for economic growth)
2. Vehicle Miles Traveled (VMT) in the Twin Cities Metro Area.
3. Emissions reductions since 1998 for criteria pollutants.
4. Emission reductions since 1990 for criteria air pollutants.

State Indicators:
1. Criteria pollutant levels in ambient air as a percent of health standards (long-term trends).
2. Number of days per year when the Pollution Standard Index (PSI) exceeds 50 (moderate levels).
3. Number of days when ambient air quality standards for criteria air pollutants are exceeded. (reported as number of days for each criteria air pollutant)

Subgoal A2: To protect human health and the environmental from the effects of air toxics.

Environmental Objectives:
a) To reduce air toxics emissions from mobile sources.
b) To reduce air toxics emission from stationary and area sources.
c) To reduce the levels of air toxics in the ambient air throughout Minnesota.

Environmental Outcome Measures:
Pressure Indicators:
1. Tons of hazardous air pollutants (HAPs) emitted from all Minnesota sources (stationary, area and mobile). (especially those HAPs identified in the Cumulative Exposure Project)

State Indicators:
1. Ambient concentrations of selected HAPs. (Units should designate target HAPs to report; i.e., the HAPs identified in the Cumulative Exposure Project)
2. Estimated number of Minnesotans exposed to high concentrations of HAPs in the Twin Cities metro area.
3. Percent of excess cancer risk in the Twin Cities metro area, the Rochester area, the Duluth area and the St. Cloud area attributable to mobile-source HAPs.

To view the entire Environmental Performance Partnership Agreement go to:
http://www.pca.state.mn.us/programs/enppa.html

2.2 National Goals For Air Toxics

The MPCA's goal of reducing measured concentrations of air toxics to below health benchmarks complements the national goals for air toxics described below.

2.2.1 Government Performance Results Act (GPRA):

Current goal:

"By 2010, reduce air toxic emissions by 75% from 1993 levels to significantly reduce the risk of the population of cancer and other serious adverse health effects caused by airborne toxics."

Future goal:

"By 20xx, eliminate unacceptable risks of cancer and other significant health problems from air toxic emission for at least 95% of the population and substantially reduce or eliminate adverse effects on our natural environment."

2.2.2 EPA's Integrated Urban Air Toxics Strategy Goals:

These goals were stated in EPA's *Integrated Urban Air Toxics Strategy* published July 19, 1999:

- **Attain a 75-percent reduction in incidence of cancer attributable to exposure to HAPs emitted by stationary sources**. This is relevant to all HAPs from both major and area stationary sources, in all urban areas nationwide. Reductions can be the result of actions by Federal, State, local and/or Tribal governments, achieved by any regulations or voluntary actions.
- **Attain a substantial reduction in public health risks posed by all 188 HAP emissions from area sources**. This includes health effects other than cancer posed by all HAPs. Reductions can be the result of actions by Federal, State, local and/or Tribal governments, achieved by any regulations or voluntary actions.
- **Address disproportionate impacts of air toxics hazards across urban areas**. This will involve consideration of both stationary and mobile source emissions of all HAPs, as well as sources of HAPs in indoor air. EPA intends to characterize risk distributions both geographically and demographically. This will include particular emphasis on highly exposed individuals (such as those in geographic "hot spots") and specific population subgroups (e.g. children, the elderly, and low-income communities.)